STIGMA: THE PSYCHOLOGY AND ECONOMICS OF SUPERFUND*

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Abstract

This study documents the long-term impacts of Superfund cleanup on property values in communities neighboring prominent Superfund sites. To understand the impacts, one must integrate the psychology of risk perceptions and stigma with the economics of property values that capture those perceptions. The research specifically examines the sale prices of nearly 35,000 homes for up to a thirty-year period near six very large Superfund sites. To our knowledge, no property value studies have examined sites in multiple areas with large property value losses over the length of time used here. The results we obtain for these very large sites are both surprising and inconsistent with most prior work. The principal result is it that, when cleanup is delayed for ten, fifteen, and even up to twenty years, the discounted present value of the cleanup is mostly lost, most likely because sites are stigmatized and the homes in the surrounding communities are shunned. The psychological model developed suggests that, for very large sites, expedited cleanup and simplifying the process to reduce the number of stigmatizing events that attract attention to sites would reduce property losses.

Chapter 1

Overview and Executive Summary

1.1 Introduction

This study attempts to evaluate the benefits (as captured in residential property values) of hazardous waste cleanup conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. When this legislation was passed in 1983, following Love Canal, the public imagined that the Environmental Protection Agency (EPA) would begin immediate cleanup of sites deemed hazardous to human and environmental health, using tax money collected from the petroleum and chemical industries. However, CERCLA's provision of joint and several liability requires that all previous and current owners could be responsible for cleanup cost, regardless of the amount of hazardous waste deposited at the site. Thus the legal complexity of CERCLA in establishing fair and just responsibility substantially delayed cleanup at many listed Superfund sites (as described in detail in Chapter 2, which provides a brief history of Superfund).

This research documents the consequences of that delay on property values in communities neighboring prominent Superfund sites. To understand those consequences, one must integrate the psychology of risk perceptions and stigma with the economics of property values that capture those perceptions. To explore the possibility that stigma can help explain public reaction to potentially hazardous sites, six Superfund sites in four geographic areas are examined: the Operating Industries, Inc. landfill site near the communities of Monterey Park and Montebello, California; the radium pollution in Montclair, Glen Ridge, and East/West Orange Townships in northern New Jersey; the Industri-Plex and water Wells G & H in Woburn, Massachusetts, and the Eagle Mine outside Vail, Colorado. The research specifically examines the sale prices of nearly 35,000 homes for up to a thirty-year period, and describes the history of each site. It should be noted that many Superfund sites have shown no or small property value losses in surrounding communities. The sites selected for this study all have shown large losses at some point in time. Furthermore, to our knowledge, no prior property value study has examined sites in multiple areas with large property value losses over the length of time used here. The results we obtain are both surprising and inconsistent with most prior work that looks at shorter time periods (e.g., McClelland, Schulze and Hurd 1990; Gayer, Hamilton, and Viscusi, 2000; Gayer and Viscusi, 2002). For our prominent sites, one can draw a variety of conclusions depending on what part of the history of property values are examined. Our results are more consistent with studies that look beyond the complete cleanup which suggest property values may only recover after cleanup is complete (Kohlhase, 1991; Dale et al., 1999).

In summary, the principal result is it that over the long term, when cleanup is delayed for ten, fifteen, and even up to twenty years, the discounted present value of benefits of cleanup are mostly lost because sites are stigmatized and the homes in the surrounding communities are shunned. Additionally, the research documents how trends in the socio-demographic composition of the communities near the sites differed from the trends in communities farther from the site.

This chapter summarizes the key findings of the study and is organized as follows. The second section briefly describes the six Superfund sites in four geographic areas throughout the U.S. The third section discusses why residents of communities neighboring Superfund sites may not completely believe the opinion of scientific experts regarding the health risks associated with the sites. The fourth section outlines what is known about the psychology of risk perceptions and stigma. The fifth section integrates the psychology of stigma with economic hedonic property value approach which, as noted by Adams and Cantor (2001), is a nontrivial task. Finally, the sixth section presents our conclusions.

1.2 Case Studies

Operating Industries, Inc. Landfill: The OII Landfill covers 190 acres and is located 10 miles (16 kilometers) east of Los Angeles between the communities of Monterey Park and Montebello, California. The Pomona Freeway (Route 60) divides the site into two parcels; one 45-acre area lies north of the freeway and the other 145-acre parcel lies south of the freeway. The landfill is in the city of Monterey and the city of Montebello borders the southern end and portions of the northern section of the landfill. Throughout its operating life, from 1948 to 1984, the landfill received 30 million cubic yards of residential and commercial refuse, industrial wastes, liquid wastes, and a variety of hazardous wastes. The EPA determined that approximately 4,000 different parties sent waste to the landfill at one point or another. In October 1984, the landfill was closed and proposed for listing on the National Priority List (NPL) In June 1986, the landfill was officially listed as a NPL Superfund site, and experts estimated that the cleanup could take as long as 45 years, and more than $600 million to complete. As of 2002, the EPA had reached settlements with almost 4,000 parties to pay for the cleanup work, with the total settlements reaching over $600 million (Table 1.1).

OII Landfill and Neighboring Community

In the early 1980's, residents near the landfill formed Homeowners to Eliminate Landfill Problems (HELP) to address increasing odor and potential health problems at the site, as well as specific issues such as leachate seepage, methane gas buildup, declining property values, and land use after closure of the site. This organization, comprised of 460 dues-paying families, was an essential force in the eventual closing of the landfill. Community council meetings became volatile as residents protested the "assaulting stench" of the air. "We could never open the [house] windows," said Montebello resident Phyllis Lee. As another resident stated, "Some nights I wake up coughing at two, three, four o'clock in the morning. The methane gas is so strong that I have a hard time breathing."

Table 1.1 Key Dates and Statistics

Site Name	Discovery	NPL Listing	Dates & Descriptions of Major Clean-up Phases		Homes in Sample	Clean-up Cost	Total Property Value Loss
Operating Industries, Inc. Landfill Los Angeles, California	1978	1985	1988	Drilling of wells and groundwater treatment	9,200	$600m	39.5%
			1997	Construction of cap on landfill			
Montclair, West Orange, & Glen Ridge New Jersey	1983	1985	1991	Phase 1	12,444	$200m	8.9%
			1993-1995	Phase 2 & 3			
			1996	Phase 4 & 5			
Industriplex and Water Wells G & H Woburn, Massachusetts	1979	1983	1992-1993	Main cleanup on both sites	11,940	$80m	14%
Eagle Mine Colorado	1984	1986	1989-1991	Problematic State-led cleanup	1,087	$70m + $0.7m/yr	15.3%
			1996	Removal of contaminated soils			
			1997	Tailing piles capped			

According to Katherine Shrine, assistant regional counsel for the EPA Region 9, "This site is basically a 300-foot-tall, 190-acre mountain of every kind of disposable item in the world." Residents say the landfill is so large that it interferes with television reception. Approximately 53,000 people live within three miles of the sites, 23,000 within one mile of the site, and 2,150 within 1000 feet of the landfill. Three schools are located within 1 mile of the landfill. The area consists of heavy residential development and mostly middle income and multi-racial neighborhoods.

For the Operating Industries, Inc. (OII) Landfill case study, we were able to obtain data on selling prices, housing characteristics, and Census information for nearly three decades (1970 to 1999). The length of this sample enables an examination of how proximity to the landfill affected housing prices well *before* the problems began to arise in the late 1970's. A relatively large footprint was selected in this study. The broader neighborhood surrounding the OII Landfill site includes 9,279 dwellings between 60 meters and about 8.5 kilometers (5.3 miles) from the boundary of the site. Chapter 3 presents a more detailed history of the OII Landfill site.

Montclair, West Orange, and Glen Ridge, New Jersey: Montclair, Glen Ridge, and East and West Orange Townships are located about eight miles from Newark Airport in northern New Jersey. These towns are densely populated, and are located in one of the most densely populated regions of the United States. Approximately 50,000 people live within one mile of the Superfund sites. The Montclair/West Orange Radium Superfund site consists of 366 residential properties on 120 acres in Montclair and West Orange. The Glen Ridge Radium Superfund site is comprised of 306 properties on 90 acres of residential land in Glen Ridge and East Orange. The soil at both sites is contaminated with radium, a naturally occurring element that can result in high levels of radon gas and gamma radiation in nearby homes. Several plants occupied the area, the largest of which was the U.S. Radium Corporation (formerly the Radium Luminous Materials Corporation) which operated between 1915 and 1926. Because of its luminescent properties, radium was added to the paint that was used for numbers on watch dials and instruments, which became especially popular during World War I. The Center for Disease Control and the New Jersey Department of Health declared these sites to be a public health hazard due to concerns about lung cancer. Montclair/West Orange and Glen Ridge were listed on the NPL for Superfund sites in 1985 because of their proximity to radium waste generated by radium processing. These plants had operated in the area after the turn of the 20th century and an estimated 200,000 cubic yards of contaminated material were placed on private and public areas in the communities.

A USEPA contractor takes gamma radiation measurements in Montclair.

New Jersey Department of Environmental Protection officials were planning to notify local government officials and residents of their findings in early December 1983. However, despite a request by officials to hold the story until official notification had been made, a November 30th television news report broke the story early. According to the *New York Times* (October 16, 1984) article published one year later, "[Many] residents of the three communities – Montclair, West Orange and Glen Ridge – were not told about the problem until... technicians, wearing protective gear began taking soil and air samples in and around their homes." A couple of news reports, referred to the radium contamination in New Jersey as "another Love Canal," since both residential areas were built on contaminated soil.

Initial attempts to remove the contaminated soil were hampered by the lack of a suitable waste depository, resulting in 4,902 drums and 33 containers of soil being stored for nearly two years on the yards of partially excavated properties in Montclair. In 1999, nearly 20 years after the initial identification of the problem and 12 years after being put on the NPL, cleanup activities continued to occur as the streets were replaced and the EPA continued to investigate the possibility of additional groundwater contamination. By 1998, a total of $175 million had been spent to remediate over 300 houses and remove 80,000 cubic yards (or 5,000 large truck loads) of contaminated soil. In 2004, estimates of total cleanup exceeded $200 million (Table 1.1).

For this case study of the radium contamination in the communities of Montclair, Glen Ridge, and East and West Orange in northern New Jersey, we were able to obtain good data on selling prices, housing characteristics, and Census information for one decade (1987 to 1997), which started just two years after the sites were listed on the NPL. This data enabled us to examine the change over time of housing prices *during* the lengthy multi-phase cleanup process.

The data for this case study showed two different patterns of affects on housing prices. For homes that neighbored the affected communities, but did not experience the contamination themselves, there was a general decrease in property values as described below. For the homes that were within the affected communities, the swings in property value changes were greater, and the initial remediation efforts appear to have caused a temporary recovery in property value, however, this recovery does not appear permanent. One possible explanation for this recovery in property values is that the process of remediation often involved some remodeling of the homes directly, such as a new garage and/or landscape. Therefore, the cleanup not only removed potential hazards, but directly improved affected homes. Chapter 4 provides a more detailed description of these sites.

Industri-Plex and Water Wells G & H, Woburn, Massachusetts: Woburn is a historic city (founded in 1640) of about 35,000 people located 12 miles northwest of Boston. The community is predominantly blue-collar because of its industrial heritage. In the mid-1800s, Woburn became known for shoe manufacturing. Local manufacturing activity later shifted from shoes to leather production, and Woburn became a leader in the U.S. tanning industry by 1865. By 1884, Woburn was home to 26 large tanneries that employed approximately 1,500 employees and produced $4.5 million worth of leather. At the peak of Woburn's tanning industry, from 1900 to 1934, an estimated 2,000 to 4,000 tons of chromium was dumped directly into Woburn's water resources, as well as 65 to 140 tons of copper, 85 to 175 tons of lead, and 40 to 75 tons of zinc.

Abandoned 55-gallon Drum with the Entire Side Corroded; Found Near Wells G & H.

Woburn is also the location of two large Superfund sites: Wells G & H and Industri-Plex. Together the sites cover almost 600 acres of land in the 14 square mile community. Both sites are located in the section of Woburn east of Main Street, a low, swampy area that includes many streams and the Aberjona River. This section of Woburn, referred to as East Woburn, is a mix of industrial and residential areas. Roughly 13,000 households are located within two miles of the Industri-Plex site, and homes are located within 1,000 feet of the site. Approximately 34,000 people live within three miles of both sites. While the two sites are distinct from each other, the pollution problems at both sites were discovered within a few months of each other. Both sites were evaluated by the EPA and added to the NPL in the early 1980s (Table 1.1).

Throughout Woburn's history, more than 100 companies used the Aberjona River, which flows through the city, for industrial waste disposal. Companies dumped wastes on land, into lagoons and ponds adjacent to the river, as well as directly into the river itself. From 1853 to 1931, compounds and chemicals such as acetic acid, sulfuric acid, lead, arsenic, chromium, benzene and toluene were dumped behind buildings, used as fill for low spots, and included in construction material for dikes and levees. Woburn has a long history of public health problems, including elevated rates of kidney and liver cancer, colon-rectal cancer, child and adult leukemia, male breast cancer, melanoma, multiple myeloma, and brain and lung cancer.

The 330-acre Wells G & H site is located near the Aberjona River, about one and a quarter miles downstream (south) of the Industri-Plex site. It once ranked as the tenth worst site on the EPA's NPL list. The site is the location of two drinking water wells for the city of Woburn, which were built in 1964 (Well G) and 1967 (Well H). These wells were located near an automobile graveyard, an industrial barrel cleaning and reclamation company, a waste oil refinery, a tannery, a dry cleaner, and a machinery manufacturer. Despite public complaints about the water from these wells, Woburn continued to use the wells, especially during the summer. Both wells were finally closed in 1979 after testing showed that the water was contaminated. Soil and groundwater at the site are contaminated with volatile organic compounds (VOCs), such as trichlorethylene (TCE) and tetrachloroethylene (also called perchlorethylne, PCE, or 'perc'). Land in this area is zoned for industrial and commercial use, with some areas for residential and recreational use.

The Industri-Plex site, the location of Woburn's most intensive industrial activity since the 1850s, consists of 245 acres in an industrial park and once ranked as the fifth worst site on the NPL. This area is located one mile northwest of the intersection of Interstate 93 and Route 128 and is bordered by the communities of Wilmington and Reading. Two tributaries of the Aberjona River flow through the Industri-Plex site. Of the 245 acres at the site, one-third was contaminated and 60 acres were used for commercial purposes throughout the remediation of the site. Contamination at the Industri-Plex site includes heavy metals and hydrocarbons. In the soil, the contamination was primarily arsenic, lead, and chromium and in the water the contamination was primarily benzene, toluene, arsenic, and chromium. Additionally, hydrogen sulfide gas emanating from wastes and buried animal hides from the tanneries, once permeated the air.

The discovery of two major hazardous waste problems in one town prompted strong media interest as well as the active response and involvement of Woburn's residents. Area newspapers and TV stations ran multi-part stories about Woburn, alluding to it as a "toxic wasteland." Millions of dollars and several years were devoted to the Woburn court case which commanded front-page national media attention. The book describing the lawsuit, *A Civil Action*, was published in 1996 and became a bestseller. In 1999, the book was made into a movie starring John Travolta.

For Woburn, Massachusetts, we were able to obtain data on selling prices, housing characteristics, and Census information from 1978 to 1997 on 12,444 homes. Therefore, the sample begins one year before the discovery of contamination at Industri-Plex and Wells G & H and extends throughout the lengthy litigation and cleanup activities. The Woburn case most clearly demonstrates the importance of accounting for socio-demographic change when conducting economic studies on the value of neighboring homes. When these factors are included, it becomes evident that part of the decline in relative values for homes near the two sites is related to a general deterioration of the neighborhoods. If these factors are not controlled for in the analysis, the property affects of proximity to the sites may be overstated. However, the sites themselves are the likely cause of neighborhood deterioration. Chapter 5 provides a detailed history of these sites.

Eagle Mine, Colorado: Eagle Mine is centrally located between Vail and Beaver Creek ski areas, approximately 100 miles west of Denver, Colorado. Eagle Mine lies between the small towns of Minturn and Red Cliff, just off U.S. Highway 24 and was once one of the nation's top producers of zinc. The property consists of approximately 6,000 acres, 340 of which are contaminated with toxic waste. Most of the contamination originates from areas located along the Eagle River, and includes: the abandoned mining town of Gilman located on a cliff just above the mine, the old Eagle Mine processing plant in Belden, two ponds containing wastes from the smelting of ore, Maloit Park, Rex Flats, various waste rock and roaster piles, and an elevated pipeline. The Eagle River (a major tributary of the Colorado River), Cross Creek, and several other tributaries run through the site.

Warning sign at the entrance to Rex Flats & OTP.

The Eagle Mine site is contaminated with eight to ten million tons of hazardous substances including arsenic, nickel, chromium, zinc, manganese, cadmium, copper, and lead. The main cause of Eagle River contamination came from acid mine drainage, which occurs when sulfide minerals, such as pyrite, are exposed to oxygen and water and then oxidize. This process creates sulfuric acid, which contaminated soil, groundwater, and surface water surrounding Eagle Mine, producing water with low pH levels. Acid drainage at Eagle Mine resulted from precipitation flowing through the waste piles that accumulated from nearly 100 years of mining. As Eagle Mine acid drainage seeped into ground and surface water, it killed aquatic life and vegetation growing along the water's edge and contaminated the river with zinc, lead, manganese, and cadmium. Not only did this contamination threaten brown trout, the most populous fish in this segment of the river, but it also permanently stained the rocks in and along the river bright orange, providing Mintum and Red Cliff residents with a constant reminder of the contamination at Eagle River.

State studies conducted in 1984 revealed dangerously high levels of cadmium, copper, lead, and zinc in local water resources. Mintum, with a population of 1,500, is the closest town and draws drinking water from Cross Creek and two wells located within 2,000 feet of the mine tailings. While Eagle Mine had a history of environmental problems dating back to 1957, the majority of the problems arose after the mine closed in 1984. In March 1985, Ray Merry, the Eagle Mine Environmental Health Officer, ordered the 14 families remaining in Gilman to leave the site because of potential human health hazards. By July, all families had left the area and

Gilman became a ghost town. A gate prohibiting entrance to the town read "Town for Sale." Eagle Mine was placed on the NPL in June 1986.

As the cleanup began, public concern about the possibility of adverse human health effects intensified. Although the EPA chose not to endorse the State of Colorado's cleanup plan because it was skeptical of the plan's long-term effectiveness, the State forged ahead with the cleanup of the Eagle River site fearing the worsening of public health and environmental damages that might result from continued acid mine drainage. However, the State's decision to pump tailings pond water back into the mine, using the mine as a holding tank, proved to be disastrous and caused even more pollution to infiltrate the Eagle River. A dry winter caused mine seepage to make up most of river water, and the river turned orange. As a result, fish populations declined dramatically. Samples taken from the river that fall revealed zinc levels were 255 times higher than fish tolerance thresholds. No fish lived in the river, and contamination was turning the Eagle River various colors.

For the Eagle Mine, near Vail, Colorado, we were able to obtain data from 1,087 owner occupied properties downstream of the Eagle Mine over a 24-year period (1976 to 1999). Unfortunately, the data available from the Eagle County Assessor's office does not span enough distinct Census tracts for the differences in socio-demographic characteristics across these tracts to be useful in explaining the variation in housing prices. A challenge with this area is that, unlike the other three cases, a high percent of the homes are recreational and not owner occupied. There is substantial evidence that areas most effected by the pollution from Eagle Mine, such as Minturn, did not experience rapid development growth that occurred in other areas of the Vail area, even though they were in closer proximity to Vail resort. Due to the lack of socio-demographic data and the fact that Eagle Mine affected a mountain community where the main pollution was observed in a river, not just the original point source, the data from Eagle Mine was not included in the psychological model and analysis described below. Chapter 6 describes the Eagle mine site and history in more detail.

1.3 Expert Error

Gayer, Hamilton and Viscusi (2000) argue that residents living near Superfund sites judge risks to be of a magnitude consistent with EPA expert opinions and that these judgments are reflected in property values. The research presented here suggests quite the opposite. However, the sites studied here are much larger and likely to attract more attention. This section documents many cases of expert error to help explain why expert opinion plays a limited role in explaining residents' risk beliefs. Thus, the judgments of experts are only one component of the mix of news media stories and perceptual cues received by the typical citizen. Even if statements by scientific experts were accepted as credible, they would compete with a mix of the other signals and perceptual cues. As simply one component, such statements are unlikely to be the primary determinant of individual risk beliefs. Thus, risk beliefs determined largely by media stories and other perceptual cues are unlikely to be easily changed by the pronouncements of a few scientists (Fischhoff, 1989).

Furthermore, it is unlikely that statements by scientific experts will be accepted as completely credible. Even when different experts are in essential agreement, the news media often focuses on those aspects where experts disagree (Wilkins and Patterson, 1990), thus lowering the perceived credibility of experts. In a study examining news coverage of Three Mile Island and Chernobyl, Rubin (1987) found that news stories tended to dichotomize events rather than blend a continuum of information to recipients. The result is that the public discredits information it receives from experts because it appears that experts cannot agree among themselves and, therefore, do not really know the risk that a site presents.

Despite the ideal that science discovers absolute truths, for every health or environment related article there appears to be a corresponding article that rejects the tenets of the previously publicized claim. Numerous famous examples exist where experts from academia, government, and industry have made errors and misestimates:

- Soil contamination at Love Canal, Niagara, New York
- Dioxin contamination in Times Beach, Missouri
- The defective Dalkon Shield for birth control
- The false discovery of Cold Fusion
- The failures at Biosphere 2
- The near nuclear meltdown at Three Mile Island
- The Union Carbide Accident in Bhopal, India

These examples, which are described in detail in Chapter 7, are not just relegated to the past, as the costly search for weapons of mass destruction in Iraq, to date, has yet to support early claims by intelligence experts.

News about human and environmental health is omnipresent, yet much of this information is contradictory. Nearly every day newspapers, magazines, and television shows report new information that tends to further obscure issues rather than clarify them. A cursory survey of two major national newspapers conducted between September 1, 1999, and November 1, 1999, yielded several articles that contested previously reported claims or presented evidence of scientific or expert misjudgment and error. These articles reported the following:

- "Studies Bolster Link between Diet Drugs, Heart-Valve Leaks." Contrary to the previous claims of the manufacturer, the diet drugs Redux and fen-phen can cause permanent heart damage (*Wall Street Journal*, September 10, 1999).
- "Questions for Drug Maker on Honesty of Test Results: FBI Asks About Diet Product's Approval." A drug manufacturer did not report to the Federal Drug Administration all relevant test results prior to petitioning for approval of a drug (*New York Times*, September 10, 1999).
- "Tobacco Industry Accused of Fraud" For more than forty years, the tobacco industry suppressed evidence that tobacco use causes cancer (*New York Times*, September 23, 1999).
- "Japanese Fuel Plant Spews Radiation after Accident." Trained operators of a nuclear power plant in Japan poured more than six times the required amount of uranium into a tank, resulting in a nuclear chain reaction (*New York Times*, October 1, 1999).
- "Two Teams, Two Measures Equaled One Lost Spacecraft." The Mars Orbiter burned in space because the spacecraft's creator used imperial measurements when the spacecraft's navigational team used metric measurements (*New York Times*, October 1, 1999).
- "Drug May Be Cause of Veterans' Illness: Pentagon Survey Links Gulf War Syndrome to Nerve-Gas Antidote." Persian Gulf War soldiers who were given a drug to protect them from nerve gas attacks suffer from damage to areas of the brain that control reflexes, movement, memory, and emotion (*New York Times*, October 19, 1999).

- "Testing in Nevada Desert is Tied to Cancers." Soldiers who participated in nuclear tests for the military in the 1950s have higher than normal death rates and an increased likelihood of developing leukemia and prostrate and nasal cancer (*New York Times*, October 26, 1999).

Due to this steady flow of events and news stories that present contradictory, inaccurate, or incomplete expert evidence, the public is unlikely to accept expert evidence as absolutely accurate all the time. The frequency of events as well as the ambiguity and uncertainty of experts, government officials, and the media, as demonstrated by these examples, leads to doubt and skepticism on behalf of the public. The implication is that residents living near Superfund sites are forced to construct their own risk beliefs based on perceptual cues and media coverage. McClelland et al. (1990) surveyed residents near OII about their risk beliefs and found a bimodal response with more than half believing that living near the site was as dangerous as smoking more than one pack of cigarettes per day, with an incremental annual risk of death of approximately 1/100. Most of the remaining residents viewed the risk as trivial. Assuming typical values for statistical life and assuming three people per home, the discounted present value of the risk for the residents that assessed the risk as similar to smoking exceeds the price paid by these residents for their homes! Residents who responded this way did report that they were desperate to sell and sought immediate cleanup.

1.4 Events, Perceptual Cues, Risk Perception, and Stigma

Given the doubts that people will inevitably have with respect to the credibility of expert risk assessment, perceived risks will be based on personal and community judgments derived from other sources of information. Events that are associated with a Superfund site will lead to perceptual cues and media attention that will most likely elevate perceived risk and stigmatize the site for reasons documented below. Some of the most important determinants of risk beliefs are perceptual cues. Perceptual cues are physical aspects of a site that are perceived by local residents, and are suggestive of risk. Examples of perceptual cues include odors emanating from landfills, unusual odors or flavors in well water, unusual soil or water coloration at the site, and a heavy volume of truck traffic going in and out of the site. Ironically, some actions taken by authorities to minimize public health and safety risks tend to exacerbate risk beliefs by providing clear cues that some risk is present. Erecting chain link fences, posting 24-hour guards, placing warning signs, conducting on-site tests (especially by workers wearing protective clothing) are all cues to residents that risk levels may be higher than they thought. Such actions, which may be necessary, almost never lower risk beliefs. Proximity to a site increases the frequency and duration of contact with, or observation of, perceptual cues, which contributes directly to the intensity of risk beliefs.

The effects of strong perceptual cues are well illustrated by the OII Landfill. Initially, concern about high volumes of truck traffic and odors (produced by decomposition in the landfill) prompted local residents to organize and confront problems associated with the site. McClelland et al. (1990) found a significant correlation between recognition of these perceptual cues and the high risk beliefs of many residents living near the site. Several of the perceptual cues were removed or reduced by (a) installing wells to extract the methane gas for commercial use and (b) closing the site, which eliminated most of the truck traffic. Even though these actions did not address risks that hazardous substances would migrate into local neighborhoods, the risk estimates of many residents dropped dramatically after the principal perceptual cues were removed. McClelland et al. also demonstrated that there were significant property value losses associated with these risk beliefs.

Attention given to a site in the media, apart from the actual content of news stories, is itself a perceptual cue that risks may be high. Many studies have shown that frequent exposure to media reports about a site increases the likelihood that residents will believe the site is very risky. The specific risk at a site and perhaps the site itself will usually be unfamiliar to residents. That in itself increases risk beliefs (Wilkins and Patterson, 1987). But more importantly, it means that residents are almost totally dependent on the news media for information about the risk. Reflecting the concerns of their consumers, the news media often focus on aspects that accentuate dread, such as the uncontrollability of the risk and the frightful worst outcome (e.g., dying of cancer), rather than on information about the low probabilities of the risk and how those probabilities compare to other risks that residents accept.

The signals that the media sends to the public regarding risks from hazardous waste sites are important, but the way in which the public interprets this information is equally important. A key feature of how news coverage is interpreted by residents is whether there is an easily identifiable "villain" responsible for the hazardous waste problems at the site. For example, if the responsible party is a corporation whose primary business activity is outside the community, then it is more easily portrayed as a villain than a local business which has strong affiliations to the community. Russell et al. (1991) found that the more important a site's potentially responsible parties (PRPs) were to the local economy, the more skeptical residents living near the site were that it needed to be cleaned up. Personal familiarity with a site also influences how news reports are interpreted. The greater the prior familiarity, the less risk beliefs are likely to be elevated by news stories.

The largest PRP for the OII Landfill was an outside corporation that had not provided significant employment or other economic benefits for the residents who lived nearby. Most of the waste, especially hazardous waste, was generated and brought to OII from outside the community. OII was primarily a commercial landfill serving many interests outside of the community. In short, conditions were ripe for news stories to elevate risk concerns significantly.

How a risk affects the community, society, and the economy will depend on individual and group perceptions of the risk (Slovic et al., 1991; Kunreuther and Slovic, 2001). There can be a compounding or "rippling" effect as more and more individuals respond to the risk (Kasperson et al., 1988). Or, as Dr. Paul Slovic describes it, interactions among individuals can produce a "social amplification of the original risk concern." The greater the population living near a site, the greater the potential for compounding or social amplification.

When residents or potential buyers are extraordinarily fearful of a site, they may respond by shunning the site. This behavioral response has been labeled stigmatization and has been explored in a number of experiments that suggest that if risks are perceived as being excessive, people replace calculations of risk versus benefit with a simple heuristic of shunning, the avoidance of the stigmatized object.

Stigma has been shown to have a number of key properties. Laboratory experiments testing these properties have involved dipping a medically sterilized cockroach into glasses of juice and gauging subjects' willingness to drink the juice after the cockroach has been removed (Rozin, 2001). First, stigma shares many of the psychological characteristics of contagion, where contagion is associated with touch or physical contact. For example, while subjects refused to drink the juice if the sterilized cockroach was dipped into the glass, they would drink the juice if the cockroach was just placed near it. Second, stigma appears to be permanent. Subjects refused to drink the juice even if it had been in the freezer for one year. Third, stigma appeared to be insensitive to dose. Reductions in the duration of contact between juice and cockroach had little effect. Any contact was sufficient for subjects to shun the juice. Fourth, the source of contagion is usually unknown. Thus, while shunning may have evolved from an adaptive response to avoid contaminated food, it can be triggered in inappropriate circumstances. For example, subjects who saw sugar water placed in a clean empty jar and then saw a cyanide label placed on the jar still tended to refuse to drink the sugar water. Finally, subjects tend to medicalize the risk, arguing that the stigmatization was the result of a fear of health effects.

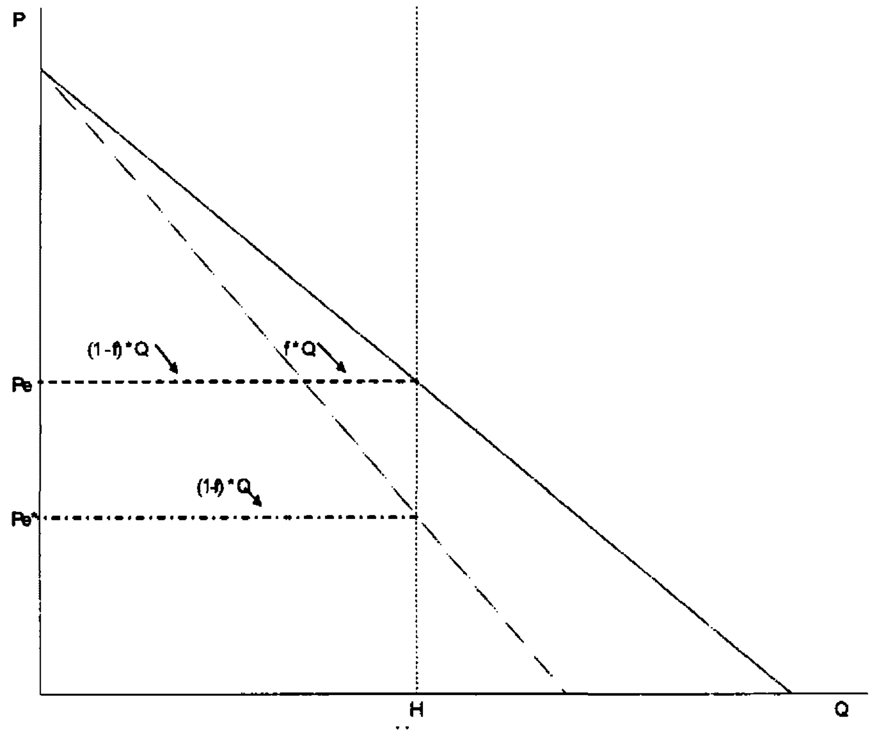
The possibility that Superfund sites might be stigmatized could have a major impact on the prospects for successful cleanup of contaminated sites. If such sites are permanently shunned because, like the "cockroached" juice, they are viewed as permanently stigmatized, property values may not recover immediately once cleanup is in progress (since future improvements should be capitalized into home values) or even when cleanup is completed.

1.5 Stigma and Property Values

The possibility that stigma may cause large losses in property values has been noted by other researchers (e.g., Dale et al., 1999; Adams and Cantor, 2001) and the EPA (Harris, 2004). In contrast to the hedonic approach (Rosen, 1974; and for application to hazardous sites see Bartik, 1998; Harris, 2004; Harrison and Stock, 1984; Ketkar, 1992; Kolhase, 1991; Mendelsohn, et al., 1992; Michaels and Smith, 1990; etc.) where risk is treated as one of many attributes that contribute to a determination of sale price, stigma is likely to effect property values in a rather different and more direct manner. Upon learning of the contamination potentially affecting their community, some current home owners may simply be unwilling to continue to live in their home, and likewise, potential buyers will be unwilling to consider buying a home in that community. If some owners and buyers have lexicographic preferences, the standard hedonic model fails since it relies on a tradeoff between risk and home prices. Rather, shunning by both current owners and potential home buyers will reduce the total demand for housing for a neighborhood near a site as shown in Figure 1.1. Imagine that the total demand for homes in a particular fully built-out neighborhood with H existing homes is Q(P) where Q is the number of desired homes, P is the sale price, and quantity demanded falls with price, $Q' < 0$. If, for example, homes were sold in a competitive uniform price auction, the equilibrium price, P_e, is obtained by solving $H=Q(P)$, so $P_e=Q^{-1}(H)$. Now consider the case where a fraction f of home buyers and owners shun a neighborhood because of a nearby Superfund site. The usual hedonic model cannot handle this phenomenon because the hedonic price adjustment for these individuals, either through very high subjective risk beliefs (assuming conventional values of statistical life) or shunning would give homes a risk deficit greater than or equal to the value of the home. In other words, in either case the perceived costs of staying in the home are greater than the entire value of the home and the observed behavior would be identical. This implies that fraction f of current owners will sell and that the number of potential buyers will be reduced by fraction f as well. As shown in Figure 1.1, since we have defined total demand for the neighborhood to include current owners, the equilibrium price will now be determined by the solving $H=(1-f)Q(P)$, so $P_e^*=Q^{-1}(H/(1-f))$ and $P_e^* < P_e$ for $f > 0$. If f falls with distance from the site, as is likely since perceptual cues decline with distance, then property values will rise with distance, *ceteris paribus*. Of course, relative demand for housing that is more distant from the site will increase, but presumably this increase in demand will fall on a much larger group of homes, resulting in a negligible increase in prices of homes farther from the site.

The next question is, since a hedonic analysis is used to incorporate normal attributes for predicting property prices, how can downward sloping demand be incorporated into the analysis? The answer proposed here is that hedonic models predict an average price based on home and community attributes, but do not take into account individual buyer characteristics, including bidding errors, which will affect the willingness to pay for homes in a particular area. So, for example, relative to a predicted hedonic price, P_h, one particular individual will be willing to pay more because grandmother happens to live in the neighborhood and another particular individual will be willing to pay less because of a random error in bidding strategy. Clearly no hedonic market can exist for such attributes since they are buyer specific, and these sale price deviations will appear as part of the error term in the estimated hedonic equation. Thus, for homes with a particular set of hedonic attributes in a homogenous neighborhood with a mean sale price of P_h, there exists an array of values for homes among potential buyers, V, with a cumulative distribution function of Q(V). Presumably, the H buyers with the highest individual values will own homes in the area.

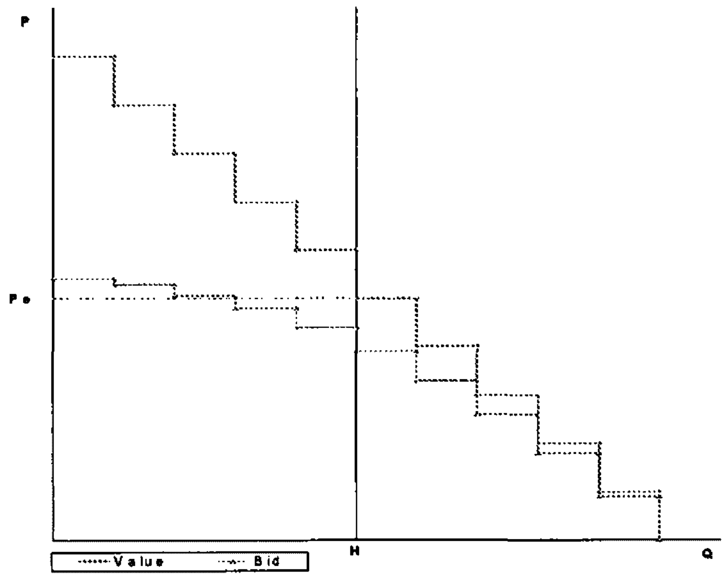
Figure 1.1 The Effect of Stigma on Equilibrium Housing Prices



To further understand the property value market, we model the market itself as a discriminative auction to account for the fact that identical homes in the same neighborhood can, in fact, sell for different prices depending on unobserved individual buyer errors and other attributes (see Cox et al, 1984, for a discussion of the relevant theory and an experimental test of this auction). Approximating the property value market with an appropriate auction where multiple buyers compete for available homes solves the potential problem associated with modeling real estate sales as bilateral negotiations where some sellers potentially have no value. Rather, in a discriminative auction other potential buyers provide competition that maintains the price at a higher level than that which would be predicted by bilateral negotiation. The properties of a discriminative auction are well understood, and this auction provides a reasonable approximation of the real estate market under the special circumstances where homes near a site are stigmatized.

As previously discussed, sellers in our model have essentially no value for the homes they are selling since they shun the site. Thus, any price they can get for the home is acceptable. This corresponds to an auction situation where buyers bid on H homes put up for sale, and the H bidders with highest bids obtain the homes for the prices bid. Figure 1.2 shows this market in the context of total demand where all homes in a neighborhood are potentially up for sale. Note that the bids in a discriminative auction (shown as the lower step function) fall below the true values (upper step function). Note also, that compared to the price that would be obtained in a uniform price auction giving a price, P_e, in a discriminative auction there is a distribution of bids and sale prices around the equilibrium price, since buyers pay accepted bid prices. In a discriminative auction, it is well known that if buyers are risk neutral, the average of the accepted bids will equal the uniform price, so revenue neutrality exists in theory between uniform price and discriminative auctions. Note also that risk aversion will increase bids in a discriminative auction and bring them closer to true values because buyers trade off the gain in consumer surplus of a lower accepted bid against the reduced probability of having their lower bid accepted. The lower bid curve shown in Figure 1.2 assumes risk neutrality and plausibly provides a lower bound for bids in a real estate market.

Figure 1.2 Discriminative Auction Market



With these concepts in mind, we can then turn to the hedonic model used to estimate property values at each of our study sites. The hedonic model estimated to explain property values uses a logarithmic specification and takes the form:

$$SPRICE_{it} = P_t DIST_{it}^{b_{1t}} e^{b_2 A_{iT}} e^{b_3 S_{it}} e^{b_4 D_{iT}} e^{\varepsilon_{it}} \qquad (1.1)$$

Here, P_t is an area-wide price index for owner-occupied housing in year t, $DIST_{it}$ is the distance of each dwelling from the Superfund site in question. The coefficient associated with this variable will be allowed to differ across years by interacting the constant distance measure with yearly dummy variables. The vector A_{iT} is property attributes and S_{it} is a vector of (interpolated) time-varying characteristics of the Census tract in which the dwelling is located, and D_{iT} is a vector of the logarithms of the distances from the dwelling to a potentially relevant set of other spatially differentiated local amenities or disamenities, calculated at time T, the end of the sample period, rather than contemporaneously.

Taking the logarithms of both sides of the equation yields a version of this model that is appropriate for estimation:

$$LSPRICE_{it} = \ln P_t + b_{1t} LDIST_{it} + b_{2t} A_{iT} + b_{3t} S_{it} + b_{4t} D_{iT} + \varepsilon_{it} \qquad (1.2)$$

where $LSPRICE_{it}$ denotes the logarithm of the observed selling price, $\ln P_t$ will be captured as an intercept for the first year in the sample and a set of intercept shifters activated by year dummy variables. The variables of key interest are the $LDIST_{it}$, which consist of a vector of logged distances from the dwelling to the Superfund site interacted with yearly dummies in order to permit year-varying elasticities of housing prices with respect to distance to the site. Geographic Information Systems (GIS) techniques were used to measure distances from the homes to the closest Superfund site in the specific year, t, that the sales price was observed and the distance to other local amenities or disamenities as they existed in year T.

An ideal sample of data would consist of transactions data and housing structural characteristics, neighborhood characteristics, distances to all relevant amenities and disamenities, all collected contemporaneously with the time of sale. This ideal data would also include analogous information (except for selling price) about houses that did not sell in these periods, either because they were not for sale, or they did not find a buyer. This would allow the researcher to control for non-random selection into the pool of dwellings actually observed to be transacted.

When a researcher has data like these data over a number of years, it is possible to control for many unobserved housing and neighborhood characteristics that do not vary across time by using the so-called "repeat sales" method. When a house has sold more than once in the observed time period, the difference in the selling price can be explained in terms of differences in any explanatory variables that have also changed over time. This method for eliminating all the time-invariant characteristics from the analysis was first proposed by Bailey, et al. (1963), and has recently been used to analyze the influence of news stories about Superfund sites on housing prices (Gayer and Viscusi, 2002). One disadvantage of this method is that the sample of repeat-sales dwellings over-represents houses with greater turnover and excludes dwellings that have been sold only once during the window of time for which data are available. There is also a problem that any remodeling or updating of the property that is not captured by the quantity variables typically recorded in multiple listing service data will go unacknowledged in the process of dropping all structural characteristics by differencing over time.

In this study, we use a source of data that over-samples houses that have been sold only once over the time period in question. Our data roughly reflect the current status of dwellings. The data are provided, for the most part, by Experian, a company which provides information to direct mail marketers and others. These data are updated at fairly regular intervals, although not simultaneously. Anyone buying these records gets the most recent information available. For each street address in the sample, most records include information on the date when the house was purchased and the price that was paid at that time. For different localities, there are different quantities of structural information in the data set. From the same data supplier, all fields will be available for all localities, but for any given locality, blocks of fields will be blank. Blank fields differ across localities, possibly reflecting different public recording requirements.

In some cases, notably the Eagle County files sought for the Eagle Mine site near Vail, Colorado, the missing data problem was so severe that, despite the appearance of over 5,000 house transactions in the data, there were less than 50 with sufficient data for estimation of a basic hedonic property value model. Part of the problem is that a large share of dwellings is not owner-occupied. In that case, we sought and received data from the Eagle County Assessors office. There were roughly 1,400 observations for owner-occupied units, lying between 2.6 and 19.3 kilometers of the nearest part of the Eagle Mine site. About 57% were owner-occupied but were not single-family dwellings. Other problems existed with this data. For example, the data indicates that there are no current owner-occupied units in the vicinity of the middle school which is only 1,500 feet from a tailings pile. It would have been vastly preferable to have acquired the same assessor's office information for each year during the time span of interest (in this case, from 1976 to 1999). However, data that are "obsolete" from the point of view of the assessor's office are apparently not retained merely for the convenience of researchers who wish to understand time patterns in property values.

An obvious disadvantage of our sample is that in all of our data sets we only observe selling prices for the most recent sale of a house. If a house is in an area where turnover is high, there will be more recent sales and fewer earlier sales. For analytical purposes, it would be preferable to have data on all sales in all years and selling price in those years, but such data do not exist. Data could be purchased from Experian every year, if a future study could be anticipated, but retrospectively, the data are not available. The data are collected primarily for current marketing purposes and records are updated without saving their previous values. Historical modeling is not a use anticipated by the providers of the data. Consequently, there may be some systematic sampling. We observe earlier transactions prices only for houses which are still occupied by the owners who purchased them at that earlier date. We do not observe many early transactions prices for houses in neighborhoods where there has been a lot of turnover. It must be a maintained hypothesis that rates of turnover are uncorrelated with identification and cleanup of Superfund sites. This may be a strenuous assumption, but there are few alternatives. So it will be necessary to speculate upon the types of biases this non-random selection is likely to produce in the effects of distance from a Superfund site on housing transactions prices. Chapter 8 presents a description of the property value approach and data used in the study, while Chapter 9 presents the property value results.

However, a distinct advantage exists of only having one observation for each home in the sample. By only having one observation per house and controlling for area-wide price index with dummy variables, we ensure that each observation is independent. Therefore, the coefficient b_{1t} (the effect of distance from the Superfund site on property values) can be observed over time by looking at the hedonic estimates for each year over the 20-30 years of observations that have been obtained for each of the sites. To dampen noise, we average b_{1t} the coefficients over three-year intervals. To get time trends in property values as affected by the site, we normalize both by the initial three-year period property value effect, t=0, and by distance. Thus, we ask the question, at a minimum distance from the site, $DIST_{min}$, how do property values compare to price at distance $DIST_{max}$ (the boundary of the available data), which was chosen to be sufficiently far away such that no effects of the site should be present, and to the magnitude of this effect in the initial period. The relative property value effect, normalized by base period and by property values at a large distance is defined as

$$R_t = \left(\frac{DIST_{\min}}{DIST_{\max}} \right)^{b_{1t} - b_{10}} \quad (1.3)$$

Thus, the index for each site starts at 1.0 (or 100% in the figures below) and either decreases or increases in successive three-year periods from this value. Table 1.2 presents the results for each of the case studies.

Table 1.2 Coefficient Determinants

	Time Period	Average Distance Coefficient	Normalized Value
OII	1970-1972	-0.133	100.00%
	1973-1975	-0.136	100.79%
	1976-1978	-0.086	86.25%
	1979-1981	-0.099	89.65%
	1982-1984	-0.015	68.94%
	1985-1987	-0.039	74.28%
	1988-1990	0.013	63.03%
	1991-1993	0.015	62.65%
	1994-1996	0.015	62.65%
	1997-1999	0.027	60.46%
Montclair (Outside)	1987-1989	-0.022	100.00%
	1990-1992	0.009	90.65%
	1993-1995	0.031	84.81%
	1996-1997	0.064	76.51%
Montclair (Inside)	1987-1989	0.102	100.0%
	1990-1992	0.174	92.9%
	1993-1995	0.094	100.8%

	1996-1997	0.191	91.1%
Woburn	1978-1979	-0.166	100.00%
	1980-1982	-0.115	87.96%
	1983-1985	-0.154	97.01%
	1986-1988	-0.157	97.85%
	1989-1991	-0.134	92.35%
	1992-1994	-0.111	87.12%
	1995-1997	-0.106	86.04%
Eagle	1976-1982	-0.814	100.00%
	1983-1988	2.134	83.88%
	1989-1994	4.815	71.48%
	1995-1999	1.966	84.72%

As can be seen in Figures 1.4, 1.5, and 1.6 presented below, relative property values of the three metropolitan case studies (OII in Los Angeles, Industri-Plex and Wells G&H in Woburn, and Montclair, New Jersey) tend to follow an overall declining trend consistent with the notion of progressive stigmatization of the site as suggested by arguments from psychology. This result is in contrast to a number of earlier studies that examined property values over shorter time periods (Carroll et al, 1996; Kiel, 1995; Kiel and Zabel, 2001).

Our concluding chapter, Chapter 10, attempts to explain the long term downward trends observed in relative property values shown in Figures 1.3-1.5 using a psychological model. If the trend is driven by f, the fraction of home owners and potential buyers who shun homes near the site, a model of the determination of f over time is needed. From the discussion of the psychology of risk perception and stigma, the determination of the fraction of shunners will be driven by media attention and perceptual cues resulting from activity at the site, which are in turn driven by "events" such as EPA announcements, discovery, NPL-listing, and cleanup. Thus, it is plausible that the percentage change between periods in the fraction of the population who shun the site is a linear function of events of type j occurring during the prior interval, characterized by the discrete dummy variable (or index summarizing a number of dummy variables), $E_{j,t-1}$, thus

(1.4) $$f_t - f_{t-1} = \alpha + \sum_j \beta_j E_{j,t-1}$$

So, in a period with no events, $E_{j,t-1} = 0\ \forall j$, we hypothesize that α is negative and f will decline, thereby raising home values, because some people who know about the site will leave the area (perhaps because of job opportunities elsewhere) and some new potential buyers will move into the area who will have no awareness of the site. Other events, such as cleanup activities, might, (a) raise awareness and thereby increase the fraction of the population who shun the site, or alternatively, (b) reduce the fraction of shunners by convincing people who know about the site that it is now safe. This latter possibility is unlikely in that the notion that, "once contaminated, always contaminated" is part of the psychology of stigmatization. Note, also, that changes in perceived risk for those who may not shun the site will likely follow a similar model.

There is no available data on f, so the model specified above cannot be estimated directly. However, if one assumes a constant elasticity of demand, $\eta<0$, and risk neutrality, a simple transformation exists between f_t and R_t as defined above: $f_t = 1 - R_t^{-\eta}$. Thus, the equation describing movement in f_t can be rewritten as:

(1.5) $$R_t^{-\eta} - R_{t-1}^{-\eta} = -(\alpha + \sum_j \beta_i E_{j,t-1})$$

Figure 1.4 Relative Property Value over Time for OII Landfill, California

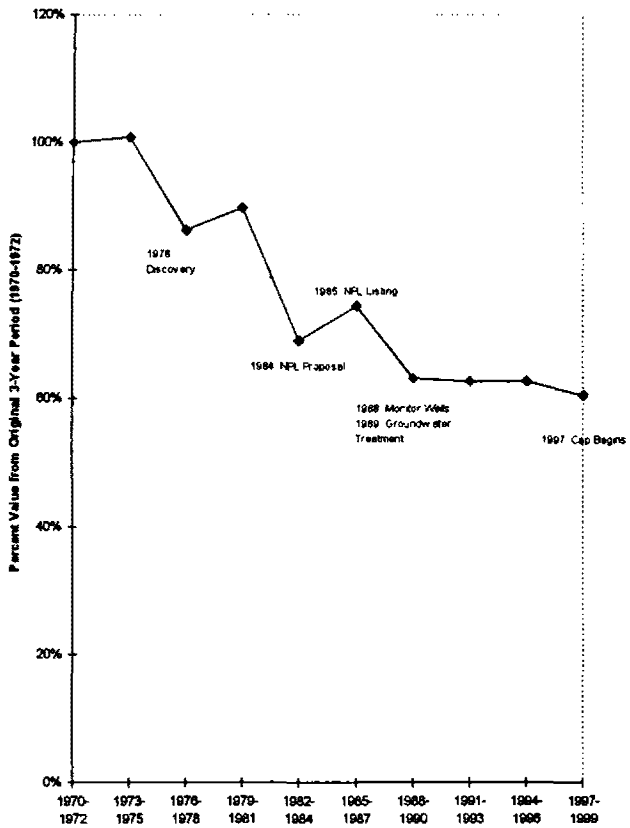


Figure 1.5 Relative Property Value over Time for Montclair, New Jersey (outside of area)

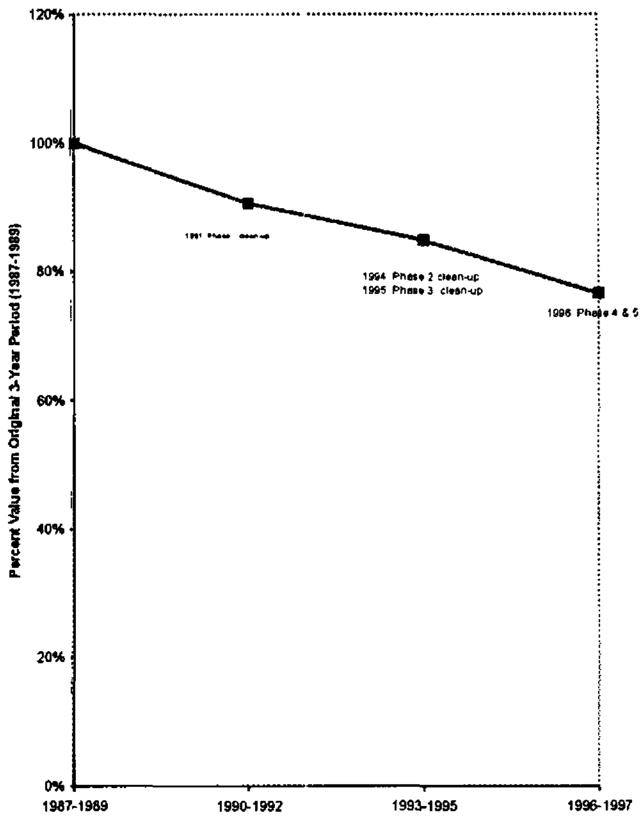
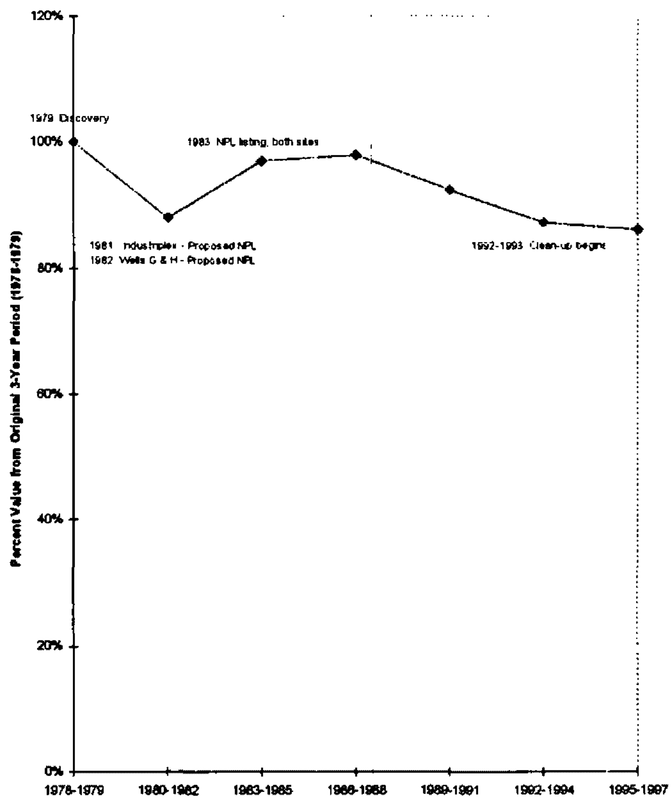


Figure 1.3 Relative Property Value over Time for Woburn, Massachusetts



To employ this transformation we need to know the relevant elasticities of demand that depend on the error distribution in bids. Since we do not have this information, we assume that the elasticities are all -1.0, consistent with a linear approximation of the relationship between f and the change in R over time.

Table 1.3 Number and Description of Events

	Number of Events			
Event Type	**OII**	**Montclair**	**Woburn**	**TOTAL**
EPA Action	11	3	14	**28**
State Government Action	6	1	4	**11**
Local Government Action	10	1	0	**11**
Public Action	2	1	9	**12**
Potentially Responsible Party Action	7	0	0	**7**
Remediation Action	6	4	3	**13**
EPA Announcement	12	3	8	**23**
Site Incident	5	2	12	**19**
TOTAL	**59**	**15**	**50**	**124**

Table 1.4 presents a psychological model using the data shown in Figures 1.3, 1.4, and 1.5 of relative property values over time for the three metropolitan sites. Note, as mentioned earlier, Eagle Mine was excluded from this analysis because the socio-demographic information for the homes were unavailable. Since all of the home sale observations were independent, a simple linear regression could be used with 18 observations of changes in relative property value ($R_t^{-\eta} - R_{t-1}^{-\eta}$) over the three-year periods for the three sites. For Discovery, NPL Listing, and the Beginning of Major Phases of Cleanup, dummy variables were used. The variable "Events" was

derived by summing the number of major announcements and actions described in EPA published reports for the relevant three-year interval for each of the three case studies (Table 1.3). Events are defined as followed:

- **EPA Action** – Includes site investigations, orders, notifications/decisions, remediation, legal actions, and regulations the EPA.
- **State Government Action** – Includes site investigations, orders, resolutions, remediation, lawsuits, reports, and regulations by state agencies.
- **Local Government Action** – Includes site investigations, orders, resolutions, remediation, lawsuits, reports, and regulations by local cities, county, and school districts.
- **Public Action** – Include the creation of public interest groups, major public meetings and protests, lawsuits by the residents, and the hiring of technical advisors for the community.
- **Potentially Responsible Parties Action** – Include site operation and closure, and committees formed. Lawsuits by PRPs.
- **Remediation Action** – Includes containment of contaminations, remediation efforts and site improvements.
- **EPA Announcement** – Includes official Consent Decrees, Record of Decisions (RODs), and announcements of settlements with PRPs.
- **Site Incident** – Includes general site facts, reports and studies regarding the contaminants and occurrences at the site.

The analysis across the three sites shows that discovery, cleanup itself, and the number of events all negatively affect property values by drawing attention to the site and possibly increasing the number of owners and potential buyers who shun the site thereafter (Table 1.4). Thus, the effect of any event, publicity or site information, good or bad, appears to increase the fraction of the current home owners and potential buyers that stigmatize and consequently shun the communities neighboring the sites. In other words, at least within the observed period of the studies, all news is bad news and causes relatively permanent property value losses as an increasing fraction of original owners leave and more potential buyers shun the site. The only good news in the study is that property values did significantly recover for a short period after sites were listed on the NPL. But, it is likely that as soon as it was realized that EPA could not immediately clean up the sites, the process of stigmatization began with consequent reduction in property values. All of these coefficients except the constant are significant at better than 1% level.

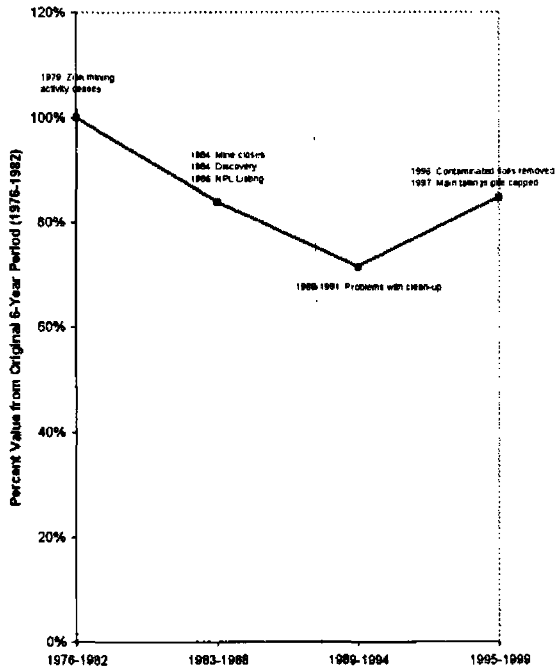
Table 1.4 Psychological Model, Dependent Variable $R_t - R_{t-1}$

Model	B	t	*p*
(Constant)	0.078	3.578	0.003
Discovery	-0.160	-4.493	0.001
NPL – Listing	0.105	4.097	0.001
Clean-up Begins	-0.096	-4.753	0.001
Number of Events	-0.016	-6.156	0.000

N=18
$R^2 = 0.855$

Rather than property losses reversing immediately once cleanup has begun, we see no permanent recovery in property values within the time period of our data and speculate that recovery will only occur as the local population gradually moves away, events cease, and perceptual cues and media attention disappear, so more buyers are uninformed. Note that McClelland et al. (1990) found that most buyers were uninformed in spite of reporting requirements. The positive intercept in the psychological model (significant at better than the 5% level) indicates that property values will increase at a linear rate of about 12% every three-years if no actions are taken and no news is generated by the site. Thus, at OII one could expect a complete recovery in about a decade if no news is generated from the site and recovery might occur in about half that time for the other sites.

Figure 1.6 Relative Property Value over Time for Eagle Mine, Colorado



The sites excluded from the model are also of some independent interest. First, although the Eagle Mine (see Figure 1.6) has very different characteristics from the three sites discussed above, it shows a similar pattern in that relative property values decline for most of the period analyzed. Given the small amount of data available along the Eagle River, we are forced to use six-year rather than three-year periods for the analysis but do confirm the general pattern shown above. Second, the "inside" Montclair property value estimates do not use distance as an explanatory variable since the homes themselves are within the Superfund site. Yearly dummy variables averaged over the same three-year intervals used in the outside-Montclair analysis show that, unsurprisingly, cleanup itself does have a positive impact on property values (Figure 1.7). Third, another interesting result in the property value studies is the effect of including socio-demographic variables. As shown in Figure 8, these make a large difference in the magnitude of property losses at the Woburn site. Negative socio-demographic trends, that may be the result of the progressive stigmatization of the site, also take a substantial toll on property values (that are not included in the psychological model), but possibly should be included in any damage assessment. These results suggest a different trend than observed by Kiel and Zabel (2001) which did not account for these socio-demographic affects.

Figure 1.7 Relative Property Value over Time for Montclair, New Jersey (inside of area)

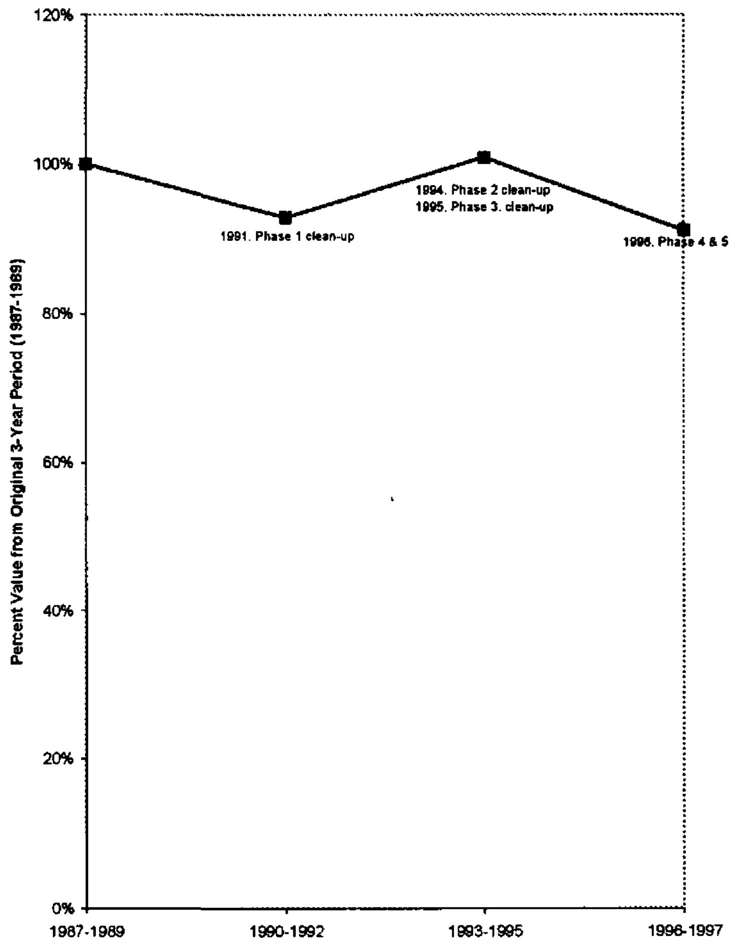
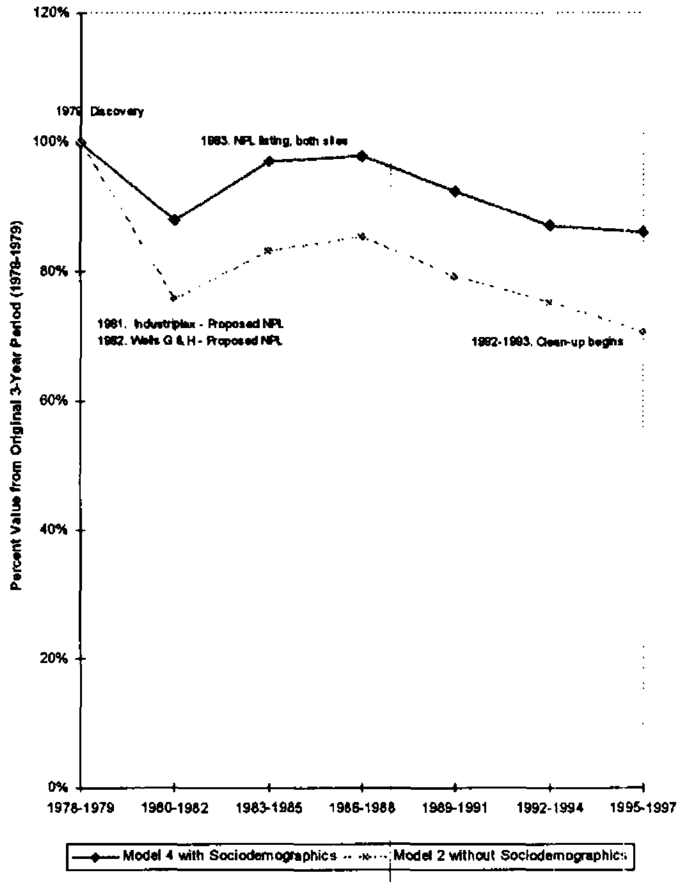


Figure 1.8 Relative Property Value over Time for Woburn, Massachusetts with and without socio-demographic variables.



1.6 Policy Implications

Since economic benefits are based on discounted present value, the benefits of delayed cleanup for homes surrounding sites are likely to be negligible where cleanup takes 20 years and another 5-10 years may be needed after cleanup is complete for property values to recover. The principal policy conclusion becomes evident from the results of the psychological model, which suggest that the promise of a prompt cleanup raises property values, while an increase in the number of events that are the root cause of perceptual cues and media attention decreases property values. Thus, an expedited cleanup should occur as quickly as possible after a site has been determined to be hazardous and this cleanup should be conducted in a way that does not arouse excessive attention. Otherwise the neighborhoods surrounding the site will-likely be stigmatized resulting in quasi-permanent economic damages.

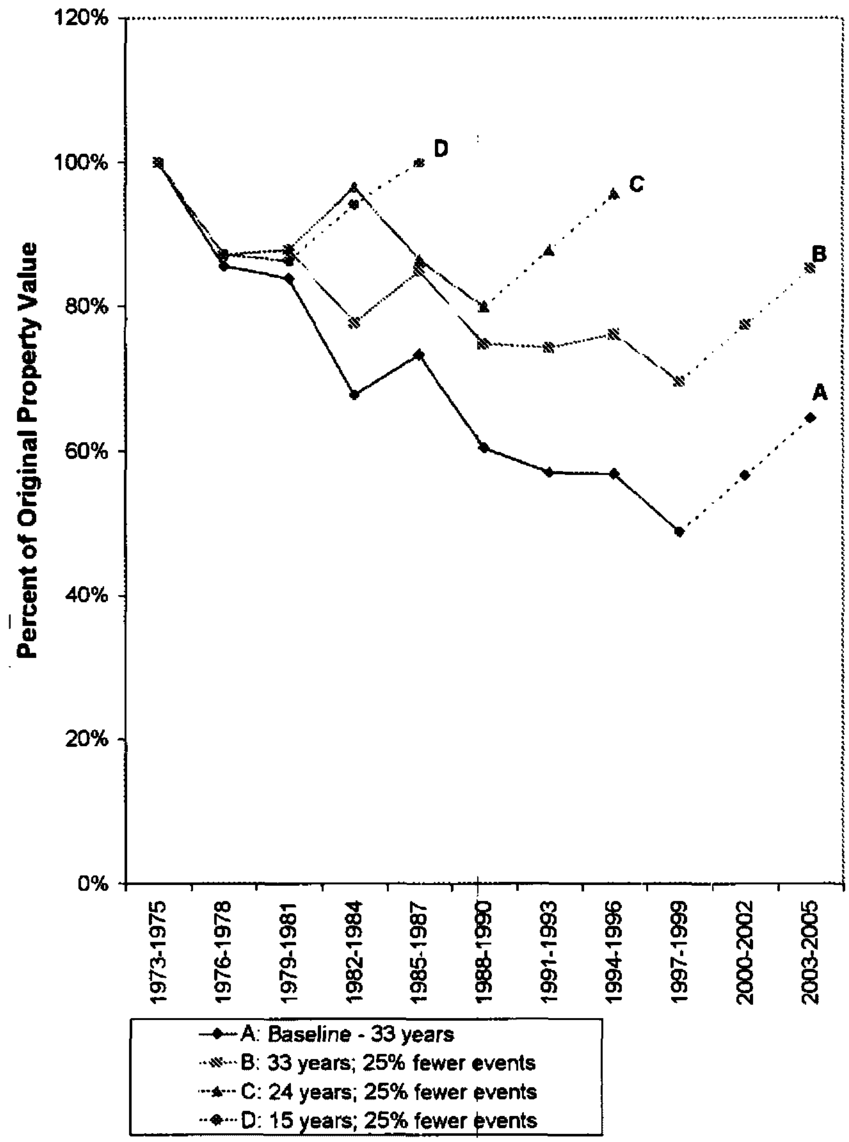
Table 1.5 Cleanup Scenarios

	Time Horizon	Events	Discovery	NPL Listing	Cleanup time periods	Recovery time periods	Final % of Original Value
Scenario A	33 years	All	1978	1985	1988-1990 & 1997-1999	2002-2005	64.5%
Scenario B	33 years	25% Fewer	1978	1985	1988-1990 & 1997-1999	2002-2005	85.2%
Scenario C	24 years	25% Fewer	1978	1982	1985-1987 & 1988-1990	1990-1995	95.6%
Scenario D	15 years	25% Fewer	1978	1979	1979-1981	1982-1987	100.0%

Using the history of the OII and the corresponding dates and events in a simulation, the potential benefits of these policies becomes evident (Figure 1.9). As shown in Table 1.5, this simulation considers four different scenarios and includes an extrapolation of a recovery in property values after cleanup is complete where there are no further events. Given the legislative history of Superfund, some of these scenarios are clearly fanciful, but the results are nevertheless suggestive as to what potential benefits could be obtained by expediting the cleanup process and reducing the number of events that drive perceptual cues, media attention, and social amplification. These results support several of the suggestions made by Kunreuther and Slovic (Chapter 21, 2001) for reducing stigma. In particular, they suggest prevention of the occurrence of stigmatizing events and the reduction of the number of stigmatizing messages and thus reducing social amplification.

Note that these results contrast with those of Gayer, Hamilton and Viscusi (2000) and Gayer and Viscusi (2002) who argue that media attention supports learning that leads to a lowering of public risk perceptions more consistent with scientific evidence for smaller sites. No credible evidence supports a significant long-term health risk to residents living near OII (McClelland et al. 1990). Yet the actual property value losses are enormous. One difference is that this study focuses on prominent sites while the two studies cited above focused on less prominent sites. Note, however, that most potential benefits from cleanup are likely to come from prominent sites. Also, both Woburn and Montclair are associated with demonstrable long-term health risks, yet property losses are much smaller than at OII. Finally, property value losses seem to be greatest when cleanup finishes, when risks should be at their lowest.

Figure 1.9 Policy Simulations Using the OII Landfill History



It is interesting to note that Carol Browner did in fact institute reforms to USEPA policy in 1995 to at least partly attempt to avoid the pattern shown in this study. EPA began to work with PRPs in an attempt to negotiate sufficient cleanup at potential Superfund sites to avoid having sites listed on the NPL. These reforms may, in fact, have represented an optimal response given the difficulty stigma presents for neighborhoods surrounding Superfund sites. It should also be noted that the enormously costly process of litigation and delayed cleanup that has occurred under the Superfund program has provided strong incentives for industry to avoid creating new hazardous waste sites. However, for residents living near very large Superfund sites, as they have often stated, the program has failed in spite of EPA's best efforts. In this regard, it should be noted that when CERCLA was passed, little or none of the work in psychology necessary to understand the phenomena described here had been completed. In fact, much of the relevant work was motivated by Superfund.

This study raises several questions for future research. First, are smaller sites truly different as the work by Gayer, Hamilton and Viscusi suggests? Second, although the psychological model developed here is statistically significant, it is based on data from just three sites. Additional work to incorporate both larger sites, as well as smaller sites, and additional explanatory variables would be worthwhile in our judgment. Finally, more research to understand and prevent stigmatization is warranted.

Chapter 2

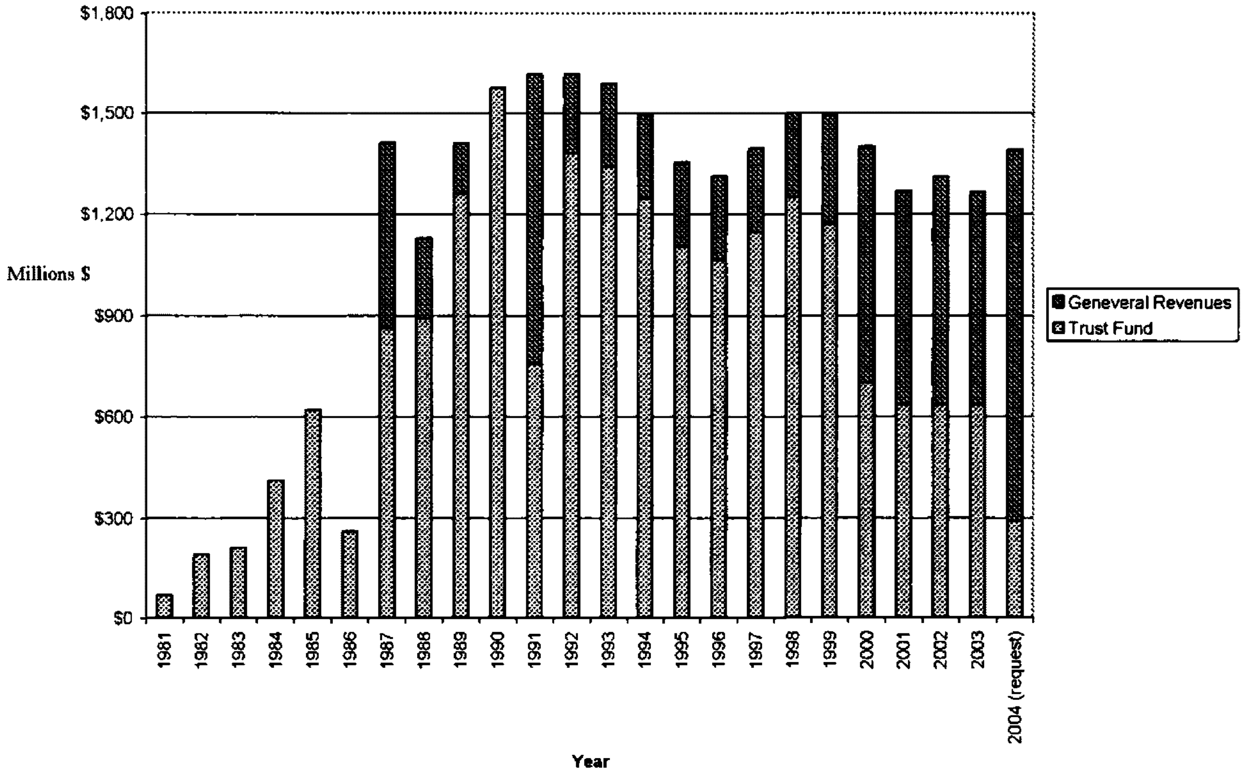
History of Current Superfund Legislation

2.1 Overview of Superfund Legislation

Superfund is one of the most controversial pieces of legislation ever implemented by the EPA, and it has been tainted for years by skepticism and uncertainty. Congress approved the Superfund bill in 1980, despite uncertainty about the number of sites, costs of cleanup, and availability of appropriate technology. The number of sites in need of cleanup and the costs of the program skyrocketed beyond the original expectations of Congress or the EPA, due to underestimates of the extent of the hazardous waste problem. The bill was reauthorized twice, but in December 1995 it was not renewed. The taxing authority of the fund expired in December 1995, leaving only fines, penalties, and interest as working income for EPA's Superfund program.

Since 1995, the Superfund program has been primarily funded by the Trust Fund, and the General Fund that supplements the Trust Fund. Since 2000, an average total of $1.3 billion is appropriated to Superfund each year with more money being allocated from the General Fund than the Trust Fund (Figure 2.1). The Superfund trust is used in cases where responsible polluting parties cannot or will not pay for cleanup. In some cases where the EPA has tapped the Superfund trust for cleanup, EPA cleans up the property itself and then sues the responsible polluting party for triple the damages. The 2004 request is $1.1 billion from the General Fund and only $290 Million from the Trust Fund. Changes in the way the Superfund program and how the EPA cleans hazardous areas are underway. On April 12, 2004, the National Advisory Council for Environmental Policy and Technology released its Final Report on the how the Superfund program could be improved.

Figure 2.1 Superfund Budget (1981-2004)



2.2 Legislative Background

The driving force for Superfund legislation came from 1978 report by Michael Brown, a local reporter for the Niagara Gazette newspaper, on Love Canal, the toxic waste site near Niagara Falls. He described children coming home from the playground with hard pimples on their bodies, women giving birth to deformed and mentally retarded children, and many other horrible consequences of Hooker Chemical and Plastics Corporation's (now Occidental Petroleum) disposal of over 20,000 tons of toxic wastes in an unlined canal (Barnett, 1994). The thought of a country filled with sites similar to Love Canal angered the American public. Shortly after the issuance of Brown's report, Congress began hearings on Love Canal and other waste disposal sites throughout the country.

The Carter Administration favored a new piece of legislation addressing the toxic waste issue because existing legislation, such as the Clean Air Act of 1970 and the Clean Water Act of

1972, regulated the emission of chemical pollutants, but did not consider the impact of chemical pollutants and toxic waste on human and ecological health. A key question in the legislative debate was whether the funds should come from general government revenues or from the financial contributions of both the offending industry and the government. In mid-1979, President Carter spoke in favor of a bill with a $1.6 billion fund, financed 80% by industry and 20% by government imposing strict, joint and several liability on responsible polluting parties (Barnett, 1994). Joint and several liability means that a company, individual, or some combination thereof, can be held responsible for the entire cleanup of a hazardous waste site regardless of the amount of pollution contributed to the site. That is, there is no proportionality with respect to liability. This "deep pockets" principle was highly controversial.

In 1979, several key issues divided the proposed Superfund legislation in the House and Senate. These included the size of the fund and if the legislation should be limited to abandoned hazardous waste sites or also include provisions for oil and hazardous substance spills. The House preferred two separate bills totaling $1.9 billion, while the Senate preferred a $4.1 billion bill that could be used for both emergency removals and more costly, long lasting projects. Both the House and Senate, however, agreed the legislation should be financed primarily through taxes imposed on chemical feed stocks. The chemical industry disputed this overall tax on the industry and advocated financing the fund through the federal treasury, responsible parties, and state contributions. The final Superfund bill did not include other House and Senate recommendations regarding public participation in the siting of hazardous wastes or determining satisfactory levels of cleanup.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (commonly referred to as Superfund) was signed into Public Law 96-510 by President Carter on December 11, 1980. It passed by wide margins in both the Senate (78 to 9) and House (274 to 94). The final Superfund bill passed under several unusual circumstances. The Senate Finance Committee sent the bill forward without a formal recommendation and President Carter pushed for it to be signed quickly, before Reagan took office. The bill, because it was rushed, was not based upon an accurate assessment of the problem, and suffered from a lack of research as well as inaccurate estimates of the potential costs and the number of toxic waste sites. As noted in a 1985 report funded by the Cato Institute, the law "was based upon misunderstandings and distortions of the situation, and zipped through a lame duck Congress in a spirit of vengeance against the polluters" (Delong, 1995).

2.3 Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA created a five-year, $1.6 billion trust fund for the cleanup of active or abandoned hazardous waste disposal sites that posed an immediate threat to public health and the environment or when a responsible party would not take action. Superfund called for two different types of cleanups: (1) Remedial Actions, which ere long-term cleanup for sites on the National Priority List (NPL), and (2) Removal Actions, which are short-term cleanups of immediate threats. Removal Actions did not require listing on the NPL.

The trust was funded by the chemical and petroleum industries, which were required to pay into the fund. The chemical industry ended up paying 85% of the $1.38 billion paid by these two industries. The States were required to contribute 10% of the total cleanup costs, provide long term maintenance at sites, and provide disposal capacity for waste removal (Office of Technological Assessment, 1984). The other component of the Superfund trust included a series of taxes. Specifically, the bill created a $0.79 per barrel tax on US refineries, crude oil and petroleum imports, and domestically produced crude oil. Hazardous chemicals and wastes were taxed at rates varying from $0.22 to $4.87 per ton. After September 30, 1983, there was an additional excise tax of $2.13 per dry weight ton of hazardous waste received at qualified hazardous waste disposal sites (Office of Technological Assessment, 1984). The taxing authority of the CERCLA legislation expired September 30, 1985, though it was reauthorized shortly thereafter.

Under the CERCLA legislation the EPA was required to assess the nation's hazardous waste sites according to the hazard ranking system, which is a numerically based screening system that determines the threat of waste sites to human health. A minimum of 400 of the worst hazardous waste sites were to be placed on the NPL, and each state was given the opportunity to place a site on the list as well. The bill also gave the EPA and the Justice Department legal authority to identify polluting parties, enforce liability, and enlist contributions for cleanup.

Superfund imposed strict, joint, and several liability, and the generators of hazardous waste substances and the owners and operators of waste facilities, past and present, were all liable to pay for the costs of cleanups. The process for cleanup entailed listing a site on the NPL. Then scientists conducted a detailed examination of the site called a remedial investigation. This was followed by a feasibility study, an ascription of the most appropriate cleanup remedies. These two processes are often referred to as the "remedial investigation/feasibility study" or "RI/FS". Once the appropriate remedies were selected, the EPA prepared, or appointed an agency to prepare specifications and timelines for the cleanup of the site and remediation begins.

2.4 Implementation of Superfund: 1980-1985

The Reagan Administration took office only weeks after the Superfund bill was signed, and it promoted an ideology that was incompatible with many of Superfund's legislative provisions. The objective of the Reagan Program was to promote economic growth by reducing the size and number of federal spending programs, cutting taxes, and reforming regulatory agencies (Barnett, 1994). Reagan reduced government spending and emphasized *voluntary* compliance with environmental regulations.

Funding Superfund presented an immediate problem. The actual costs of cleanups were much higher than the original estimates of $7 to $10 million (Barnett, 1994). By 1992, 42 of the 50 states lacked adequate resources to fulfill their obligations to pay 10% of the costs of cleanup (Office of Technology and Assessment, 1983). During the first three years of the program, appropriations for Superfund also fell far below those initially authorized by Congress. Of the $960 million authorized in the first three years, $74.4 million was appropriated in 1981, $26.6 million in 1982, and $210 million in 1983. Most funding for the program was devoted to legal battles with polluters as well, and the federal government wrote off $270 million because responsible parties could not be found or were unable to pay (New York Times, 1993). As a result of these funding setbacks, elements of the Superfund program were cut back in 1981 and 1983. The EPA's total outlays were cut by one third (Shabecoff, 1983), the abatement and control staff declined 21%, the enforcement staff decreased 33%, and the research and development staff declined16% (Crandall and Portney, 1984: 68).

While the funding for Superfund was less than originally anticipated, the number of sites identified for the National Priority List far exceeded expectations. The legislation called for an identification of at least 400 sites to be added to the NPL. The EPA quickly identified 16,200 potentially hazardous sites and placed 546 sites on the proposed National Priority List. The first official National Priority List, released in September of 1983, included 406 sites (Environmental Protection Agency, 1997). The following year, the EPA added 132 more sites to the List bringing the total up to 538 (Environmental Protection Agency, 1997). While the list continued to grow, only 119 site removals and two full cleanups were completed by mid-1983 (Davis, 1983). Various government and private agencies re-estimated the number of sites in need of cleanup. The new figures were much larger than originally anticipated, and ranged from EPA's initial estimate of 2,000 sites to the Office of Technological Assessment's estimate of over 10,000 sites (Office of Technological Assessment, 1985). As of March 31, 2004, 1,239 sites were listed on the National Priorities List (NPL).

To further complicate the bill's implementation, a scandal concerning the manipulation of hazardous waste programs by some EPA officials erupted in 1982. Top officials were charged with using political criteria to determine Superfund spending and making "sweetheart" deals with industry members for partial cleanup, perjury, and the manipulation and destruction of government files. EPA Administrator Anne Burford and 13 other top EPA officials, including Rita Lavelle (head of the Superfund program), were forced to resign in March of 1983. This "Sewergate" scandal dominated the front pages of major newspapers for the first three months of the year, causing the EPA to lose a considerable amount of legitimacy and some of its own morale. This scandal, furthermore, undermined the momentum of the already struggling program.

After the resignation of Administrator Anne Burford, William Ruckelshaus took office in 1983. Ruckelshaus adopted a more aggressive approach to remediation and often used lawsuits to force industry members into compliance. The EPA financed 102 waste removals within the first six months of Ruckleshaus' term and an additional 157 waste removals from 1984 to 1985. The EPA's combined outlays in fiscal years 1984 and 1985 totaled over $600 million, a 261% increase over the $233 million spent between 1981 and 1983 (Barnett, 1994).

2.5 1985: The Expiration of Superfund

Superfund legislation expired on September 30, 1985. Debates about reauthorization of the bill continued for over a year because of uncertainty about how to improve the program's performance. Reauthorization issues included concerns over health and environmental risks at waste sites, questions about risk assessment, frustration with lengthy cleanups, and burgeoning costs. Many cleanup cases were embroiled in legal battles which often expanded into complex webs of multiple party lawsuits, further compounding Superfund's problems. The public's expectations of the program were initially very high, but they found the rate and success of cleanups disappointing (Office of Technological Assessment, 1984). Changes to the Superfund legislation were imminent and necessary.

The House and Senate proposed different reauthorization bills in 1985. The House was overwhelmingly (391 to 33) in favor of a bill creating a five-year, $10.1 billion dollar program. Revenues would include $3.1 billion from a tax on petroleum companies, $2 billion from a tax on chemical companies, and $2 billion from a tax on toxic wastes. The Senate proposed a five-year, $7.5 billion program. General revenues would provide approximately $1 billion with the remaining $6.5 billion to come from special taxes on manufacturers and processors of raw materials with annual sales of $5 million or more (Shabecoff, 1985). Environmentalists argued that the bill would not raise enough money and was described by the Washington representative of the Sierra Club as "a missed opportunity to build an effective program" (Shabecoff, 1985).

The EPA anticipated that the debate between Congress and the House would continue past the bill's expiration date and began to halt or slow cleanup at 57 sites in August of 1985 (New York Times, 1985). As the authorization debate continued through April, the Agency reduced its response rate to toxic waste emergencies by 80%. Although EPA Administrator Lee Thomas said that $5 billion was the most EPA was capable of spending over the next five years, the House and Senate remained firm in their higher requests of $10.1 billion and $7.5 billion respectively (New York Times, 1985). As a result of the lengthy debates in 1986, appropriations for the program were reduced from the expected $900 million to $206 million (Shabecoff, 1986).

2.6 Superfund Amendments and Reauthorizations

A conference committee finally approved a plan on July 31, 1986 for a five-year, $9 billion fund. The bill included $500 million for regulating leaky underground storage tanks; created a new, broad based tax on corporations earning more than $2 million a year; and increased taxes on oil products (Shabecoff, 1986). Other provisions imposed new regulations throughout all EPA offices with respect to deadlines and cleanup standards, increased public involvement by requiring industry to provide local residents with information about chemicals used, and required the EPA to provide technical assistance grants to communities proximate to NPL sites.

President Reagan signed this bill known as the Superfund Amendments and Reauthorization Act of 1986 (SARA) on October 17, 1986. After the expiration of Superfund's taxing authority, the CERCLA legislation was extended two more times: first for a four-year period at which time $5.1 billion was authorized for the program and second through December 1995.

The 1986 reauthorization failed to solve many of the Superfund's problems. The EPA still lacked adequate financial resources to cleanup many waste sites due to difficulties collecting money from responsible parties. The liability scheme caused funds to be tied up in legal battles. The EPA spends approximately 15-18% of the Superfund budget on the legal enforcement of its cleanup mandates. There were often over 100 PRPs at large sites, creating complex webs of lawsuits (Barnett, 1994). Responsible parties found it worthwhile to litigate in hopes of spreading costs among many responsible parties (as opposed to settling) because the average cost of cleanup at a site was approximately $30 million. A 1993 report funded by the Cato Institute indicated that, in 1989, insurance companies spent an average of $470 million on costs related to the Superfund program, $410 million of which went to defending their policy holders (New York Times, 1992). According to a RAND Corporation survey in 1994, legal fighting over prior liability was costing a total of $1 billion a year, while fewer than 200 of the most serious 1200 sites had been cleaned up (Quint, 1994).

To help remedy inefficient spending on legal fees, the Congressional Budget Office (CBO) studied the costs of repealing prior liability, a provision in the Superfund legislation that holds a company legally responsible for cleanups when the waste was dumped before Superfund was enacted. The CBO found that repealing prior liability would reduce transaction costs and increase efficiency of the program. It might also, however, reduce the speed of cleanup or require lowering cleanup standards. Additionally, federal government spending on Superfund would need to increase by $1.6 billion per year and the government would incur an additional one-time cost of almost $7.5 billion for PRPs' ongoing expenses plus $6 billion for past costs (Committee for the National Institute for the Environment, 1997). Consequently, many government officials remain opposed to the repeal of prior liability. They believe that the general public should not have to pay for the costs of hazardous waste cleanup and that tax money should be reserved for orphan sites and emergency actions.

Other challenges with the Superfund program remain as well. Cleanup times were criticized as being too slow. According to the General Accounting Office (GAO), the average time to cleanup a site increased from 3.9 years in 1986 to 10.6 years in 1996 to 11.5 years in 1999. The time it took from discovery of a problem site to its final listing increased from 5.8 years in the 1986-1990 time period to 9.4 years in 1996 (GAO, 1998). The GAO concluded that these increases are due to the legislation's ambiguous cleanup requirements (GAO, 1998). The structure of the program was fundamentally flawed because it neither provided contractors with incentives for cost effective remediation nor encouraged innovation. Responsible parties were reluctant to try new technology because they feared inadequate results and the possibility of having to conduct a second costly remediation. The legislation also required copious amounts of paperwork and authorizations. Critics also were concerned about the EPA's risk assessment procedures, claiming that the true risks of most people living near sites are overstated, resulting in costly remedies and little gain in risk reduction. Polluters and their insurance companies are dissatisfied with the law's retroactive provisions, requirements to reach "gold plated" cleanups, and disregard for cost when selecting cleanup remedies (Center for Hazardous Waste Management, 1997).

In December 1995, Superfund lost the ability to tax, and this taxing authority has not been renewed. Since taxes on the industry could not finance the Superfund Trust Fund, it began to rely heavily on appropriations from general revenue. Other income also included fines, penalties, and cost recoveries. Since 1995, there have been several bills debated in Congress, yet none have been approved.

Reauthorization was a top environmental priority for the 105th and 106th Congresses, according to Congressional leaders, but action on Superfund legislation never materialized. President Clinton toured a Superfund site in Wallington, NJ in March 1996 to show his concern about Superfund's shortcomings. Reauthorization issues include the size of the fund, broad liability scheme, high contractor costs, and slow pace of cleanups. Most Republicans, and some Democrats, continue to support repealing prior liability (Government and Commerce, 1997). There are also disagreements over who should be required to pay for cleanups, the stringency of cleanup currently required by the law, whether cleanup results in too few benefits for the costs, and whether or not to limit the National Priority List. Another issue that has gained more attention recently is the damage to natural resources, such as rivers, caused by hazardous wastes (Government and Commerce, 1997). The Senate proposed to allow the addition of only 90 more sites (30 annually for three years) to the National Priority List. The House proposed to allow 125 sites over an eight-year period, declining from 30 sites in the first year to 10 sites in each of the last three years.

2.7 Superfund Reforms and Successes

Under the leadership of Carol Browner, in 1995, the EPA implemented three series of more than 45 administrative reforms designed to strengthen Superfund by targeting its problems with cleanups and enforcement. The reforms sought the goal of being "faster, fairer, more efficient" and were similar to provision of the 1994 reauthorization legislation that died in the previous Congress. These reforms expanded beyond the scope of the reforms in the reauthorization of 1986 and have been even more successful than originally anticipated (Nakamura and Church, 2003).

While the federal government maintains control of determining appropriate remedies for hazardous waste sites, states have recently taken on more responsibility for the cleanup of Superfund sites. States have developed the capacity and technical expertise necessary for successful remediation of Superfund sites. Currently, the federal government enters into cooperative agreements with states, on a site-by-site basis, which authorizes the states to conduct cleanup activities.

In 1995, the EPA also implemented a new "brownfields" economic redevelopment program. Brownfields are sites contaminated with hazardous waste that are possible candidates for the National Priority List. These sites often remain abandoned for long periods of time because they are undesirable to lenders and developers who fear that they will assume liability or that the land will remain undervalued. To date, the brownfields program has been highly successful and helps states, communities, and other stakeholders work together to safely and efficiently cleanup and reuse brownfields (Environmental Protection Agency, 1997).

The Superfund program has been much more successful in recent years as a result of the aforementioned reforms. As of 2004, more than 82% of the sites on the final Superfund NPL were either undergoing or had completed cleanup (NACEPT, 2004). Furthermore, the number of sites added to the National Priority List is currently declining, while the number of sites deleted is increasing. Only 12 sites were added in 2003, as opposed to 162 additions in 1986. The total number of sites listed as possible National Priority List sites also decreased over the past years. In 1988, there were 378 sites on the proposed list. In 2003, 54 sites were on the list. As of 2003, the total number of sites on the National Priority list is 1,572 while 274 sites have been deleted from the NPL list. Deletion from the NPL list means that the remedial goals had been achieved even if operation and maintenance of the site continues (NACEPT, 2004).

Responsible parties were also paying a higher percentage of the cleanup costs than in the past. Polluters were now contributing more than 75% of long term cleanup costs compared to 37% in 1987 (EPA, 1997). This has saved taxpayers a total of over $12 billion and resulted in the EPA obtaining over $7.00 in private cleanup commitments for every $1.00 spent in Superfund enforcement. The EPA also reached settlements with more than 14,000 smaller polluting parties (such as small businesses and municipal governments) and gave over $457 million in compensation to responsible parties willing to negotiate long-term cleanup settlements (Superfund Administrative Reforms, 1996). Moreover, the Justice Department collected $790 million for cleanup activities from responsible parties in 1996. As a result, the EPA was able to preserve the Superfund budget for sites where responsible parties could not be identified.

In July 2001, the Superfund Subcommittee of the National Advisory Council for Environmental Policy and Technology was formed to evaluate the Superfund Program. In April 12, 2004, the Final Report was released which recommend improvements to three main areas:

what types of sites should be listed on the NPL, how to measure performance, and what to do about "mega sites" (cleanup costs greater than $50 million).

2.8 Conclusion

Superfund has been controversial since its inception. Many of the problems with the program, such as high legal costs, inadequate funding, slow pace of cleanups, and high contractor costs, plagued the program from the outset because it was developed in response to an emergency situation of uncertain proportions. However, Superfund did have some success in the 1990s. As of 2004, over 82% of the sites on the final Superfund NPL were either undergoing construction or have completed cleanup. Responsible parties are paying more of the costs of cleanups, allowing the EPA to conserve its budget for orphaned hazardous waste sites. In the next chapters, detailed site histories are provided for the six "mega-sites" examined in this study.

Chapter 3

Operating Industries, Inc. Landfill

3.1 Overview

The Landfill covers 190 acres and is located 10 miles (16 kilometers) east of Los Angeles between the communities of Monterey Park and Montebello, California (Figure 3.1). The Pomona Freeway (Route 60) divides the site into two parcels, one 45-acre area lies north of the freeway and the other 145-acre parcel lies south of the freeway (Figure 3.2). The landfill is in the city of Monterey and the city of Montebello borders the southern end and portions of the northern section of the landfill. Throughout its operating life, from 1948 to 1984, the landfill received 30 million cubic yards of residential and commercial refuse, industrial wastes, liquid wastes, and a variety of hazardous wastes. The EPA determined that approximately 4,000 different parties sent waste to the landfill at one point or another. In October 1984, the landfill was closed and proposed for listing on the National Priority List (NPL). In June 1986, the landfill was officially listed as a NPL Superfund site, and experts estimated that the cleanup could take as much as 45 years and more than $600 million to complete. As of 2002, the EPA had reached settlement with more than 1,250 parties to pay for the cleanup work, with the total settlements reaching more than $600 million.

Figure 3.1 OII Landfill Vicinity

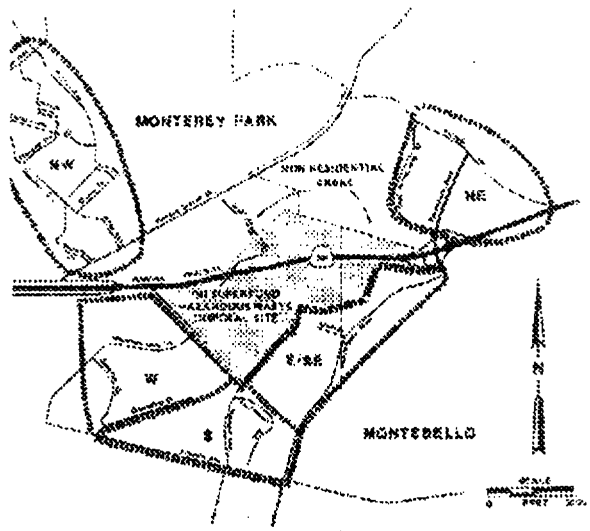
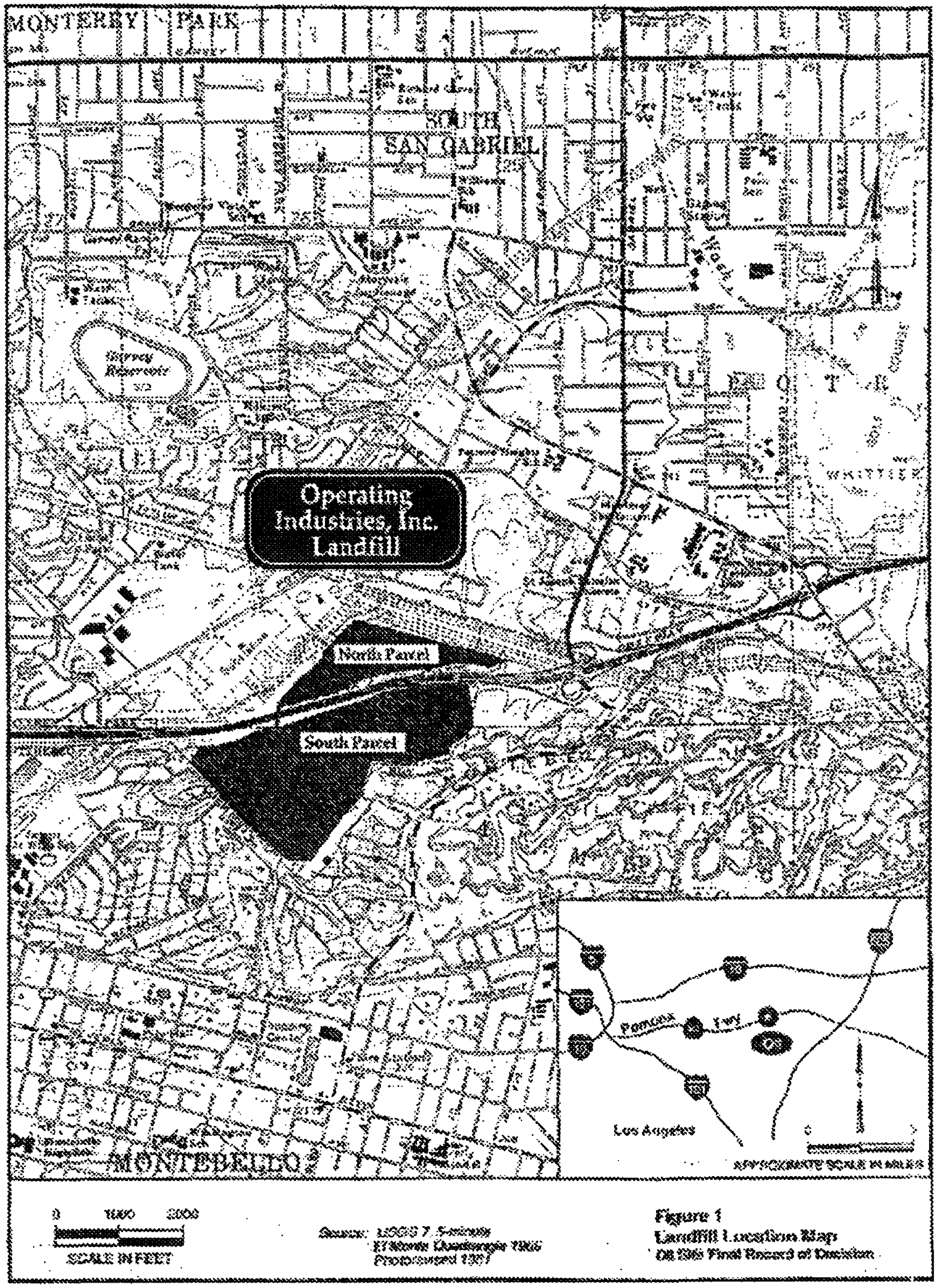
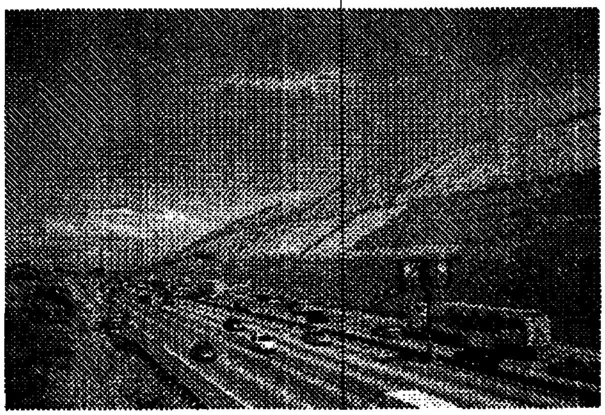


Figure 3.2 OII Landfill



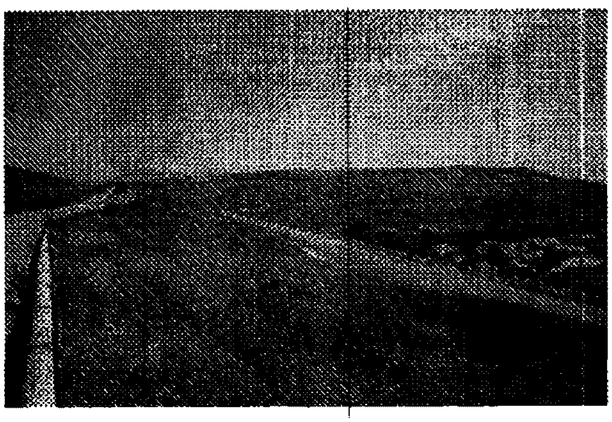
The landfill remains a particularly prominent feature of the area, towering more than 300 feet above the surrounding community.

On the road to completion: OII's final landfill cover along the Pomona Freeway.



According to Katherine Shrine, assistant regional counsel for the EPA Region 9, "This site is basically a 300-foot-tall, 190-acre mountain of every kind of disposable item in the world." Residents say the landfill is so large that it interferes with television reception. Approximately 53,000 people live within three miles (4.8 kilometers) of the sites, 23,000 within one mile (1.6 kilometers) of the site, and 2,150 within 1000 feet (0.3 kilometers) of the landfill. Three schools are located within 1 mile (1.6 kilometers) of the landfill. The area consists of heavy residential development and mostly middle income and multi-racial neighborhoods.

OII Landfill and Neighboring Community.



3.2 History of the Landfill

Before 1970

In 1948, the Monterey Park Disposal Company began municipal dump operations in a former stone and sand quarry. At this time there was very little development neighboring the site. Operating Industries, Inc. (OII) purchased the site four years later in January 1952. OII continued municipal operations, but began accepting industrial wastes at the site as well.

1970-1972

In the early 1970's, the population of southern California blossomed and development pressure in areas surrounding Los Angeles increased dramatically. To help alleviate this pressure, the land surrounding the landfill was approved by Montebello for residential use. Promised closure of the landfill by the city and proposed development of a golf course on the site prompted rapid development of the area.

1973-1975

The Pomona Freeway was built in 1974 and intersected the 190-acre landfill. Soon the middle income communities of Monterey Park and Montebello encircled the OII Landfill. Landfill activities were restricted to the larger southern area (South Parcel) of the landfill, closest to Montebello. In compensation for the closure of the North Parcel, the city increased the height limits on the South Parcel of the landfill.

1976-1978

The increase in the height limit on the South Parcel led to increased erosion, mudslides, and ultimately exposed refuse. Starting in 1978, leachate seepages were observed periodically on the slopes of the South Parcel of the OII Landfill. The leachate contained both organic constituents (such as volatile organic compounds, semi-volatile organic compounds, oil, and grease) and inorganic constituents (such as metals, ammonia, chloride, and high levels of total dissolved solids). Large amounts of landfill gas, generated by the natural decomposition of organic and hazardous wastes, were also reported at the site. Tests of the landfill gas found its primary components to be methane, nitrogen, carbon dioxide, and volatile organic compounds (approximately 0.05 percent). Threats of contamination at OII stemmed from exposure to toxic compounds (such as trichloroethane and toluene) and carcinogenic compounds (such as vinyl chloride, benzene, trichloroethylene, and carbon tetrachloride) via air, groundwater, soil, and leachate.

Before the EPA's involvement, numerous state, regional, and local agencies were involved with the OII site. The earliest government intervention began in March 1978 when the South Coast Air Quality Management District (SCAQMD) issued an order requiring OII to follow proper maintenance and disposal procedures. One year later, OII hired Getty Synthetic Fuels to collect methane gas generated by the landfill. Getty Synthetic Fuels then removed the methane gas from the site and refined it for commercial purposes but these activities, including drilling, exacerbated odor problems

1979-1981

In 1980, the Los Angeles County Department of Health Services (LACDOHS) realized that the original methane gas collection system by itself was insufficient and directed OII to institute a second gas control system.

Residents near the landfill formed Homeowners to Eliminate Landfill Problems (HELP) to address increasing odor and potential health problems at the site, as well as specific issues such as leachate seepage, methane gas buildup, declining property values, and land use after closure of the site. This organization, comprised of 460 dues-paying families, was an essential force in the eventual closing of the landfill. According to testimony from Montebello Councilwoman Norma Lopez-Reid:

> "... residents living near the Operating Industries Landfill came home each evening to an area filled with migrating gases, that made them suffer from headaches, nauseating odors, and grass-less yards due to the hazardous liquid waste, called leachate, that seeped out of the ground. These difficult circumstances made the quality of life in this bedroom community decrease considerably, we couldn't even open our windows on hot summer nights. Little did our residents know the extent to which companies, large and small, had been allowed to dump incredible amounts of hazardous waste, including carcinogens, into the landfill that was only supposed to contain regular trash."

In the early 1980's, community council meetings became volatile as residents protested the "assaulting stench" of the air. "We could never open the [house] windows," said Montebello resident Phyllis Lee. As another resident stated, "Some nights I wake up coughing at two, three, four o'clock in the morning. The methane gas is so strong that I have a hard time breathing."

On March 5, 1981, the Montebello School District passed a resolution objecting to the landfill odors and ordering an investigation of potential health risks. Later that year, county health officials cited OII for not controlling the migration of potentially hazardous gasses. The OII Landfill was ordered to temporarily shut down.

1982-1984

Despite resident complaints, heavy criticism from state health and air quality officials, possible $1,000 per day operating fines, and the previous temporary order to shutdown, OII reopened and continued to operate. Finally, in January 1983, OII ceased accepting hazardous liquid waste. In April, they stopped accepting any liquid waste. Also in April, offsite levels of vinyl chloride gas (a known carcinogen) were measured at 19 parts per billion (the state regulated level at that time for vinyl chloride was 10 parts per billion), however, in a random sample of 12 homes elevated levels of vinyl chloride gas were not detected. In June, a buildup of methane within the landfill caused several underground fires. Potentially explosive levels of methane were also discovered underneath city streets adjacent to the landfill. Levels of air-borne vinyl chloride in excess of EPA and state health standards were also detected around the site. However, the LA County Department of Health released a 1983 study showing no pattern of school absence and that there was not excess mortality around the OII Landfill compared to other areas of Los Angeles.

In January 1984, the State of California placed the OII Landfill on the California Hazardous Waste Priority List.

In August 1984, the LACDOHS cited OII for allowing landfill gas concentrations which exceeded the lower explosive limit (5% methane in air) to migrate beyond landfill boundaries. That same month, California Department of Health Services (CADOH) also issued its first Remedial Action Order against OII. It required OII to completely phase out the on-site disposal of leachate and to provide plans for implementing leachate collection and treatment systems, site characterization and groundwater monitoring programs, landfill gas collection and monitoring programs, and slope stability corrective measures.

In October 1984, after four years of legal battles, public hearings, and tremendous community public hearings, SCAQMD issued a second order of abatement requiring the landfill to close permanently, thereby ending the disposal of all solid wastes. This order also instructed OII to install a landfill gas emission control system, a permanent leachate control system, and also to perform specified landfill maintenance. Soon after the closure of the landfill, the owner of OII declared bankruptcy.

Also in October, the EPA proposed OII for the federal Superfund NPL, making it eligible for federal Superfund money. Likewise, the California Regional Water Quality Control Board (RWQCB) issued its own abatement order requiring that the on-site disposal of leachate be phased out.

In December 1984, the EPA dug six wells around the OII site to test for possible groundwater contamination. The test results showed organics and trace mineral contamination in three of the wells, but no pesticide contamination. Fortunately, the drinking water used by the neighboring residents of the landfill came from a number of municipal water companies, which did not operate any wells located on or near the site. However, based on their initial tests, the EPA decided to conduct further testing to determine the specific location and potential movement of the groundwater contamination. The EPA installed an additional 24 wells around the perimeter of the site, which tested positively for soil and groundwater contamination.

1985-1987

In April 1985, while the OII Landfill awaited its final federal NPL listing, the EPA began its Remedial Investigation/Feasibility Study (RI/FS) which assessed and prioritized remedial actions for the site. This did not, however, assuage state concerns about the site. One month later, the California Waste Management Board (CWMB) joined the CADOHS and filed a joint suit against OII for not complying with the CADOHS's first Remedial Action Order issued in August 1984.

In June 1986, the EPA placed the landfill on the NPL of Superfund sites and assumed responsibility for all remedial activities at the site. Shortly after the NPL listing of the site, the California Department of Health Services conducted an extensive epidemiological investigation comparing health symptoms of residents near the site with those of control communities (Satin et al., 1986). The results indicated no significant differences between the health of local residents and that of control communities.

The EPA began its search for OII's PRPs concurrent with the NPL listing. Because of the nature of landfills, the EPA estimated that as many as 4,000 companies were potentially liable for dumping hazardous waste at the OII Landfill during its operable years. Although not all of these PRPs contributed to the cleanup of the landfill, the first of several cleanup agreements was signed in May 1989 between the EPA and over 110 polluting companies. Valued at approximately $66 million, this First Partial Consent Decree required site control and monitoring activities and construction of an interim leachate treatment facility. In return for their immediate cooperation and financial contributions, the Consent Decree released from future liability several large national corporations including Mobil, Exxon, and General Motors. A group of PRPs then organized the OII Steering Committee, of which OII was not a part, to handle legal and environmental issues at the site. This committee eventually formed a corporation called the Coalition Undertaking Remedial Efforts, Inc. (CURE), which would remediate leachate at the site according to the established leachate management plan.

The EPA signed its first Record of Decision (ROD) for the OII site in July 1987, authorizing short-term control and management activities to prevent further contamination and exposure to potential health risks. One such action included fencing the site and posting a guard at the entrance to ensure that no trespassers come into contact with the contaminants. Other emergency measures included gas migration control measures, slope stability, leachate control measures, erosion control, and runoff and drainage improvements.

Once these emergency measures were in place, the EPA signed the second ROD, in November, for control and cleanup of leachate at the site. The EPA proposed several alternative plans and submitted its draft plan for public review. As it often did for area residents, the EPA extended the 30-day public comment period to allow ample time for all interested parties to respond. Based on these public comments, the EPA decided to replace the system of off-site leachate treatment with an on-site treatment plant because it found this alternative to be more acceptable, more cost effective, and more protective of public health and the environment. While the surrounding communities were supportive of this decision, they were greatly concerned that the plant might be used to process liquid wastes from other sites as well. The EPA assured local citizens that only liquids generated from the OII site would be treated at the on-site plant, and then preceded with its remedial plan. The plant would treat 43,200 gallons of OII leachate per day, test it for compliance, and then discharge it into the Los Angeles County Sanitation District sewer system. Natural attenuation and degradation of contaminants would also help reduce groundwater contaminant levels beyond the site boundary, and the EPA agreed to routinely monitor groundwater under and near the site.

1988-1990

Landfill gas migration was the second major problem the EPA addressed at the OII Landfill. The EPA's third ROD for OII called for special gas migration and treatment studies so that gas control systems could be improved prior to the final site cleanup. The results of these studies called for the design and construction of a new gas flare facility (thermal destruction facility), new gas piping and extraction wells, use of existing extraction wells until they are no longer functional, discontinuing use of the air dike system, construction of additional gas monitoring probes, and the installation of gas extraction wells on the North Parcel. Fifty gas wells were also installed in the South Parcel to help control gas and liquid migration. During this time, the EPA notified residents that workers wearing protective gear and loud drilling noises would be present at the site for several months. The EPA estimated that with these improvements 70% more of the landfill gas would be collected, but that the landfill still would not reach the EPA's goal for surface emissions until the final landfill cover was put into place.

The cost of the leachate treatment facility was estimated to be $1.6 million, with annual operation and maintenance cost of $700,000. Although the plant was originally scheduled for construction in the summer of 1988, it was delayed almost a year because of the lack of appropriate funding and the long processes of public comment and facility design and finalization. Likewise, plant operation, scheduled to begin in early 1989, did not begin until August 1994.

In 1989, a Consent Decree was signed by the EPA and more than 100 companies that disposed wastes during the operation of the landfill. These companies formed a committee to examine the issues facing the cleanup effort. Also in 1989, over 100 businesses and public entities filed a lawsuit against other PRP's to share in the cleanup costs.

As part of the gas control system, the EPA amended the ROD to add a landfill cover that sought to better control gas emissions and improve surface water management. The existing cover was highly variable in its thickness and ability to limit surface emissions and odor. A new landfill cover would make gas control remedies more effective and efficient, reduce the amount of gas escaping into the atmosphere, and facilitate the cost effectiveness of the final site remedy. The new landfill cover sought to keep water and oxygen out of the landfill and prevent erosion and run-off from the landfill's slopes. The cover also was designed to improve the appearance of the site. Vegetation has been planted, whenever possible, over the cover. The EPA estimated that the construction of the landfill cover would cost between $61 million and $116 million dollars.

1991-1993

In 1991, the EPA extended the settlement offer to another 154 PRPs, which resulted in a Second Partial Consent Decree similar to the first. In August, 63 of the 154 companies signed the Second Partial Consent Decree worth $8.5 million. Those that did not sign the agreement denied the charges, asserted that they dumped only non-hazardous materials at the site, or maintained that their refuse dumping records didn't exist or were unrecoverable. A third settlement between the EPA and approximately 178 PRPs was reached in December 1991. It required the defendants, later organized into a corporation called the New CURE, to implement major portions of the gas control and landfill cover remedies, improvements worth $130 million. In addition, the EPA sent letters to more than 50 additional PRPs informing them of their liability at the site. During this time, several private companies brought suit against nearby communities to make them liable for contaminants dumped at the landfill. To recoup legal costs resulting from these accusations, one city raised trash collection rates and several other cities sued trash haulers.

In November 1991, the EPA installed another 21 wells beyond the perimeter of the site, which determined that groundwater contamination had not spread beyond the boundaries of the landfill. In total, the EPA constructed 75 wells and conducted six major hydrologic investigations over the course of 28 years.

In April 1992, Judge Mariana R. Pfaelzer of Montebello, California, enforced the previous $130 million agreement. The EPA also entered into another Consent Decree with a variety of contributing companies to begin the initial cleanup activities related to gas control and landfill cover as designed by the EPA.

Implementation of gas control remedies began in 1992. The construction, operation, and maintenance of these remedies were estimated to cost $73 million over a 30-year period. From 1993 to March 1994, during the construction of the new gas flare facility, low levels of vinyl chloride escaped into the atmosphere because the temperature of the old gas flare treatment system was insufficient to incinerate the gas. Although they had no way of monitoring emissions, the EPA maintained there was no problem with air quality. However, the EPA still tested 197 Montebello homes for vinyl chlorine. Four percent of the homes tested positively and the EPA installed gas management systems to aerate the homes and prevent further the contamination from entering the houses. The EPA is required to monitor these homes for ten years.

1994-1996

In 1994, the leachate treatment facility began operations. A settlement was reached in 1994 that resolved the 1989 lawsuit filed by 137 businesses and public entities that had already contributed more than $200 million to the cleanup efforts.

In April 1995, a Fourth Partial Consent Decree was reached between the United States, the State of California, several private companies, 14 cities and municipalities that disposed of municipal waste at the landfill, and those who transported municipal waste to the landfill. The agreement provided $51 million for the Final Remedy and construction of a Thermal Destruction Facility on the North Parcel.

In March 1996, thirty companies signed a final Fifth Partial Consent Decree to pay $18.7 million for interim site costs and the Final Remedy. In total, over $270 million had been collected from almost 400 different entities for the cleanup of the OII Landfill. This estimate represents only private money contributed to site cleanup. An additional estimated $165 million of public dollars will be spent for site remediation.

In September 1996, the fourth OII ROD for Final Site Remedy was signed. The EPA agreed to evaluate and monitor the site and the success of their cleanup efforts every five years after the remedial action plan is implemented. The EPA also decided to replace the gas flare disposal system with a new landfill gas thermal destruction facility, which would be used to treat or destroy landfill gas produced at the site.

1997-1999

In mid-February, 50 new testing wells were installed on the southern and western perimeter of the former OII Landfill near Montebello. These wells were designed to better control gas and liquid migration from the landfill. The EPA advised residents to not interpret the workers protective clothing as an indicator of a "hazard for the neighborhood". Additionally they emphasized that during the drilling process "**there will be no contamination hazard to nearby residents during these activities**" (emphasis in original).

Additionally, construction of the landfill cover began. The EPA mailed out a special notice to residents informing them of the upcoming constructions and possible disturbances that may result. Construction of the cover involved moving six million cubic yards of soil. The old dirt on the landfill was removed and was replaced with a six-foot-thick "monocover"of clean soil. A variety of native vegetation including grasses and shrubs was added to the slopes of the landfill and the flat top of the landfill was covered by a multi-layer "geosynthetic clay liner" (a system of woven matting and clay). The objective of both covers was to prevent rainwater from entering the landfill and to stop gas from escaping.

In March 1997, the EPA issued a universal administrative order requiring seven more companies, which collectively dumped six million gallons of hazardous substance into to the OII Landfill, to contribute to OII's remediation. Specifically, these companies are responsible for maintaining the on-site leachate treatment facility until December 1999, which will cost a total of approximately three million dollars.

In 1999, the EPA reached a settlement with 327 parties which allegedly disposed small amounts of waste at OII. These parties contributed between 4,200 and 110,000 gallons of waste.

After 1999

In 2000, the landfill cap and the new gas control systems (Thermal Destruction Facility) were essentially completed, gas flares were replaced and the treatment of groundwater commenced. Development of a shopping center at the North Parcel of the landfill began. This North Parcel was not significantly affected by the hazardous waste and is one of the largest pieces of undeveloped property in the Los Angeles area.

In December 2001, a $340 million settlement was signed with 161 PRP's. This was the eighth settlement since 1986. Settlements up to this point had totaled over $600 million.

Also in 2001, the construction of the groundwater remedy was completed and the EPA ended its in-home monitoring and random sampling programs after it found no evidence of a problem in any of the houses for several years.

The eighth Consent Decree was approved in May 2002, which outlined the final cleanup remedies.

Chapter 4

Woburn, Massachusetts

4.1 Overview

Woburn is a historic city (founded in 1640) of about 35,000 people located 12 miles (19.3 kilometers) northwest of Boston (Figure 4.1). The community is predominantly blue-collar because of its industrial heritage. It is also the location of two large Superfund sites: Wells G & H and Industri-Plex. Together the sites cover almost 600 acres of land in the 14 square mile (36.3 square kilometer) community. Both sites are located in the section of Woburn east of Main Street, a low, swampy area that includes many streams and the Aberjona River (Figure 4.2). This section of Woburn, referred to as East Woburn, is a mix of industrial and residential areas. For the Industri-Plex site, homes are located within 1,000 feet and 13,000 households are within a two mile (3.2 kilometer) radius. Approximately 34,000 people live within three miles (4.8 kilometer) of both sites. While the two sites are distinct from each other, the pollution problems at both sites were discovered within a few months of each other. Both sites were evaluated by the EPA and added to the NPL in the early 1980s.

Figure 4.1 Woburn Vicinity

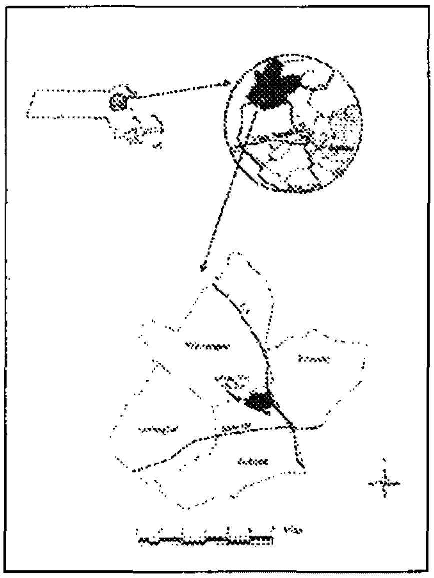
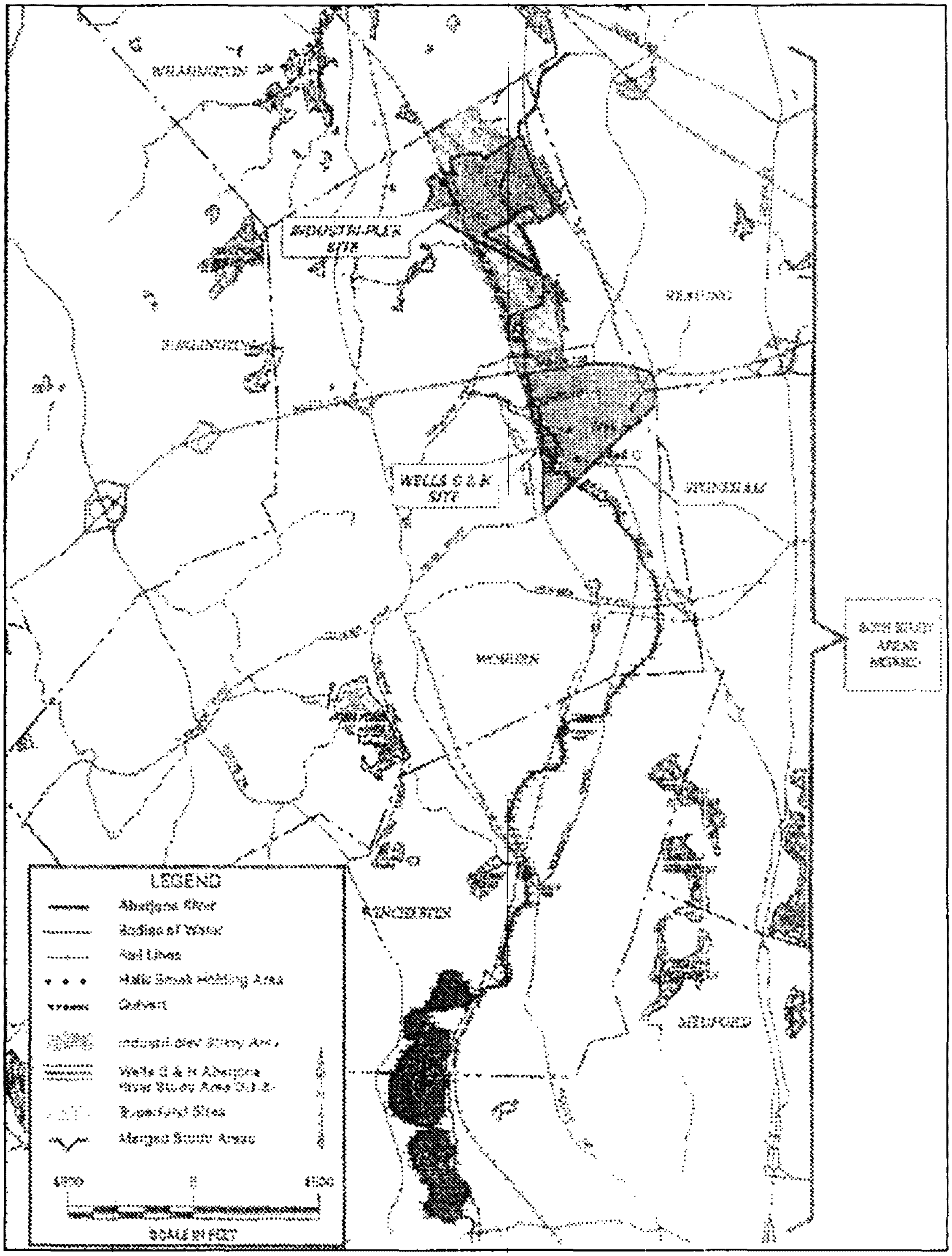


Figure 4.2 Industri-Plex and Wells G&H Sites



Throughout Woburn's history, more than 100 companies used the Aberjona River, which flows through the city, for industrial waste disposal. Companies dumped wastes on land, into lagoons and ponds adjacent to the river, as well as directly into the river itself. From 1853 to 1931, compounds and chemicals such as acetic acid, sulfuric acid, lead, arsenic, chromium, benzene and toluene were dumped behind buildings, used as fill for low spots, and included in construction material for dikes and levees. Woburn has a long history of public health problems, including elevated rates of kidney and liver cancer, colon-rectal cancer, child and adult leukemia, male breast cancer, melanoma, multiple myeloma, and brain and lung cancer.

The 330-acre Wells G & H site is located near the Aberjona River, about one and a quarter miles (2 kilometers) downstream (south) of the Industri-Plex site. It once ranked as the tenth worst site on the EPA's NPL list. The site is the location of two drinking water wells for the city of Woburn, which were built in 1964 (Well G) and 1967 (Well H). These wells were located near an automobile graveyard, an industrial barrel cleaning and reclamation company, a waste oil refinery, a tannery, a dry cleaner, and a machinery manufacturer. Despite public complaints about the water from these wells, Woburn continued to use the wells, especially during the summer. Both wells were finally closed in 1979 after testing showed that the water was contaminated. Soil and groundwater at the site are contaminated with volatile organic compounds (VOCs), such as trichlorethylene (TCE) and tetrachloroethylene (also called perchlorethylne, PCE, or 'perc'). Land in this area is zoned for industrial and commercial use, with some areas for residential and recreational use.

The Industri-Plex site, the location of Woburn's most intensive industrial activity since the 1850s, consists of 245 acres in an industrial park and once ranked as the fifth worst site on the EPA's NPL. This area is located one mile (1.6 kilometers) northwest of the intersection of Interstate 93 and Route 128 and is bordered by the communities of Wilmington and Reading. Two tributaries of the Aberjona River flow through the Industri-Plex site. Of the 245 acres at the site, one-third was contaminated and 60 acres were used for commercial purposes throughout the remediation of the site. Contamination at the Industri-Plex site includes heavy metals and hydrocarbons. In the soil, the contamination was primarily arsenic, lead, and chromium and in the water the contamination was primarily benzene, toluene, arsenic, and chromium.

Additionally, hydrogen sulfide gas emanating from buried animal hides from the tanneries and wastes once permeated the air.

Redevelopment plans are now underway for the Industri-Plex site and consist of a Regional Transportation Center (train station, park and ride), a recycling center, highway interchange, an office park, and retail space. This development is expected to yield between 12,000 and 16,000 jobs by 2010, relieve traffic congestion in Woburn, and help the Boston area come into compliance with EPA air emissions standards by enhancing public transportation in the area. However, as of 1999, the City of Woburn estimated that the number of permanent jobs at the redeveloped site was 4,315.

Groundwater remediation and monitoring now constitute the bulk of the remaining work to be done. As of December 1998, three groundwater treatment plants operating at the site had pumped and treated more than 150 million gallons of water. In addition, all the contaminated soil has been removed (approximately 150 tons) and 1,360 pounds of VOCs have been destroyed. Although major strides in the remediation of the property have taken place, according to EPA lawyers, complete cleanup of the site will cost approximately $80 million and could take another 20-30 years because of the site's extensive groundwater contamination.

4.2 History of Woburn and its Superfund Sites

1600-1700's

Woburn was incorporated as a town in 1640 and shortly thereafter became a center of manufacturing in New England, because its location was ideal for industry because of its accessibility to major transportation throughways (roadways and seaports) and proximity to the consumer market of Boston. In 1648, the first tannery opened in Woburn.

1800's

In the mid-1800s, Woburn became known for shoe manufacturing. Local manufacturing activity later shifted from shoes to leather production, and Woburn became a leader in the U.S. tanning industry by 1865. By 1884, Woburn was home to 26 large tanneries that employed approximately 1,500 employees and produced $4.5 million worth of leather. At the peak of

Woburn's tanning industry, from 1900 to 1934, an estimated 2,000 to 4,000 tons of chromium was dumped directly into Woburn's water resources, as well as 65 to 140 tons of copper, 85 to 175 tons of lead, and 40 to 75 tons of zinc.

Numerous chemical manufacturing firms occupied the Industri-Plex land, which is upstream from water Wells G & H, for almost 150 years. In the 1800s, several firms operated on the site, producing chemicals for the local tanning, textile, and paper industries. In 1863, theMerrimac Chemical Company (Merrimac) became the leading industry on the site.

1900's

From 1863 to 1931, Merrimac produced lead-arsenic insecticides, TNT and other explosives, dyes, and organic chemicals such as phenol, benzene, and toluene. Between 1900 and 1914, Merrimac was one of the largest producers of arsenic insecticides in the country. In 1915, as part of the war effort, industry in Woburn began to diversify to include munitions, chemicals, and insecticides. (Until the war, Germany had been the major source of these chemicals.) By 1917, Merrimac had grown into the largest chemical manufacturer in New England.

1920's

The City of Woburn built a sewer due to concerns about pollution of the Aberjona River and Upper Mystic Lake. Monsanto acquired Merrimac in 1929 and moved the chemical operations off the Industri-Plex site in 1931.

1930's

In 1934, Monsanto sold the Industri-Plex land. Between 1934 and 1968, the companies that occupied the Industri-Plex site manufactured glue and gelatin by extracting collagen from animal hides and chrome-tanned leather. Wastes generated by these processes included animal hide residues and metals such as arsenic, lead, and chromium. These wastes were generally deposited on top of existing waste deposits. Waste piles, including the animal hides, covered tens of acres and reached heights of 40 to 50 feet above the natural grade.

1950's

In the 1950s, East Woburn began discussing the need for additional water supplies for the city's expanding population. In 1958, the city hired an engineering consultant to examine the possibility of utilizing the Aberjona River water for drinking. Although the consultant concluded that the water was too heavily contaminated to be safe for drinking, the city began constructing two new wells, Wells G & H.

1960's

Water Wells G & H, located on the east side of town, began operating in 1964 and 1967, respectively, to provide Woburn's growing population with drinking water. At that time, these two wells supplied 30% of the city's drinking water. The 330-acre Wells G & H site contains five contaminated properties bounded by Route 128 to the south, Interstate 93 to the east, the Boston and Maine Railroad to the west, and Salem Street to the south. The Aberjona River also flows through the site, through on-site wetlands found immediately adjacent to both sides of the river, and into the Mystic Lakes. The Mystic Lakes are a popular recreational destination including swimming and fishing.

Shortly after the installation of the two wells, residents of East Woburn complained that the water smelled and tasted funny, corroded their pipes, discolored their dishwashers, and stained clothing and fixtures. Prompted by citizen complaints, city officials tested the water from the two wells. Test results only revealed high levels of salts in the water and officials downplayed citizen's concerns about the water.

In 1967, the Massachusetts State Department of Health (MSDH) recommended that Well G & H be closed because of concerns about bacteria and only recommended their use in conjunction with continuous chlorination. Soon residents reported concerns about their water tasting like "bleach". In the spring and summer of 1968, residents complained about their "red water," but city officials claimed it was due to the city's unlined old cast iron pipe. MSDH gave the city permission to add sodium hexametaphosphate ("Calgon") to Well G & H to remedy the problem and to adjust the water's pH content. In an attempt to find a long term water supply solution that did not involve the use of Wells G & H, the Woburn City Council authorized the Mayor to negotiate with the Metropolitan District Commission (MDC) about joining its water system with the neighboring town of Stoneham. Starting in February 1969, the City of Woburn increased the chlorine feed at Well G by 50%. Due to resident's complaints, Well G was closed for the winter starting in October.

At Industri-Plex, Stauffer Chemical Company (Stauffer) bought the last of the glue manufacturers in the 1960s and ceased operation in 1968. In 1968, Mark Philip Realty Trust (MP Trust), a real estate developer, bought the Industri-Plex land from Stauffer to develop it as an industrial park. MP Trust began preparing for construction of a shopping mall and an industrial park. In 1969, the project started illegally without a permit, though a permit was obtained a year later. The construction at Industri-Plex involved moving piles of waste accumulated over 130 years and filling in low-lying areas and wetlands.

Early 1970's

Throughout the early 1970s, despite the repeated reassurances from city and state officials, the citizens of East Woburn continued to express concerns about the water from Wells G & H. In response to public pressure, Well G was frequently turned off in the winter when water was more abundant only to be called into service again during hot, dry summers. Voluntary water restrictions were put into place in 1972 and 1973 to avoid use of the wells, while the city continued to work with MDC to provide a long-term water solution. In the summer of 1974, water shortages forced the city to consider activating both Wells G & H, which caused a "storm of protest" from residents. In 1975, a fire destroying the MDC pumping state at Spot Pond in Stoneham interrupted construction of the water main connecting Woburn and MDC.

In 1975, as part of the development of the south end of Industri-Plex, 20 acres of animal hide piles and animal glue waste were disrupted releasing hydrogen sulfide fumes into the air. This "rotten egg" smell, extremely potent at times, elicited numerous complaints from citizens of Woburn and the neighboring Town of Reading, downwind of Industri-Plex. Citizens and the media referred to the omni-present stench as the "Woburn odor." This odor at times prevented children from playing outside during noon recess at school and residents of affected areas claimed that they could not use their yards. When the odor was strong, citizens working outside complained of nausea, burning eyes, and difficulty breathing. Residents even mentioned that the airborne chemicals caused the exterior paint on their houses to peel. Large open-air pits of waste at the site allowed humans and animals to come into direct contact with the contaminants.

According to one Woburn mother, "It was only a five-minute walk and you see the open pits filled with chemicals. We used to go blueberry picking where they found the arsenic."

The Massachusetts Department of Environmental Quality Engineering (MDEQE) [now the Massachusetts Department of Environmental Protection] issued MP Trust numerous violation notices, orders to halt construction, and requests to cleanup wastes at the Industri-Plex site. In 1977, MDEQE and the Town of Reading filed a lawsuit against MP Trust demanding that MP Trust be prohibited from disturbing the two parcels where the glue waste was buried. However, MP Trust continued its construction because it had the permission of Massachusetts Department of Health (MDOH) (which was responsible for hazardous waste management at that time) to excavate and dispose of hazardous wastes on the site. "It [remediation] would make the land too expensive to develop. It [the waste] can stay there as far as I'm concerned," said William D'Annolfo, owner of MP Trust.

1978-1979

The major pollution problems at both of Woburn's Superfund sites were discovered within six months of each other.

Abandoned 55-gallon Drum with the Entire Side Corroded; Found Near Wells G & H.

Wells G&H. In May 1979, construction workers discovered that 184 55-gallon barrels of waste had been dumped near the Wells G & H. Immediately after this discovery, the MDEQE tested the wells for possible contamination. These tests revealed high concentrations of several VOCs, known carcinogens in animals, but indicated that the barrels were not the source. Officials were particularly concerned about TCE and perc in the well water because TCE levels tested as high as 267 parts per billion and VOC levels tested as high as 100 parts per billion. (The EPA considered anything more than 27 parts per billion and 5 parts per billion, respectively, to be hazardous.) Additionally, river sediments were found to be contaminated with polycyclic aromatic hydrocarbons (PAHs) and heavy metals such as chromium, zinc, mercury, and arsenic. Adjacent soils also contained PAHs, poly-chlorinated biphenyls (PCBs), VOCs, and pesticides. Anyone coming into contact, swallowing, or ingesting this groundwater, soil, or river sediments would be at risk.

Although the EPA discovered these problems with Wells G & H in July of 1979, Woburn officials and residents were not notified of the problem by the EPA, COE, or MDEQE until an enterprising reporter released the information in a local newspaper story. The problems described in the news story and the lack of notification by the official organizations involved, generated much outrage and distrust on the part of local citizens. Likewise, contamination at Industri-Plex was documented in federal and state COE and EPA records in August 1979, but local officials were notified of the contamination not through official channels but, again, by a local newspaper article reporting the results of EPA investigations conducted earlier that summer.

Industri-Plex. At Industri-Plex, the Massachusetts Department of Environmental Protection (MDEP) asked the Army Corps of Engineers (COE) to investigate alleged wetlands violations and help control the activities of MP Trust. After conducting a preliminary survey of the site, the COE solicited the help of EPA. In late 1979, based on their discovery of illegal filling of wetlands, the EPA and the U.S. Attorney's office (on behalf of the Army Corps of Engineers) obtained a court order against MP Trust to stop development at the Industri-Plex site. Additionally, the EPA discovered pits of buried animal hair and barrels of slaughterhouse waste. In December, regional EPA officials requested funds for the installation of a permanent air monitoring station for North Woburn.

Groundwater was contaminated with arsenic and VOCs, including benzene and toluene, and soil was extensively contaminated with arsenic, chromium, and lead. Benzene has been proven to cause leukemia. In fact, EPA investigations revealed a football field-sized arsenic pit that rose 40 feet into the air. Arsenic was used in the production of lead-arsenate, an insecticide that was replaced by DDT in the 1940s. Arsenic is a known human carcinogen and can cause skin tumors when ingested, and lung tumors when inhaled. Arsenic is also linked to chromosomal damage in humans and animals. Measured arsenic concentrations in this pit reached as high as 1,100 parts per million (ppm) and debris from the pit was detected on the slopes of Route 93, a half-mile away (0.8 kilometers). Although EPA officials were uncertain about when the arsenic was dumped, they believed it dates between 1899 and 1934, meaning that the arsenic has been in Woburn soil for 85 to 100 years. Other contaminants permeated the site as well. Recorded levels of chromium reached 3,000 ppm in one place and 78,000 ppm in another. The concentration of lead was as high as 1,200 ppm. At the time, the standards for both of these contaminants were 0.05 ppm.

Community Reaction. The discovery of two major hazardous waste problems in one town prompted strong media interest as well as the active response and involvement of Woburn's residents. Area newspapers and TV stations ran multi-part stories about Woburn, alluding to it as a "toxic wasteland." Local newspapers and magazines featured articles with headlines such as: "Lagoon of Arsenic Discovered in North Woburn" (*The Daily Times*, September 10, 1979), "Chasing A Radioactive Ghost" (*The Daily Times*, October 16, 1979), "Deaths From Cancer Increase in Woburn" (*The Daily Times*, December 12, 1979). In particular, *The Daily Times* published two notorious articles about Woburn's hazardous waste contamination, which reported higher rates of adult and childhood leukemia, bone and skin cancer, prostate cancer in men, and breast cancer. However, the estimates quoted in the article were not confirmed by MDOH until the following spring. Interestingly, in its final report, the MDOH used the same statistics reported in *The Daily Times* months earlier.

One east Woburn resident, Anne Anderson, began to suspect a link between the well water and her son's leukemia. "From the time we moved here, the water was bad in the summer. It had an unpleasant odor and a terrible taste," she later recalled. "My mother brought jars of MDC water when she came to visit. The kids used to always ask for 'Nana water.' It was like a mother's milk, for God's sake. She still brings it when she visits." Anderson began recognizing some of her neighbors at the hospital, who were also there with children suffering from leukemia. "I just don't see where all the leukemia cases in our area aren't correlated," she said. "It seems they have to be. The thing that strikes me is there are two neighbors off of Pine Street who have children with leukemia. A year later people on the other side of the street had their child diagnosed and two people we know personally were diagnosed." Her husband continued, "Before, in all of my life, I knew of only one child with leukemia. But these are all in Woburn." Anderson had requested that city officials test the water, but she was informed that it was not standard procedure to perform such tests on the basis of one individual's request. Unsatisfied with this response, Anderson, with the help of her minister Reverend Bruce Young, convened a meeting in September 1979 for parents of children with leukemia. Attendees of that meeting counted the number of local leukemia cases and mapped the homes of the sick children—eight leukemia cases were clustered within one square mile (1.6 square kilometers) in East Woburn, six in a six-block square served by Wells G & H.[1] Sparked by these findings, the citizens of Woburn formed the group For A Cleaner Environment (FACE) in October 1979. Two months later (December), FACE and the doctor treating Woburn children with leukemia convinced the Woburn City Council to contact the Centers for Disease Control (CDC). After examining the situation, the CDC found that Woburn's childhood leukemia rate was two to three times that of the national average and four times the average of other communities the size of Woburn. As CDC described it, Woburn had the most persistent leukemia cluster it had ever seen.

Later that December, MDOH released a preliminary report on the second five-year study[2] of the health effects of Woburn's drinking water, which contradicted the clustering of leukemia in East Woburn and the pronouncements of CDC. It stated that Woburn had a higher than normal incidence of many cancers but that there was no "association between environmental hazards and the incidence of childhood leukemia." (As later determined, the state had used in its calculations, a population estimate for Woburn, taken from the 1970 Census, which was much greater than Woburn's population at the time the study was conducted.) When MDOH corrected this inaccuracy, its calculations revealed several statistically significant rates of cancer and leukemia.

1980-1982

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[1] Between 1964 and 1997, 28 leukemia cases were diagnosed in Woburn. Of these 28 cases, 16 resulted in death. (The last case of documented childhood leukemia in Woburn was reported in 1986.)

[2] Dr. Robert Tuthill and Dr. Leslie Lipworth, of the University of Massachusetts, conducted the first five-year study, which found a slightly elevated but statistically insignificant increase in Woburn's rates of cancer and leukemia.

Wells G&H. Initial EPA investigations of potential contamination at Wells G & H began in 1981. Per these investigations, the EPA divided the site into three areas, or "operable units", and identified five likely sources of pollution. The operable units included five properties inside the site boundary, the area immediately surrounding the wells, and a segment of the Aberjona River and adjacent wetlands. Three of the sources of pollution that EPA identified were W.R. Grace, UniFirst, and the John J. Riley Tannery (Riley) which had been purchased by Beatrice and then again purchased by Wildwood Conservation Corporation. Grace operated an equipment manufacturing plant located about 2,500 feet northeast of the wells; the firm used solvents at several points in the manufacturing process. The Riley Tannery, and an adjacent 15 acre property, was bought by Beatrice in 1978 and sold back to Riley in 1983, but Beatrice retained legal liability for environmental matters at the tannery property. UniFirst, located about 2,000 feet north of the wells, used perc as part of its industrial dry-cleaning business. The other two sources of contamination were New England Plastics and Olympia Nominee Trust. Final testing conducted in September 1988 confirmed that groundwater contamination emanated from pollution at these properties. On December 30, 1982, the EPA proposed adding Wells G & H to the NPL.

Installation of a groundwater monitoring well near Wells G & H.

Industri-Plex. In 1980, the EPA allocated $150,000 for an investigation of the Industri-Plex site, which revealed major pollution problems. In May of 1980, a judge ordered MP Trust to halt construction until it designed, with the help of MDEQE, an appropriate cleanup plan for the site.

Also in 1980, MDEP placed a latex cover over the inorganic wastes at the site. At that time, the site contained streams, ponds, remnant manufacturing, buildings, a warehouse, office buildings, and waste piles.

The EPA began negotiating remediation with the primary polluting parties. On October 23, 1981, the EPA proposed the Industri-Plex site for inclusion on the NPL. The EPA installed chain link fence. This fence was subsequently damaged by ATVs and was not permanently fixed until 1986. During this time period, illegal dumping occurred at the Industri-Plex site.

Unlike the lengthy lawsuit with MP Trust over the Industri-Plex site, negotiations with Stauffer were expeditious. In May 1982, Stauffer signed a Consent Decree with the EPA and MDEQE to undertake a remedial investigation and feasibility study (RI/FS) for the site.

Community Reaction. In May 1980, the CDC and the National Institute for Occupational Safety and Health initiated a more detailed study of Woburn's rates of leukemia, which confirmed the presence of elevated levels of kidney cancer and childhood leukemia. However, the final report stated that the results of the study were inconclusive because of the lack of data prior to 1979. It also failed to attribute elevated levels of leukemia to hazardous wastes, "The information gathered thus far fails to provide evidence establishing an association between environmental hazards and the incidence of childhood leukemia... in Woburn." The public was outraged and felt betrayed by this persistent stonewalling from governmental agencies. According to local residents, state and city health officials worked to preserve public health in theory only. The media continued to document concerns about the sites including "Workers Near Waste Site Complain of Headaches, Fatigue" (*The Daily Times*, July 2, 1980), and "Toxic Waste: One Year Later, Still No Answers" (*The Daily Times*, August 1, 1980).

The reports fueled community activism and led FACE to question the validity of the reports. Seven months after their initial meeting, FACE convened a group of state and federal agency representatives to discuss the plight of Woburn residents. At that meeting, the EPA agreed to investigate the wells. An EPA report released later that year confirmed what the public already knew, that high levels of contamination were present in groundwater, particularly in the areas of Wells G & H. This was the first of FACE's many victories, as the group was instrumental in the remediation of both the Wells G & H and the Industri-Plex sites.

In 1982, eight Woburn families filed a highly publicized $400 million lawsuit against several industries alleging that they had contaminated the aquifer for the two wells, and that this contamination caused the high rate of childhood leukemia and other health problems in Woburn. While the court case proceeded, FACE continued its grassroots advocacy work and held numerous public meetings to mobilize community leaders and local residents. Two professors studying the clustering of disease heard of FACE's struggles and invited activists Anne Anderson and Reverend Bruce Young to present the Woburn case at the Harvard School of Public Health (HSPH). As a result of this presentation, the HSPH and FACE collaborated on a more detailed study of environmental contaminants at Woburn. The HSPH designed and administered a public health survey of the area with the help of FACE, which coordinated 235 volunteers to implement the survey. Between April and September, 54% (3,257 households) of all Woburn residents answered the survey. The results revealed a clear linkage between leukemia, fetal and newborn deaths, birth defects, and childhood illnesses within the neighborhoods that received most of their water from Wells G & H. The survey also found that the well water caused ten times the expected rate of stillborn births. As Reverend Young described the situation, "For seven years we were told that the burden of proof was upon us as independent citizens to gather the statistics.... All our work was done independent of the Commonwealth of Massachusetts. They offered no support, and were in fact one of our adversaries in this battle to prove that we had a problem."

Millions of dollars and several years were devoted to the Woburn court case which commanded front-page national media attention. The book describing the lawsuit, *A Civil Action*, was published in 1996 and became a bestseller. In 1999, the book was made into a movie starring John Travolta.

1983-1985

Wells G & H. On September 8, 1983, Wells G & H were officially listed on the NPL. In 1983, the EPA issued its first order requiring Grace, Beatrice, and UniFirst to begin initial investigations on the contamination at their properties affecting Wells G & H. In 1985, the EPA's second order mandated that Wildwood Conservation Corporation fence its property and hire a 24-hour guard to prevent any additional human contact with the contaminants present on that property. An EPA Technical Assistance Grant, awarded to FACE, allowed the community to hire a consultant who could interpret technical information and reports about the site. FACE heavily utilized the expertise of their consultant, providing community members the opportunity to actively participate in the development of the Record of Decision (ROD) and final remediation guidelines for the site.

Industri-Plex. On September 8, 1983, the EPA placed the Industri-Plex site on the NPL. Stauffer completed the RI/FS in April 1985 and found that arsenic contamination was even greater than initially suspected. Stauffer's investigation also revealed that the northeast section of the property would require only groundwater monitoring and might be appropriate for future development. Finally, the report concluded that although Wells G & H and Industri-Plex were hydraulically connected, contamination present at Wells G & H is the result of pollution dumped not at the Industri-Plex site, but at a location south of Route 128. The EPA ordered a full-blown investigation of the entire 330-acre Wells G & H site. Stauffer chemical signed a consent order with EPA to pay for its apportioned share of the remediation efforts. In May 1985, the parties approved decrees requiring MP Trust to investigate and cleanup the site, but MP Trust never undertook these activities citing financial concerns.

1986-1988

Wells G & H. In 1986, after five years, the $400 million lawsuit filed by the eight Woburn families went to trial. The initial trial lasted only 80 days and none of the surviving plaintiffs ever took the witness stand to talk about their loss resulting from contamination at Wells G & H. Woburn residents were embittered by the results of the verdict:

- UniFirst Corporation (UniFirst) settled for $1.05 million prior to the trial without admitting any wrongdoing.
- Although a jury found Grace & Company (Grace) negligent, a district judge dismissed the ruling because of inconsistencies in the evidence. Grace eventually settled for $8 million without admitting any wrongdoing. After lawyer's fees, each family received approximately $300,000.

- A jury dismissed the charges against Beatrice Foods (Beatrice), but the judge reopened the case because of legal misconduct on the behalf of Beatrice's lawyers.

In 1986, an EPA administrative order required Olympia Nominee Trust to remove all drums and debris from the western portion of its property. Additionally, in 1987, EPA issued an administrative order requiring UniFirst to install monitoring wells and remove contaminants near Wells G & H. Also in that year, the U.S. Geological Survey reports that approximately 50% of the water for Wells G & H originated, from the polluted Aberjona River. In 1988, the EPA conducted a detailed investigation showing the groundwater contamination from the five properties near the wells.

Industri-Plex. Also in 1986, to restrict access to the Industri-Plex site, the EPA ordered the fence to be fixed and a 10,000-foot extension. A year and a half after the RI/FS was complete, in September the ROD was finalized; the EPA published its ROD describing the remedies selected for the Industri-Plex site. The remedy consisted of five elements:

- The "soil remedy" called for installation of a permeable cap over 105 acres to prevent physical contact with soils and sediments contaminated with high concentrations of lead, arsenic, or chromium.
- The "air remedy" called for placement of an impermeable cap over five acres of the site to prevent water infiltration and gas release, and installation of a gas collection and treatment system.
- Interim groundwater treatment of a benzene/toluene "hot spot" on the site to reduce concentrations and limit migration of the chemicals.
- Investigation into and development of a plan for treatment of groundwater and surface water.
- Implementation of institutional controls to limit the future use of the site because available cleanup technology could not provide the safety necessary for unrestricted use.

The total cost of site investigations and remedial actions was estimated to be $50 million. Although cleanup remedies for the Industri-Plex site were identified in 1986, actual cleanup activities did not begin in until 1993.

The fence around the Industri-Plex site was completed in 1988, but shortly thereafter dirt bikes and ATV riders again destroyed a section of the fence, and several barrels of waste were dumped illegally at the site. Three months after the repair, the fence and posted warning signs were demolished by vandalism.

1989-1991

Wells G & H. In 1989, the EPA granted Woburn a Technical Assistance Grant enabling the community to hire a technical advisor to help them better understand the technical aspects of the contamination and remediation efforts and take an active part in decision making processes for Wells G & H. On September 14, after incorporating issues mentioned in the public comment phase, the EPA released its final ROD. The ROD addressed the properties contained within the site, the accompanying groundwater contamination, and the subsequent investigations of the other two operable units of the site.

In July 1991, after only four months of negotiation, the EPA finalized a "record-breaking" settlement with four of the five PRPs for the Wells G & H site (Grace, UniFirst, Beatrice, and North Eastern Plastics). At the time, it was the most expensive Superfund settlement ever achieved in New England. Although an agreement with the fifth PRP, Olympia Nominee Trust, was never reached, the comprehensive cleanup of the G & H Wells site began immediately upon the closing of this multi-million dollar deal. The settlement stipulated that the companies would:

- Clean up their own properties simultaneously, at a collective cost of approximately $68.4 million,
- Provide funding for EPA's oversight of cleanup activities, valued at $6.4 million,
- Conduct a risk assessment of the area immediately surrounding Wells G & H, and
- Reimburse the EPA for its investigation studies, which cost approximately $2.65 million.

Due to the amount of contamination present at the site, agency officials knew long-term remedial plans for the site would be critical and remediation of groundwater resources would be extensive. These plans included excavating and incinerating 2,100 cubic yards of contaminated soils, extracting toxins from soil vapors (this entailed, literally, suctioning the toxins out of soil), and pumping groundwater from the underground aquifer and returning it after treatment.

Although the problems at both the Wells G & H and Industri-Plex sites were identified in 1979, local citizens grew increasingly frustrated by the 14 year delay in remediating Industri-Plex and the 13 year delay in remediating Wells G & H.

Industri-Plex. Trespassing on the Industri-Plex site ceased after the Industri-Plex Site Remedial Trust (ISRT) established its office on the site in 1989 and posted 24-hour security guards.

After five years of arduous negotiation, MP Trust signed a Consent Decree to investigate contamination at the site and resolve wetland infilling violations. Unable to comply with terms of this agreement, MP Trust filed for bankruptcy. A Consent Decree was signed for Industri-Plex site in April 1989, Monsanto, Stauffer-ICI (ICI Americas, Inc, purchased Stauffer in 1987), and twenty smaller other PRPs established the Industri-Plex Site Remedial Trust (ISRT) to implement the agreement. In addition to forming a remedial trust, this Consent Decree allowed Monsanto and Stauffer-ICI to create a Custodial Trust which would technically own title to contaminated areas of the Industri-Plex property, protecting Monsanto and Stauffer-ICI from liability relative to the site, attempt to avoid conflicts among PRPs, and set-up a mechanism to sell the land after completion of the remediation of site. A key feature of this agreement required that the recently bankrupt MP Trust sell all of its Industri-Plex holdings to fund its share of remediation of the toxic contamination and in return to have no additional liability.

1992-1994

Wells G&H. One year after signing their multi-million dollar agreement with the EPA, in September 1992, UniFirst and Grace began groundwater remediation, and Wildwood and New England Plastics began soil excavation. This progress was viewed as a mixed blessing. Government officials applauded the PRPs for ultimately accepting responsibility and then acting expediently, but residents felt betrayed. According to Gretchen Latowski, director of FACE, "The Woburn experience is the ultimate failure of Superfund. It took 12 years since the problems at the wells were first identified before anything was done or any responsibility taken."

Excavation of contaminated soil near Wells G & H.

Industri-Plex. Although cleanup remedies for the Industri-Plex site were identified in 1986, actual cleanup activities did not begin in until 1993 when construction began on the permeable and impermeable cap for Industri-Plex site. By the summer of 1994, EPA had approved 100% of the remedial design. Also in the early 1990's the EPA and the ISRT amended the groundwater remedies listed in the Industri-Plex ROD (Element 3) because of unanticipated contamination, advancing technology, and cost efficiency. As a result of this change, groundwater was treated by a pilot oxygenation and bioremediation process as opposed to the original remedial prescription to pump groundwater, strip it of contamination, and return it to the aquifer.

Industri-Plex during remediation: site with cap on contaminated soils.

1995-1997

Wells G & H. On April 27, 1995, Jeffery Purvis, Chief of the Community Assessment Unit of the Bureau of Environmental Health Assessment, reported on the status and conditions of Wells

G & H. Though not clearly identified, the well field was easily accessible and a No Trespassing sign was posted. However, the area was not fenced and rolls of fold fencing and piles of concrete piping lay in the area. The site did not appear to have been accessed recently, though trash, including clothing, furniture, tires, and other debris, littered the site. In 1995, the UniFirst Corporation and W.R. Grace and Company installed UV-oxidation systems to treat groundwater in area bedrock.

The bestselling book, *A Civil Action*, was published in 1996.

After extensive but fruitless efforts to bring Olympia Nominee Trust to the table, the EPA in 1997 agreed to remediate that part of the site with money from the Superfund trust. Initial tests of the Olympia Nominee Trust property began in September 1997.

Industri-Plex. By 1997 the soil and air "remedies" ordered in 1986 for Industri-Plex were in place (Elements 1 and 2), the groundwater treatment to reduce the benzene/toluene "hot spot" was only partially implemented (Element 3), and the instructional controls to determine future use of the site were still not finalized (Element 5).

1998 and later

Wells G & H. In 2000, North Eastern Plastics completed the remediation of the soil and water contaminants related to Wells G & H. In 2003, six years after reaching agreement with the other four responsible parties, EPA reached an agreement with Olympia Nominee Trust, the fifth source of pollution for Wells G & H. The EPA entered into administrative order by consent with all parties this year to address PAH and PCP contamination.

Phase II investigation of the groundwater contamination, beyond the five sources continues. As part of Phase III, which focuses on the Aberjona River, the EPA prepared a risk assessment.

Industri-Plex. At the Industri-Plex site, the gas collection and treatment system were completed in December 1998. Groundwater remediation and monitoring constitute the bulk of the remaining work to be done. As of December 1998, the three groundwater treatment plants operating at the site had pumped and treated more than 150 million gallons of water. In addition, all the contaminated soil was removed (approximately 150 tons) and 1,360 pounds of VOCs had been destroyed. Although major strides in the remediation of the property have taken place, according to EPA lawyers, complete cleanup of the site will cost approximately $80 million and could take another 20-30 years because of the site's extensive groundwater contamination. An investigation of groundwater contamination at the Industri-Plex site began in 1999. Initially it was expected to be completed by early 2000; however, it was not finished until 2003.

State and local governments and EPA officials have been successfully working together to promote commercial redevelopment of the Industri-Plex site. For example, with the support of state and local officials, the EPA pursued prospective purchaser agreements which limit the liability of property purchasers and, in some cases, offered previously contaminated properties at reduced rates. Plans included having Home Depot and Target serve as anchor stores of the 110 acres of commercial development at the site, with 35 acres being devoted to a regional transportation center, and 100 acres being preserved as wetlands and open space. As one development engineer recently observed, foxes and snapping turtles now frequent Industri-Plex wetlands.

Industri-Plex after remediation: regional transportation center.

Though soil data was collected in 1995 and 1997, additional sediment and surface soil sampling was conducted in 2000 and 2001 to fill in data gaps of the Human Health and Ecological Risk Assessments. In 2002, sediment and soil samples were collected along the

Aberjona River to evaluate the potential impacts from the river, including on the cranberry bog, on flood source soil conditions, and on areas the City of Woburn was interested in developing in the future.

Chapter 5

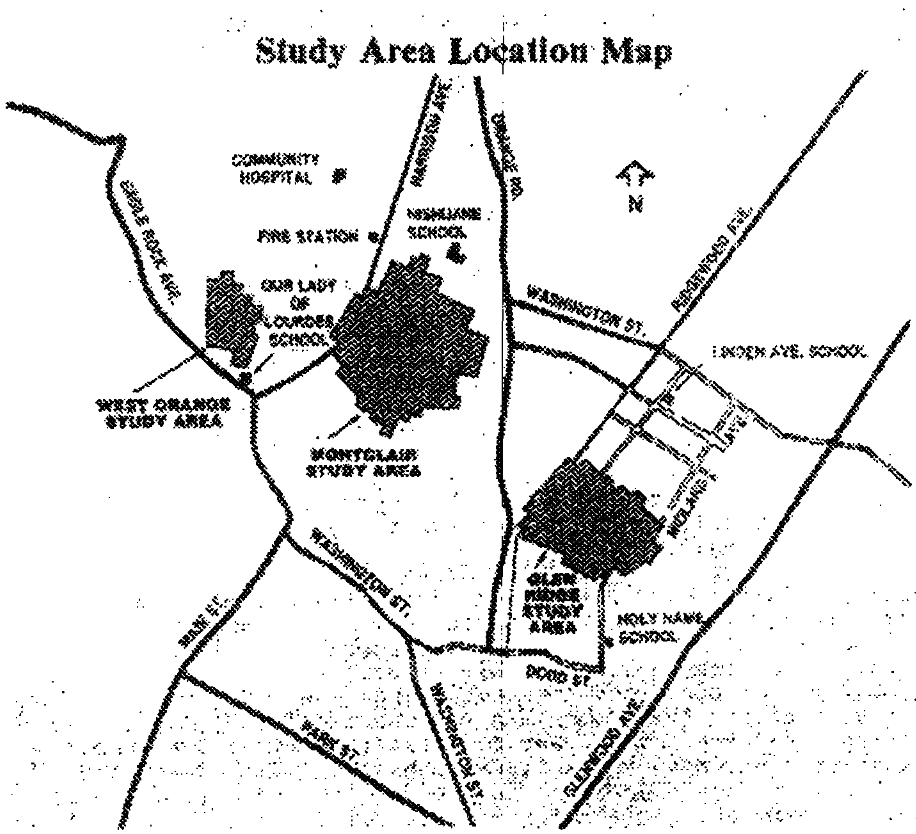
Montclair, New Jersey

5.1 Overview

Montclair, Glen Ridge, and East and West Orange Townships are located about eight miles (12.9 kilometers) from Newark Airport in northern New Jersey. These towns are densely populated, and are located in one of the most densely populated regions of the United States. The Montclair/West Orange Radium Superfund site consists of 366 residential properties on 120 acres in Montclair and West Orange (Figure 5.1). The Glen Ridge Radium Superfund site is comprised of 306 properties on 90 acres of residential land in Glen Ridge and East Orange. The soil at both sites is contaminated with radium, a naturally occurring element which can result in high levels of radon gas and gamma radiation in nearby homes. The Center for Disease Control (CDC) and the New Jersey Department of Health (NJDOH) declared these sites to be a public health hazard due to concerns about lung cancer. Montclair/West Orange and Glen Ridge were listed on the NPL for Superfund sites in 1985 because of their proximity to radium waste generated by radium processing. These plants had operated in the area after the turn of the 20th century, and an estimated 200,000 cubic yards of contaminated material were placed on private and public areas in the communities.

Initial attempts to remove the contaminated soil were hampered by the lack of suitable waste depository, resulting in 4,902 drums and 33 containers of soil being stored for nearly two years on the yards of partially excavated properties in Montclair. In 1999, nearly 20 years after the initial identification of the problem and 12 years after being put on the NPL, cleanup activities continued to occur as the streets are replaced and the EPA continued to investigate the possibility of additional groundwater contamination. By 1998, a total of $175 million had been spent to remediate over 300 houses and remove 80,000 cubic yards (or 5,000 large truck loads) of contaminated soil. In 2004, estimates of total cleanup exceeded $200 million.

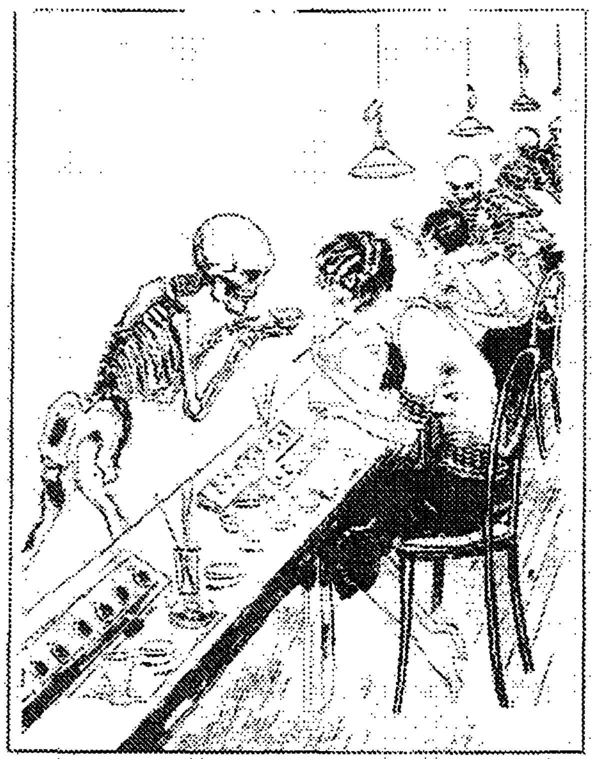
Figure 5.1 West Orange, Montclair, Glen Ridge Sites



5.2 Timeline and History

1915-1926

Northern New Jersey was a center for radium processing and the dial-painting industry in the 1900's. Several plants occupied the area, the largest of which was the U.S. Radium Corporation (formerly the Radium Luminous Materials Corporation) which operated between 1915 and 1926. Because of its luminescent properties, radium was added to the paint that was used for numbers on watch dials and instruments, which became especially popular during World War I. At various times, U.S. Radium Corporation employed between 100 to 300 young women as watch dial painters. Corporate supervisors instructed the painters to lick the tips of their brushes to create the fine point needed for the detailed work. As a result of this process, the dial painters ingested a significant amount of radium. Since clothes were often speckled with this luminous paint, many of the dial painters glowed in the dark by the time they returned home from work. Women sometimes painted their fingernails, buttons, or eyelids with the paint for its special glow-in-the-dark effects. One worker reportedly painted her teeth with the luminous paint in preparation for a date after work one evening. Because of their exposure to radium, some of the workers developed bone diseases, such as necrosis of the jaw, anemia, and cancer. Many factors, including health problems and the discovery of richer uranium ore in the Belgian Congo led to the closing, and eventual destruction, of New Jersey's radium plants.



"POISONED! -- as *They Chatted Merrily at Their Work*

Painting the Luminous Numbers on Watches, the Radium Accumulated in Their Bodies, and Without Warning Began to Bombard and Destroy Teeth, Jaws and Finger Bones. Marking Fifty Young Factory Girls for Painful, Lingering, But Inevitable Death"[3]

[3] Source: Hearst Sunday supplement *American Weekly*, February 28, 1926.

The U.S. Radium Corporation extracted and purified radium from carnotite ore found in New Jersey soils. It processed approximately one and a half to two tons of ore each day, and generated large amounts of radium contaminated waste. This waste was stored temporarily on-site, and then transported and dumped on nearby rural areas.

1930's

During the 1930's, the contaminated soil was used as fill to prepare approximately 200 acres of low-lying areas in Essex County, New Jersey, for residential development. Contaminated soil was also mixed with cement for foundations and sidewalks. An estimated 200,000 cubic yards of contaminated material is believed to have been disposed of on private and public lands within the communities before the area was fully developed. This area, contaminated by radium infill, eventually gave rise to the townships of Montclair, Glen Ridge, and East & West Orange.

The Montclair site was almost entirely residential with some small businesses and a park nearby. Within a half-mile (0.8 kilometer) of Montclair were five schools, a hospital, one health care facility, and a nursing home. West Orange was also predominantly residential with some businesses located on the north/northeast side of the site. Located within one half-mile of the West Orange site were two schools and one hospital. The Glen Ridge site was primarily residential, and encompassed a park and had several small businesses nearby. No hospitals were located near the Glen Ridge site, but three schools exist within a half-mile.

A USEPA contractor takes gamma radiation measurements in Montclair.

Pre-1987

The New Jersey Department of Environmental Protection (NJDEP) discovered radium contamination in these communities in 1979 during an investigation of the former radium processing facilities. In 1981, the NJDEP requested EPA funding to perform an aerial gamma radiation survey of 12 square miles (19.3 kilometers) of Essex County to identify possible contamination from offsite disposal of radium processing waste. This survey identified three distinct areas of elevated radiation in the townships of Montclair, Glen Ridge, and West Orange.

The NJDEP conducted additional screening surveys and ground readings in Glen Ridge in July 1983, and in Montclair and West Orange in October 1983. As part of this screening, 17 homes in Montclair and 10 homes in Glen Ridge underwent additional testing for radiation, 19 of which were found to exceed federal safety standards for radium (13 in Montclair, 6 in Glen Ridge).

NJDEP officials were planning to notify local government officials and residents of their findings in early December 1983. However, despite a request by NJDEP officials to hold the story until official notification had been made, a November 30th television news report broke the story early. According to the *New York Times* (October 16, 1984) article published one year later, "[Many] residents of the three communities – Montclair, West Orange and Glen Ridge – were not told about the problem until… technicians, wearing protective gear began taking soil and air samples in and around their homes." Within a few days of the television news report, New Jersey Governor Kean convened a news conference to make an official announcement about the radium contamination. That month, local newspapers reported extensively on the areas of radium contamination in their communities. Response to the announcement of radium contamination was immediate, widespread, and occurred at many levels from local neighborhood residents to federal agencies. With this heightened public concern, the EPA immediately installed temporary radon ventilation systems in 38 homes and gamma radiation shielding in 12 homes.

A combined federal and state task force formed in December 1983 to devise a comprehensive sampling plan that would better define the areas of contamination and provide a benchmark for remedial action. This plan included an initial screening of "grab" samples which showed above background radon levels. Long term units for continuous sampling and monitoring were later installed. Technicians in protective suits performed surface gamma radiation surveys on the properties surrounding affected homes. Soil samples were also collected. In response to local citizens' and officials' concerns, two schools in Montclair were tested but no contamination was found.

At the local level, community members received different messages from different agencies about the health risks involved. NJDEP Commissioner Hughey portrayed radon as strictly an environmental problem. A New Jersey Department of Health (NJDOH) representative said that the only known health risk was lung cancer, and a NJDOH representative was made available to meet with affected families for advice. According to the EPA, risks associated with radon were equivalent to the risks associated with cigarette smoking. A couple of news reports, however, referred to the radium contamination in New Jersey as "another Love Canal," since both residential areas were built on contaminated soil. Even EPA officials expressed great concern, among themselves, about this case, because it identified the first residences built directly on contaminated ground. In response to this mixed information, the Montclair Township Council formed its own task force in December 1983, which held its first organizational meeting that month. Montclair residents from the contaminated neighborhoods also formed a Radiation Ad Hoc Committee in December 1983.

Within a month of the November 30, 1983, news report, three bills to aid the affected communities were introduced into the New Jersey state legislature. One bill requested cleanup funds, another victim compensation, and the third would require the NJDEP to investigate any potentially affected homes at the owner's request and provide a certificate of clearance if the property was not contaminated. The latter bill was passed in January 1984, and by July 20, 1984, some residents received certification that their homes had been tested and were clean.

The EPA began field investigations in Glen Ridge and Montclair in January 1984 to determine the boundary of the contamination and to quantify gamma radiation and radon levels in the affected areas. Residents were asked for permission to collect samples and were then provided with the results for their homes. Field investigations continued throughout the fall of 1984. By the end of the year, the EPA had completed all radon source characterization surveys in the three townships.

The NJDOH conducted an epidemiological assessment of the three radium sites and found a possible, but not statistically significant, increase in lung cancer among white males at these sites. As a result of this study, the CDC and NJDOH declared these sites to be a public health hazard. The Centers for Disease Control (CDC) released a Public Health Advisory for Glen Ridge and Montclair which quantified health risks and recommended appropriate remedial actions. The CDC divided homes into four categories based on their levels of contamination and the actions necessary to reduce human exposure contamination:

- Level I homes required remedial action within two days and restricted smoking and time spent in high radon level areas of the homes.
- Level II homes necessitated remedial action in 1-3 months.
- Level III homes necessitate remedial action within 1-2 years.
- Level IV homes required no action.

Prescribed actions included the installation of remedial systems such as dilution air fans, air filtration systems, and sealing foundations. The plan also suggested additional studies to determine the boundaries of the contaminated areas, locate and characterize the source of the contamination, and assess the potential for groundwater and vegetation contamination.

All this testing and EPA attention prompted local realtors to gather at a Task Force meeting to discuss the potential impact of radon on the housing market. Reactions were mixed. Some realtors reported that there was no decrease in the number of homes sold. However, other realtors reported, anecdotally, a decrease in the selling prices of the homes *if* the homes were known to be in affected areas. Fearing lower property values, local residents felt strongly that they should not have to pay full property taxes on their homes. In response to these concerns, the Essex County Board of Taxation granted to petitioners in 1984 tax relief on 39 properties in Montclair: 20% relief if there was soil contamination and 50% relief if radon levels required installation of ventilation systems. The County also granted tax relief for 22 properties in Glen Ridge, but the town appealed this in State Court. In West Orange, tax relief was granted for eight properties – including some adjacent to contaminated properties.

In June, the media agitated already deepening concerns with a spate of negative publicity which included local newspaper articles and several special news features on major television stations. Residents and officials of Montclair grew more concerned, and decided to hire a private consultant, David Rosenbaum, a former EPA official. Many of Rosenbaum's views were published in the local newspaper, including: 1) levels of radiation are the highest ever determined in a dwelling in the U.S.; 2) residents in these homes were exposed to "some of the highest concentrations of any carcinogen ever recorded"; and 3) "Affected residents are in considerably more danger than the people who once lived in the Love Canal region in NY." Rosenbaum concluded that the contaminated soil should be dumped in the ocean and that the EPA could approve this solution (*Montclair Times*, October 11, 1984). Residents of Montclair, Glen Ridge, and West Orange filed suit against the U.S. Radium Corporation. The 7-year legal battle went to the State Supreme Court and ended in 1991 when 237 residents received a $4.2 million settlement (average $18,000/house) from remnants of the U.S. Radium Corporation.

The entire backyard of this property in Montclair was excavated during cleanup.

A joint EPA/NJDEP task force identified 12 homes in the three communities for a proposed pilot study involving soil excavation and removal. The EPA decided to postpone the pilot study until the completion of the requisite feasibility study, scheduled to begin later that year. The NJDEP, however, planned to proceed with the pilot study on its own. The search for an acceptable disposal site stalled progress of the pilot program and ultimately generated a great deal of public anger and distrust of the NJDEP. In August, the NJDEP proposed to temporarily store contaminated soil from the pilot study at the National Guard Armory in West Orange. Residents of West Orange strongly opposed this plan and the proposal was withdrawn. The Montclair Township Council was then asked to help locate a disposal site in Montclair for the radioactive waste. In response, the Council passed a resolution stating that the Township would under no circumstances comply with the request because: 1) complete cleanup was the only acceptable alternative; 2) high population density and development pressures excluded the possibility of local storage sites; and 3) securing a disposal site was a state and federal responsibility.

As the search for a suitable storage site for the contaminated soil became a major problem, the NJDEP considered several other options, but significant resistance from people living in or near the potential sites caused each of these possibilities to be abandoned. For example, protests and demonstrations were held to prevent storage of contaminated soil at a dump site on the Montclair State College campus. During this time, questions were raised about the desirability of a pilot project. Those in favor of the project said that it would shorten the time it would take the EPA to start cleanup because the project would demonstrate the feasibility of the cleanup approach.

In the fall of 1984, the NJDEP and federal officials considered simply buying and fencing-off the contaminated properties. This option deeply concerned the townships, which soon deemed it the least desirable alternative because it would transform whole neighborhoods into "radium dumps." Finally, in September 1984, the Montclair Township Council and community task forces announced their intention to undertake legal action against the EPA and the NJDEP to facilitate timely removal of contaminated soil.

The Montclair/West Orange and Glen Ridge sites were added to the proposed NPL in October 1984, and the EPA began its Remediation Investigation/Feasibility Study (RI/FS) the following month. Three months later (January 1985), both sites were added to the final NPL. In April, the EPA finalized its RI/FS and submitted it to the public for final approval.

Also in April, the New Jersey Governor signed a bill appropriating eight million dollars for the pilot study (this was later increased to $15 million). With this money, the NJDEP was able to locate a storage site in Beatty, Nevada, and the pilot study began with four homes in Glen Ridge in June of 1985. In August, five Montclair families were temporarily moved from their homes for an expected two months and excavation of the contaminated soil began. Prior to its shipment to the permanent storage site, approximately two-thirds of the contaminated soil excavated for the pilot project (9,500 drums and 51 containers) was stored in Kearny, New Jersey, and the remainder of the soil (4,902 drums and 33 containers) was stored in the yards of the partially excavated properties in Montclair.

Immediately preceding the completion of the pilot project and soil shipment, the state of Nevada revoked the NJDEP's disposal permit. In October 1985, the U.S. Supreme Court directed the NJDEP to look for a disposal site within the state. Once again there was no place to store the contaminated soil from the complete remediation of four homes in Glen Ridge and the partial remediation of five homes in Montclair. Consequently, almost 5,000 containers of contaminated soil remained in the yards of the partially excavated Montclair homes.

In July 1986, the NJDEP made plans to ship the excavated soil to an abandoned quarry in Vernon, New Jersey, where it would be blended with clean dirt to bring radium levels down to acceptable levels. Thousands of Vernon residents vigorously protested against this plan by obtaining temporary restraining orders and demonstrating with chants of "Hell no, we won't glow." Several state and federal lawsuits were also filed against the NJDEP, and the NJDEP dropped the plan in November. As the search for a storage site dragged on, the plight of the relocated Montclair families continued to be the subject of media attention. Three hundred people from Montclair and surrounding communities rallied in support of the indefinitely displaced families.

1987 – 1989

The NJDEP made several offers to buy these five properties from their owners at market value -- as if the homes were not contaminated -- and to pay relocation costs, but these offers were refused. The NJDEP also offered to bury the contaminated soil more deeply in the yards and install filtering systems. This offer was also refused. The Township of Montclair again filed suit in State Supreme Court to force the NJDEP to remove the barrels. Judgment was passed in March 1987 requiring the NJDEP to start removing the barrels by May 15, 1987.

Eventually, the EPA negotiated a disposal site, and in December 1987 the NJDEP spent almost four million dollars to ship the barrels of soil to Oak Ridge, TN where the soil was mixed with radioactive waste from power plants and shipped to a storage site in Washington State. Likewise, the soil stored at Kearny, NJ was shipped out of state in the summer of 1988.

An excavator removes radium-tainted soil from Barrows Field in Glen Ridge.

In April 1989, the EPA released its draft remediation plan and held public meetings for discussion and comment. The EPA's $53 million action plan called for a five-tiered approach to remediation based on the level of contamination found in the homes. In June, the first Record of Decision (ROD) was signed. It established five classifications related to the level of contamination and subsequent required remediation:

Tier A (23 homes): Complete soil removal and replacement of the most contaminated areas.

Tier B (75 homes): Covering of contaminated soil and installation of radon control systems in homes with very high radiation levels.

Tier C (65 homes): Installation of anti-radiation devices in less severely contaminated homes, which would also be subject to deed restrictions and other controls.

Tier D (296 homes): Monitoring homes with low levels of radon.

Tier E: The homes had no evidence of radium contamination and would receive no further action.

The public staunchly opposed this plan and all proposed remedial efforts short of complete removal of contaminated soil. In response to public concerns, the EPA installed a fence around two of the sites to prevent the public from coming into contact with hazardous materials. They began removing soil at the most contaminated homes and extended the comment period on the plan, while deferring decisions on the less contaminated homes.

In 1989, Dr. William Kinnard of the Real Estate Counseling Group of Connecticut, Inc. was retained to conduct a market research study of all single-family residential property sales within the three radium Superfund site areas. This analysis identified, reported, and measured the actual market sales behavior of homebuyers and sellers using a total of 1,423 housing sales in three different locations from July 1, 1980 to June 30, 1989. In one location, Dr. Kinnard found a statistically significant decrease in property values and volume of housing sales after the public announcement of contamination discovered at these sites. In the other two locations, the rates of property value appreciation and housing sales volume increased more slowly than in locations without Superfund sites. Evidence from Kennard's study also suggests that the housing market response to a known Superfund site is a direct function of the speed, proximity, and apparent effectiveness of any remediation or cleanup efforts.

1990 - 1992

In January 1990, the twice-extended public comment period ended and by June, the public agreed to a revised $250 million plan and the second ROD was signed. This plan included removal of the first 15 feet of contaminated soil from approximately 400 homes in the three towns. Cleanup efforts would be spread out over a maximum of 10 years, and radiation-ventilating devices would be installed in homes in the interim. As part of this plan, the EPA would also replace existing radon units with higher efficiency radon units.

In 1991, as discussed above, after seven years of litigation, 237 residents received a $4.2 million settlement (average $18,000/house) from the remnants of U.S. Radium Corporation.

While the pilot study involving a limited number of affected homes started in 1984, the major cleanup activities of other areas began in 1991. The cleanup was divided into seven phases based on the severity of contamination, owner access agreements, and location. Radon mitigation systems were maintained in almost 40 homes throughout each phase of the cleanup and until remediation was complete. Each phase of the remedial plan required access to properties to perform a design survey, which included gamma radiation surveys, installation of radon and alpha detectors, and soil sampling and drilling. If the survey found no evidence of contamination, the property owner was given the results of the test, and a follow-up radon test was conducted one year later. If the follow-up test confirmed the lack of radium contamination, the property owner was given a final report summarizing all results. If contamination was present in the initial or any of the follow-up surveys, the EPA remediated the property. After remediation was complete, monitoring and sampling were done for one year to evaluate the success of the cleanup. Once the property was cleared of all contamination, a detailed summary package was provided to each homeowner, which included details of excavation and results of the testing. Over the course of cleanup, approximately 100 families were temporarily relocated.

The cleanup process was highly disruptive to the neighborhood as it involved, in some cases, the installation of building supports and the use of large machinery to remove contaminated soil. The Pilot Phase and Phase I entailed the cleanup of 56 properties, temporary relocation of 22 families, and removal of over 15,000 cubic yards of contaminated soil. After the cleanup was complete, houses, property, driveways, and sidewalks were restored to at least their original condition and in many cases were improved by enhanced landscaping and sidewalk and/or garage replacement. Additionally, the amount of radon remaining in the soil at these locations after remediation was well below the natural level of radon contained in most New Jersey soils

1993-1995

In 1993, Phase IIA was underway, which included the cleanup of 26 additional properties. In 1994, Phase IIB started which called for the remediation of 53 properties. During this time period, EPA had still not made a final decision regarding remediating the three communities' streets. Phase III was completed in 1995 and consisted of remediation of 54 homes.

1996-1997

Phase IV and Phase V were completed in 1996, and included the partial demolition and rehabilitation of 55 homes. Phase VII of the cleanup began in the summer of 1997, which included continuing remediation of properties with post excavation radon levels above normal and beginning remediation of six additional homes. Remediation at 441 properties complete at Montclair/West Orange, but 20 additional properties were discovered to need remediation.

After 1997

By 1998, a total of $175 million had been spent to remediate 300 houses and remove 80,000 cubic yards (or 5,000 large truck loads) of contaminated soil. In the fall of 1998, a two-year remediation plan for the streets finalized and began in 1999, as part of Phase VI. Also, an additional 30 homes were rehabilitated and 35,000 cubic yards of soil were removed as part of Phase VI, which was completed in 2001. In 1999, the EPA began testing groundwater for possible contamination, and a January 2003 Remedial Investigation Report revealed that elevated levels of radon were found in the groundwater. Phase VIII was completed by the end of 2003. Three additional properties require remediation and are included in Phase IX, currently scheduled for completion in January 2005.

Chapter 6

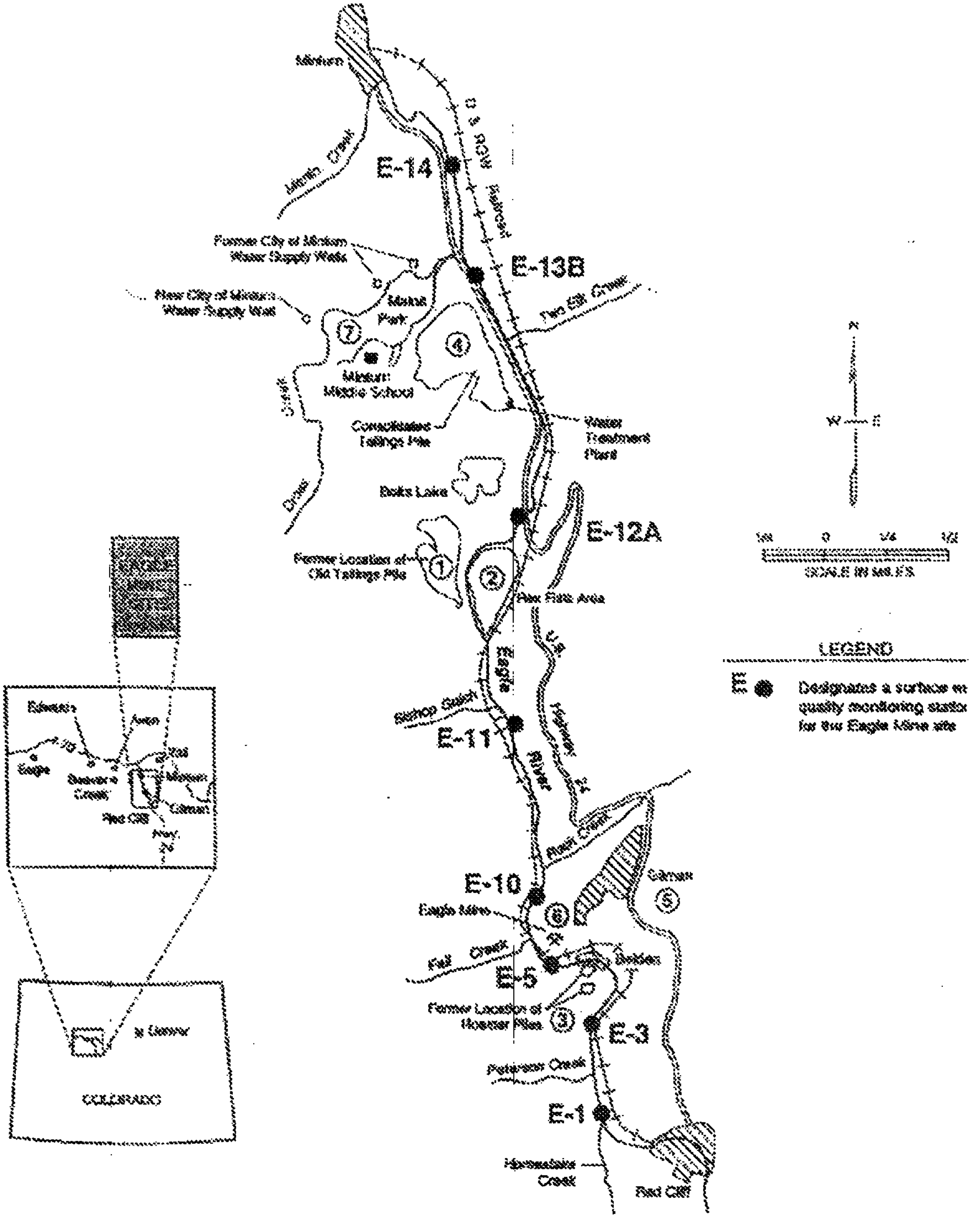
Eagle Mine, Colorado

6.1 Overview

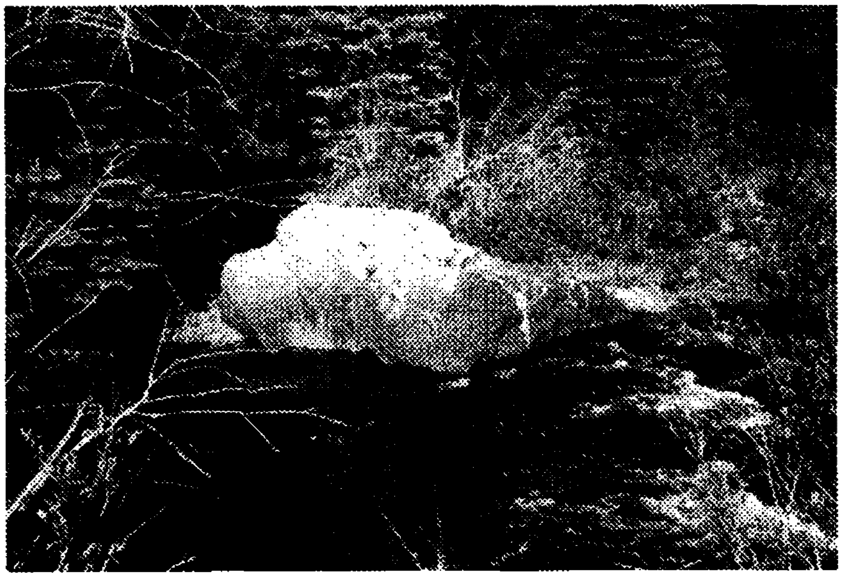
Eagle Mine is centrally located between Vail and Beaver Creek ski areas, approximately 100 miles (160 kilometers) west of Denver, Colorado and about 14 miles (22.5 kilometers) southeast of Vail, Colorado (Figure 6.1). Once one of the nation's top producers of zinc, the mine lies between the small towns of Minturn and Red Cliff, just off U.S. Highway 24. The property consists of approximately 6,000 acres, 340 of which are contaminated with toxic waste. Most of the contamination originates from areas located along the Eagle River, and includes: the abandoned mining town of Gilman located on a cliff just above the mine, the old Eagle Mine processing plant in Belden, two ponds containing wastes from the smelting of ore, Maloit Park, Rex Flats, various waste rock and roaster piles, and an elevated pipeline. The Eagle River (a major tributary of the Colorado River), Cross Creek, and several other tributaries run through the site.

The Eagle Mine site is contaminated with eight to ten million tons of hazardous substances including arsenic, nickel, chromium, zinc, manganese, cadmium, copper, and lead. The main cause of Eagle River contamination came from acid mine drainage, which occurs when sulfide minerals, such as pyrite, are exposed to oxygen and water and then oxidize. This process creates sulfuric acid, which contaminated soil, groundwater, and surface water surrounding Eagle Mine, producing water with low pH levels. Acid drainage at Eagle Mine resulted from precipitation flowing through the waste piles that accumulated from nearly 100 years of mining. As Eagle Mine acid drainage seeped into ground and surface water, it killed aquatic life and vegetation growing along the water's edge and contaminated the river with zinc, lead, manganese, and cadmium. Not only did this contamination threaten brown trout, the most populous fish in this segment of the river, but it also permanently stained the rocks in and along the river bright orange, providing Minturn and Red Cliff residents with a constant reminder of the contamination at Eagle River.

Figure 6.1 Eagle Mine Site



Eagle River across from CTP, stained rock.



State studies conducted in 1984 revealed dangerously high levels of cadmium, copper, lead, and zinc in local water resources. Minturn, with a population of 1500, is the closest town and draws drinking water from Cross Creek and two wells located within 2000 feet of the mine tailings[4]. While Eagle Mine had a history of environmental problems dating back to 1957, the majority of the problems arose after the mine closed in 1984. Eagle Mine was placed on the national Superfund priorities list (NPL) in June 1986.

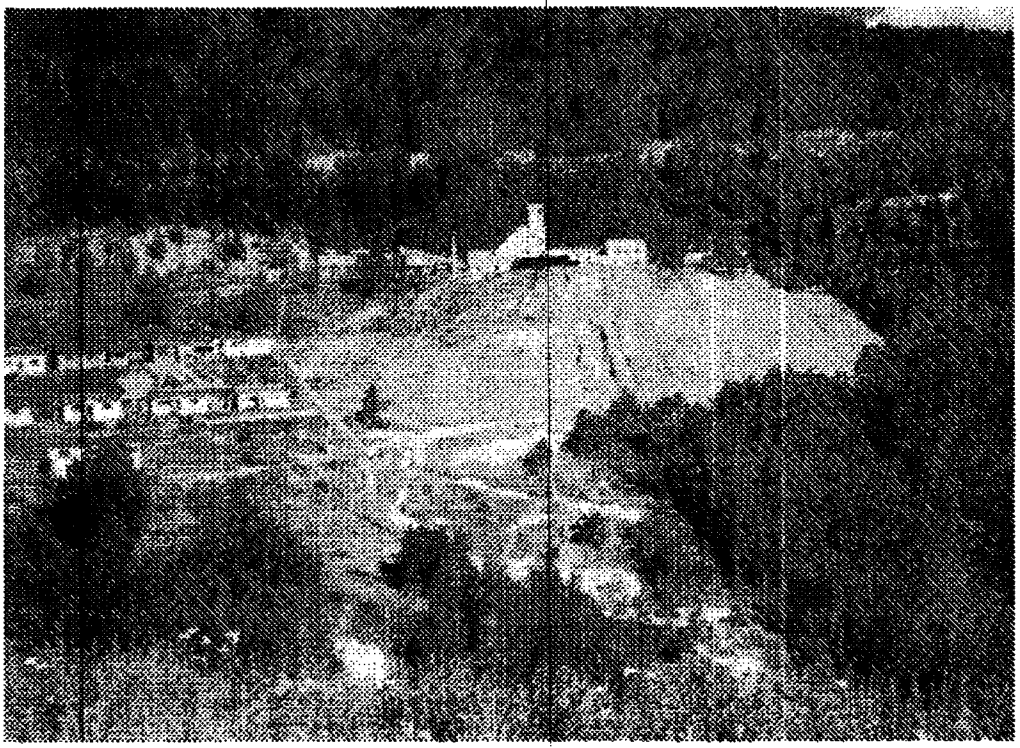
6.2 History and Timeline

Mining in Colorado began with the discovery of silver-lead and gold-silver in 1879, and played an important role in the economic development of many Colorado mountains. In the mid 1890s, a new ore was discovered in Battle Mountain, and the bulk of mine extractions shifted from gold and silver to zinc. Zinc extracted by independent miners was shipped off site until 1905, when a zinc ore processing plant was built near Belden, approximately a half-mile (0.8 kilometers) southeast of Gilman. The plant heated the ore to extreme temperatures and then extracted the zinc using magnets, a process called roasting. After the roasting was complete, a

[4] Most mine tailings are disposed of in an on-site compound, and are typically comprised of 40-70% effluent liquids used in the mining process and 30-60% solids.

tramway transported roasting wastes across the Eagle River and dumped them into three piles on the west side of the canyon in direct sight of Gilman. In addition to these piles, two more waste piles were located on the east side of Eagle River.

North face of Gilman and waste rock pile.



Around 1912, the Empire Zinc Company began buying small independent mines. By 1915, the company had consolidated the small independent operations into one business which it named the Eagle Mine. Gilman became a company town and, at its peak, was home to over 400 residents.

The New Jersey Zinc Company constructed an underground flotation mill to process the zinc ore from Eagle Mine. The ore was ground into a powder and then mixed with water and treated with chemicals to bring the zinc to the surface of the mixture. The waste from this process consisted of slurry, which was transported north via an underground pipe and dumped in the Old Tailing Pile (OTP) and Rex Flats areas just west of the Eagle River. In 1928, the zinc operation ceased due to falling prices resulting from the Great Depression. Mining of gold and silver ore continued, but the ores were shipped off-site for processing.

Ownership of the Eagle Mine Superfund site is quite complex. In 1938, Empire Zinc Company merged with the New Jersey Zinc Company, making it the new owner of Eagle Mine. Later in 1966, New Jersey Zinc Company merged with Gulf & Western Industries, Inc., which later changed its name to Gulf+Western, Incorporated.

Because it was used to harden steel, a valuable commodity during the war, zinc production resumed in the early 1940s. Once again the tailings were deposited at the Old Tailing Pile (OTP). By 1946, the pile had reached capacity and a New Tailings Pile (NTP) was established one-half mile (0.8 kilometers) northeast of the OTP, near the confluence of Cross Creek and the Eagle River, just south of Minturn Middle School and Maloit Park. Approximately, 75,000 tons of waste, covering 15-20 acres, were dumped at this site.

Long before Eagle Mine was listed on the NPL of Superfund sites, state officials expressed concern about the amount of hazardous pollution originating at the site. In fact, a March 17, 1957 *Denver Post* article reported that a zinc mine in Gilman, CO was asked to pay $15,000 for 75,000 trout that suffocated in the Eagle River due to an oil fuel spillage. Another *Denver Post* article (October 20, 1974) reported that the New Jersey Zinc Company paid "$3,308 for trout and other fish which died July 19 after 12,000 gallons of liquid wastes and 100,000 pounds of mill tailings polluted the Eagle River".

Peter Seibert and Bob Parker founded Vail ski resort in 1962 less than 14 miles (22.5 kilometers) from Gilman and the Eagle Mine. The resort opened for business on January 10, 1963 and 12 skiers bought lift tickets. Within two years, more than 14,000 skiers visited the resort. Vail's reputation blossomed in the mid 1970s when Gerald Ford became president. Ford had lived part-time in the Vail area since the 1960s, and during his tenure as president, the resort became known as the "Western White House". Starting in the 1970s, Vail experienced explosive growth and building construction. Golf courses, tennis courts, and other sports activities attracted summer tourists almost as plentiful as Vail's winter tourists.

1976-1982

Zinc production continued until 1977 when, due to falling zinc prices, the operation was shut down again and more than 150 mineworkers were laid off. Most families moved out of Gilman at this time.

By 1981, one million tourists visited Vail resort annually.

1983-1988

On September 1, 1983, Glenn Miller, a Colorado businessman, bought the Eagle Mine property for $17.5 million with the intention of developing it into a ski resort. Unable to finance this venture, Miller sold to Battle Mountain Corporation (BMC) 1,400 acres of the property including Rex Flats, the tailings ponds, 70 homes, a bowling alley, and several business offices.

In December 1983, the State of Colorado filed a lawsuit against Gulf+Western and New Jersey Zinc for contaminating the Eagle River. At this time, the State also initiated a preliminary risk assessment of the site. As the State and PRPs were unable to come to an out-of-court agreement, the complaint evolved into a court-ordered negotiation regarding who was responsible for the $80 million cleanup of the 7.5 million tons of tailings at the site.

In 1984, while the State of Colorado's lawsuit awaited settlement, the new owner of the site, Glenn Miller, lost his financial backing and lost the balance of the property due to nonpayment of taxes. These lands were sold at Eagle County tax sales.

Copper-silver ore mining continued sporadically until 1984 when all mining operations at the Eagle Mine halted. At that time the mine began to fill with water because of the many fissures and cracks inside the mine. The Colorado Department of Public Health and Environment (CDPHE) estimated that approximately 250 gallons of water per minute entered the mine. If the mine flooded, the water would come in contact with transformers in the mine which contained an estimated 3,000 pounds of the known-carcinogen polychlorinated biphenyls (PCBs), which could then potentially seep into local water supplies.

In June, the Public Service Company of Colorado informed the EPA that it was going to turn off the electric power supplied to the Eagle Mine because Mr. Miller was unable to pay the mounting electric bill, which was in excess of $90,000. This posed a problem because the mine was being pumped to prevent it from flooding and coming into contact with PCBs. The EPA intervened and agreed to pay approximately $1,000 a day to keep the power on, until they could perform an emergency removal of the PCB-laden transformers. Before the end of the month, the EPA drained PCBs from all three of the transformers. The transformers remained in the mine, however, to help prevent the mine from collapsing. The EPA also built dikes inside the mine to divert water from entering the Eagle River.

In October 1984, the EPA added Eagle Mine to the list of proposed NPL sites. However, action was delayed because Congress was unable to garner support for additional Superfund funding. The State proceeded by developing a cleanup proposal for the site.

In March 1985, Ray Merry, the Eagle Mine Environmental Health Officer, ordered the 14 families remaining in Gilman to leave the site because of potential human health hazards. By July, all families had left the area and Gilman became a ghost town. A gate prohibiting entrance to the town read "Town for Sale." In December, the Colorado Department of Health conducted a Remedial Investigation/Feasibility Study (RI/FS).

Warning sign at the entrance to Rex Flats & OTP.

The EPA placed Eagle Mine on the National Priority List on June 10, 1986. The EPA then formally designated the State of Colorado to act as lead agency for the cleanup of the site, but both agencies retained the right to take independent actions.

In 1986, the State of Colorado filed $50 million lawsuit against Paramount (owner of Gulf+Western and now Viacom). The lawsuit was resolved in 1988 and the parties entered into a Consent Decree and Remedial Action Plan (RAP). It was estimated that the cleanup would cost $150 million and take ten years to complete. The agreement drafted by Colorado State health officials set acceptable zinc standards and pH levels for the river and relevant soils and required:

1. Plugging the mine portals to stop the production of acid mine drainage;
2. Removal of the roaster piles and reprocessing of the tailings;
3. Collection and treatment of mine water and groundwater;
4. Revegetating the waste removal areas and the Consolidate Tailings Pile (CTP); and
5. Long-term monitoring of the site.

1989 - 1994

As the cleanup began, public concern about the possibility of adverse human health effects intensified. In March 1989, fearing that no assessment had been conducted, federal EPA officials conducted their own investigation of potential contamination at Minturn Middle School, located 400 yards from the mine. A *Vail Daily* article (July 18, 1989) reported on this investigation and indicated that "Richard 'Dick' Parachini [CDPHE Project Manager] told the governor that dust levels [from the cleanup] are 'right on the break point' of what is generally considered environmentally safe. Breathing the heavy metals present at the Minturn site, in high enough levels and over a period of years, is expected to greatly increase cancer risks." This news generated alarm among local residents because the school was located less than one mile (1.6 kilometers) from the 70-acre CTP, which was used for waste dumping until 1977. The EPA convened a well-attended public meeting regarding the issue. Approximately 1,000 irate citizens attended this meeting, which EPA officials characterized as a "lynch mob". At this meeting, the state agreed to amend its RAP to include the construction of a permanent waste water treatment plant that would reduce the level of zinc in the river and raise the pH level of the river. This plant would be operable by July 1, 1990. Additional plugs were installed in the mine to stop water from pouring directly out of the mine and into the river. Unfortunately, the volume of waste water needing treatment exceeded the capacity of the new plant, allowing contaminated water to seep into the river. Viacom was forced to begin construction on a second water treatment plant.

In the interim, the local school board hired a private environmental consultant, Leonard Slosky, to evaluate air quality and dust emanating from the roasting piles. Slosky installed 15 air monitoring stations in and around the school and enlisted the help of several school teachers as well. Every day for six weeks, select teachers wore small compact devices that resembled portable headphone stereos. At the end of each day, a field technician analyzed the filters for toxic residue. Slosky confirmed the presence of heavy metals in and around the school, but concluded that the amount of metals present fell far below hazardous levels. For example, arsenic found at the site presented the greatest potential health risk, but Slosky likened the children's chance of developing arsenic-related cancer to that of smoking eight cigarettes in a lifetime.

Although the EPA chose not to endorse the state's RAP because it was skeptical of the plan's long-term effectiveness, the State forged ahead with the cleanup of the Eagle River site fearing the worsening of public health and environmental damages that might result from continued acid mine drainage. However, the State's decision to pump tailings pond water back into the mine, using the mine as a holding tank, proved to be disastrous and caused even more pollution to infiltrate the Eagle River. A dry winter caused mine seepage to make up most of river water, and the river turned orange. As a result, fish populations declined dramatically. Samples taken from the river that fall revealed zinc levels were 255 times higher than fish tolerance thresholds. No fish lived in the river, and contamination was turning the Eagle River various colors.

Media headlines reinforced the environmental and health related fears of local residents: "Eagle 'cleanup' casts doubt on state" *Denver Post* April 20, 1990; "Eagle River fish population smaller than expected" *Denver Post* April 24, 1990; "Fish fading in river polluted by mine" *Rocky Mountain News* April 27, 1990; "Mine cleanup again called inadequate" *Denver Post* July 13, 1990; "Polluted water flows to Minturn wetlands" *Rocky Mountain News* July 13, 1990; and "More problems foul cleanup of zinc mine -- mine's toxic metals pollute Eagle River" *Rocky Mountain News* August 28, 1990. The cleanup was obviously failing, and local citizens felt state and federal agencies were shirking their responsibilities. In an article published in the *Rocky*

Mountain News on April 18, 1990, a letter from the Minturn town council to Governor Roy Romer stated, "Our river continues to run from murky green to sickly red... Above the mine the river is crystal clear. The town of Minturn believes that we are being held hostage to a bureaucratic nightmare. Minturn is a small town with very limited resources. We find ourselves unable to get any action from our state officials who are supposed to be acting on our behalf."

In April, Paramount's new facility began to treat polluted water State and PRPs amended RAP to add a chemical water treatment plant and install additional mine plugs. Colorado Department of Wildlife began monitoring the fish and macroinvertebrates populations in the Eagle River on an annual basis. At the start of this process, virtually no fish were found in the Eagle River.

In September, a newly formed Eagle County Oversight Committee citizens group, joined by Trout Unlimited, Eagle River White Water, Inc., and the Gore Creek Flyfisher, filed a $300 million class action suit against Paramount Communications, Inc. for water, air, and soil contamination originating from the Eagle Mine property. The organizations claimed that Eagle Mine seepage was contaminating the Eagle River as well as the Minturn Middle School. They added that faulty water treatment plans were causing as much as 40 gallons of contaminated water per minute to be dumped into Maloit Park wetlands. From Paramount, the plaintiffs sought damages for potential health risks, compensation of economic harm due to lower property values, funds for removal of the tailings, and "exemplary damages for wanton and reckless disregard" of residents' rights. Cindy Cacioppo, a member of the Committee, said "We decided a lawsuit was needed for people to recover damages because there's nothing in Superfund that allows citizens to recoup."

In 1991, the EPA became increasingly concerned about the site and notified the State of Colorado that Paramount was in violation of six different aspects of the Clean Water Act because of the mine seepage and discharge from the waste piles that had contaminated the river the previous year. The water treatment plant was replaced and the EPA conducted a risk assessment for PCBs.

Remediation efforts removed five piles of waste materials from the ore roasting plant near Belden. This waste was relocated to the CTP, and former waste piles were revegetated.

During this time period, Vail Associates started silently acquiring options to buy portions of Eagle Mine property.

In June 1992, the EPA decided to conduct a Feasibility Study Addendum, which found that the Eagle River ecosystem continued to suffer severely from heavy metal contamination. Part of the study included additional risk assessments that resulted in a more comprehensive investigation of the health of fish and other natural resources. Additional soil studies and risk assessments of ground water quality were conducted in Maloit Park, Minturn Middle School, and the town of Gilman. The Feasibility Study Addendum identified the following activities to supplement the State's RAP: collect additional seepage from the Rock Creek drainage; monitor former roaster pile areas and waste rock piles; continue operation of the Water Treatment Plant; collect additional groundwater from CTP and treat it at the Water Treatment Plant; and cleanup Maloit Park wetlands area. Risks to human health were also reviewed, but no appreciable threat to drinking water was found, and heavy metals in soil and dust were found to be well within acceptable standards.

Regardless of these findings, Viacom later moved Minturn's drinking wells upstream of their old location. Finally, the EPA concluded that the potential risk of PCB ingestion from the 15 pounds of PCBs remaining in the transformers was low. The EPA agreed to continue to monitor for potential PCB contamination, which has never been found. In June of 1992, the EPA proposed a second and preferred remedial plan for the site, which included an alternative cleanup for each of the individual areas contributing metals to the Eagle River. Cleanup activities focused on removing the 150,000 tons of tailings deposited at Rex Flats and the one million tons of tailings deposited at the Old Tailings Pile (OTP). All of these tailings were relocated to the consolidated tailing pile (CTP). After the removal of the tailings, revegetation efforts were undertaken. Restrictions were put into place to restrict the use of groundwater below the OLP. Efforts were made to control seepage, surface water drainage, and groundwater flow in Rock Creek Canyon. The seepage and drainage were collected for treatment.

In 1992, recognizing an opportunity for even more expansion, Vail Associates covertly funded Turkey Creek, LLC's payment of three years of back taxes on over half of the Eagle Mine site. Payment of these back taxes guaranteed Turkey Creek LLC and Vail Associates a first bid option on the Eagle Mine property.

In March, 1993, the EPA issued a Record of Decision (ROD) that required additional site investigations and remedial actions to be implemented. The ROD included modifications of the established remediation standard, proposed monitoring of additional metals, collection of additional groundwater seepage, monitoring runoff, accelerating the capping of the CTP, removal of the contaminated material from the Maloit Park wetlands, development of a monitoring plan, and implementation of an inspection and maintenance plan.

The 1993 risk assessment determined that soils in Maloit Park Wetlands contained elevated levels of arsenic, cadmium and lead. In June, the State amended the remedial plan for the third time. Viacom was to permanently remove pond water from the top of the CTP, implement a sludge dewatering system, and construct a sludge disposal cell.

In the summer of 1994, the EPA issued a unilateral administrative order that consisted of additional monitoring and testing of the site, which was amended again in 1995 to add a work plan for Maloit Park waste removal and restoration.

1995 – 1999

By 1995, more than 2.1 million tourists visit the Vail Valley annually.

In August, 1995, the State of Colorado, US EPA, and Viacom agree to a Three-Party Consent Decree and Statement of Work to implement the 1993 Record of Decision. The agreement called for sampling of water quality, along with assessments of the aquatic insect and fish populations in the Eagle River to determine the effectiveness of the cleanup actions. Additionally, the three parties agreed to investigate the adaptation of biological-based cleanup standard for the site.

In addition to the actions taken in 1992, more efforts were made to control seepage, surface water drainage and groundwater flow in Rock Creek Canyon.

At Rex Flats and OLP, more than 800 cubic yards of zinc concentrates were removed and moved to the consolidate tailing pile. To prevent ground water contamination, remediation efforts involve intercepting and diverting 100-200 gallons of clean water per minute from the Eagle Mine.

In 1996, the contaminated soils in Maloit Park Wetlands were removed. Clean soil was used to cover the previously contaminated area and revegetation efforts were undertaken.

On February 21, 1986, 32 cars of an 82-car train derailed on the Tennessee Pass heading towards Minturn. Two crew members on the train were killed and another was injured. According to the EPA, four tank cars ruptured, spilling approximately 54,000 gallons of sulfuric acid. Five to six acres of nearby trees and vegetation were blackened by the sulfuric acid that went over an embankment and across the two lane highway. Other contaminates spilled including Triethylene glycol (antifreeze) and small amounts of diesel fuel. However, the overall environmental damage appeared to be less than originally feared. Tests of the Eagle River revealed no significant levels pollution in the river or other water sources.

By 1997, the main tailing pile was capped. Residents reported increasingly better water quality in the Eagle River. In August, the EPA awarded "Environmental Achievement Awards" to both the Eagle River Environmental and Business Alliance and Viacom. The Eagle River Environmental Business Alliance was acknowledge for their efforts in the successful cleanup of the site by "keeping area residents informed, providing technical input, and discussing with people their concerns about a hazardous waste cleanup in their neighborhood." Viacom was lauded for their cleanup efforts that had "gone beyond legal requirements, furnishing the town of Minturn with a safe water supply, voluntarily cleaning up large amounts of hazardous materials, planning to intercept clean water flowing onto its site and keeping a skeptical public informed about the cleanup."

In 1998, the EPA issued a final ROD ensuring it would provide ongoing monitoring of the site. In 1999, state and federal authorities formally sought to change the cleanup agreement to include pumping of groundwater to keep it from filling the mine and complicating treatment of contaminated water from the mine.

Although they denied their intentions for years, Vail Associates revealed, under oath in March, its intention to buy and develop the Gilman property. By April, Vail was already 93% built out, so it turned its eyes on neighboring communities. While the remediation and bankruptcy proceedings for the Gilman property progressed, Vail filed suit against Minturn for its under-utilized water rights, which it would use for its controversial back bowl ski trail expansion. Much to the dismay of Minturn residents, Vail won the rights to 4.76 cubic feet per second of running water during the driest months from October to April. The value of these water rights is estimated to be $14 to $16 million. The enormity of the Vail resort, as well as the wielding of its political power, caused a tremendous amount of animosity between Vail Associates and the small nearby communities. In June, six environmental groups sued the US Forest Service over the expansion of Vail resort and its threat to wildlife.

With its option to purchase portions of the Eagle Mine property, as well as an easement from the Forest Service and entitlement to some of Minturn's water supply, Vail Associates began construction of its controversial 885-acre back bowl expansion in July 1999. The expansion opened in the 2000-2001 ski season and brought skiers within a mile (1.6 kilometers) of the Gilman property. Local residents feared that surroundings communities were destined for yet another Vail-controlled real estate expansion similar to that of Bachelor Gulch where ski-in, ski-out homes were sold for $750,000 each. According to local residents, such a surge in housing and rental rates would threaten the stability of the blue-collar families and communities already struggling to afford Vail Valley's ever-increasing cost of living.

However, in November, Vail Associates announced its plan to protect some of Eagle County's last remaining open space, the Eagle Mine property. Some in the Colorado environmental community viewed the announcement as public relations effort. According to Ted Zukoski of the Land and Water Fund, "We're going to be watching this very closely to make sure this isn't just a green-washing effort to make people feel warn and fuzzy about a big development. It's potentially a step in the right direction, but we're going to have to wait and see how far it goes."

2000 and Beyond

According to the first 5-Year Review completed in October, 2002, the cleanup of the Eagle Mine site, both the federal and the state portions, were essentially complete. The review concluded that public health risks had been removed and restoration of the Eagle River had progressed significantly. Eight million tons of waste rock, tailings, and roaster debris were moved to the Consolidated Tailings Pile, and the CTP was capped and revegetated. The tailings from Rex Flats and the Old Tailings Pile adjacent to Rex Flats had been removed, and the area was revegetated. The roaster piles that were directly across the canyon from Gilman had been moved to the CTP. Maloit Park wetland had been cleaned and a barbwire fence was constructed around it.

Rock Creek no longer flowed directly into the Eagle River; its water continues to be treated at the water treatment plant before being released. Also, approximately 250 gallons per minute (gpm) of water from the mine is being treated before being released into the river. In total, the water treatment plant treats about 360,000 gpm every day. In October, 2001, *The Denver Post* reported that as a result of the 14-year effort and a cost of $70 million that the Eagle River once again ran clean enough for a healthy fish population. Groundwater remediation efforts would continue in order to cleanup an estimated 700 million gallons of contaminated groundwater in the 70 miles (113 kilometers) of tunnels within the mine. The annual cost will be approximately $750,000.

The only indication of past contamination is permanent oxidized manganese and iron stains, which give the rocks along the river's edge a rusty brown "bathtub ring". The results of the annual biological assessment of the Eagle Mine site show dramatic improvements in the Eagle River aquatic community such as higher numbers of fish and macroinvertebrates.

Chapter 7

Expert Error and the Psychology of Risk and Stigma

7.1 Expert Error

Gayer, Hamilton and Viscusi (2000) argue that residents living near Superfund sites judge risks to be of a magnitude consistent with EPA expert opinions and that these judgments are reflected in property values. The research presented here suggests quite the opposite. However, the sites studied here are much larger and likely to attract more attention. This section documents many cases of expert error to help explain why expert opinion plays a limited role in explaining residents' risk beliefs. Thus, the judgments of experts are only one component of the mix of news media stories and perceptual cues received by the typical citizen. Even if statements by scientific experts were accepted as credible, they would compete with a mix of the other signals and perceptual cues. As simply one component, such statements are unlikely to be the primary determinant of individual risk beliefs. Thus, risk beliefs determined largely by media stories and other perceptual cues are unlikely to be easily changed by the pronouncements of a few scientists (Fischhoff, 1989).

Furthermore, it is unlikely that statements by scientific experts will be accepted as completely credible. Even when different experts are in essential agreement, the news media often focuses on those aspects where experts disagree (Wilkins and Patterson, 1990), thus lowering the perceived credibility of experts. In a study examining news coverage of Three Mile Island and Chernobyl, Rubin (1987) found that news stories tended to dichotomize events rather than blend a continuum of information to recipients. The result is that the public discredits information it receives from experts because it appears that experts cannot agree among themselves and, therefore, do not really know the risk that a site presents.

Despite the ideal that science discovers absolute truths, for every health or environment related article there appears to be a corresponding article that rejects the tenets of the previously publicized claim. Numerous famous examples exist, which are described in detail below, where experts from academia, government, and industry have made errors and misestimates:

- Soil contamination at Love Canal, Niagara, New York

- Dioxin contamination in Times Beach, Missouri
- The defective Dalkon Shield for birth control
- The false discovery of Cold Fusion
- The failures at Biosphere 2
- The near nuclear meltdown at Three Mile Island
- The Union Carbide Accident in Bhopal, India

These examples are not just relegated to the past, as the costly search for weapons of mass destruction in Iraq, to date, has yet to support early claims by intelligence experts. Each of the short descriptions below serves to illustrate the characteristics and media attention that such failures attract.

7.1.1 Love Canal, Niagara, New York

Love Canal is permanently etched in the collective conscious of America, and these words were synonymous with hazardous waste contamination, cancer, and distrust of authorities. Love Canal brought about a new understanding of the potential health effects of hazardous waste as well as Superfund legislation designed to deal with chemical disposal sites.

Located in Niagara Falls, New York, Love Canal is named for William Love who began digging a canal in 1896 for a proposed hydroelectric power plant. Love abandoned the project when he declared bankruptcy, and in 1920 the city of Niagara Falls purchased the site for use as a landfill. In 1942 Hooker Chemicals and Plastics Corporation (now Occidental Chemical Corporation) purchased the landfill for their own disposal purposes. From 1942 to 1953, Hooker dumped into Love Canal 21,800 tons of toxic waste including more than 400 different chemicals, 11 known carcinogens, PCBs, dioxins, pesticides such as DDT and lindane (both of which have been banned in the United States), heavy metals, and multiple solvents. Three years after Hooker's dumping began, an internal memo from an engineer foreshadowed the disaster to come, "[Love Canal is a] quagmire which will be a potential source of lawsuits."

Once the site reached capacity, Hooker covered the 16-acre toxic waste site with a 40-acre clay seal to prevent chemical seepage. (A 1981 EPA report confirmed that Hooker's waste disposal techniques required only minor adjustments to come into compliance with the hazardous waste disposal standards in place at the time.) Under threats of acquisition by eminent domain and extreme pressure from the city school board, Hooker reluctantly sold the site to the New York State Department of Education for $1.00, on the condition that Hooker would be indemnified from any future liability concerning the site. Because of the potential dangers associated with the site, Hooker insisted that deed restrictions accompany the property transfer and repeatedly warned the school board of potential health hazards at the site. Hooker also stressed that under no circumstances should the land be excavated or the clay cap be jeopardized. Despite these warnings, the city constructed a school on site and sold the remaining parcels of land to real estate developers. The community of Love Canal was born

Love Canal residents first began complaining of chemical odors and residues in the 1960s. By 1976 chemical seepage had infiltrated neighborhood creeks, sewer lines, sump pumps, and soil – even the air inside several Love Canal homes. That year, the New York Department of Environmental Conservation initiated the first environmental testing of Love Canal which found contaminated groundwater, soil, and air. Once the results of that research were released, local and national media responded quickly: "Vapors from Love Canal Pose Serious Threats" (*Courier Express Niagara*, May 15, 1978), "Toxic Exposure at Love Canal Called Chronic" (*Courier Express Niagara*, May 25, 1978), "Wider Range of Illnesses Expected" (*Courier Express Niagara*, August 4, 1978), "Upstate Waste Site May Endanger Lives" (*New York Times*, August 2, 1978), and "The Devil's Brew in Love Canal" (*Fortune*, November 19, 1979). Heightened alarm among community members and media attention prompted the New York State Department of Health to test Love Canal homes close to the disposal site for environmental contamination. Two years later, the State Department of Health declared a state of emergency, ordered the school to be closed, and recommended an evacuation of the 239 homes that tested positive for environmental contamination. This news spread rampantly throughout the community causing a widespread panic and loss of property values of homes adjacent to and outside the immediate canal area. Fearing for their health, the lives of their children, and their futures, the remaining 660 families pressured both New York State Governor Hugh Carey and President Jimmy Carter to expand the evacuation area.

One year later, in February 1979, Dr. Beverly Paigen, a biologist with Roswell Park Memorial Institute in Buffalo, conducted a study which revealed that between 1974 and 1978:

56% of the children born at Love Canal had birth defects; miscarriages had increased 300%; urinary tract disorders had increased 300%; and the frequency of asthma, epilepsy, suicide, and hyperactivty had increased. Dr. Paigen also claimed to have evidence that these conditions subsided once residents moved away from Love Canal. These findings fueled the Love Canal panic, even though Dr. Paigen's research was not a scientific controlled study but, instead, based on anecdotal evidence from personal interviews with Love Canal residents. Dr. Paigen's research was thoroughly discredited at that time by the NY Department of Health. A governor's panel charged with reviewing her work found that, "[Dr. Paigen's research] falls short of the mark as an exercise of epidemiology. She [Dr. Paigen] believes fervently that her observations prove the existence of multiple disease states directly attributable to chemical pollution, but her data cannot be taken as scientific evidence for her conclusions. The study is based largely on anecdotal information provided by questionnaires submitted to a narrowly selected group of residents. There are no adequate control groups, the illnesses cited as caused by chemical pollution were not medically validated.... This panel finds the Paigen report literally impossible to interpret. It cannot be taken seriously as a piece of sound epidemiological research...."

However, two studies conducted in 1980 by the EPA initially seemed to confirm portions of Dr. Paigen's research and found chromosomal irregularities and nerve damage among Love Canal residents. Upon release of these findings, chaos broke loose at Love Canal and two EPA officials were involuntarily detained. That evening, Lois Gibbs, a member of the Love Canal Homeowners Association, phoned the White House to inform them of their hostages. Pressured by the unfavorable findings of the research and extreme political pressure from local residents, the President issued orders on May 20, 1980, to permanently relocate all families that wished to leave. In total, approximately 950 families (2,500 residents) evacuated the area, leaving the government with $3-5 million in relocation costs. These relocations eventually became permanent costing the government over $30 million.

The integrity of the two 1980 EPA reports as well as the validity of their findings have since been questioned by the Center for Disease Control (*Morbidity and Mortality Weekly*, May 1983), American Medical Association (March 1984), National Research Council, and New York State Department of Health on the basis of the lack of control group (adjusted for by comparing Love Canal results with a control group from a previous unpublished experiment), incorrect statistical analysis, small sample sizes, inadequate experimental methodology, report release prior to peer review, and drawing conclusions that in some cases were not supported by the evidence. For example, the chromosome study actually found a lower rate of chromosomal damage among Love Canal residents than the control group. According to a 1981 *New York Times* article, "it may well turn out that the public has suffered less from the chemicals [at Love Canal] than from the hysteria generated by flimsy research irresponsibly handled."

Research conducted in 1982 by EPA found no unusually high levels of contamination outside the area immediately surrounding the canal, confirming the results of several previously conducted reports. This EPA report was considered to be highly controversial and was eventually dismissed. (However, another EPA study conducted in 1987 confirmed the results of the 1982 study.)

Despite the lack of evidence to support such an action, Love Canal was declared a national Superfund priority on September 1, 1983. Federal and state remediation activities were expensive and highly intrusive. Fences were erected around the site and bulldozers demolished the abandoned homes and school within. Leachate treatment plants, high temperature incineration, excavation and off-site disposal of contaminants and hydraulic cleaning of sewers and culverts removed wastes and hazardous toxins from the site. Although twenty thousand tons of waste currently remains at the site, the area was declared "habitable" in September 1988. Initial redevelopment of the site was difficult because local banks were hesitant to grant home mortgages for fear of being held liable for environmental contamination. Although the value of the homes was approximately 20% lower than comparable markets, 239 of the 240 homes in the Love Canal neighborhood, now called Black Creek Village, have been successfully rehabilitated and sold. Approximately 30% of the purchasers are original Love Canal residents.

In 1991, the Committee on Environmental Epidemiology of the National Research Council thoroughly reviewed all Love Canal research and reports and concluded that there was no definitive link between the health conditions of Love Canal residents and the chemical seepage from the canal, with the possible exception of decreased birth weights and heights. Legal settlements are starting to be resolved as well. In 1998, 2,300 Love Canal families received between payments ranging from $83 to $400,000 from Occidental Chemical Corporation.

Two quotes will serve to summarize public reaction to the site that eventually led to the Superfund program:

"Love Canal doesn't end with this generation's cancer or even with the next generation's birth defects. For many residents, the damage is permanent in their genes and their children's. The mutated genes will affect all of their descendents, one generation after another."
Lois Gibbs, (executive director of the Center for Health, Environment and Justice and former Love Canal resident) *Who's Poisoning America*, p. 270.

"It is not enough for industry and government to act in good faith – their mistakes are counted in human lives."
Glamour, November 1980

7.1.2 Times Beach, Missouri

All that remains of Times Beach, Missouri, a small community once located 17 miles west of St. Louis, is a legacy of an environmental disaster. In 1972 and 1973, the city of Times Beach hired Russell Bliss to manage air-borne dust from its unpaved roads. During that time, Northeastern Pharmaceutical and Chemical Corporation also hired Bliss to dispose of their wastes, including dioxin yielded from the production of a then popular skin cleanser called hexachlorophene. In an attempt to complete both tasks efficiently, Bliss mixed Northeastern Pharmaceutical and Chemical Corporation's wastes with oil and sprayed the mixture on Times Beach roads. Days later animals started dying, and months later children got sick. After Bliss sprayed Shenandoah Stables' roads, several horses died and the proprietor's daughter became very ill. In November 1982, the EPA found Bliss' oil mixture to be contaminated with dioxin, a known human carcinogen. Dioxin is an unintentional hazardous byproduct of many common industrial processes such as the bleaching of paper and wood pulp; production of herbicides and wood preservatives; and incomplete combustion of wood and industrial and municipal wastes. One month later, the nearby Meramee River flooded. As the water receded, experts predicted that it would redistribute dioxin throughout the city. Consequently, not only would Times Beach roads be contaminated, but the entire Times Beach community might also be laden with dioxin contamination.

During this time, several studies emerged supporting the highly carcinogenic nature and potential dangers associated with dioxin. Based on this research, in 1982, the Centers for Disease Control and other experts recommended completely evacuating Times Beach. On March 4, 1983, Times Beach was proposed for Superfund's NPL. The town was officially closed in April 1985 and six months later, on September 8, 1983, Times Beach was placed on the final NPL. By the end of 1986, the federal government had spent $33 million to permanently relocate all 2,240 Times Beach residents. The title to the town was conveyed to the State of Missouri, and any remaining parcels of land were purchased by the Federal Emergency Management Agency (FEMA). As part of the remediation of the site, almost all buildings in the city were demolished and the entire area was enclosed by a chain-link fence.

Doubtful of the severity of the adverse health impacts associated with dioxin (such as cancer and infertility), as well as the proposed pathways of human exposure, many scientists and experts characterized the Times Beach relocation as an over reaction. An article in the *Wall Street Journal* written the week of the evacuation supported this sentiment, "There are two dangers with toxic wastes. One is the very real threat to health posed by the chemicals themselves. The second is that a hysterical exaggeration of that threat will needlessly frighten people and drive them from their homes." Considering the best available research at that time, the Times Beach evacuation was indeed an over-reaction because it was based primarily on the analysis of soil samples, rather than the potential human health risks and exposure pathways of dioxin.

In 1991, several scientific experts, including Dr. Vernon Houk of the Centers for Disease Control, reversed their initial conclusions about the toxicity of dioxin and their recommendations to evacuate Times Beach. This reversal was based on new research, which wholly contradicted previous conclusions about dioxin. The new research found dioxin to be less harmful to human health than originally suspected, making the Times Beach evacuation seem that overly drastic and unwarranted. As Houk stated, "Times Beach was an over-reaction. It was based on the best available scientific information we had at the time. It turns out that we were in error.... The only thing I would have done differently, I would have said we may be wrong. If we're going to be wrong, we'll be in the wrong side of protecting human health. I don't think we ever said we may be wrong."

Upon learning of the new research, industry representatives complained vociferously about the over-regulation of dioxin and the exorbitant costs associated with its stringent regulation. Prompted by these complaints and under the direction of William Reilly, the EPA Administrator under President Bush, Sr., the EPA undertook an extensive series of highly technical experiments on the toxicity of dioxin. Three years later, to the surprise and dismay of industry representatives, these experiments reaffirmed the link between dioxin and cancer even at very low levels of exposure. These experiments also revealed that dioxin bioaccumulates in living tissue and can cause stunted fetal development, suppression of the immune system, interference with regulatory hormones, and increased likelihood of developing endometriosis and diabetes. However, like the second round of dioxin research, this research also revealed that the major pathway of dioxin exposure is not environmental but through the ingestion of dairy foods which contain small amounts of the compound.

Armed with this new knowledge, the EPA devised a plan for the remediation of Times Beach contamination that included the construction of an on-site thermal destruction plant. Incineration of the dioxin-contaminated soil began in March 1996. Community action groups, such as the Times Beach Action Group and Dioxin Incinerator Response Group, strongly opposed this incinerator fearing that burning the dioxin might spread contamination rather than reduce it. Research studies conducted on a Jacksonville, Arkansas incinerator -- similar to the one constructed at Times Beach -- confirmed these fears: blood levels of dioxin among residents living near the Arkansas incinerator were 22 times higher than before incineration began. The Arkansas studies further concluded that these elevated levels of dioxin caused increased incidences of diabetes among residents living near the incineration plant. In 1993, Missouri state officials confirmed that the Times Beach incinerator was also producing more dioxin than it was destroying, and the EPA disbanded the plant in 1997. Remediation of the site cost $200 million and was completed in 1997 with the closing of the incineration plant. The property, now a 40-acre state park was named Route 66.

Although more than two decades have passed since the Times Beach evacuation, many former residents still speculate about the true effects of dioxin on their families and friends. One Times Beach resident recalls several now-dead community members that suffered from cancer, immune deficiencies, miscarriages, and suicides. She laments, "I'm so tired of death. There's not a day [that] goes by that I don't wonder if all this is coincidence – or dioxin."

7.1.3 The Defective Dalkon Shield

In the 1960s, many women became concerned about the possible adverse health effects, such as cancer and strokes, associated with oral contraceptives and began seeking alternatives. In response, several pharmaceutical companies invested heavily in the development of intrauterine devices (IUDs) as a potentially substitute for birth control pills. A.H. Robins (Robins) decided to enter the IUD market in 1970 by acquiring Dalkon Corporation, a manufacturer of the Dalkon Shield. Robins had no experience in the development of contraceptive devices and was best known for its non-prescriptive remedies such as flea and tick collars and cough medicine. Because Robins had neither obstetricians nor gynecologists on its staff (nor an appropriate department at that time), it assigned the production and assembly of its IUD, the Dalkon Shield (Shield), to its Chap Stick division.

Other than one research study conducted by Dr. Hugh Davis, a co-inventor of the Shield, Robins had conducted no testing of the Shield in women or animals when it entered the market in 1971. Yet A.H. Robins positioned the Dalkon Shield as the "Cadillac of contraceptives" and "the truly superior modern contraceptive". Dr. Davis' research boasted, among other things, that the Shield was five times safer than other IUDs. After its release in January 1971, the popularity of the Shield blossomed as a total of 4.5 million Dalkon Shields were sold to women worldwide by 1975. However, as early as the summer of 1972, Robins began receiving reports of the Shield's ineffectiveness in preventing pregnancy as well an increased incidence of pelvic infection among its users. In 1974, Robins was ordered to stop producing the Dalkon Shield and required to recall the product. By the time most Dalkon Shields had been removed, reports documented a total of 15 premature Shield-related deaths and an estimated 90,000 Shield-related injuries including sterility, pelvic inflammatory disease (PID), septic abortions, hemorrhaging, perforated uteri, and birth defects in children.

Even though the shortcomings of the Dalkon Shield were well known to A.H. Robins, the company continued to produce and distribute its product. Evidence contrary to the purported comfort, effectiveness, and safety of the Shield was suppressed. For example, research conducted by Dr. Davis claimed the Shield's failure rate in preventing pregnancy was 1.1%. Davis did not reveal, however, that participants in his study used a backup method of birth control for three months after the Shield was inserted. An independent researcher later found the Shield's failure rate to be 3-5%, making it inferior to other IUDs and the pill in preventing pregnancy. Robins was also forewarned in several memos and conversations of the Shield's tendency to cause infection. R.W. Nickless, management coordinator for pharmaceutical products, wrote a memo to 39 officials at Robins on June 29, 1970, detailing the Shield's propensity for wicking and infection. A July 28, 1971 memo written by Wayne Crowder, a quality control supervisor in Robins' Chap Stick Department, reinforced these findings as well as the need to address the issue immediately. Crowder's memo was ignored and his position later eliminated. Evidence presented by Crowder was confirmed several months later by Irwin Lerner, the inventor of the Dalkon Shield, in an October 11, 1971, conversation with Kenneth Moore, Shield project coordinator. In 1972, Dr. Thad Earl, an investor in Dalkon Corporation prior to its acquisition by Robins, also sent Robins a memo in 1972 warning that women who became pregnant while using the Shield needed to have it removed immediately to prevent infection. However, Robins warned neither physicians nor Shield users of the dangers associated with the Shield for another three years, despite being alerted to the potentially dire consequences of its use.

The Centers for Disease Control (CDC) substantiated the results and warnings contained in previous memos, correspondence, and conversations. Its study conducted from 1976 to 1978 found that, depending on the length of use, the risk of developing PID among Shield users was five to ten times higher than for non-Shield IUD users. Two studies conducted in 1985 in Boston and Seattle yielded similar results.

Researchers found the defective component of the Shield to be the unique design of the string, or "tail", which facilitates the removal of IUDs. Previously, a single piece of nylon formed the tails of IUDs. But the tail of the Shield was comprised of many strands of nylon encased in a nylon sheath to prevent the spread of bacteria. But the nylon sheath was left open at both ends of the Shield, allowing bacteria to spread up, or "wick" into, the tail into the uterus.

Although Robins had been warned of this wicking tendency numerous times, it was reluctant to withdraw the Shield from the market because it generated profit margins of 40% in the United States and 70% internationally.

In 1974, Dr. Howard Tatum, an independent researcher, testified before Congress about the relationship between Dalkon Shields and PID. Based on this testimony, FDA officials pressured Robins into halting production of the product. Robins stopped distributing the Shield in the United States in June 1974, but continued to market the Shield abroad for another 10 months. Finally, in April 1975, Robins stopped international distribution of the Shield. By the time distribution of the Shield ceased, it had been used by 2.8 million American women and another 1.7 million women worldwide. Fearing legal repercussions, however, Robins refused to recall Shields already in use for several more years. In 1983, when FDA officials suspected that most Shields had already been removed, Robins publicly recalled the Shield and offered to pay for the removal of any still in use. Over 4,000 women accepted this offer within the first two months of the announcement.

By 1984, more than 10,000 claims for Shield-related injuries had been filed against Robins. According to U.S. District Court Judge Miles Lord, who presided over 21 Shield court cases, "The only conceivable reasons you [Robins] have not recalled this product are that it would hurt your balance sheet and alert women who have already been harmed that you may be liable for their injuries. You [E. Claiborne Robins Jr. (President and CEO), William Forest (General Counsel), and Dr. Carl Lunsford (Director of Research)] have taken the bottom line as your guiding beacon and the low road as your route." Robins' former general attorney, Roger Tuttle, echoed this sentiment, "Robins entered a therapeutic area with no prior experience, no trained personnel, and reliance on statistics from an admittedly biased source. Although the device was based on sound scientific principles, Robins over-promoted it without sufficient clinical testing in an effort to ride the crest of a marketing wave for financial gain."

Largely as a result of litigation over the Dalkon Shield, A.H. Robins filed for Chapter 11 bankruptcy in 1985 and established a multi-million dollar trust for unresolved complaints three years later. Prior to the court trial regarding Robins' negligence, 12 boxes of correspondence attributing PID in Dalkon Shield users to the wicking effects of the Shield's tail disappeared, and Aetna Life Insurance canceled its contract with Robins.

In 1989, American Home Products purchased A.H. Robins. As of July 1992, 115,000 of the 137,000 claims that have been finalized have received a settlement of $1,000 or less from the trust. Since the problems with Dalkon Shield, product labeling and package inserts for all IUDs include extensive and comprehensive information regarding user profiles and potential side-effects.

7.1.4 The Discovery of Cold Fusion

Imagine a world of equitable nations where resource-poor countries no longer struggle to survive on dwindling natural resources; where industrialized countries are not tethered to the vast oil riches of the Middle East; where energy consumption does not necessarily mean environmental degradation. This is the world promised by cold fusion, the remarkable discovery of two highly respected University of Utah chemists.

Prior to this discovery, scientists, physicists, and chemists around the world had deemed cold fusion impossible because the fusion of two atoms required extreme heat temperatures and expensive heavy metals such as uranium. In March 1989, Stanley Pons and Martin Fleischmann held a press conference claiming to have had detected bursts of excess heat and the appearance of neutrons that exceeded background levels in their cold fusion experiments. This unprecedented discovery astounded the world and promised the world great amounts of energy generated simply and inexpensively. Cold fusion meant an abundance of energy and the end of all potential future energy crises.

The day of their announcement, Pons and Fleischmann intimated that their results could be easily replicated and scaled up for a nuclear reactor, despite the fact that their experiments substantiated neither claim. A worldwide flurry of media articles, accusations, press conferences, confirmations, and objections ensued as governmental agencies, scientists, and industrial representatives raced to replicate the results of Pons's and Fleischmann' experiments.

Many experts remained skeptical of cold fusion, because of the inability to replicate their results. The few experts who claimed to successfully repeat Pons's and Fleischmann's experiments later retracted their results. As was later determined, neuron detectors, used by Pons and Fleischmann, are very inaccurate and often detect "neutrons" that are actually small variances in temperature, humidity, or electric power surges. In the end, Pons's and

Fleischmann's results were rejected because they not only lied about the amount of energy produced in their experiments, but they also failed to conduct control experiments to establish accurate baseline data.

Despite the credibility of the scientists who announced cold fusion, the integrity of the institutions that supported them, and the scientific fervor that surrounded the incidence, cold fusion's skeptics prevailed, and Pons's and Fleischmann's experiments are now largely recognized as a scientific hoax. According to one CalTech researcher, "[Cold fusion] has been cast out by the scientific establishment. Between cold fusion and respectable science there is [now] virtually no communication at all."

7.1.5 The Failure of Biosphere 2

On September 26, 1991, eight "biospherians" entered the world's first self-contained, human-constructed, completely independent ecosystem. A massive media blitz highlighted the lofty goals of this experiment, to test the ability of humans to construct and survive independently in a self-contained environment that would provide everything necessary to sustain life. The construction of Biosphere 2 took six years and cost $200 million. It contained five distinct ecosystems (rain forest, ocean and coral reef, fog desert, marsh, and grasslands) and 3,800 different species of animals. Scientists and engineers designed the structure to replicate as closely as possible the metabolic and biologic functions of the first biosphere, earth. Once they entered, the biospherians would remain inside the three-acre Biosphere 2 for two years, growing and harvesting their own food, managing their own wastewater systems, monitoring ecological systems, etc. According to the project goals, any contact whatsoever with the outside world, be it importing food or allowing air to escape into the Earth's atmosphere, would completely destroy the experiment. Only in the event of a medical emergency would the biospherians be allowed to leave Biosphere 2.

Discover heralded Biosphere 2 as "the most exciting scientific project to be undertaken in the United States since President Kennedy launched us toward the moon." The *New York Times* and the *Boston Globe* followed *Discover*'s enthusiastic lead. As they reported, hummingbirds pollinated the flowers within; a colony of termites aided the decomposition of vegetation; and bugs such as ladybugs, lacewings, and spiders minimized insect damage to Biosphere 2 crops.

No outside energy entered the structure. Energy was, instead, provided by an internal solar power plant. Sensors placed throughout the structure provided 24-hour monitoring of the balance within Biosphere 2, including the mixture of gasses in the air, emotional and mental stress of the biospherians, and aerobic rate of microbes in the soil. Lastly, Biosphere 2 was completely sealed off to prevent any atmospheric exchange between the earth and Biosphere 2.

The purposes of the experiment, as portrayed by the media, varied from developing the new science of "biospherics" to "develop[ing] the technology necessary to colonize other planets with biosphere structures" (*New Republic*). The public later learned that indeed Space Biosphere Ventures (SBV), the owner of Biosphere 2, intended to develop and sell this type of technology to NASA and the European Space Agency. SBV also had other intentions, to develop an extensive 2,500-acre theme park adjacent to Biosphere 2. As the knowledge of these plans became more common, it strained the credibility of the program among the public as well as many scientists nationwide.

Within weeks of the biospherians' entrance, problems arose inside Biosphere 2. One biospherian, Jane Poynter, cut off the tip of her finger while using the thresher. She left Biosphere 2 to seek medical attention and returned two days later with a duffel bag purportedly containing fresh food and new sealant to patch Biosphere 2's air leaks. SBV denied these rumors for three months until they admitted that Poynter had indeed returned with a duffel bag containing items such as plastic bags, film, and computer parts. Two months later, Marc Cooper of the *Village Voice* confirmed and reported that SBV had installed a carbon dioxide scrubber in Biosphere 2 just before its closure. Later that month, SBV secretly injected Biopshere 2 with 600,000 cubic feet of outside air to relieve its falling atmospheric pressure. Upon learning of this injection, Biospherians Linda Leigh and Roy Walford threatened to leave Biopshere 2 unless a public announcement of the injection was made.

These incidents led SBV to hire a panel of scientists to review how Biosphere 2 science was being conducted. During this time, the amount of oxygen inside the structure was dropping from a normal 21% to 14%, approximately the amount of oxygen found at an altitude of 17,500 feet. SBV had no choice but to breach the structure's seal once again and inject oxygen-enriched air into the Biosphere 2. Despite the recommendations of the science review panel, business remained as usual at Biosphere 2 and by the end of April 1993, all of the science panel review members had resigned. As the chair of the science review panel, Thomas Lovejoy of the Smithsonian Institution indicated, "The Biospherians will soldier on, but their two-year experiment in self-sufficiency is starting to look less like science and more like a $150 million stunt." Two years after their entrance, the biospherians emerged from Biosphere 2 as planned, but were greeted with much less public and media enthusiasm. Fifteen to thirty percent of Biosphere 2 species had gone "locally extinct" while other populations exploded. Fruit trees had produced little to no fruit, and all seven species of frogs disappeared. Despite these problems and repeatedly breaking Biosphere 2's atmospheric seal, SBV proclaimed Biosphere 2 a success.

Biosphere 2's reputation and credibility never recovered from the deliberate public deceptions of its management and the media ridicule that followed. After remaining dormant for two years, Columbia University's Lamont-Doherty Earth Observatory took over Biosphere 2 and is currently using it as a hands-on research and educational center.

7.1.6 The Three Mile Island Accident

Although it led to no immediate deaths to plant workers or citizens of nearby communities, the accident at Three Mile Island on March 28, 1979, was the most serious nuclear power plant accident in the history of the United States. Unbeknownst to the 140,000 residents of Harrisburg, Pennsylvania ten miles away, a combination of human and system errors caused the nuclear core of the Three Mile Island nuclear power plant to dangerously overheat and melt.

At about 4:00 a.m., primary water pumps at the plant shut down allowing the cooling waters circulating through the core of the plant to escape. The emergency backup water coolers failed because their flow valves had not been reopened after routine testing two days prior. Pressure immediately began to build in the main nuclear portion of the plant. A safety pressure release valve opened to relieve the pressure, but later failed to close causing the pressure of the system to fall below normal. This combination of decreasing pressure and delayed water cooling produced erroneous readings in the control room. In response to these faulty readings, plant operators shut off the cooling waters, and the temperature within the reactor core climbed above 4,300 degrees Fahrenheit, 900 degrees below the complete meltdown threshold. This extreme heat caused fuel to melt through the concrete containment floor of the reactor, and as a result, radiation leaked into other areas inside the plant as well as into the outside environment. There was great uncertainty about how to properly contain and minimize the exposure to radiation. However, predicting the next reaction of the core under such stress became a much greater concern. One possibility was that pressure within the core would continue to increase, causing an explosion of radioactive gas and debris. According to Walter Cronkite on CBS Evening News, "The world has never known a day quite like today. It faced the considerable uncertainties and dangers of the worst nuclear power plant accident of the atomic age. And the horror tonight is that it could get much worse."

With these impacts and uncertainties in mind, all non-essential staff were evacuated by 11:00 a.m. that day. Over the next two days, efforts to halt toxic releases to the environment failed. Two days later on March 30, Pennsylvania Governor Thornburgh called for the evacuation of all preschool children and pregnant women within a five-mile radius of the plant and ordered everyone within a ten-mile radius of the plant to remain indoors with their windows closed. Unlike the April 1986 accident at Chernobyl, the nuclear power plant at Three Mile Island was fortunately encased in a protective dome that prevented the leakage of large amounts of radiation. Estimates of immediate exposure to radiation ranged from one millirem of radiation to 100 millirems of radiation per person. (A standard x-ray exposes an individual to approximately six millirems.) Phone calls to the Governor's Three Mile Island hot-line reported dramatic effects related to radiation exposure, including stillborn and deformed pets and livestock, unexplainable livestock deaths, radiation poisoning, and mutated vegetation. Two dentists eight miles northwest of Three Mile Island also found that all dental x-rays of their patients' teeth taken within two days of the Three Mile Island accident were fogged or banded. After the Three Mile Island accident, residents also found dandelion and maple tree mutations comparable to what was later found in Germany after the Chernobyl accident.

The health affects of the Three Mile Island accident were greatly disputed. After the accident, several hundred people in the area reported hair loss, eye irritations, skin rashes, headaches, menstrual irregularities, blistered noses and lips, nausea, vomiting, and a number of livestock and pet deaths. However, initial studies of the area conducted by the U.S. Nuclear Regulatory Commission (NRC); U.S. EPA; U.S. Department of Health, Education and Welfare (now Health and Human Services); National Cancer Institute; Pennsylvania Department of Energy; and State of Pennsylvania revealed the presence of "very little off-site releases of radioactivity." These reports further stated that "comprehensive investigations and assessments by several well-respected organizations [conclude] that in spite of serious damage to the reactor, most of the radiation was contained and that the actual release had negligible effects on the physical health of individuals and the environment". In fact, according to one report, "residents within 20 miles downwind of the plant had fewer cancer deaths than expected during the five-year period." The report of the President's Commission on the accident at Three Mile Island found the only adverse health effect of the Three Mile Island accident to be psychological. A 1990 study conducted by the Division of Epidemiology at Columbia University confirmed that there were no significant adverse health impacts resulting from the Three Mile Island accident.

Finally, Dr. Steve Wing, associate professor of epidemiology at the University of North Carolina, School of Public Health, led a ten-year study (1975-1985) of residents within ten miles of Three Mile Island. His study found two to ten times more lung cancer and leukemia among residents downwind of the plant than among those upwind. Dr. Wing also reanalyzed data from the 1990 Columbia University study that concluded no significant increase in cancer due to the Three Mile Island accident. According to Dr. Wing's analysis of the data and adjustment for pre-accident cases of cancer, the 1990 Columbia University study *does* reveal "a striking increase in cancers downwind from Three Mile Island." Dr. Wing further stated, "The cancer findings, along with studies of animal, plant, and chromosomal damage in the Three Mile Island area residents, all point to much higher radiation levels than were previously reported. If you say that there was not high radiation, then you are left with higher cancer rates downwind of the plume than are otherwise unexplainable."

The cleanup of the nuclear power plant took nearly twelve years and cost approximately $973 million. As a result of the incident at Three Mile Island, the U.S. Nuclear Regulatory Commission significantly tightened its regulatory standards and oversight of nuclear power plants. Yet, the public still perceives that nuclear power poses a significant threat to public safety. This distrust of nuclear power and scientific estimates is not unwarranted. According to the Reactor Safety Study conducted in 1975 by Professor Norman Rasmussen of the Massachusetts Institute of Technology with the financial support of the NRC, the probability of any nuclear power plant accident happening was .000001 accidents per 1,000 reactor years.[5] However, five years after the Three Mile Island accident, another NRC-sponsored study increased this likelihood of a nuclear power plant accident to 1.7 to 4.5 accidents per 1,000 reactor years.

No new nuclear reactors have been built since the accident at Three Mile Island. Recently, however, as of 2004, two groups of companies have formed with the intentions of applying for licenses to build new nuclear power plants. Though neither group actually has plans yet to build the power plant, they intend to work with the U.S. Department of Energy to obtain a license for an advanced nuclear power reactor.

7.1.7 Union Carbide Accident in Bhopal, India

At approximately 1:00 a.m. on December 3, 1984, hundreds of residents of Bhopal, India, sought medical attention for persistent coughing, extreme difficulty breathing, fever, eye tearing, vomiting, difficulty keeping their eyes open, and brief spells of blindness. Because of the number of complaints and the symptoms described, doctors at Hamidia Hospital immediately suspected the release of toxic chemicals from the nearby pesticide-producing Union Carbide plant. When questioned, the Chief Medical Officer for Union Carbide, Dr. L.D. Loya, admitted to an accidental gas emission of methyl isocyanate (MIC) the night before. Dr. Loya, however, denied that MIC was toxic and poisonous even though Union Carbide's plant manual clearly stated that "MIC is a poison to human beings by inhalation, swallowing, and skin contact." Dr. Loya explained that any temporary side effects experienced, such as agitated eyes and strained breathing, would soon subside. Over the course of the next weeks and months, Union Carbide maintained this position and claimed that MIC was "nothing more than a potent tear gas." They refused to divulge any information regarding the composition or toxicity of the gas. Likewise, Medical research conducted by the Indian Government regarding the Union Carbide-MIC accident was also immediately classified as confidential by the government under the Official Secrets Act. The effects of this "non-poisonous" gas, however, included approximately 3,800

[5] Reactor years are the cumulative number of years in which ALL nuclear power plants have been operational. For example, two nuclear power plants operating a total of two years each yields four reactor years.

immediate deaths and the hospitalization of 200,000 more people. One thousand animals were also killed by the accident and another 6,000 harmed.

Studies conducted by the Indian Council of Medical Research (ICMR) revealed that 40,000 new cases of asthma were reported three months after the accident. Five years after the accident victims continued to display chronic deterioration of the lungs, gastrointestinal disorders, partial and complete blindness, impaired immune systems, neurological disorders, menstrual irregularities, reproductive disorders (including stillbirths and deformities), and post traumatic stress symptoms. Additional ICMR studies also found: three times more people suffered from MIC-related respiratory disorders in 1991 than in 1987; a three-fold increase in pulmonary tuberculosis and cataracts among those exposed to MIC (as compared to an unexposed control group of Bhopal residents); a 300% increase over the national average for spontaneous abortions; delayed motor and language skills among children conceived or born after the accident; and the likelihood of permanent damage given the 10-year persistence of symptoms. The International Medical Commission of Bhopal, comprised of 14 medical specialists from 11 different countries, confirmed these findings in January 1994, and additionally reported lung impairment, loss of limb control, neurotoxic injuries, reduced memory, and 10-15 related deaths per month among those exposed to MIC.

Union Carbide's accidental 40-ton release of MIC is attributable to human and design errors as well as to a history of unsafe operations. Inadequate systems and unsafe operations are not unique to the Union Carbide plant in Bhopal. In 1981, Union Carbide was fined $50,000 for spilling 25,000 gallons of a cancer-causing chemical into the Kanawha River in West Virginia. That year, 402 Union Carbide Eveready workers in Indonesia developed kidney disease from exposure to mercury. Between 1980 and 1984, the EPA detected 61 MIC leaks in the West Virginia Union Carbide plant. According to the International Confederation of Free Trade Union, "[B]roken gauges made it hard for the MIC operators to understand what was happening. In particular, the pressure indicator/control, the temperature indicator, and the pressure level indicator for the MIC storage tanks had been malfunctioning for more than a year." Bhopal operators considered this to be the status quo, "[having broken gauges] was not unusual at the factory" (*New York Times*, January 30, 1985). The consequences of this negligence culminated on December 2, 1984. That night 1,000 to 2,000 gallons of water leaked into an MIC storage tank causing a highly exothermic reaction and the formation of a high-pressure MIC gas bubble. This increase in pressure went undetected by plant operators. Apparently, the MIC pressure value gauge was giving abnormally low-pressure readings (i.e. 2 psi instead of 20 psi) prior to the accident. Two hours before the accident, the gauge indicated an increase in pressure from 3 psi to 10 psi, but plant operators decided that, like many others in the plant, the gauge was faulty.

Thirty minutes after the MIC reaction began, operators suspected a gaseous leak not because of the plant's monitoring systems, but because their eyes began to tear. Unable to see or breath, operators immediately abandoned their control panels. The refrigeration capacity of the MIC storage tank had been turned off to conserve electricity, and all of the plant's backup safety systems failed or were delayed allowing a massive amount of the gas to escape the plant. Although a safety alarm sounded an hour after the spill, most of the damage had already been done. Before residents could escape, MIC gas contaminated a 20 square kilometer area. People within two and a half kilometers of the plant sustained lethal injuries, and people within a four kilometer radius sustained severe injuries.

Union Carbide officials never notified local authorities of the toxicity of the chemicals they produced. Consequently, no evacuation or emergency medical procedures were in place, and no public knowledge of how to deal with the toxic gas cloud existed. Health officials estimate that hundreds of lives could have been saved had the public been instructed to breathe through a damp cloth. The catastrophe might also have been avoided if Union Carbide had: 1) heeded the safety warnings issued after the death of one plant worker in December 1981, the injury of 28 workers in January 1982, or the October 1982 spill of MIC, hydrochloric acid, and chloroform and/or 2) repaired the "61 hazards, 30 of them major and 11 in the dangerous phosgene/MIC units" as reported in a May 1982 safety audit. This outright negligence on the behalf of Union Carbide affected almost a third of all people living in Bhopal at the time. To date, approximately 20,000 people have died from MIC exposure.

Victims of the Union Carbide accident filed a $3 billion lawsuit against the corporation, but Union Carbide adamantly denied liability blaming a fictitious disgruntled worker for the accident. The Central Bureau of Investigation (CBI), with the help of plant workers, developed a strong case supporting a connection between the MIC incident and negligent management. On December 7, 1984, Union Carbide's Bhopal CEO, Warren Anderson, and 11 other corporate officials were arrested for culpable homicide, grievous hurt, and death and poisoning of animals. Warren Anderson bailed himself out of jail for $2,000 (US) and has never returned to India.

In private, out-of-court deliberations and fearing the loss of other transnational corporations, the Indian government settled on a payment of $470 million for the survivors of the accident (an average payment of $940) as well as a full liability release for Union Carbide. In an attempt to create goodwill, Union Carbide agreed to set up the Bhopal Hospital Trust, a hospital to treat the victims of the 1984 accident. Today, Union Carbide's plant in Bhopal no longer operates, but the site remains, never cleaned up and still potentially releases dangerous chemicals into the environment. The Indian government has not been able to extradite Warren Anderson, and in 2002 the Indian government was prevented by Indian courts from reducing the charges against Union Carbide officials in an attempt to speed extradition from the United States.

7.2 Contradictory Information in the News

As the examples presented above show, news about human and environmental health is omnipresent, yet much of this information is contradictory. Nearly everyday, newspapers, magazines, and television shows report new information that tends to further obscure issues rather than clarify them. A cursory survey of two major national newspapers conducted between September 1, 1999, and November 1, 1999, yielded several articles that contested previously reported claims or presented evidence of scientific or expert misjudgment and error. These articles reported the following:

- "Studies Bolster Link between Diet Drugs, Heart-Valve Leaks." Contrary to the previous claims of the manufacturer, the diet drugs Redux and fen-phen can cause permanent heart damage (*Wall Street Journal*, September 10, 1999).
- "Questions for Drug Maker on Honesty of Test Results: FBI Asks About Diet Product's Approval." A drug manufacturer did not report to the Federal Drug Administration all relevant test results prior to petitioning for approval of a drug (*New York Times*, September 10, 1999).
- "Tobacco Industry Accused of Fraud Lawsuit by U.S." For more than forty years, the tobacco industry suppressed evidence that tobacco use causes cancer (*New York Times*, September 23, 1999).

- "Japanese Fuel Plant Spews Radiation after Accident." Trained operators of a nuclear power plant in Japan poured more than six times the required amount of uranium into a tank, resulting in a nuclear chain reaction (*New York Times*, October 1, 1999).
- "Two Teams, Two Measures Equaled One Lost Spacecraft." The Mars Orbiter burned in space because the spacecraft's creator used imperial measurements when the spacecraft's navigational team used metric measurements (*New York Times*, October 1, 1999).
- "Drug May Be Cause of Veterans' Illness: Pentagon Survey Links Gulf War Syndrome to Nerve-Gas Antidote." Persian Gulf War soldiers who were given a drug to protect them from nerve gas attacks suffer from damage to areas of the brain that control reflexes, movement, memory, and emotion (*New York Times*, October 19, 1999).
- "Testing in Nevada Desert is Tied to Cancers." Soldiers who participated in nuclear tests for the military in the 1950s have higher than normal death rates and an increased likelihood of developing leukemia and prostrate and nasal cancer (*New York Times*, October 26, 1999).

Due to this steady flow of events and news stories that present contradictory, inaccurate, or incomplete expert evidence, the public is unlikely to accept expert evidence as absolutely accurate all the time. The frequency of events, as well as the ambiguity and uncertainty of experts, government officials, and the media, as demonstrated by these short case studies, leads to doubt and skepticism on behalf of the public. The implication is that residents living near Superfund sites are forced to construct their own risk beliefs based on perceptual cues and media coverage. McClelland et al. (1990) surveyed residents near OII about their risk beliefs and found a bimodal response with more than half believing that living near the site was as dangerous as smoking more than one pack of cigarettes per day, with an incremental annual risk of death of approximately 1/100. Most of the remaining residents viewed the risk as trivial. Assuming typical values for statistical life and assuming three people per home, the discounted present value of the risk for the residents that assessed the risk as similar to smoking exceeds the price paid by these residents for their homes! Residents who responded this way did report that they were desperate to sell and sought immediate cleanup.

7.3 Events, Perceptual Cues, Risk Perception, and Stigma

Given the doubts that people will inevitably have with respect to the credibility of expert risk assessment, perceived risks will be based on personal and community judgments derived from other sources of information. Events that are associated with a Superfund site will lead to perceptual cues and media attention, that will most likely elevate perceived risk and stigmatize the site for reasons documented below. Some of the most important determinants of risk beliefs are perceptual cues. Perceptual cues are physical aspects of a site that are perceived by local residents, and are suggestive of risk. Examples of perceptual cues include odors emanating from landfills, unusual odors or flavors in well water, unusual soil or water coloration at the site, and a heavy volume of truck traffic going in and out of the site. Ironically, the actions taken by authorities to minimize public health and safety risks tend to exacerbate risk beliefs by providing clear cues that some risk is present. Erecting chain link fences, posting 24-hour guards, placing warning signs, conducting on-site tests (especially by workers wearing protective clothing) are all cues to residents that risk levels may be higher than they thought. Such actions, which may be necessary, almost never lower risk beliefs. Proximity to a site increases the frequency and duration of contact with, or observation of, perceptual cues, which contributes directly to the intensity of risk beliefs.

The effects of strong perceptual cues are well illustrated by the OII Landfill. Initially, concern about high volumes of truck traffic and odors (produced by decomposition in the landfill) prompted local residents to organize and confront problems associated with the site. McClelland et al. (1990) found a significant correlation between recognition of these perceptual cues and the high risk beliefs of many residents living near the site. Several of the perceptual cues were removed or reduced by (a) installing wells to extract the methane gas for commercial use and (b) closing the site, which eliminated most of the truck traffic. Even though these actions did not address risks that hazardous substances would migrate into local neighborhoods, the risk estimates of many residents dropped dramatically after the principal perceptual cues were removed. McClelland et al. also demonstrated that there were significant property value losses associated with these risk beliefs.

Attention given to a site in the media, apart from the actual content of news stories, is itself a perceptual cue that risks may be high. Many studies have shown that frequent exposure to media reports about a site increases the likelihood that residents will believe the site is very risky. The specific risk at a site and perhaps the site itself will usually be unfamiliar to residents. That in itself increases risk beliefs (Wilkins and Patterson, 1987). But more importantly, it means that residents are almost totally dependent on the news media for information about the risk. Reflecting the concerns of their consumers, the news media often focus on aspects that accentuate dread, such as the uncontrollability of the risk and the frightful worst outcome (e.g., dying of cancer), rather than on information about the low probabilities of the risk and how those probabilities compare to other risks that residents accept.

The signals that the media sends to the public regarding risks from hazardous waste sites are important, but the way in which the public interprets this information is equally important. A key feature of how news coverage is interpreted by residents is whether there is an easily identifiable "villain" responsible for the hazardous waste problems at the site. For example, if the responsible party is a corporation whose primary business activity is outside the community, then it is more easily portrayed as a villain than a local business which has strong affiliations to the community. Russell et al. (1991) found that the more important a site's PRPs were to the local economy, the more skeptical residents living near the site were that it needed to be cleaned up. Personal familiarity with a site also influences how news reports are interpreted. The greater the prior familiarity, the less risk beliefs are likely to be elevated by news stories.

The largest PRP for the OII Landfill was an outside corporation that had not provided significant employment or other economic benefits for the residents who lived nearby. Most of the waste, especially hazardous waste, was generated and brought to OII from outside the community. OII was primarily a commercial landfill serving many interests outside of the community. In short, conditions were ripe for news stories to elevate risk concerns significantly.

How a risk affects the community, society, and the economy will depend on individual and group perceptions of the risk (Slovic et al., 1991; Kunreuther and Slovic, 2001). There can be a compounding or "rippling" effect as more and more individuals respond to the risk (Kasperson et al., 1988). Or, as Dr. Paul Slovic describes it, interactions among individuals can produce a "social amplification of the original risk concern." The greater the population living near a site, the greater the potential for compounding or social amplification.

When residents or potential buyers are extraordinarily fearful of a site, they respond by shunning the site. This behavioral response has been labeled stigmatization and has been explored in a number of experiments that suggest that if risks are perceived as being excessive, people replace calculations of risk versus benefit with a simple heuristic of shunning, the avoidance of the stigmatized object.

Stigma has been shown to have a number of key properties. Laboratory experiments testing these properties have involved dipping a medically sterilized cockroach into glasses of juice and gauging subjects' willingness to drink the juice after the cockroach has been removed (Rozin, 2001). First, stigma shares many of the psychological characteristics of contagion, where contagion is associated with touch or physical contact. For example, while subjects refused to drink the juice if the sterilized cockroach was dipped into the glass, they would drink the juice if the cockroach was just placed near it. Second, stigma appears to be permanent. Subjects refused to drink the juice even if it had been in the freezer for one year. Third, stigma appeared to be insensitive to dose. Reductions in the duration of contact between juice and cockroach had little effect. Any contact was sufficient for subjects to shun the juice. Fourth, the source of contagion is usually unknown. Thus, while shunning may have evolved from an adaptive response to avoid contaminated food, it can be triggered in inappropriate circumstances. For example, subjects who saw sugar water placed in a clean empty jar and then saw a cyanide label placed on the jar still tended to refuse to drink the sugar water. Finally, subjects tend to medicalize the risk, arguing that the stigmatization was the result of a fear of health effects.

The possibility that Superfund sites might be stigmatized could have a major impact on the prospects for successful cleanup of contaminated sites. If such sites are permanently shunned because, like the "cockroached" juice, they are viewed as permanently stigmatized, property values may not recover immediately once cleanup is in progress (since future improvements should be capitalized into home values) or even when cleanup is completed.

Chapter 8

Property Value, Approach, and Data

8.1 Introduction

In this chapter, we undertake a comparison of hedonic property value models across four different Superfund sites: The Montclair, NJ, area radium sites, the OII landfill in the County of Los Angeles, CA, the Wells G&H and Industri-Plex sites in Woburn, MA, and the Eagle Mine site near Vail, CO. Our goal is to clarify whether the effects on property values of distance from a Superfund site vary over time in a manner that is related to the progress of remediation at that site. Distance is treated as a proxy for perceived risk. We control for area-wide variations in housing prices and we also use GIS techniques to measure distances to other local amenities or disamenities, which can confound the effects of proximity to the Superfund site. Some provocative results stem from our extensive efforts to control for variations in the socio-demographic characteristics of the surrounding neighborhood as measured by trends inferred from tract-level data from multiple decennial Censuses. Neighborhood change occurs and may be brought about in large part by the episode of "taint" precipitated by the identification and remediation of the Superfund site. These shifting socio-demographics can easily confound evidence about the rebound of property values that one would expect to observe following the cleanup of a Superfund site.

There is considerable public concern about how hazardous waste sites impact property values in their neighborhoods, both in the short run and in the long run. For a careful review of empirical studies that assess the negative effects on property values of locally undesirable land uses (LULUs) such as waste sites, hazardous manufacturing facilities, and electric utility plants, see Farber (1998). The typical implicit or explicit goal in this literature is to establish a monetary measure of the loss of welfare experienced by people who live near these sites. This monetary loss can be interpreted as the amount of money that would be required to compensate these individuals for this loss, or alternatively as a partial measure of the social benefits that would ensue from affecting a cleanup.

We examine distance and time patterns in property values in the vicinity of four different sites on the NPL for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or "Superfund") sites in four different states. These include sites in

- Woburn, MA (the Wells G & H site that was the subject of the book and motion picture, *A Civil Action*, and the nearby Industri-Plex site);
- Montclair, NJ (three large areas with radium contamination of the soil);
- Monterey Park, CA (the Operating Industries, Inc (OII) landfill site), also featuring some of the most dramatic demographic changes in Los Angeles County over the time period in question; and
- Vail, CO (the Eagle Mine site, upstream on the Eagle River from a sizeable fraction of housing along Interstate 70 west of Vail). Vail is notable as a winter resort area.

The key insights drawn from this work stem from our measurement of trends in both socio-demographic characteristics and housing stock characteristics at the neighborhood level. Taking advantage of the large data increment provided by the 2000 U.S. Census, we construct approximate time-series for the set of conformable Census-tract-level variables in order to span a 31 year time period, based on the 1970, 1980, 1990 and 2000 Censuses. We consider neighborhood change, both in terms of socio-demographics (ethnicity, age, and household composition) and the housing stock (owner- versus renter-occupancy and vacancy rates, as well as shifts over time and with distance from the Superfund site in the characteristics of homes in our large sample of transactions).

Our findings, borne out across several sites, suggest that endogenous neighborhood change can be precipitated by the identification and remediation of a Superfund site. While the objective or subjective risk associated with the site may initially account for decrements in housing prices around the site, these lower prices also make the neighborhoods more accessible to lower income groups, younger families, minorities, and non-traditional households. The increased presence of these groups can replace Superfund site risks as an explanation for systematically lower property values near the site over time, even after the site has been cleaned up.

A number of threads in the literature on hedonic property values must be acknowledged explicitly, since each has some bearing on the approach we take here.

8.1.1 Objective versus Subjective Risk

One body of work in this literature emphasizes the effects of objectively measured risk on property values. In a series of related papers concerning assorted hazardous waste sites and housing prices in Greater Grand Rapids, Michigan, Gayer (2000), Gayer and Viscusi (2002), and Gayer, et al. (2002) use detailed calculations of objective risk based partly on distance but also on assumed transport of pollutants.

An alternative approach typically involves the use of distance from the site as a proxy for either objective or subjective risk. This research falls into this second category. Even scientists have difficulty assessing the true levels of risk from a hazardous waste site with any degree of accuracy. Furthermore, home buyers tend to be less than perfectly well-informed about environmental risks (see Hite, 1998), and it is the perceptions of home buyers and sellers, rather than the facts, that will determine the prices observed for housing transactions. However, McClelland, et al. (1990) explore the distinction between subjective and objective risks to homeowners and their differential effects in hedonic property value models for the OII landfill. They find that distance to the site and odor levels are not statistically significant when included in a model in addition to a neighborhood average of homeowner risk levels.

8.1.2 Distance Effects over Time

In this research, we address some interesting empirical results concerning distance effects over time in the hedonic property value literature concerning hazardous waste sites. Farber (1998) reports that the literature suggests that the post-announcement impact of proximity to a site is roughly $3500 per mile (in 1993 dollars). There is evidence in some cases that property values that have been temporarily depressed by the announcement of Superfund status rebound fully after cleanup (see Kohlhase, 1991).

A number of researchers have looked for this rebound effect. In particular, we will refer to a style of hedonic inquiry represented in work by Kiel (1995) and Kiel and Zabel (2001), in two papers by Kiel and McClain (1995), one paper by Dale, et al. (1999) and one by Carroll, et al. (1996). In these works, the authors estimate separate hedonic property value functions for discrete intervals of time separated by mileposts in the process of identifying and remediating a hazardous site.

Two of the Kiel papers (Kiel, 1995; and Kiel and Zabel, 2001) concentrate on a pair of Superfund sites in Woburn, MA, Wells G &H (the subject of the book and motion picture entitled *A Civil Action*) and the nearby Industri-Plex site. They identify six time periods: 1975-76, 1977-81, 1982-84, 1985-88, 1989-91 and 1992. (These sites are also one of the cases examined in our research, albeit for the time period 1978-97, and our data source is different. Kiel provides a very thorough background for the Woburn sites.) The earlier paper controls for a variety of structural characteristics of the house itself, and for the logarithm of minimum distance from the Superfund sites, finding strong evidence of a positive price gradient away from these sites in the second, fourth and fifth periods. The later paper also controls for two Census tract variables: the proportion of unemployed workers and median household income in nominal dollars. The paper does not appear to indicate whether more than one decennial Census was used to create values for these variables. The variables are billed as being necessary to control for omitted variables bias, and there is little further discussion of their contribution, since their coefficients are not statistically significant.

Kiel and McClain (1995) consider the timeline for the siting of an incinerator in North Andover, MA. These papers seek to discern different distance effects on housing prices in four different time intervals, 1989-90, 1981-84, 1985-88 and 1989-92.

Dale and his coauthors focus on the RSR lead smelter site in Dallas, Texas, identifying five time periods: 1979-80, 1981-84, 1985-86, 1987-90, and 1991-95. They use a sample of over 200,000 house sales distributed across these time periods, at an average distance of 11.8 miles from the smelter. The geographic scope of the sample subsumes 14 school districts. These authors interpolate between 1980 and 1990 tract-level Census data, and extrapolate based on the growth rates in variables for 1979 and the years beyond 1990. They control only for the percent of the Census tract below the poverty line, the percent Hispanic, and the percent black. These Census variables are the only ones that vary over time, beyond the yearly dummy variables included in the model. A simple distance variable is the key explanatory variable in these models, and the authors find that house prices increase with distance during the first three time periods, but fall with distance in the last two.

8.1.3 Endogenous Socio-demographics

Each of these substantial studies that focuses on the time pattern of distance effects on property values around a locally undesirable land use controls for two or three Census tract level characteristics, if not in earlier papers from the project, then in later ones. But these earlier studies were hampered by the absence of the 2000 Census data needed to construct plausible trends over time in neighborhood characteristics beyond 1990. These researchers have been limited to extrapolations based on the 1980 and 1990 Census data sets. The present work was also delayed considerably in its completing while the authors awaited the release of the year 2000 Census results.

None of the earlier papers addressing the time pattern of distance effects reports any exploration of whether population characteristics near the hazardous waste site also vary systematically with distance as well as with time. Concerns about omitted variables bias are acknowledged as justifications for including a few socio-demographic variables, but there are no reports of scrutiny of the correlations of these Census variables with distances over time.

Why might we expect socio-demographics, potentially, to be correlated with distance in ways that change over time? Housing prices are expected to be lower, the closer a property lies to a newly identified Superfund site. These lower prices may result in dwellings being sold to new owners who differ systematically from the existing population. If neighborhoods with greater proportions of residents with the characteristics of these new arrivals are typically associated with lower housing prices, this transition in the neighborhood may result in property values in this area failing to completely recover their original trajectories over time.

The existing studies which control for time-varying neighborhood demographics when measuring the effect on property prices of distance from a hazardous waste site may conclude, from the estimated coefficient on distance that property values have rebounded from an episode of Superfund designation and cleanup. However, demographics may be endogenously determined by this process. The evolution of the neighborhood over this time period may leave it with a different socio-demographic mix than prior to the episode. If these socio-demographic shifts have a negative effect on housing prices, these prices may not fully recover. Most models attempt to make welfare inferences concerning the losses in capitalized housing values to pre-existing owners based on the dynamics of the distance coefficient. What matters, however, is the actual effect on housing prices.

8.1.4 Endogenous Housing Stock Attributes

In addition to localized demographic changes that differ from trends in the broader community, the housing stock in the area near the hazardous waste site may also be affected differentially. There may be a shift in tenure from owner occupancy to more rental occupancy, and there may be changes in vacancy rates. If homeowners are less inclined to remodel houses nearest the site during the Superfund identification and remediation process, and developers are less inclined to replace older houses or construct new dwellings for sale in this area, or if new dwellings here are systematically different from new dwellings in areas beyond the influence of the hazardous waste site, then these changes in the housing stock in neighborhoods nearer the site can also contribute to sustained lower housing prices.

It is appropriate to control for demographic and housing stock changes, but all these hedonic studies implicitly assume that these changes are exogenous, and therefore do not bother to scrutinize them. We provide evidence that these variables are endogenously determined, and changes in their levels are correlated with distance from the site and dynamically related to the identification and remediation process. The full effect on housing prices of "proximity to a hazardous waste site" over time is captured not just by the simple distance coefficient, but also in part by the full complement of socio-demographic and housing stock variables whose values are also affected by the identification and remediation process.

McCluskey and Rausser (2001) utilize a dynamic, discrete-time model to analyze the evolution of perceived risk around a hazardous waste site and its effect on property values. Perceived risk enters the model as a state equation that involves a media coverage variable, and is an unobserved variable whose values are imputed from the model. (Gayer and Viscusi, 2002; also explore media coverage (newspaper stories) and their effect on property value changes in the vicinity of Superfund sites.) McCluskey and Rausser's results suggest that media coverage and high prior risk perception increase current perceived risk, which in turn lowers property values. However, the pattern of evolution of these imputed perceived risks over time is derived from a specification that controls for distance from the site, but not for any changes in demographics, which could also account for systematic shifts in housing prices. Perceived risk is inferred to remain high if housing prices remain low. But if housing prices remain depressed near the site because of changes in neighborhood socio-demographics precipitated by the Superfund identification and remediation, such a model could falsely conclude that perceived risk remains high.

8.1.5 Environmental Justice/Equity

This research also contributes to the environmental justice literature by explicitly examining the effects on the socio-demographic mix of neighborhoods over space and time in response to the identification and cleanup of three different Superfund sites. (The Vail, CO, case has a settlement pattern that is too localized to allow for enough Census tracts for reliable analysis.)

The neighborhoods containing hazardous waste sites tend to be lower-income and possibly more non-white in their racial makeup. Bowen (2002) offers a critical review of the existing environmental justice literature and concludes, on the basis of studies that he identifies to be of relatively high quality, that

> "...it appears to be that hazardous sites are located in white working-class neighborhoods with residents heavily concentrated in industrial occupations, living in somewhat less expensive than average homes."

He acknowledges the possible presence of other patterns at the subnational level, but that these vary in their character from region to region.

When a spatial pattern of concentration of hazardous facilities in low-income or minority communities can be established, the question arises of which came first. Do industries or governments seeking to locate hazardous facilities disproportionately choose low income or minority neighborhoods, or does the tendency of these facilities to reduce the prices of nearby properties attract lower income home-buyers over time, and is ethnicity sufficiently correlated with income to produce this observed spatial pattern. Single cross-sections of data do not afford an opportunity to discern which came first, the low-income or minority neighborhood, or the hazardous waste site. It is necessary to determine how neighborhoods change over time, both close to the hazardous facility and elsewhere. A discussion of the issues is presented in Liu (1997), and in Been (1994) and Been and Gupta (1997).

Graham, et al. (1999) explore the siting of coke plants and oil refineries. They identify the year of the siting decision and retrieve historical Census data for the decennial Census preceding that year (or the earliest adequate Census data, if the siting decision preceded the advent of sufficiently detailed Census information). They conclude that market and non-market mechanisms, such as redlining, block-busting and other legal and illegal activities, may dominate the original coke plant and oil refinery siting decisions as explanations for the 1990 proportion of non-white residents near these facilities.

Graham, et al. (1999) cite "market dynamics theory" as predicting, over time, that hazardous or unattractive residential areas will lose high-income residents and attract low-income residents (due to the relatively depressed property values in these areas.)

8.2 The Sample

An ideal sample of data would consist of transactions data and housing structural characteristics, neighborhood characteristics, distances to all relevant amenities and disamenities, all collected contemporaneously with the time of sale. This ideal data would also include analogous information (except for selling price) about houses that did not sell in these periods, either because they were not for sale, or they did not find a buyer. This would allow the researcher to control for non-random selection into the pool of dwellings actually observed to be transacted.

When a researcher has data like these data over a number of years, it is possible to control for many unobserved housing and neighborhood characteristics that do not vary across time by using the so-called "repeat sales" method. When a house has sold more than once in the observed time period, the difference in the selling price can be explained in terms of differences in any explanatory variables that have also changed over time. This method for eliminating all the time-invariant characteristics from the analysis was first proposed by Bailey, et al. (1963), and has recently be used to good effect to analyze the influence of news stories about Superfund sites on housing prices (Gayer and Viscusi, 2002). One disadvantage of this method is that the sample of repeat-sales dwellings over-represents houses with greater turnover and excludes dwellings that have been sold only once during the window of time for which data are available. There is also a problem that any remodeling or updating of the property that is not captured by the quantity variables typically recorded in multiple listing service data will go unacknowledged in the process of dropping all structural characteristics by differencing over time.

We use a source of data that over-samples houses that have been sold only once over the time period in question. Our data roughly reflect the current status of dwellings. The data are provided, for the most part, by Experian, a company which provides information to direct mail marketers and others. These data are updated at fairly regular intervals, although not simultaneously. Anyone buying these records gets the most recent information available. For each street address in the sample, most records include information on the date when the house was purchased and the price that was paid at that time. For different localities, there are different quantities of structural information in the data set. From the same data supplier, all fields will be available for all localities, but for any given locality, blocks of fields will be blank. Blank fields differ across localities, possibly reflecting different public recording requirements.

In some cases, notably the Eagle County files sought for the Eagle Mine site near Vail, Colorado, the missing data problem was so severe that, despite the appearance of over 5,000 house transactions in the data, there were less than 50 with sufficient data for estimation of a basic hedonic property value model. It seems that a large share of dwellings are not owner-occupied. In that case, we sought and received data from the Eagle County Assessors office. There were roughly 1400 observations for owner-occupied units, lying between 2.6 and 19.3 kilometers of the nearest part of the Eagle Mine site. About 57% were owner-occupied but were not single-family dwellings. While the site description for the Eagle Mine site indicates that one of the main deposits of tailings was within 1500 feet of a middle school, there are apparently no current owner-occupied units in the vicinity. It would have been vastly preferable to have acquired the same assessor's office information for each year during the time span of interest (in this case, from 1976 to 1999). However, data that are "obsolete" from the point of view of the assessor's office are apparently not retained merely for the convenience of researchers who wish to understand time patterns in property values.

The feature that has the greatest potential to compromise these data, then, is the fact that, in all of our data sets, we only observe selling prices for the most recent sale of a house. If a house is in an area where turnover is high, there will be more recent sales and fewer earlier sales. For analytical purposes, it would be preferable to have data on all sales in all years and selling price in those years, but such data do not exist. Data could be purchased from Experian every year, if a future study could be anticipated, but retrospectively, the data are not available. The data are collected primarily for current marketing purposes and records are updated without saving their previous values. Historical modeling is not a use anticipated by the providers of the data.

Consequently, there may be some systematic sampling. We observe earlier transactions prices only for houses which are still occupied by the owners who purchased them at that earlier date. We do not observe many early transactions prices for houses in neighborhoods where there has been a lot of turnover. It must be a maintained hypothesis that rates of turnover are uncorrelated with identification and cleanup of Superfund sites. This may be a strenuous assumption, but there are few alternatives. So it will be necessary to speculate upon the types of biases this non-random selection is likely to produce in the effects of distance from a Superfund site on housing transactions prices.

From these difficulties, we can glean an important item for the future research agenda.

8.2.1 Descriptive Statistics, Exclusions

For all of our sites, we exclude dwellings which are not owner-occupied, or if the selling price or lot size or other key variables are missing. We also omit houses which could not be successfully geolocated based on address information. For each site, we also limit the sample to the range of years for which data are sufficiently plentiful. We exclude dwellings with very unusual characteristics, such as very large values for number of floors, total numbers of rooms, numbers of bedrooms, numbers of bathrooms, square footage, and lot size, or extraordinarily high or low selling prices. We are attempting to model housing prices for a generous range of "typical" dwellings in the geographic areas in question. Very unusual dwellings are therefore excluded. Each of these exclusions accounts for a very small relative number of dwellings, and these unusual values may, in many places, be simply errors in data entry.

Selection on housing sale prices was conducted as judiciously as possible. Year by year distributions of house prices, in levels and in log form, were scrutinized for obvious outliers. Typically there were at most one or two deleted outliers in each year (aggregating across all Census tracts). Prices are in nominal terms, so it is important not to exclude outliers based on their identification from a marginal distribution.

Details are presented in the appendix for each site, along with complete descriptive statistics for each of the classes of variables used in our models.

8.2.2 Extent of the Market

It is at the discretion of the researcher to decide upon the extent of the market that may be influenced by proximity to a Superfund site. In some cases, if the disamenity is out of the line of sight, it will have negligible effects. In other cases, where it may contribute to unhealthful air quality or other obvious externalities, the geographic scope of its effects can be much more far-reaching. Furthermore, perception of the disamenity can be directional. For example, it can be influenced by prevailing winds (as in the case of the "Woburn odor"), or by the direction of water flow in a river (some houses in the Eagle Mine sample are downstream of the mine, others are not).

We selected a relatively large footprint for our initial models for each sample. For Montclair, the 11,982 houses in the sample range from zero to about 6.7 kilometers away from the site and a number of houses are actually located on top of areas of contaminated soil. The broader neighborhood for the OII landfill site includes 9,279 dwellings between 60 meters and about 8.5 kilometers from the boundary of the site. In Woburn, we characterize distances in terms of the distance from the nearer of the two sites, since they are in such close proximity. The sites are located in a non-residential area, so the range of distances represented among the 12,444 houses in the sample is from about 375 meters to about 8.4 kilometers.

The Eagle Mine site is anomalous. This is the mountainous territory around Vail, and most settlement is clustered along either the Eagle River or Gore Creek, which runs west through the town of Vail and into the Eagle River at a point downstream of the Eagle Mine site. Our sample of assessor's data should be relatively complete, but there is a very high proportion of non-owner-occupied properties in the region. There are only a handful of houses within six kilometers of the Superfund site, and we delete these because of their potential to have an inordinate effect on the price gradient in different years. The 1,087 owner occupied properties in the Eagle Mine sample lie between 6.09 and about 13 kilometers from the downstream portion of the site. No houses in the sample are upstream of the site. Furthermore, the numbers of transactions in each of 1976 through 1999 are sufficiently small that we needed to constrain the site distance effects to be equal across three-year intervals in order to discern any reliable effects.

The size of the sampling area in a study such as this should be sufficiently large that the distance premium in housing prices should arguably be zero near the boundary. We expect that statistically discernible distance premia should emerge only for houses considerably closer to each site.

8.3 Hedonic Property Value Models

Hedonic property values models have been used widely in literature, so we do not undertake in this research to explain their theoretical justification or limitations for their use. Many papers contain clear expositions of the underlying intuition. One recent example is Gayer and Viscusi (2002).

Most housing attributes are dummy variables or small integer values, with the exception of square footage and lot size. We retain square footage and lot size in linear form. However, all key continuous variables, including selling price SPRICE, the value of improvements, IMPVAL, and all distances, are logged. This allows sufficient flexibility for us to see diminishing marginal increases in housing prices with distance from a Superfund site, culminating in an essentially flat distance profiles beyond the radius at which further increases in distance have a negligible effect on property values.

Our basic model seeks to explain variations over space (i) and time (t) in nominal selling prices of dwellings, $SPRICE_{it}$. For some variables, the only available data correspond to the status of the structure in the last year of the sample, which we will denote as t=T. Our generic model takes the form:

$$(8.1) \qquad SPRICE_{it} = P_t \cdot DIST_{it}^{(\beta_{10t} + \beta_{11t} v_i)} e^{\beta_2 A_{iT}} e^{(\beta_{30} + \beta_{31} v_i) S_{it}} e^{(\beta_{40} + \beta_{41} v_i) D_{iT}} e^{\varepsilon_{it}}$$

Here, P_t is an area-wide price index for owner-occupied housing in year t, $DIST_{it}$ is the distance of each dwelling from the Superfund site in question, defined in a manner appropriate to the case. The coefficient associated with this variable will be allowed to differ across years by interacting the constant distance measure with yearly dummy variables. The variable v_i signifies lot size. This variable also appears as an element of the vector A_{iT} of property attributes. S_{it} is a vector of (interpolated) time-varying characteristics of the Census tract in which the dwelling is located, and D_{iT} is a vector of the logarithms of the distances from the dwelling to a potentially relevant set of other spatially differentiated local amenities or disamenities, calculated at time T, the end of the sample period, rather than contemporaneously.

Taking logarithms of both sides of the equation yields a version of this model that is appropriate for estimation:

$$(8.2) \qquad \begin{aligned} &LSPRICE_{it} = \\ &\ln(P_t) + (\beta_{10t} + \beta_{11t} v_i) LDIST_{it} + \beta_2 A_{iT} + (\beta_{30} + \beta_{31} v_i) S_{it} + (\beta_{40} + \beta_{41} v_i) D_{iT} + \varepsilon_{it} \end{aligned}$$

where $LSPRICE_{it}$ denotes the logarithm of the observed selling price, $\ln(P_t)$ will be captured as an intercept for the first year in the sample and a set of intercept shifters activated by year dummy variables. The variables of key interest are the $LDIST_{it}$, which consist of a vector of logged distances from the dwelling to the Superfund site interacted with yearly dummies in order to permit year-varying elasticities of housing prices with respect to distance to the site. The control variables include the property attributes A_{iT}, the S_{it} vector of proportions of the number of persons, households, or dwellings in the Census tract falling into specific categories, and the D_{iT} set of logged distances to other local features, the identities of which vary according to the case in question. The effects of these other logged distances are constrained to be constant over the sample period.

The version of the estimating specification in Equation 8.2 highlights the special role of lot size, v_i, in the modeling. Each locational amenity or disamenity should be permitted to affect not just the price of the property overall, but its price per unit area. In our specifications, lot size can affect property values outright, but it can also shift the marginal effects of amenities and disamenities upon house prices. Our primary specifications restrict β_{1it}, β_{31}, and β_{41} to be zero, but in the Appendices, we explore the consequences of allowing these parameters to be non-zero.

8.4 Control Variables

The main objective in this study is to determine whether there are statistically detectable effects on the selling prices of houses due to proximity to a Superfund site, and whether these effects, if any, vary over time as the site is identified and remediated. Before the incremental effects of such proximity can be isolated, it is necessary to control for other factors which might influence these prices. If any of these factors is correlated with distance from the site, or varies over time, or especially both, then the apparent timewise variations in prices due to proximity to the site could be distorted by omitted variables bias.

In this study, we use four main classes of covariates to control for systematic variations in housing prices due to heterogeneity *other than* the effects of proximity to the Superfund site over time.

8.4.1 Annual Dummy Variables

The average price of housing in a region will rise and fall over time in response to regional business cycles that affect area-wide housing demand and other exogenous macroeconomic factors, such as interest rates. To the extent that housing prices vary over time independently of the dwelling's distance from the local Superfund site, we control for all these implicit time-varying factors with a set of yearly dummy variables in each of our models. Our dependent variable in all cases is the log of the most recent selling price of the dwelling. The annual dummy variables associated with all but the earliest period (the omitted category) therefore bear coefficients that can be interpreted as the area-wide percentage difference in housing prices, relative to the first year of data, in each year of the sample.

Appendices A through D contain descriptive statistics on the frequencies of observations in each year of the period spanned by each sample. Given the systematic selection on house sale data for houses still occupied by the same owner since the time of the sale, there are fewer observations with earlier sale dates and proportionately more observations with recent sale dates.

8.4.2 Distance to the Superfund Site

Montclair: For Montclair, the radium sites spanned three large footprints, and housing had been built on top of much of the affected areas. Distance is captured by a dummy variable for whether the house in question was on top of one of these sites (INSIDE) interacted with yearly dummies. It is also captured by distance from the boundary of the closest site, for houses which are not on top of a site. Both of these variables—the dummy for being inside or outside a boundary, and distance from the nearest boundary, if outside—are also interacted with lot size in a set of auxiliary models. This allows for overall distance effects on selling price to be influenced by lot size.

OII: In the OII case, there is one well-defined site with all housing external to that site. Distance from the boundary of that site interacted with yearly dummies. It is also interacted with lot size in auxiliary models.

Woburn: In the Woburn case, there are two fairly distinct sites, so the distances are calculated to each of them separately. But there are relatively few housing transactions right near these sites, since they are not located in residential areas. We went to considerable lengths to attempt to capture the independent effects on housing prices of proximity to each of these sites: Wells G & H, and Industri-Plex. However, the two sites are in too-close proximity relative to the distribution of housing locations, so we were forced, in the end, to consider the distance from each house to the nearest of the two sites.

The Industri-Plex site is known to have had a distinct olfactory externality downwind that we have attempted to accommodate. We have included variables measuring the absolute latitude and absolute longitude position of each dwelling. These variables allow for an underlying spatial profile in the form of a plane that rises most steeply in any arbitrary direction, whatever the data dictate. On top of this spatial profile can be stacked an additional spatial profile of housing prices that could rise with distance from the Superfund sites. If the distance premium is not symmetrical around the site, the combination of these two patterns will allow the level curves of housing prices relative to the site location to be elliptical and asymmetric around the site, as opposed to circular and centered on the site.

Preview: If anything, the strategy of using latitude and longitude (separately for each year of the sample) produced a suggestion that housing prices in many years seem definitely to rise towards the south and rise towards the east (although possibly at a decreasing rate the further north one goes). These absolute position effects are strengthened when distance from the nearest Superfund site is also included in the model.

Eagle Mine: There are four major parts to the Eagle Mine site, each of which we mapped with our GIS software and included as polygon features. In determining the distance from each house in the sample to the Eagle Mine site, we used the distance to the boundary of the nearest feature. In almost all cases, this is the feature that is furthest downstream towards the populated areas along the Eagle River and Gore Creek, north of their point of confluence.

8.4.3 Housing Characteristics

The dependent variable in all of our models is the logarithm of the selling price of the house.

All hedonic property value studies include at least some characteristics of the dwelling itself and the property upon which it is situated. For each of our samples, the available structural characteristics are as follows:

Montclair: In the Montclair case, the number of non-missing structural characteristics in the data is unfortunately rather small. We therefore experiment with using the information in the property tax assessment distinction between land value and the value of improvements. In the assessment data, the total (most recent) assessed value of most properties is divided into land value and the value of improvements. In principle, the land value should reflect the value of the location of the dwelling and the value of the improvements should reflect the quality of the structure itself. The impact of proximity to a Superfund site should show up the assessed value of the land, and should vary over time as the perceived negative impact of proximity changes. But the assessor's 1997 value of the improvements should reflect the size and quality of the structure itself. This assessed value of the improvements will reflect any remodeling or additions that have taken place since the last sale of the dwelling, so this is an imperfect control for the structural quality of the dwelling when it was last sold. However, it is worth exploring the assessed value of the structure as a rough proxy for missing structural information.

In some of the models we report, we have opted to employ the estimate of the value of the improvements to the property as a regressor in the class of housing characteristics. We continue to use all available and complete measures of the physical characteristics of the house. These are typically quantity measures, rather than quality measures (e.g. number of bathrooms, rather than how expensive the fixtures, flooring, and countertops might have been), so we use the improvements value as a proxy for the "fit and finish" and the quality of the materials embodied in the structure. Higher quality architectural features in a dwelling would be more likely to be captured by the improvements value than by strict counts of bedrooms or floor space.

The quality of the most recent assessed value of improvements as a proxy for housing quality at the time of the last sale will deteriorate with the elapsed time between that sale and the most recent assessment.

Table 8.1 Montclair Housing Characteristics

Variable	Definition (n=11940)
impval	assessed value of improvements, 1997
knowflr	=1 if number of floors is known, =0 otherwise
floors	= number of floors, if known
ageknown	=1 if age of structure is known, =0 otherwise
age20	=1 if age>=10 and age <20, =0 otherwise (omitted category= age<10)
age30	=1 if age>=20 and age <30, =0 otherwise
age40	=1 if age>=30 and age <40, =0 otherwise
age50	=1 if age>=40 and age <50, =0 otherwise
age60	=1 if age>=40 and age <60, =0 otherwise
age70	=1 if age>=40 and age <70, =0 otherwise

age70plus	=1 if age>=70, =0 otherwise
lot size	Size of lot, in ratio to sample average lot size = **9232 sq. ft.**

OII: The OII data are drawn from the same Experian source as the Montclair data, but many more data fields are non-empty in these data. Thus, a wider range of explanatory variables capturing structural characteristics can be entertained.

Table 8.2 OII Housing Characteristics

Variable	**Definition (n=9211)**
notold	=1 if structure was built after 1900, =0 otherwise
age	Age of structure if built after 1900
age2	Age of structure, squared
sqft	Square feet of floor space, in '000s
sqft2	Square feet of floor space, squared
bedrms	Number of bedrooms
bthrms	Number of bathrooms
sqftbed	Interaction term: sqft * bedrms
sqftbth	Interaction term: sqft * bthrms
fplace	=1 if at least one fireplace, =0 otherwise
knowflr	=1 if number of floors is report, =0 otherwise
floors	Number of floors, if data not missing
lot size	Size of lot, in ratio to sample average lot size = **6199 sq. ft.**

Woburn: The explanatory variables available for the Woburn model are the same as those available for the OII site, although lot size will be normalized on the mean for this different sample.

Table 8.3 Woburn Housing Characteristics

Variable	**Definition (n=12444)**
notold	=1 if structure was built after 1900, =0 otherwise
age	Age of structure if built after 1900
age2	Age of structure, squared
sqft	Square feet of floor space, in '000s
sqft2	Square feet of floor space, squared

bedrms	Number of bedrooms
bthrms	Number of bathrooms
sqftbed	Interaction term: sqft * bedrms
sqftbth	Interaction term: sqft * bthrms
fplace	=1 if at least one fireplace, =0 otherwise
knowflr	=1 if number of floors is report, =0 otherwise
floors	Number of floors, if data not missing
lot size	Size of lot, in ratio to sample average lot size = **15129 sq. ft.**

Eagle Mine: Given that the Eagle Mine data are drawn from the Eagle County assessor's office, rather than from the Experian data, the available variables are somewhat different.

Table 8.4 Eagle Mine Housing Characteristics

Variable	**Definition (n=1087)**
sfd	=1 if single-family dwelling, =0 if condominium
age	Age of dwelling
age2	Age of dwelling, squared
bedrms	Number of bedrooms
bthrms	Number of bathrooms
notwdframe	=1 if not wood-frame construction, =0 otherwise
heatelec	=1 if electric heating, 0 otherwise
constgood	=1 if construction quality rated as "good" or better, =0 otherwise
constfair	=1 if construction quality rated as "fair" or worse, =0 otherwise
downstream	=1 if nearest to Eagle River, =0 if nearest to Gore Creek
lot size	Size of lot, in ratio to sample average lot size = **5154 sq. ft.**

8.4.4 Neighborhood Characteristics

We define the neighborhood in which a house is located as synonymous with its Census tract. Been and Gupta (1997) give a very thorough rationale for the desirability and tractability of using Census tracts when there is a need to quantify socio-demographic and other very local characteristics over time. Since neighborhoods change over time, and might be expected to change as a result of the discovery and remediation of a Superfund site, it is important to distinguish between changes over time in the effect on housing prices of mere proximity to the site, versus the influence of changing local demographics on property values. Hedonic property value studies which ignore changing demographics are essentially estimating reduced form model, which confounds the proximity effects with the changing demographics. It is possible that the pure effects of proximity to a site are completely resolved with remediation, but the effects of changing demographics as a result of the experience are more permanent.

We have been careful to collect Census data from all relevant decennial Censuses and interpolated all of the conformable socio-demographic characteristics. For some sites, we needed the 1970, 1980, 1990 and 2000 Census counts in order to interpolate a series between, for example, 1978 and 1997. Obviously, the decennial interval is problematic and these characteristics will inevitably be measured with some error. Errors-in-variables attenuation may lead to underestimates of the effect of neighborhood characteristics on housing prices.

The 2000 Census will offer greater resolution for a number of these variables, but the complete 2000 Census data at the Census tract level are not yet available at the time of this writing. We strived to achieve comparability across the different Censuses in these data, subject to the constraints imposed by the available data in each year. Counts were collected for each Census tract in each of four Census years, and categories were aggregated until they conformed and the data could be pooled and used in an algorithm to interpolate approximate values for each variable in each year between Census years. This procedure resulted in a Census dataset that could be merged with housing transactions by Census tract and year, so that the approximate current neighborhood mix could be used to explain housing prices in each year.

The Census variables we constructed that conformed across all four Census years and could be computed for each Census tract for each of our four sample areas are described in the following table. A smoothing algorithm was used to "connect the dots" in each Census year and to impute approximate values for each inter-Census year. These approximated time series will not accurately represent inter-Census variations in each variable, but this procedure seems to dominate the use of just one single year of Census year or the use of all three or four spanning Census years for each of our samples.

Table 8.5 Neighborhood Characteristic Variables

Variable	Description
tract	Each tract number represented in the sample

year	Actual data for each Census year; interpolated data for between-Census years
population	Total population of the tract in each year
households	Number of households in each tract in each year
housing units	Number of housing units in each tract in each year
males	Number of males
females	Number of females
white	Number identifying race as "white" (omitted category)
black	Number identifying race as "black"
other	Number identifying as "other race"
age_under5	Number of persons aged under 5
age_5_29	Number of persons aged between 5 and 29
age_30_64	Number of persons aged between 30 and 64 (omitted category)
age_65_up	Number of persons aged 65 or older
marhh_chd	Number of households consisting of married heads of household with children
mhh_child	Number of households consisting of male head of household with children
fhh_child	Number of households consisting of female head of household with children
vacant	Number of housing units vacant
owner_occ	Number of housing units owner-occupied (omitted category)
renter_occ	Number of housing units renter-occupied

These Census variables were converted to analogous percentage variables, prefixed with the letter "p", based upon the appropriate denominator (either population, households, or housing units). Where percentages sum approximately to 100%, the majority or (typically omitted) category is dropped. For example, we will arbitrarily drop pmale, pwhite, page_30_64, pmarhh_chd, and powner_occ. This leaves a typical vector of socio-demographic variables in the same Census tract as each observation that includes:
[pfemale, pblack, pother, page_under5, page_5_29, page_65_up, pmhh_child, pfhh_child, pvacant, and prenter_occ].

We anticipate that these Census tract characteristics may be very important to the problem of sorting out the variations over time in the effect of proximity to a Superfund site on housing values. Over the time horizons involved in our different cases (which range from 11 years to almost 30 years), there is a substantial scope for demographic shifts. Initial decreases in housing prices due to the recognition of an environmental disamenity can make the neighborhood accessible to lower-income households, who may be prepared to accept the disamenity in exchange for more housing at the same price, or cheaper housing, than they can obtain elsewhere. Neighborhood characteristics are not independent of the "taint" due to a Superfund site. It is important to ascertain whether the observation that housing price gradients often tend to rise as one moves away from a Superfund site, even after remediation, may be due to filtering-down of this housing stock that occurs during the period when taint is maximum.

It is entirely possible that, controlling for neighborhood changes that ensue from an episode of major environmental taint, the eventual effect of proximity to the site is actually positive (the price gradient moving away from the site is negative following remediation). Homeowners may value proximity to a cleaned up site more than they value proximity to other less-certifiably safe features.

The fact that Census data are available only at ten-year intervals has been an impediment to addressing this research issue. It was necessary to wait for the availability of the year 2000 Census data to be able to interpolate between the 1990 Census tract information and the 2000 Census information in order to construct usable data for the last seven to nine years of housing sales in our various data sets.

8.4.5 Other Local Amenities and Disamenities

Many earlier hedonic property value studies have included only one or two other distances in their models (such as distance to the nearest shopping center, or the central business district), or even no other distance variables at all. In the last few years, a number of environmental aspects of spatial data have been examined by researchers who are interested in determining their potential effects on property values. Acharya and Bennett (2001) use a sample of about 4000 houses in New Haven county in Connecticut between 1995 and 1997 to explore whether open space and land-use diversity affect housing prices. Diversity, richness, evenness and dominance measures are used to quantify the patterns of land use within a fixed radius of each dwelling. Among the spatial features they include as controls are distances to open space, lakes, streams, the ocean, parks, and highways. They also use Census block group data for the percentage of white households, the crime rate, average income, percentage college-bound students, to quantify neighborhood characteristics. However, they do not attempt to isolate variations over time in the effects of perceived environmental quality on housing prices. The marginal effects are assumed to be static.

In this research, based on our geo-location of each property using GIS software, we have measured for each house the distance to a wide variety of other topographic features, land uses, and institutions. Some of these are common to all four of our samples, such as distance to the nearest park and distance to the nearest school or shopping center. Others are unique to each site. Major freeways may be close enough to matter, or they may not, and airports or the flight paths implied by their runway configurations may be close enough to affect housing prices, or they may not. Based on a careful examination of the features in the region of each sample, we have identified and measured distances for a wide variety of things that could plausibly affect housing sale prices. The "other distance" variables relevant to each Superfund site are discussed in detail in the appendices devoted to each site, but will be summarized briefly below.

Concerning precedents in the literature for controlling for certain classes of variables, we can identify the following:

Summits: Benson, et al. (1998) assess the influence on housing prices of a variety of views, differentiated by both type and quality. They find that depending upon the particular view, willingness to pay for this type of amenity is quite high. While map proximity to a summit does not translate into the presence of a view, there may be some correlation.

Schools: "Close to schools" is considered by many home-buyers to be a positive feature of housing location, but Clauretie and Neill (2000) find that proximity to year-round schools, tends to decrease housing values.

Roads: Spatiotemporal fluctuations in location premiums associated with a major urban highway construction project in a study by Vadali and Sohn (2001). Boarnet and Chalermpong (2001) consider the effect of introducing new toll roads that increase accessibility.

Airports: Espey and Lopez (2000) find the airport in their study to be a disamenity. This stands in contrast to earlier work by Tomkins, et al. (1998), who found proximity to one particular airport to be a net positive amenity.

Railroads: Strand and Vagnes (2001) study the relationship between the price of residential properties and proximity to railroads in Oslo. Bowes and Ihlanfeldt (2001) consider the effect of commuter rail stations on the value of nearby properties.

Parks: Open spaces are not synonymous with parks, but work by Smith, et al. (2002) and by Geoghegan (2002) considers the impact of open spaces on housing prices, suggesting that urban parks may play this role to a certain extent in the more heavily settled examples in this research.

Water Bodies: Poor, et al. (2001), Spalatro and Provencher (2001), and Mahan, et al. (2000) all consider hedonic property models with water features incorporated.

One shortcoming of these data concerning other distances is that they are "snapshot" data based on the present geographic configuration of the local area. We have no way (at reasonable cost) to reconstruct the appearance, during our sample periods, of new airports or new parks, for example. We must rely upon the assumption that each of these features has remained fairly constant over time (the 11 to 30 years of our samples) so that its effects are independent of time. Of course, one could interact each of these distances with annual dummy variables to distinguish year-specific distance effects for each, but the number of regressors would rapidly become even more unmanageable than it is at present.

It must be acknowledged, however, that the emergence (part-way though our sample period) of one of the shopping malls present in our sample in 2000 could distort the apparent effect of distance from a Superfund site in that year. Suppose a shopping mall appears inside the sample area, close to the Superfund site, half-way through the sample period. Suppose further that the presence of the shopping mall causes housing values to increase with proximity to the mall. Prior to the introduction of this mall, the prevailing effect might be the negative effect of proximity to the Superfund site. Proximity to the yet non-existent mall would have no effect.

After the mall appears, however, proximity to the mall will increase prices, but proximity to the Superfund site will decrease it, and the effects essentially wash out. The coefficient on the distance from the mall location would be the average over the whole time period of the zero effects without the mall and the positive effects with the mall, which would be overall positive but smaller than their "true" effects. The coefficients on proximity to the Superfund site are allowed to vary by year, however.

In the hedonic property value literature, there is some discussion about whether local amenities and disamenities should make a fixed difference in the price of a property, regardless of the size of that property, or whether these factors should in fact affect the per-unit-area price of the property. We deem it unlikely that either one of these assumptions is entirely credible. Hence, whenever a local amenity or disamenity enters a model, we explore expanded models with both the amenity/disamenity distance and this distance interacted with the lot size of the property in question. The effect of the amenity on house price (the derivative of expected property price with respect to the amenity or disamenity) is therefore permitted to depend, in a linear fashion, on the size of the property in question. If no such dependence is present in the data, the coefficient on the property size interaction term will be indistinguishable from zero.

The "typical" magnitude of a non-constant marginal effect can sometimes be difficult to appreciate when pondering regression results. Thus we undertake a convenient normalization. Whatever our estimating sample, we first scale the raw data on lot size by the sample average of the lot size variable, so that the sample mean of the scaled variable is one. Then, at the mean lot size in the sample, the marginal effect of an amenity or disamenity that is interacted with lot size will be given simply by the sum of the coefficient on the level of that amenity and the coefficient on the interaction term. If these two coefficients are of opposite signs, the coefficient with the larger absolute value will determine the sign of the effect at the means of the data. This convention is observed for all of our local amenity and disamenity effects: neighborhood socio-demographic and housing stock characteristics, distances from other potentially relevant amenities and disamenities (parks, freeways, etc.), and the effects of distances from the Superfund site in each year.

Montclair We will mention the other distances in the order in which they appear in the estimating models. By using an additively separate specification in the logarithms of "distance to the nearest X," we are of course imposing the strong assumption that the distance gradients relative to all amenities or disamenities of the same type are identical, and that the effect on house prices of proximity to one site is not affected by proximity to another. These are strong assumptions, but given the number of candidate variables, a considerably larger data set would probably be required to discern the magnitudes of these interactions.

For Montclair, we include distances to the nearest summit of land, to the nearest school and nearest retail center (shopping mall). We also use distance to the nearest hospital, church, and cemetery. With respect to surface transportation, we control for distance from a railroad, a major road, Interstate 280 and the Garden State Parkway. We include distance from parks and major bodies of water. Among institutions, we have distance to the nearest college or university and distance to the nearest golf or country club. In addition to controlling for distance from the nearest airport, we include a separate airport distance unique to Newark International Airport. The details for each of these amenities or disamenities are included in Appendix A.

OII: For our housing price model for the OII landfill area, we measure and control for distances from the nearest school, retail center (shopping mall), hospital, church and cemetery. We also control for distance from the nearest railroad and for distances from a number of specific Southern California freeways: Interstate 5, Interstate 605, Interstate 10 and State Route 60. The effects for these distances are in addition to those of the distance from the nearest major road, which may sometimes be one of these freeways, but will often be a large "surface street." We control for distance to the nearest "river" (often seasonal in Southern California) and the nearest major body of water (typically a non-seasonal river constrained within concrete for flood control). The distance to the nearest park is measured, with additional controls for distance from the largest regional park, the Whittier Narrows recreation area. There is one college campus that may be relevant, the California State University at Los Angeles, and we also control for distances from the nearest country club or golf course.

Full details of the features captured by the "other distance" variables for the OII landfill site are included in Appendix B.

Woburn: For Woburn, we control for distance from the nearest summit of land, as well as distances from the nearest school, retail center (shopping mall), hospital, church and cemetery. Along with distance to the nearest railroad, we include a number of different measures of proximity to roads: the distance to Interstates 93 and 95, the distance to the nearest principal artery, the distance to the nearest other principal road, the distance to the nearest road including smaller roads.

Air transportation corridors could also have an effect on housing prices in this area. We control for distance from each of Boston's four airports: Logan airport, Beverly Municipal airport, "Tew-Mac" airport and Hanscom Air Force Base. In addition to the simple distance measures, we also plotted the potential flight paths over the sample area, based on the trajectories of runways at each airport. We then computed the distance from each house to the nearest flight path associated with each airport.

Finally, we include distances to the nearest park, major body of water, and country club. Details concerning each of these types of "other distances" we have computed for the dwellings in the Woburn area sample are contained in Appendix C.

Eagle Mine: The universe of available and potentially relevant "other distance" variables considered in the Eagle mine analysis is displayed below. While we measured distances for variables in the similar classes as those used for other Superfund sites, the distances to many features, for the Eagle Mine sample, were great enough that one would not expect them to have an influence on variations in housing prices within the sample.

Measured distances include distances to the nearest summit (and there are about 20 named summits in the sample area) and to the nearest river, either Eagle River or Gore Creek. Elevation might plausibly explain housing values, but horizontal distances to the nearest summit are likely to be a poor proxy for elevation in this terrain. We also collected information about distances to the nearest school and retail area, hospital, church and cemetery, as usual. Only schools, however, are contained in the sample area and some of the other distances are extremely large (up to 50 miles). The effects of distances from the nearest railroad or road will be confounded by proximity to the nearest river, since the highways and railroad follow either the

Eagle River, or Gore Creek, or both, due to the topography of the area. There are no "major bodies of water" in the area other than the rivers. "Recareas" include three golf clubs, and these may have independent distance effects. Other points of local interest are too heterogeneous to be combined (e.g. campgrounds, ranger stations). The one exception is distance to the Vail ski area.

We did measure distances from each site to the nearest town for seven distinct towns (Avon, Eagle, Eagle-Vail, Leadfille, Minturn, Redcliff, and Vail itself). However, the linear arrangement of houses and towns along Interstate 70, leaves very little independence in these distances. The main distance variable we retain in the model is the distance to the Vail ski area.

A full description of these "other distances" for the Eagle Mine sample is included in Appendix D.

Chapter 9

Property Value Results

9.1 Classes of Hedonic Property Value Models

Our most basic specification, called Model 1, explores for time-varying proximity effects in a generic specification of the following sort:

$$(9.1) \qquad LSPRICE_{it} = \ln(P_t) + (\beta_{10t})LDIST_{it} + \beta_2 A_{iT} + \varepsilon_{it}$$

This model is designed to mimic the most rudimentary type of specification that a researcher might first explore when looking for time-varying distance effects. Distance is interpreted as a proxy for perceived risk. When we estimate each of our models with time-varying distance effects, we test the hypothesis that the profile of the distance premium (i.e. the perceive risk premium) is the same in all years in the sample, since a simpler model yet would not even distinguish distance effects that may vary over time.

The key argument of this research is that time-varying socio-demographics, both near and further away from the Superfund site, can have a systematic effect on housing prices. To determine the effects of demographics when other distances are not controlled, the generic version of Model 2 is:

$$(9.2) \qquad LSPRICE_{it} = \ln(P_t) + (\beta_{10t})LDIST_{it} + \beta_2 A_{iT} + (\beta_{30})S_{it} + \varepsilon_{it}$$

However, the question of whether there are any general proximity effects, at all, cannot be reliably ascertained without controlling for proximity to other amenities and disamenities. The apparent magnitude of the proximity effects across years may be rendered generally higher or lower by controlling for time-constant effects of proximity to other features. Model 3 will take the general form:

$$(9.3) \qquad LSPRICE_{it} = \ln(P_t) + (\beta_{10t})LDIST_{it} + \beta_2 A_{iT} + (\beta_{40})D_{iT} + \varepsilon_{it}$$

This model is similar to the type of model estimated by many previous researchers, although most models of this form control for a rather limited selection of other distances.

Our most complete general model is Model 4, corresponding to Equation 8.2 above, which employs all five classes of regressors: the set of year dummies that reveals the area-wide price index, $\ln(P_t)$; the complete set of interactions between the logarithms of distance from the Superfund site and annual dummy variables, giving $(\beta_{10t})LDIST_{it}$; the structural characteristics, A_{iT}; the other distances, D_{iT}, and the time-varying demographics, S_{it}. In selected cases, we will include other or different variables, such as potential lot size shifters on the key coefficients, or, in the case of Woburn, latitude and longitude shifters for the entire price function, or downstream/non-downstream variables, as in the case of Eagle Mine.

Before we delve into the details of the estimated hedonic property value models, however, it is important to look at some auxiliary models. These models specifically examine the trends over time in the socio-demographic characteristics of the populations both near, and further away from, each Superfund site.

9.2 Auxiliary Models Time-Varying Demographic Patterns

There has been considerable interest in the environmental equity/justice literature about whether hazardous waste sites are selected because the population in the area is relatively lower income, has a larger proportion of minorities, or unlikely to organize to resist a siting decision. The Superfund sites in our sample are not new siting decisions. These sites were in place before much of the residential development around them began to occur. [See the approximate timelines listed above.] Much of the population around the site has accumulated during or since the time the site was in operation. The environmentally relevant "events" in our cases are not decisions to site a new facility, but the news surrounding each site's designation as a Superfund site and the resulting deliberation about cleanup strategies and actual remediation. So in this context, it is not so much the siting decision that matters, but the consequences over time of the publicity about the site's Superfund status, and therefore public awareness of the site and the hazards that it may represent. Perceived risk is assumed to vary over time, and should also vary over space in a way that is approximately correlated with possible exposure.

It is difficult to reconstruct reliable time-series of neighborhood socio-demographic characteristics. As Gayer (2000) points out, Census block groups allow a more refined measure of a dwelling's neighborhood than the Census tract. However, even Census tracts pose problems for splicing together data across different Censuses. Tracts tend to be split as density increases, and it is enough of a challenge to construct a time series at the tract level, since coding categories change across time. We constructed a set of characteristics that aggregated socio-demographic groups sufficiently to afford a match across decennial Censuses and aggregated Census tracts to a common denominator across years. This leads to a loss of some resolution both in detail and spatially, compared to what is available if one relies solely on the 1990 Census, for example.[6] However, we deem it important for us to use a comparable set of variables across the three samples where this strategy is feasible. We also need to approximate neighborhood characteristics for years that span the 1970's, 1980's and 1990's, which requires conformation across four different Censuses.

One of the most significant empirical enquiries into the effects of hazardous waste sites on local demographics is described in Been and Gupta (1997). These researchers identify 608 commercial hazardous waste treatment, storage, and disposal facilities opened between 1970 and 1990. They collect Census data for the Census prior to the opening, and for 1990 for each of these tracts. As controls, they draw a random 5% sample of all tracts in the U.S. They analyze "before" demographics and "after" demographics, but of primary interest in the context of the present work is their study of the difference-in-differences between the host tracts and all other tracts, between the Census prior to the facility opening and 1990. As multivariate analyses, these researchers pooled the host and non-host Census tracts and regressed the 1990 values for each demographic characteristic (in percentage terms) against the value of this variable in the Census prior to the siting, along with a dummy variable for whether the tract hosted a site.

Using these empirical techniques, Been and Gupta (1997) conclude that their study "does not support the argument that market dynamics following a siting of a TSDF change the racial, ethnic, or socioeconomic characteristics of host neighborhoods. The analysis suggests that the areas surrounding TSDFs sited in the 1970s and 1980s are growth areas: in host areas, the

[6] Only "short-form" 2000 Census statistics are available at the Census tract level as of this writing.

number of vacant housing units was lower than in sample areas, and the percentage of housing built in the prior decade was higher. Such growth suggests that the market for land in the host areas is active and should respond to any nuisance created by the TSDFs. It also may suggest that the burdens of the TSDF are being off-set by the benefits, such as increased employment opportunities."

As Liu (1997) prescribes, any assessment of market dynamics as a potential explanation for neighborhood change around a locally undesirable land use requires controlling both for the characteristics of the neighborhood before a siting decision and for changes in other neighborhoods. The Been and Gupta (1997) approach uses randomly selected Census tracts elsewhere in the country as a control for what is happening in "other neighborhoods." Here, we control for patterns in other neighborhoods by enlisting the broader area around the host tract as control tracts. Rather than looking for discrete differences in socio-demographic characteristics between a host tract and tracts that are greatly displaced in terms of distance, we look for patterns in demographics over time that differ continuously with distance from our Superfund sites. If the socio-demographic patterns near the site are indistinguishable from those farther away the distance gradient relative to the site will be flat. Depending upon conditions at the beginning of our sample periods, there may be other reasons why we might observe a positive or negative distance gradient in socio-demographic characteristics. What matters, however, is how this gradient changes over time. If white residents tend to move out, and non-white residents to move in, in the wake of publicity about Superfund designation and remediation, then the distance gradient for whites should be observed to become relatively more positively sloped (or less negatively sloped) with time. Likewise, the distance gradient for non-whites would be expected to become less positively sloped (or more negatively sloped) over time.

In the auxiliary models described in this section, we explore the simple trends in demographics near our four Superfund sites over time. Each observation is a house sale, and for each observation we know the log of the distance from the site in question. As dependent variables, we use the Census tract proportions of inhabitants in each class, pX, where X is a Census category. These are the neighborhood characteristics associated with each house in our main sample. In future work, we plan to aggregate the analysis to consider each Census tract as a unit of observation, but for now we preserve houses as observations since this will most clearly highlight the multicollinearities present in our main hedonic property value models. For the purposes of these main models, we interpolate the information for each Census tract across time to provide approximate time series for each variable.

We assess the propensity for lower-income families, non-whites, and non-traditional families to "come to the nuisance," possibly attracted by lower housing prices brought about by taint from the Superfund site. The models we examine regress proportions for each socio-demographic and housing tenure characteristic, across Census tracts and over time, against a measure of distance, a time trend, and an interaction between distance and time. We use the log of distance, since this transformation is important in our main hedonic property value models. The log transformation allows any effect of proximity to the Superfund site to dissipate with distance until, in the limit, further increases in distance have very little effect on socio-demographic proportions. This is a reasonable maintained hypothesis, since the "reach" of influence of any particular Superfund site must be finite.

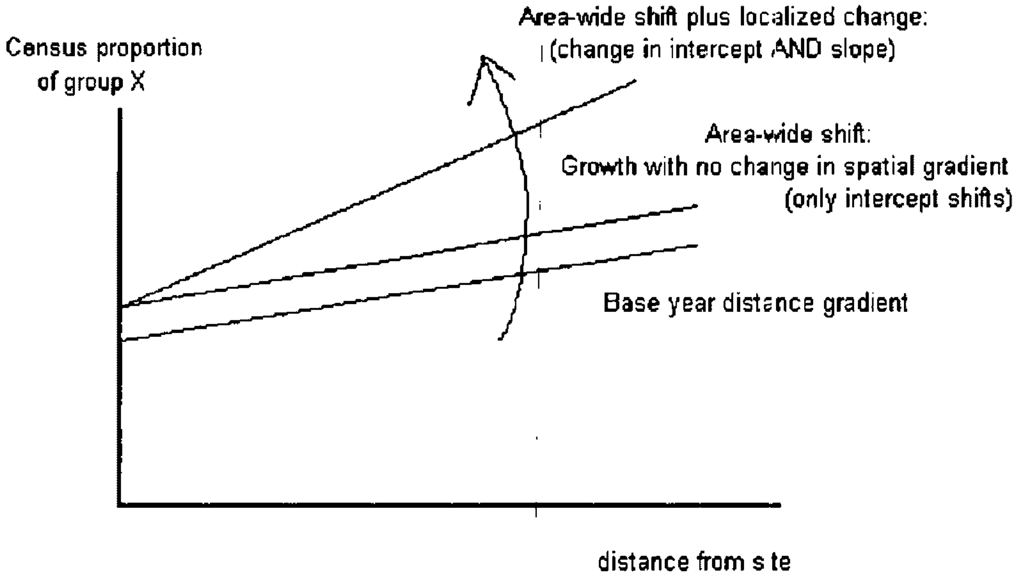
Our specifications take the following simple form:

$$pX_{it} = \alpha_0 + \alpha_1 LDIST_{it} + \alpha_2 t + \alpha_3 t \cdot LDIST_{it} + v_{it} \qquad (9.4)$$

Using the log of distance from the site permits the marginal effect of distance on proportions to decline with distance, since as distance increases, the same percent change in distance corresponds to a greater and greater increment of distance. This functional form assumes that the effect of a percent change in distance is constant.

The effect of the log of distance from the Superfund site on the neighborhood proportion of a given group is given by $\alpha_1 + \alpha_3 t$. The effect of the passage of time on the neighborhood proportion of a given group is given by $\alpha_2 + \alpha_3 LDIST_{it}$. If the distance profile for the proportion of residents of a particular type is merely shifting upwards or downward everywhere in the region, we would expect to see α_2 nonzero, but $\alpha_3 = 0$. In contrast, if the distance profile is changing systematically over time, we will see $\alpha_3 < 0$ if this group is becoming relatively more numerous near the Superfund site, and $\alpha_3 > 0$ if this group is becoming relatively less numerous near the Superfund site (Figure 9.1).

Figure 9.1 Changes in Socio-demographics near Superfund site over time



In the Montclair case, there is not only a distance variable measured from the perimeter of the nearest site for houses outside the sites, there is also a dummy variable indicating whether the dwelling in question is inside the site boundaries. In this case, Equation 9.4 will be adapted to:

$$pX_{it} = \alpha_0 + \alpha_1 LDIST_{it} + \alpha_2 t + \alpha_3 t \cdot LDIST_{it} + \alpha_4 INSIDE_{it} + \alpha_5 t \cdot INSIDE_{it} + \nu_{it} \quad (9.5)$$

In reporting these results, we concentrate on the estimated value of α_3 (and α_5 in the Montclair case) for each type of Census group, X, for each of the Superfund sites for which we are able to employ Census tract characteristics (i.e. all sites except Eagle Mine). In the case of groups becoming relatively more numerous throughout our sample areas, independent of distance from the Superfund site, any effects of these changes on housing prices will be picked up by the estimated area-wide price index, P_t, that is captured by the set of year dummies in the model for $LSPRICE_{it}$.

In perusing the estimated values of α_3 in the tables that follow, keep in mind that the dependent variable is constant for all houses in a particular Census tract in a particular year. To the extent that this variable does not perfectly reflect the "neighborhood" that is relevant to the house sale in question, there will be a degree of error in this dependent variable. The explanatory variables, distance and year, are observation-specific.[7]

It must also be acknowledged that these specifications constrain the time trends to be monotonic. If they are non-monotonic, perhaps first increasing then decreasing, for example, or vice versa, this would tend to obscure any trends.

(9.6) $$pX_{it} = \alpha_0 + \alpha_1 LDIST_{it} + \alpha_2 t + \alpha_3 t \cdot LDIST_{it} + \alpha_4 t^2 + \alpha_5 t^2 \cdot LDIST_{it} + \nu_{it}$$

This specification yields a distance gradient for Census tract characteristic X in the form of

(9.7) $$\frac{\partial pX_{it}}{\partial LDIST_{it}} = \alpha_1 + \alpha_3 t + \alpha_5 t^2, \text{ or}$$
$$\frac{\partial pX_{it}}{\partial DIST_{it}} = \frac{\alpha_1 + \alpha_3 t + \alpha_5 t^2}{DIST_{it}}$$

This implies that the effect will decrease with distance, and is quadratic in time, if the α_5 coefficient is significantly different from zero. The fitted turning point occurs at $t^* = -\alpha_3/(2\alpha_5)$. If t^* lies within the range of the data, the fitted time trend in the Superfund

[7] There is an alternative strategy, which we are currently exploring. We find the effective center of gravity for the all the houses in each Census tract across all years by computing the mean latitude and mean longitude of these houses. We then locate these centers of gravity in our GIS software and use ArcMap to measure the distance from each tract centroid to the boundary (or center) of the Superfund site. The number of observations can then be limited to just actual Census years and individual or merged tracts that can be conformed across all Census years. In these more limited data, we lose the resolution on distance for each house, but avoid the spurious estimation precision that accompanies the use of the same Census tract information for all houses in a tract and smoothes the time profile by interpolating. These results are not yet finalized.

distance profile of Census characteristic X changes sign. If t^* lies beyond the range of the data, the trend is approximately monotonic.

We have explored the data for evidence of significance in quadratic terms and found some evidence. But one must bear in mind that the underlying real data consist of only four decennial snapshots of neighborhood characteristics. The interpolated data are only approximate. Given the quality of the data, we do not deem it judicious to push too hard on this generalization.

In this research, we report only the key coefficient estimates, and their standard errors, for the α_3 coefficient in Equation 9.4. The rest of the results for each model for each Census tract attribute are presented in Appendices A through D. The appendices also illustrate the progression of fitted distance profiles over time, with the heavier line in each graph depicting the first-year in the sample and the progression being captured by representative intervening years between then and the end of the sample period.

9.2.1 Montclair

There are significant numbers of observations from each of over 60 different Census tracts represented in the Montclair sample, so there is considerable variation in tract characteristics across the sample in any one year, and also in the interpolated time series within each tract.

The Montclair model for each Census tract characteristic differentiates between distance effects, implied by α_3, and the effect of being on top of one of the radium sites, α_5. Only these two coefficients for each model are presented in the following table. The rest of the results for each model are presented in Appendix A.

Table 9.1 Montclair Census Tract Proportion Coefficient

Census tract proportion	α_3 Coefficient (robust t-test statistic)	α_5 Coefficient (robust t-test statistic)
pfemale	.0000813 1.33	.00078 2.94***
pwhite	.0028637 3.00***	-.0171576 -3.84***
pblack	-.0033634 -3.39***	.0184994 4.13***
pother	.0003952 1.85*	-.0013925 -1.03

page_under5	-.000146 -3.98***	-.0000739 -0.38
page_5_29	-.0005365 -3.00***	.0012068 1.68*
page_30_64	-.000451 -3.33***	-.0007805 -1.16
page_65_up	.001029 6.10***	-.000403 -0.57
pmarhh_chd	-.0005364 -1.79*	.0002539 0.18
pmhh_child	-2.45e-06 -0.06	.0002933 1.68*
pfhh_child	-.0003317 -1.90*	.002167 2.54***
powner_occ	-.0002585 -0.26	-.0023418 -0.45
pvacant	-.0000826 -1.11	-.0002405 -0.50
prenter_occ	.0003412 0.36	.0025831 0.53

Over the 1987-1997 time period for which we have data for the Montclair area, we will first consider changes in the distance profile of relative concentration for different groups. The α_3 coefficient if negative, conveys that the group in question has been becoming *more* concentrated closer to the Superfund site. Groups that have become statistically significantly more prevalent nearer the site include: blacks, children under 5, young people aged 5-29 and people aged 30-64, as well as (possibly) married heads of household with children and female-headed households with children. Positive α_3 coefficients indicate that a group has become relatively less numerous closer to the site. These groups include whites and seniors, and possibly other non-white ethnic groups.

For houses inside the contaminated areas, a positive α_5 coefficient implies an increase in the proportion of that group over time. The relative share of female residents has become statistically significantly higher over time here, as has the proportion of blacks, female-headed households with children, and possibly young persons between the ages of 5 and 29 and male heads of household with children. In contrast, whites have tended to move away from the contaminated areas.

One notable feature of these results is that there seem to have been no systematic effects on housing tenure or vacancy rates, either on top of the Montclair sites, or close to them.

9.2.2 OII

There are over 50 different Census tracts around the OII landfill. This creates a diversity of different values for neighborhood effects within any one year, and more variation across years in the interpolated Census tract data.

In the 1960's and 1970's, Asian emigrants began to populate what had been a mostly white bedroom community. By the 1980s, racial tension between longtime residents and new immigrants became significant, leading to a controversial law requiring English on business signs, Chinese books in the public library and attempts to make English the city's official language. Racial problems have now mostly subsided and Monterey Park has become the only city in the San Gabriel Valley with an Asian majority.

The pattern in this Southern California community is somewhat different from that in the Montclair and Woburn cases. Our conformable Census measures do not include a distinct category for Asian ethnic groups, so these populations are captured by the "pother" category. Again, only the key α_3 coefficient for each model is presented in the following table. The remainder of the results for each model appear in Appendix B.

Table 9.2 OII Census Tract Proportion Coefficients

Census tract proportion	α_3 Coefficient (with robust t-test statistic)
pfemale	-.0000198 -1.27
pwhite	-.0018906 -10.81***
pblack	.000019 2.57***
pother	.0020202 11.42***
page_under5	.0000226 0.92
page_5_29	.0002393 4.20***
page_30_64	.0003549 6.10***
page_65_up	-.0004772 -10.35***
pmarhh_chd	.0009305 9.33***
pmhh_child	-.0002995 -8.45***
pfhh_child	.0000927 2.21***
powner_occ	.0009346 4.05***
pvacant	.000279 15.02***
prenter_occ	-.0012124 -5.54***

Over the 1970-1999 time period for which we have data for the vicinity of the OII landfill site, groups that have become relatively *more* numerous nearer the site include: whites, seniors, and male heads of household with children (although this last group is very small everywhere). The relative increase in whites near the site could be the flip side of a relative increase in Asian groups at locations further way from the Superfund site. In an area experiencing a wave of immigration, if immigrants avoid tainted neighborhoods and settle away from them, the older racial mix of inhabitants will persist nearer the site. Renter-occupied housing has also become more common near the site.

The groups that have become significantly relatively *less* numerous nearer the site include blacks, and especially other non-whites (including Asians), as well young people aged 5-29, middle aged persons aged 30-64, married heads of household with children and female heads of household with children. Owner occupied housing has become less prevalent near the site, but so have vacant properties. There has been little discernible change in the relative abundance near the site of women or children under 5.

Graphical depictions of the implications of these models are presented along with complete regression results in Appendix B.

9.2.3 Woburn

Our estimating sample contains significant amounts of data from 22 different Census tracts in the Woburn area. Again, only the estimates for α_3 for each model are presented in the following table. The estimates of these key coefficients control for the baseline trend in concentrations with distance, and for trends in the area-wide concentration of each group. See Appendix C for more details on the remaining coefficients in each model.

Table 9.3 Woburn Census Tract Proportion Coefficients

Census tract proportion	α_3 Coefficient (with robust t-test statistic)
pfemale	.0000174 0.42
pwhite	.0019515 14.34***
pblack	-.0003281 -14.38***
pother	-.0024137 -14.64***

page_under5	.0002072	5.33***
page_5_29	-.0003548	-1.93*
page_30_64	.0001168	0.93
page_65_up	-.0000607	-0.41
pmarhh_chd	.0016572	6.66***
pmhh_child	-.000145	-11.20***
pfhh_child	-.0006561	-10.69***
powner_occ	-2.66911	-1.54
pvacant	-.0003236	-9.13***
prenter_occ	-.0033483	-7.69***

Over the 1978-1997 time period for which we have data for the Woburn area, groups that have become *relatively* more numerous *nearer* the site include: blacks, other non-white groups, the age 5-29 group, male heads of household with children, female headed households with children, vacant properties, and rental properties. Groups that have become relatively less numerous near the site include: whites, children under 5, and households with children headed by married couples. Groups for which there has been little discernible change in the relative abundance near the site are: females, persons between the ages of 30 and 64, seniors, owner occupants.

Woburn was incorporated in 1652 and leather, tanning, and boot and shoe production was the main industry from the mid-1800's to 1915. Suburban growth began in the mid-1900's and has continued. The site has been described extensively by other authors, including Kiel (1995) and Kiel and Zabel (2001).

9.2.4 Eagle Mine

There are insufficient numbers of Census tracts represented around the Eagle Mine site to allow an analysis of trends in Census tract attributes associated with house sales over time.

9.2.5 Synthesis

It seems eminently clear that there is a strong tendency for fundamental neighborhood change in the wake of a Superfund identification and remediation process. The property prices we use from our analysis stem from house sales, and every time there is a house sale, the occupants of that dwelling typically change. Who moves out and where they choose to go, and who moves in, determines the change in the composition of the community in the vicinity of a site. If the negative price shock accompanying a Superfund designation and the cleanup process make housing in the vicinity of the site more affordable to lower income households, unconventional households, ethnic minorities, or absentee landlords, a sufficient number of sales can detectibly alter the makeup of the community.

There is a considerable literature in urban economics concerning the mechanisms of neighborhood change (invasion-succession, tipping). The precipitating agent for the process, in our cases, seems likely to have been the identification of the Superfund site.

Empirical models may fail to control for neighborhood change over time as a Superfund identification and remediation process takes place. This can lead to omitted variables bias that creates the impression that the Superfund process "taints" a neighborhood long after the site itself has been cleaned up. In reality, what accounts for the persistent negative price differential closer to the site could be the gradient in socio-demographic and income classes approaching the site.

With site-induced neighborhood change, this "income-socio-demographic" gradient will masquerade as a persistent "Superfund site proximity" gradient. When the site is clean, it may be that nobody in the neighborhood or beyond is the least worried about any residual hazard. In fact, having been certifiably cleaned, the site may even appear safer and more environmentally attractive than competing uncertified areas elsewhere in the region. The true post-cleanup "environmental gradient" might even display higher property prices near the cleaned site. However, if one fails to control for the changed "income-socio-demographic gradient," it is possible to misidentify the phenomenon as a persistent taint or perceived risk due to the site.

9.3 Auxiliary Models: Time-Varying Housing Attributes

The housing stock in a region can change more slowly than the characteristics of the population. Many houses are remodeled and updated, sometimes to include additional bathrooms or perhaps bedrooms, lots are subdivided in order to permit increases in density. In this section, we examine the trends over time in the average characteristics of houses sold, as a function of their distance from each Superfund site. To the extent that the housing stock around a Superfund site is not upgraded or renovated at the same rate as dwellings in the more distant surrounding area, this decline in the relative quality of the housing stock can account for persistent negative price differentials in the region nearest the site. In the text of this research, we report only the most significant effects. For complete models, see the Appendices A-D associate with each site.

The same basic estimating models used for Census tract proportions of different groups in the neighborhood around the site are used in this section (either Equation 9.4, or 9.5 for Montclair). Now, however, the dependent variables are not all proportions of the population of persons, households, or structures. Instead, the dependent variables are discrete or continuous measures of structural attributes of each house itself.

9.3.1 Montclair

For the Montclair site, the data provide very few housing attributes to use in the property value model. We exploit the age variable as completely as possible and substitute the most recent tax assessor's "value of improvements" as a proxy for the current quality of the housing stock. Interpretation of "impval" as a dependent variable is therefore somewhat problematic. We do not observe its value contemporaneously with the sale of the house, but only currently.

Table 9.4 Montclair Housing Attribute Coefficient

Housing Attribute	α_3 Coefficient (robust t-test statistic)	α_5 Coefficient (robust t-test statistic)
knowflr	-.0032718 -2.30***	-.0065508 -0.73
floors*	.0029175 1.45	.0123721 1.00
ageknown	-.0045979 -2.71***	-.000424 -0.04
age10*	-.0002659 -0.41	.0126552 1.52
age20*	-.0009382 -1.80*	-.0023625 -0.76
age30*	-.0005861 -0.51	-.0050581 -0.59
age40*	-.0111006 -5.79***	-.0137029 -1.13
age50*	.0055656 2.93***	-.0093004 -0.87
age60*	.0016836 0.94	-.002016 -0.33
age70*	.0053225 2.12**	.0208763 1.55
age70plus*	.0003191 0.10	-.0010915 -0.06
age*	.2577415 1.61	.1463102 0.13

lot size	.0002315 0.08	.015799 1.41
* in first column: if data observed;		

The statistically insignificant α_5 coefficients indicate that none of the information about age, floors, or lot size for the Montclair properties displays any tendency to change systematically over time for houses located on top of any of the radium contaminated sites.

The age dummy variables, capturing decade intervals of age for each house at the time it was sold for the observed price, show a few notable patterns. The relative proportion of houses that are less than 40 years old at the time of sale (age40=1) seems to have been increasing nearer the site. The relative proportion of houses more than 40 years old at the time of sale has been falling nearer the sites.

9.3.2 OII

Table 9.5 OII Housing Attribute Coefficient

Housing Attribute	α_3 Coefficient (with robust t-test statistic)
age	-.0009755 -0.06
sqft	.0007751 1.03
bedrms	.0020337 1.55
bthrms	.0006031 0.53
fplace	.0022162 3.20***
knowflr	.002548 4.76***
floors*	.0038295 4.12***
lot size	.0026144 3.98***
* calculated only for observations where data are observed	

In the OII sample, the houses sold which are nearest the landfill site are not becoming relatively older than are those at locations further away. More distant houses are also becoming more likely to have fireplaces, to have more than one floor, and to be situated on larger lots.

Lot sizes are getting relatively smaller nearest the site. This suggests more subdivision or R-2 zoning in this area than in more distant areas, where lot sizes are being preserved. R-2 zoning increases density and makes a neighborhood less attractive to many potential homeowners. Lot sizes do not appear to be shrinking farther away from the site.

9.3.3 Woburn

Table 9.6 Woburn Housing Attribute Coefficients

Housing Attribute	α_3 Coefficient (with robust t-test statistic)
notold	6.06e-06 0.01
age*	-.3173891 -3.99***
sqft	.0026118 1.00
bedrms	.0042233 1.33
bthrms	.0109726 3.75***
fplace	-.0060986 -3.52***
knowflr	-.0152776 -8.89***
floors*	-.0051249 -1.59
lot size	-.0026604 -1.04
* calculated only for observations where data are observed	

Over time, houses which are sold nearer the site are becoming differentially older than those sold elsewhere in the sample area. Number of baths per house are increasing over time at points more distant from the site, but not nearby the site. Fireplaces are becoming a more commonplace feature in houses sold at points farther from the site. All this points towards a conclusion that the housing stock nearest the site is not undergoing the amount of renewal and there is not as much new construction near the site as there is elsewhere. If the housing stock near the Superfund site is in decline compared to the stock elsewhere, then it is not surprising if observed housing prices persist in being lower near the site than elsewhere in the sample.

9.3.4 Eagle Mine

The Eagle Mine data come from a different source than the data for the other sites, so the available structural variables are somewhat different.

9.3.5 Synthesis

In none of our examples does it appear that the housing stock nearest the Superfund site is being renewed and upgraded at the same rate as housing at locations further removed from the site. It may be the case that after a sufficient period of time has passed following a cleanup project, and the site is designated as "safe" that homeowners in the area will again undertake to accelerate maintenance of the housing stock to bring it back into line with the typical housing stock in the surrounding area. However, if lower-income homeowners have moved into the area, and if rental rates have increased, this may not set the stage for such accelerated renewal of the stock. Despite cleanup, housing price may remain lower than the surrounding area due to deferred maintenance and slower remodeling schedules or teardowns and replacements.

As in the case of the "income-socio-demographic" gradient created by earlier price differentials due to the Superfund identification and cleanup process, we may see a "deferred maintenance" gradient come into being relative to the location of the Superfund site. To the extent that degradation of the housing stock accompanies a Superfund experience and the attendant income and socio-demographic changes, and persists beyond the end of the cleanup process, this factor may also masquerade as a persistent environmental taint.

9.4 Hedonic Property Value Models with Time-Varying Proximity Effects

Due to the very large number of control variables, and hence estimated coefficients, in each of the models we estimate, we limit our discussion in the text of this research to the properties of the key set of year-specific coefficients that describe the elasticity of selling prices with respect to distance from the Superfund site, by year.

Our key results will be displayed in tables that merely note the presence or absence of the other types of regressors in the specification. An extensive appendix for each site contains the full specifications and other supporting statistical results. In the text of this research, we limit our attention to specifications that constrain the lot size effects to be zero. In some cases, these lot size effects are individually statistically significant, but including this generalization in the model does not alter the general weight of the findings in any case, so we do not emphasize those results.

9.4.1 Montclair

The format of the estimating model for the Montclair sample is somewhat different from the generic specification. Suppressing the β_{11t}, β_{31}, and β_{41} parameters on the lot size interaction terms, the Montclair estimating model is:

$$(9.8)\quad LSPRICE_{it} = \ln(P_t) + (\beta_{00t})INSIDE_{it} + (\beta_{10t})LDIST_{it} + \beta_2 A_{iT} + (\beta_{30})S_{it} + (\beta_{L0})D_{iT} + \varepsilon_{it}$$

Recall that since there are houses being sold that lie inside the boundaries of the radium sites in the Montclair area, we include year-specific dummy variables, $INSIDE_{it}$, for these houses. The coefficients on these variables may also be permitted to vary systematically with lot size, but this interaction is suppressed in this equation. For houses outside the radium sites, we compute the distance from the boundary of the site to each house.

If the radium contamination negatively affects housing prices, we expect the coefficients β_{00t}, in some or all years, will be negative. If proximity to the radium contamination depresses housing prices in some or all years, we expect the coefficients β_{10t} to be positive in those years, reflecting the increase in average selling prices at locations further away from the boundaries of these sites.

The change in neighborhood characteristics over time, in the vicinity of a Superfund site, can contribute to the changes in observed property values that have nothing to do with levels of perceived risk over time.

Table 9.7 presents the portion of the results for the Montclair sample concerning the price differentials for being on top of the site, as well as the distance coefficients intended to capture perceived risks. Complete results are presented in Appendix A.

Table 9.7 Montclair

	Model 1		Model 2		Model 3		Model 4	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
inside87	-.0657	(-.41)	-.06151	(-.38)	-.0907	(-.56)	-.06221	(-.38)
inside88	-.1609	(-.92)	-.1263	(-.7)	-.2015	(-1.15)	-.1822	(-1.01)
inside89	-.0995	(-2.23)**	-.07226	(-1.36)	-.1029	(-2.08)**	-.06194	(-1.1)
inside90	-.02656	(-.56)	.04012	(.76)	-.03043	(-.67)	.01035	(.19)
inside91	-.5115	(-2.28)**	-.4604	(-2.1)**	-.5175	(-2.29)**	-.4786	(-2.13)**
inside92	-.08959	(-1.06)	-.02405	(-.29)	-.1016	(-1.11)	-.05251	(-.58)
inside93	-.2383	(-2)**	-.1378	(-1.13)	-.2408	(-2.02)**	-.1809	(-1.48)
inside94	-.06177	(-1.58)	-.0458	(-1.27)	-.03933	(-.87)	-.041	(-.97)
inside95	-.05908	(-1.33)	-.04211	(-.95)	-.06601	(-1.35)	-.05923	(-1.14)
inside96	-.1324	(-1.94)*	-.1386	(-2.09)**	-.131	(-1.96)**	-.1389	(-2)**
inside97	-.1899	(-.98)	-.205	(-1.1)	-.246	(-1.21)	-.243	(-1.23)
ldis87	-.02189	(-.84)	-.06202	(-2.35)***	-.03166	(-1.24)	-.06222	(-2.39)***
ldis88	.03968	(1.83)*	.01417	(.7)	.0374	(1.76)*	.02204	(1.09)
ldis89	.008715	(.87)	-.02332	(-2.34)***	-.003609	(-.33)	-.02613	(-2.31)**
ldis90	.03492	(2.62)***	-.0007486	(-.06)	.02711	(1.96)**	-.00106	(-.08)
ldis91	.04532	(3.8)***	.02125	(1.83)*	.03412	(2.78)***	.01903	(1.57)
ldis92	.0368	(3.04)***	.008775	(.8)	.02854	(2.32)**	.01049	(.89)
ldis93	.03403	(3.74)***	.01032	(1.19)	.02741	(2.88)***	.01467	(1.59)
ldis94	.05929	(4.19)***	.03949	(2.73)***	.04881	(3.31)***	.04154	(2.74)***
ldis95	.0551	(5.34)***	.03157	(3.16)***	.04518	(4.1)***	.03649	(3.37)***
ldis96	.04956	(4.46)***	.03363	(3.13)***	.04136	(3.57)***	.03739	(3.27)***
ldis97	.09538	(5.62)***	.08996	(5.26)***	.08389	(4.96)***	.09065	(5.37)***
structure	yes		yes		yes		yes	
other distances	no		no		yes		yes	
neighborhood characteristics	no		yes		no		yes	
years	yes		yes		yes		yes	

9.4.1.1 Model 1: No Census Variables or Other Distances

At the Montclair site, the problem was identified prior to the beginning of our data. The first Record of Decision was issued in 1989, whereupon remediation could begin. Remediation was essentially completed by 1997, at the end of our sample period. We are looking for statistically significant price differentials associated with a house being on top of one of the radium contaminated areas, and/or positive coefficients on the log distance variables, suggesting a premium for houses at locations which are exposed to lower risks. We find negative coefficients on the INSIDE dummies in all years, and statistically significant coefficients in 1989, the year of the first ROD, in 1991, in 1993, and again in 1996. The distance premia in this model are all positive after 1987 and statistically significantly different from zero in all years after 1989. These results would suggest significant perceived risks closer to the site.

9.4.1.2 Model 2: Including Census Variables

When we control for variations over time in the socio-demographic makeup of the population near the site, compared to changes elsewhere in the study area, we find that the point estimates for all of the decrements in house value on top of the site shrink in size up until 1996, and only the decrements for 1991 and 1996 remain individually significant. The distance effects actually change sign in the early years, becoming statistically significantly negative in 1987 and 1989, and they lose their statistical significance in 1990 through 1993. If distance captures perceived risk, this perceived risk is only evident in housing prices during 1994-1997, and its magnitude is diminished from what was suggested in Model 1.

In the rest of the results for Model 2, reported in Appendix A, it is notable that the proportion of blacks in the neighborhood makes a very strongly significant positive difference in housing prices in this context. Appendix A also shows changes in the degree of racial integration across the different Census tracts over time. There are several predominantly black communities and several predominantly white communities. Some of these remain strongly segregated throughout the sample period, but a wide range of other communities in the area has become considerably more integrated. Blacks, in particular, have moved nearer to the Superfund site in considerable numbers. It also seems somewhat counter-intuitive that housing prices are highest where there is a higher proportion of vacant dwellings and a higher proportion of renter-occupied units.

9.4.1.3 Model 3: Including Other Distances

When we include only other distances in Model 3, and leave out the Census variables, the patterns in terms of the Superfund proximity variables exhibited in Model 1 are mostly restored, although the point estimates of the distance (perceived risk) effects shrink very slightly. The other distance effects, reported in Appendix A, seem to imply that high points of land (for New Jersey), retail centers, hospitals, roads, Interstate 280, and especially the Garden State Parkway, major water bodies (again, this is New Jersey), and Newark International Airport are considered to be disamenities. Desirable features include: cemeteries, parks, colleges, and airports other than Newark International. All of these seem to qualify as examples of open space, to some extent.

9.4.1.4 Model 4: Both Census Data and Other Distances

This final model wherein the coefficients on neighborhood characteristics and other distances do not depend upon lot sizes more or less preserves the same results obtained for the Superfund site proximity variables attained separately in Models 2 and 3.

9.4.1.5 Models with Lot size Interaction Terms

In Table 9.8, we present just the coefficients on the Superfund proximity variables, but in these four models, we now interact all of the proximity variables, the neighborhood characteristics variables, and other distances variables with lot size to determine whether the premium or discount associate with different attributes is independent of lot size or changes with the size of the parcel in question. Recall that lot sizes are scaled to equal one at the means of the data, to aid in the interpretation of the estimates. At the means of the data, the effective slope coefficient will be the sum of the base coefficient and the coefficient on the lot size interaction term. These models can reveal whether the losses in property values near a Superfund site are borne disproportionately by homeowners selling smaller properties, or whether they are borne disproportionately by homeowners selling larger properties.

Table 9.8 Montclair (with lot size interactions)

	Model 1		Model 2		Model 3		Model 4	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
inside87	1.204	(1.57)	1.328	(1.74)*	1.312	(1.76)*	1.32	(1.72)*
inside88	-.2893	(-1.16)	-.314	(-1.23)	-.2724	(-1.09)	-.2131	(-.81)
inside89	-.156	(-2.17)**	-.09118	(-1.09)	-.1442	(-1.79)*	-.05622	(-.54)
inside90	.03244	(.51)	.07578	(1.04)	.08889	(1.11)	.115	(1.41)
inside91	-.8026	(-2.52)***	-.7539	(-2.39)***	-.8318	(-2.6)***	-.7885	(-2.45)***
inside92	.1341	(1.11)	.1988	(1.65)*	.1736	(1.39)	.2425	(1.9)*
inside93	-.4908	(-1.95)*	-.4436	(-1.83)*	-.4005	(-1.64)	-.3638	(-1.5)
inside94	.08437	(1.05)	.1083	(1.37)	.1253	(1.38)	.1475	(1.56)
inside95	-.01186	(-.08)	-.01322	(-.09)	.03542	(.2)	.001388	(.01)
inside96	.02536	(.28)	.04732	(.54)	.0682	(.75)	.03598	(.36)
inside97	.1995	(.62)	.1772	(.54)	.235	(.72)	.1947	(.57)
ldis87	-2.032	(-1.5)	-2.211	(-1.63)	-2.242	(-1.7)*	-2.195	(-1.61)
ldis88	.2354	(.71)	.3521	(1.02)	.1583	(.48)	.1111	(.31)
ldis89	.08432	(1.63)	.005509	(.08)	.06731	(.85)	.002244	(.02)
ldis90	-.08558	(-1.2)	-.07026	(-.67)	-.1523	(-1.92)*	-.1619	(-1.69)*
ldis91	.4007	(2.08)**	.409	(2.1)**	.4514	(2.3)**	.4508	(2.24)**
ldis92	-.2878	(-1.33)	-.3188	(-1.47)	-.3377	(-1.52)	-.3933	(-1.73)*
ldis93	.2283	(1.65)*	.2368	(1.7)*	.1408	(1.07)	.1374	(1)
ldis94	-.2021	(-2.08)**	-.2102	(-2.07)**	-.2235	(-1.92)*	-.2371	(-1.84)*
ldis95	-.07835	(-.31)	-.0282	(-.11)	-.14	(-.43)	-.05203	(-.19)
ldis96	-.1843	(-1.85)*	-.2274	(-2.16)**	-.2392	(-2.16)**	-.1943	(-1.52)
ldis97	-.5096	(-.86)	-.491	(-.81)	-.598	(-1)	-.5287	(-.84)
vinside87	-.04527	(-1.34)	-.06673	(-1.98)**	-.06854	(-2.06)**	-.08702	(-2.61)***
vinside88	.02927	(1.04)	.001667	(.06)	.01633	(.59)	-.007	(-.26)
vinside89	.04006	(2.54)***	.01334	(.8)	.01808	(1.13)	-.009747	(-.53)
vinside90	.0554	(2.81)***	.02067	(1.15)	.01132	(.57)	-.02621	(-1.33)
vinside91	.06625	(3.6)***	.05084	(2.85)***	.03852	(2.16)**	.02363	(1.23)
vinside92	.05323	(2.85)***	.02485	(1.44)	.02719	(1.47)	.00332	(.18)
vinside93	.07795	(4.94)***	.05211	(3.38)***	.04443	(2.76)***	.03258	(1.97)**
vinside94	.05488	(2.63)***	.04984	(2.36)***	.02964	(1.36)	.02317	(1.02)
vinside95	.0653	(3.54)***	.04575	(2.19)**	.02722	(1.37)	.01563	(.74)
vinside96	.07897	(4.55)***	.07134	(4.05)***	.04789	(2.66)***	.04409	(2.26)**
vinside97	.06813	(2.3)**	.08531	(2.76)***	.05896	(2.05)**	.0669	(2.22)**
vldis87	.02719	(.94)	.002705	(.09)	.03459	(1.15)	.02197	(.75)
vldis88	.01052	(.53)	.0135	(.68)	.02157	(1.04)	.03402	(1.66)*

vldis89	-.0331	(-2.56)***	-.03629	(-2.35)***	-.02188	(-1.66)*	-.01317	(-.76)
vldis90	-.02587	(-1.45)	-.02958	(-1.75)*	.01631	(.9)	.02515	(1.29)
vldis91	-.02399	(-1.46)	-.03508	(-2.14)**	-.006006	(-.38)	-.004871	(-.25)
vldis92	-.01942	(-1.14)	-.02103	(-1.25)	-.0006561	(-.04)	.00637	(.33)
vldis93	-.04774	(-3.15)***	-.04496	(-2.89)***	-.01848	(-1.15)	-.01703	(-.99)
vldis94	.004041	(.26)	-.01731	(-1.09)	.01786	(1.05)	.01603	(.86)
vldis95	-.0126	(-.5)	-.0219	(-.71)	.01796	(.65)	.01531	(.51)
vldis96	-.03439	(-2.23)**	-.0479	(-2.81)***	-.01098	(-.67)	-.01636	(-.81)
vldis97	.02978	(1.1)	.0002769	(.01)	.02711	(1.01)	.01808	(.63)
structure	yes		yes		yes		yes	
distance from nearest site interacted with lot size	yes		yes		yes		yes	
other distances	no		no		yes		yes	
other distances interacted	no		no		yes		yes	
neighborhood characteristics	no		yes		no		yes	
neighborhood characteristics interacted with lot size	no		yes		no		yes	
years	yes		yes		yes		yes	

In the version of Model 1 with lot size interaction terms, the coefficient on the interaction terms for being on top of the site is statistically significant and positive in all time periods after 1988, suggesting that the impact of house prices of being on top of the site gets more positive (less negative) as lot sizes get bigger, and these results control for lot size itself. Where significant, the distance premium for a decrease in perceived risk, which can also be interpreted as a proximity discount for increased perceived risk, gets smaller as lot sizes get larger. This means that houses on smaller lots at any given distance from the Superfund site experience a larger relative decrease in value than do houses on large lots.

In the more complete specification in Model 4, however, with both neighborhood and other distances in the model, lot size effects on the distance premium are much less apparent. Appendix A also displays the lot size effects on all of the other variables. Over half of the Census tract variables, and over half of the other distance variables retain statistically significant lot size effects. In general, the lot size interaction terms have coefficients bearing the opposite sign to the main effects, indicating that the housing price premiums or discounts associated with location decrease in absolute magnitude as lot size grows.

9.4.2 OII

For the OII site, the generic estimating formula suffices. There are no special features to these data. The estimates for the distance effects are contained in Table 9.9.

9.4.2.1 Model 1: No Census Variables or Other Distances

In this model, with no controls for socio-demographic change or distances to other amenities or disamenities, the fitted model creates the impression that the locale of the landfill was systematically more desirable than the surrounding area until about 1983. In 1984, the landfill was closed and the site was proposed for the NPL. Following this, there is evidence of a proximity premium in 1987, 1992, and again in 1999, although a proximity discount is evident at the 10% level in 1989, 1991 and 1997. A Consent Decree was signed in 1989, and construction of some of the remediation measures began in 1991. 1996 was the year of the final Record of Decision and landfill cover work began in 1997, so activity at the site would have been apparent then.

Table 9.9 OII Landfill

	Model 1		Model 2		Model 3		Model 4	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
ldis70	-.09106	(-1.34)	-.07008	(-.99)	-.1274	(-1.71)*	-.08746	(-1.17)
ldis71	-.1911	(-2.86)***	-.153	(-2.28)**	-.2088	(-2.98)***	-.1682	(-2.39)***
ldis72	-.1452	(-3.34)***	-.129	(-2.96)***	-.1767	(-3.81)***	-.1442	(-3.03)***
ldis73	-.1446	(-4.15)***	-.1135	(-3.18)***	-.1642	(-4.17)***	-.1307	(-3.27)***
ldis74	-.1544	(-3.18)***	-.1353	(-2.78)***	-.1842	(-3.5)***	-.1533	(-2.88)***
ldis75	-.1339	(-5.8)***	-.1044	(-4.47)***	-.1461	(-5.55)***	-.1234	(-4.38)***
ldis76	-.08965	(-5.91)***	-.0682	(-4.31)***	-.1182	(-6.14)***	-.09191	(-4.42)***
ldis77	-.09486	(-4.65)***	-.07244	(-3.67)***	-.1215	(-5.12)***	-.09261	(-3.69)***
ldis78	-.07947	(-4.49)***	-.05892	(-3.35)***	-.09687	(-4.36)***	-.07437	(-3.09)***
ldis79	-.02105	(-.53)	.0009394	(.02)	-.04875	(-1.13)	-.01745	(-.4)
ldis80	-.1574	(-3.79)***	-.147	(-3.56)***	-.1827	(-4.29)***	-.1584	(-3.65)***
ldis81	-.1389	(-1.05)	-.1049	(-.8)	-.1629	(-1.22)	-.12	(-.89)
ldis82	.1391	(1.69)*	.1327	(1.56)	.104	(1.16)	.1175	(1.32)
ldis83	-.1294	(-3.28)***	-.1166	(-2.98)***	-.1617	(-3.81)***	-.1318	(-3.1)***
ldis84	-.02547	(-.53)	-.009132	(-.19)	-.05933	(-1.17)	-.03113	(-.61)
ldis85	-.05666	(-1.26)	-.03818	(-.85)	-.08788	(-1.85)*	-.05643	(-1.18)
ldis86	.001428	(.04)	.01342	(.43)	-.03696	(-1.05)	-.005591	(-.16)
ldis87	-.05865	(-2.15)**	-.04202	(-1.56)	-.08905	(-2.8)***	-.05456	(-1.67)*
ldis88	-.0136	(-.25)	.0005704	(.01)	-.04601	(-.81)	-.01318	(-.23)
ldis89	.08966	(1.7)*	.1019	(1.98)**	.05101	(1.03)	.08643	(1.74)*
ldis90	-.03567	(-.96)	-.0164	(-.45)	-.07362	(-1.91)*	-.03331	(-.86)
ldis91	.1127	(1.8)*	.1236	(1.95)*	.07644	(1.11)	.111	(1.61)
ldis92	-.0556	(-2.59)***	-.03762	(-1.8)*	-.08487	(-3.25)***	-.04724	(-1.74)*
ldis93	-.02067	(-.94)	-.005524	(-.25)	-.05289	(-1.94)*	-.01805	(-.64)
ldis94	-.01194	(-.61)	.01012	(.54)	-.04331	(-1.74)*	-.003816	(-.15)
ldis95	.001991	(.05)	.01688	(.42)	-.0317	(-.72)	.003596	(.08)
ldis96	.04686	(1.25)	.06034	(1.67)*	.01493	(.37)	.0459	(1.13)
ldis97	.0606	(1.75)*	.08704	(2.56)***	.03561	(.96)	.0734	(1.98)**
ldis98	-.004532	(-.34)	.009177	(.72)	-.03436	(-1.76)*	-.004028	(-.2)
ldis99	.02549	(2.15)**	.02755	(2.22)**	-.01498	(-.75)	.01017	(.48)
structure	yes		yes		yes		yes	

other distances	no	no	yes	yes
neighborhood characteristics	no	yes	no	yes
years	yes	yes	yes	yes

9.4.2.2 Model 2: Including Census Variables

When we include Census variables, there are no statistically significant proximity premia after the site closure in 1984, with the possible exception of 1992, where the distance effect is negative and significant, but only at the 10% level. The apparent proximity premia suggested by Model 1 for two other years after the landfill closure all disappear. Proximity discounts become more strongly significant in 1989, 1991, 1997, 1999, and possibly in 1996, which was the year of the final ROD.

The coefficients on the Census tract variables are presented with the full results in Appendix B. Housing prices are enhanced in tracts with a higher proportion of females, but are lowered when there are higher proportions of children under 5, married heads of household with children, and male heads of household with children. These Census data are very highly correlated, so one cannot be certain that the independent effects of each variable are being accurately captured. See the auxiliary R-squared values for each one of the Census variables, presented in Appendix B.

9.4.2.3 Model 3: Including Other Distances

If we introduce into Model 1 only a set of other distance variables, not the set of Census tract variables, the apparent proximity premia in the vicinity of the landfill site, evident in Model 1, reappear. These effects are strongly significant in many years prior to 1984, and considerably less so afterwards. Again, there is little evidence in this model of any increase in perceived risk nearer the site.

The distance variables suggest that in this area, churches, Interstate 10, and golf and country clubs are amenities, while cemeteries, Interstates 5 and 605, railroads, rivers (this is Southern California, where many riverbanks are concrete to protect against flash floods), roads, and California State University at Los Angeles are all considered disamenities, as may be the Whittier Narrows Recreation Area.

Table 9.10 OII Landfill (with lot size interactions)

	Model 1		Model 2		Model 3		Model 4	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
ldis70	-.27	(-1.83)*	-.2827	(-1.8)*	-.2855	(-1.83)*	-.2893	(-1.76)*
ldis71	-.1485	(-1.2)	-.175	(-1.27)	-.1823	(-1.31)	-.1592	(-1.04)
ldis72	-.0259	(-.28)	-.09312	(-.93)	-.09609	(-.94)	-.09796	(-.85)
ldis73	-.07654	(-.91)	-.1058	(-1.21)	-.08494	(-.99)	-.08642	(-.87)
ldis74	-.1172	(-1.31)	-.1764	(-1.86)*	-.194	(-1.92)*	-.2076	(-1.92)*
ldis75	-.005313	(-.09)	-.04556	(-.73)	-.04565	(-.61)	-.07106	(-.89)
ldis76	-.1384	(-3.02)***	-.1926	(-4.28)***	-.1906	(-3.08)***	-.2316	(-3.67)***
ldis77	-.09239	(-2.24)**	-.1263	(-2.97)***	-.1348	(-2.2)**	-.1678	(-2.52)***
ldis78	.01811	(.41)	-.06694	(-1.51)	-.03481	(-.56)	-.1049	(-1.64)
ldis79	-.02743	(-.34)	-.0795	(-.95)	-.06993	(-.75)	-.1102	(-1.16)
ldis80	-.1004	(-1.29)	-.1876	(-2.28)**	-.1599	(-1.78)*	-.2106	(-2.22)**
ldis81	.3079	(1.1)	.2662	(.95)	.2934	(1.01)	.2646	(.91)
ldis82	.2359	(1.9)*	.1086	(.86)	.1516	(1.07)	.06886	(.48)
ldis83	-.07051	(-.74)	-.0834	(-.92)	-.08315	(-.86)	-.09621	(-.98)
ldis84	.1435	(1.6)	.08438	(.97)	.05283	(.53)	-.005956	(-.06)
ldis85	.06277	(.89)	.01631	(.23)	-.00965	(-.11)	-.02657	(-.3)
ldis86	.1827	(1.79)*	.154	(1.44)	.113	(1)	.1158	(1.01)
ldis87	-.09714	(-1.95)*	-.131	(-2.58)***	-.1757	(-2.47)***	-.1703	(-2.25)**
ldis88	-.05173	(-.65)	-.05799	(-.73)	-.1172	(-1.28)	-.1056	(-1.09)
ldis89	.1526	(2.01)**	.1368	(1.9)*	.08203	(1.02)	.09581	(1.15)
ldis90	.107	(1.07)	.1163	(1.17)	.0691	(.67)	.09904	(.95)
ldis91	.3504	(3.37)***	.3204	(3.04)***	.2788	(2.33)***	.2747	(2.28)**
ldis92	-.009454	(-.2)	-.01275	(-.26)	-.08638	(-1.34)	-.05117	(-.72)
ldis93	.009659	(.24)	.0063	(.16)	-.07089	(-1.18)	-.03885	(-.58)
ldis94	-.02342	(-.48)	-.004869	(-.1)	-.08747	(-1.28)	-.03493	(-.47)
ldis95	.1405	(2.49)***	.1549	(2.67)***	.08279	(1.12)	.1349	(1.67)*
ldis96	.1152	(1.63)	.1441	(2.05)**	.03524	(.42)	.1013	(1.12)
ldis97	.09979	(1.97)**	.1283	(2.56)***	.04271	(.65)	.111	(1.53)
ldis98	.03436	(1.07)	.05402	(1.59)	-.03338	(-.62)	.0321	(.51)
ldis99	.03965	(1.6)	.05542	(1.92)*	-.03476	(-.68)	.03708	(.61)
vldis70	.1847	(1.37)	.2119	(1.48)	.1554	(1.1)	.2052	(1.37)
vldis71	-.03955	(-.47)	.01896	(.2)	-.02667	(-.26)	-.007716	(-.07)
vldis72	-.1149	(-1.42)	-.03491	(-.4)	-.08224	(-.94)	-.04611	(-.45)

vldis73	-.06112	(-.76)	-.008749	(-.11)	-.08803	(-1.14)	-.04798	(-.55)
vldis74	-.0304	(-.44)	.03737	(.49)	.01076	(.13)	.05655	(.64)
vldis75	-.1062	(-2.25)**	-.04743	(-1)	-.09497	(-1.64)	-.04278	(-.67)
vldis76	.04763	(1.08)	.1328	(2.99)***	.07517	(1.23)	.1502	(2.36)***
vldis77	-.004628	(-.15)	.05602	(1.72)*	.008887	(.17)	.07814	(1.29)
vldis78	-.089	(-2.05)**	.009527	(.21)	-.06312	(-1.08)	.03014	(.48)
vldis79	.005398	(.08)	.07723	(1.13)	.01691	(.21)	.08485	(1.05)
vldis80	-.05687	(-.81)	.04746	(.65)	-.03085	(-.39)	.05572	(.65)
vldis81	-.4912	(-1.56)	-.4108	(-1.29)	-.5125	(-1.57)	-.423	(-1.29)
vldis82	-.07137	(-1.17)	.02564	(.39)	-.04998	(-.65)	.03959	(.47)
vldis83	-.05983	(-.63)	-.02607	(-.29)	-.08017	(-.87)	-.0243	(-.25)
vldis84	-.1691	(-2.12)**	-.09	(-1.22)	-.119	(-1.36)	-.02818	(-.31)
vldis85	-.1112	(-2.57)***	-.04642	(-1.1)	-.07743	(-1.25)	-.0189	(-.3)
vldis86	-.1753	(-1.73)*	-.1323	(-1.25)	-.1492	(-1.33)	-.1136	(-1.01)
vldis87	.03552	(.87)	.088	(2.07)**	.08476	(1.36)	.1174	(1.73)*
vldis88	.03658	(.58)	.05722	(.9)	.05822	(.77)	.08596	(1.06)
vldis89	-.06469	(-1.12)	-.03303	(-.61)	-.0361	(-.52)	-.00754	(-.1)
vldis90	-.1528	(-1.37)	-.1389	(-1.26)	-.1618	(-1.45)	-.1448	(-1.28)
vldis91	-.2477	(-2.63)***	-.2025	(-2.16)**	-.2142	(-2.08)**	-.1698	(-1.65)*
vldis92	-.04449	(-1.18)	-.02181	(-.53)	-.001723	(-.03)	.003867	(.06)
vldis93	-.03445	(-.97)	-.01395	(-.43)	.01704	(.32)	.02118	(.34)
vldis94	.01093	(.27)	.01633	(.36)	.03404	(.57)	.02696	(.4)
vldis95	-.1418	(-2.64)***	-.1395	(-2.55)***	-.1218	(-1.81)*	-.1381	(-1.82)*
vldis96	-.071	(-1.6)	-.08543	(-1.86)*	-.02421	(-.39)	-.05795	(-.84)
vldis97	-.04198	(-1.26)	-.04459	(-1.28)	-.01321	(-.25)	-.04349	(-.7)
vldis98	-.03999	(-1.38)	-.0434	(-1.37)	-.007049	(-.14)	-.0393	(-.68)
vldis99	-.01624	(-.69)	-.02705	(-1.04)	.01472	(.32)	-.03046	(-.54)
structure	yes		yes		yes		yes	
distance from nearest site interacted with lot size	yes		yes		yes		yes	
other distances	no		no		yes		yes	
other distances interacted	no		no		yes		yes	

neighborhood characteristics	no	yes	no	
neighborhood characteristics interacted with lot size	no	yes	no	yes
years	yes	yes	yes	yes

9.4.2.4 Model 4: Both Census Data and Other Distances

When both Census variables and other distances are included in the model, there are no strongly significant proximity premia after 1983. There is some evidence (at the 10% level) of proximity premia in 1987 and 1992, and some evidence of a proximity discount in 1989 and 1997, the year a Consent Decree was signed and the year landfill cover work began respectively.

The only strongly significant demographic effects in this model remain the positive effects of higher percentages of females and the negative effects of children under 5. There may be a modest decrease in housing values accompanying greater renter-occupancy.

The only remaining apparent disamenities are the I-605 freeway, rivers, roads, and the Cal State campus. The only remaining significant amenity is the I-10 freeway.

9.4.2.5 Models with Lot Size Interaction Terms

Distance effects for models with lot size interaction terms are displayed in Table 9.10. As was the case for the Montclair models, the inclusion of lot size interaction terms tends to lead to lot size diminishing the absolute magnitude of the effect. The interaction terms typically have the opposite sign from the baseline effect of any variable.

9.4.3 Woburn

Very conveniently, Kiel (1995) and Kiel and Zabel (2001) have labeled their six different phases of the process at the Woburn sites: pre-discovery (1975-76), discovery (1977-81), EPA announcement of Superfund listing (1982-84), cleanup discussion (1985-88), cleanup announcement (1989-91), and cleanup (1992). Our results are detailed in Table 9.11.

9.4.3.1 Model 1: No Census Variables or Other Distances

The most interesting feature of our Woburn results is that our simplest models tend to confirm the findings of Kiel and Zabel (2001), who find that housing prices increase with distance from the Woburn sites. In Model 1, we see that the distance elasticities in housing prices are insignificantly different from zero up through the end of the cleanup discussion. Beginning in 1990, however, there is evidence of a positive distance elasticity. The effect appears to dip in 1994, and again in 1997 (probably because of our smaller sample size covering only part of 1997). Otherwise, the distance elasticity ranges between 0.05 and 0.10.

Table 9.11 Woburn

	Model 1		Model 2		Model 3		Model 4	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
ldisw78	-.02852	(-.74)	-.07515	(-2.01)**	-.0816	(-1.93)*	-.1184	(-2.67)***
ldisw79	-.1323	(-1.78)*	-.1633	(-2.24)**	-.1858	(-2.47)***	-.2127	(-2.75)***
ldisw80	-.0005082	(-.01)	-.02039	(-.34)	-.05354	(-.84)	-.07207	(-1.11)
ldisw81	-.05335	(-.63)	-.1036	(-1.24)	-.1366	(-1.58)	-.1565	(-1.79)*
ldisw82	.007758	(.14)	-.04167	(-.77)	-.09406	(-1.66)*	-.1157	(-1.97)**
ldisw83	-.09781	(-1.8)*	-.1412	(-2.74)***	-.1711	(-3.06)***	-.1991	(-3.56)***
ldisw84	.04437	(1.17)	-.1057	(-2.68)***	-.1122	(-2.64)***	-.1772	(-3.91)***
ldisw85	.1042	(2.37)***	-.02891	(-.69)	-.01804	(-.39)	-.0843	(-1.79)*
ldisw86	-.008799	(-.2)	-.101	(-2.39)***	-.1165	(-2.47)***	-.1607	(-3.35)***
ldisw87	-.01143	(-.34)	-.1306	(-3.84)***	-.1179	(-3.11)***	-.1775	(-4.39)***
ldisw88	.04308	(1.54)	-.07725	(-2.64)***	-.08086	(-2.39)***	-.1327	(-3.64)***
ldisw89	.03717	(1.36)	-.08354	(-2.89)***	-.08138	(-2.46)***	-.1365	(-3.84)***
ldisw90	.05218	(1.93)*	-.07328	(-2.62)***	-.0873	(-2.66)***	-.1376	(-3.79)***
ldisw91	.05028	(1.76)*	-.06244	(-2.2)**	-.08535	(-2.52)***	-.1279	(-3.47)***
ldisw92	.07371	(2.63)***	-.03901	(-1.32)	-.05477	(-1.54)	-.0982	(-2.55)***
ldisw93	.07933	(3.6)***	-.02932	(-1.26)	-.03415	(-1.19)	-.08197	(-2.63)***
ldisw94	.04168	(1.67)*	-.08882	(-3.48)***	-.1062	(-3.54)***	-.1525	(-4.79)***
ldisw95	.1095	(4.41)***	-.01088	(-.43)	-.03558	(-1.19)	-.08104	(-2.48)***
ldisw96	.1032	(5.65)***	-.01269	(-.65)	-.04663	(-1.83)*	-.0921	(-3.22)***
ldisw97	.04631	(1.28)	-.0573	(-1.59)	-.1077	(-2.79)***	-.1448	(-3.54)***
structure	yes		yes		yes		yes	
other distances	no		no		yes		yes	

neighborhood characteristics	no	yes	no	yes
years	yes	yes	yes	yes

9.4.3.2 Model 2: Including Census Variables

Model 2, however shows what happens when we introduce our time-varying Census tract information. What once were insignificant or positive distance elasticities now turn negative and significant in many cases. The effect is dramatic. This model does not control for distances to other amenities and disamenities, so we will not yet attempt to interpret individual Census tract characteristics coefficients. However, only the proportion of black and the proportion of male heads-of-household fail to make a statistically significant contribution. This is due to the tiny absolute numbers of these groups in the tracts represented in our sample. In contrast, the only neighborhood variables that Kiel and Zabel (2001) control for are the proportion of unemployed in the Census tract and median household income in the Census tract. They find that the unemployment rate influences housing prices only in the 1982-84 period, and median income influences housing prices only in the 1989-91 period.

Why does the inclusion of time-varying Census tract information have such a profound influence on the distance elasticity of housing prices? The answer seems to lie in the different trends over time in the characteristics of Census tract nearest the site versus farther away. Appendix C presents a full set of regression models and fitted time-and-distance profiles for the neighborhood characteristics associated with each house in our sample. Since our main hedonic price models employ the logarithms of distance, we use the log of distance in these specifications as well. The most substantial socio-demographic effects we discover include:

- The proportion of whites near the site fell more than it did further away.
- The proportion of blacks, while remaining small, grew much more near the site than elsewhere in the sample area.
- The proportion of other ethnic groups grew faster near the site than elsewhere.
- About a 30% growth elsewhere in the sample in the proportion of children under 5 whereas the population of young children nearest the site increases hardly at all.
- The proportion of 5-29 year olds shrank more slowly near the site than elsewhere.

- The population of prime-aged 30-64 year olds grew more slowly near the site than elsewhere, as did the population of seniors.
- There was no discernible difference in the rate of decrease over time in the proportion of married heads of household with children by distance from site.
- The proportion of male heads of household with children, while very small, grew more quickly near the site than further away.
- Female headed households with children grew, close to the site, but declined as a proportion of the population further away.
- Owner-occupancy fell near the site, but remained more or less constant further away.
- Renter-occupancy grew over time near the site, but remained relatively constant farther away.
- There was no discernible difference in the growth in vacancy rates across the sample area.

It must be noted that the suite of Census variables at our disposal are very highly correlated with one another. The appendix reports the R-squared values for auxiliary regressions conducted among the Census variables used in our Models, and these R-squared values are all over 60% and range as high as almost 96%. As a consequence, it will be difficult to attribute variations in housing prices to the independent effects of each of these variables. Collectively, however, they make a considerable difference (for micro-data) to the R-squared value between Model 1 and Model 2, boosting it from 0.49 to 0.53.

9.4.3.3 Model 3: Including Other Distances

Instead of controlling for different and shifting Census tract characteristics, we include distances to other amenities in Model 3. These distances do not vary over time, but their presence in the model also causes the previously significant site distance elasticities to change sign and even become significantly negative. Among the set of other distances, auxiliary R-squared values reveal that the distances to the nearest d_retail, d_hospital, d_church, and distances to the four airports (all of which lie outside the sample area) are highly correlated with the rest of the variables in the model. The coefficients on these particular distance variables are prone to multicollinearity problems.

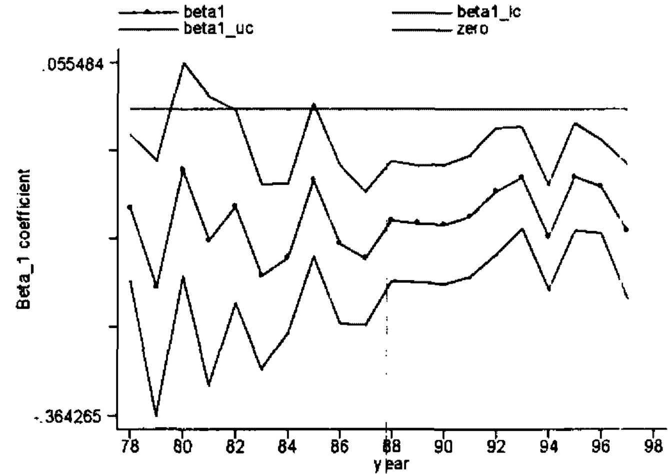
When we do not control for socio-demographic characteristics, it appears that the housing prices increase with distance from: hospitals, churches, railroads, "other" primary roads, smaller roads, Interstate 93, and all four airports. Housing prices appear to decrease with distance from: schools, retail centers, cemeteries, principal arteries, the flight-path of Tew-Mac airport, parks, major water bodies, and golf and country clubs. Each of these effects could be argued to be plausible.

9.4.3.4 Model 4: Both Census Data and Other Distances

In Model 4, where we include both time-varying Census tract characteristics and other distance variables, we find that housing prices seem to vary significantly with a number of individual Census characteristics, although the resolution on these variables is doubtful because of the high multicollinearity. Most plausible are the findings that housing prices tend to vary negatively with the proportion of young people aged 5-29 in the population, and positively with the proportion of married heads of household with children. Many of the "other distance" coefficients lose their individual significance, leaving only the results that prices no longer significantly increase with distance from: churches, and one of the four airports. Prices no longer significantly decrease with distance from: cemeteries, the flight-path of Tew-Mac airport, or golf and country clubs, but they now decrease with distances from summits. This seems plausible, since proximity to a summit is likely to increase the chance of the dwelling having a view.

The striking effect of including these Census tract attributes and other distances in Model 4 is that the site-distance elasticity of housing prices is now negative and significant at the 10% level for all but one year in the 1978-1997 interval. It is significant at the 5% level in all but four years. Next, we need to consider the time profile of these distance elasticities. How do they change over time?

Figure 9.2 Woburn Model 4



Model 4 fitted site-distance elasticities: Woburn

9.4.3.5 Synthesis

In a naïve specification, there do seem to be measurable impacts of proximity to the nearest of two Woburn Superfund sites. However, when we control for other distances, it is plausible that the apparent negative effect of proximity to the Superfund sites is just a manifestation of greater distance from other desirable amenities or greater proximity to other undesirable disamenities, including physical features as well as neighborhood socio-demographic effects.

What then of the apparent variations in the effects of proximity to the nearest of the two Woburn Superfund sites over time? There appears to be a substantial likelihood that the negative effect of proximity to these sites towards the end of the sample period in a naïve model like Model 1 may be due to neighborhood transition. Lower housing prices in the vicinity of the Superfund sites can be explained in part by demographic trends in that areas that differ from those in the broader sample area.

There is evidence that Superfund site identification and remediation may at first lower housing prices, but this impact in turn initiates a pattern of in-migration by socio-demographic groups that previously would have been unable to afford housing in this area. Traditional higher-income groups will be inclined to buy elsewhere and lower-income groups will have an opportunity to move in. However, their growing presence may then become the dominant factor keeping downward pressure on housing prices, even though the Superfund remediation takes place.

9.4.3.6 Models with Latitude and Longitude Variables

The Woburn models can differ from the generic model if we allow the absolute location of each house to systematically affect the sales price. This permits a tilted planar spatial pattern in housing prices to overlay the systematic effects due to distance from each house to the nearest of the two Woburn sites; Wells G&H, or the Industri-Plex facility. The rationale for allowing this generalization is that it may pick up the asymmetric spatial effects due to the "characteristic Woburn odor" that was apparently carried generally eastward from the area of the sites by the prevailing winds. The most general model for the Woburn site, short of including lot size effects, is:

$$LSPRICE_{it} = \ln(P_t) + (\beta_{00t})LL_{it} + (\beta_{10t})LDIST_{it} + \beta_2 A_{iT} + (\beta_{30})S_{it} + (\beta_{40})D_{iT} + \varepsilon_{it} \tag{9.9}$$

Here, LL_{it} denotes vectors of interaction terms between year dummies and the latitude and the longitude of the house location (in decimal degrees, to six decimal places). We also consider models wherein these latitude and longitude dummies in each year are interacted with the distance variable. The models reported in the text of this research do not include this generalization. These results are reported in Appendix C along with other more general models.

Appendix C details models that include latitude and longitude variables by year, and latitude and longitude by year also interacted with log(distance from site), in addition to Census variables and other distance variables. Housing prices appear to be significantly increasing to the east and increasing to the south, overall (or, roughly increasing in the direction of Boston). This is not surprising, and undoubtedly captures an accessibility effect as well as any directional gradient in distance effect for the Woburn sites. Adding these variables to Model 4, discussed above, does not alter its findings concerning the separate effects of the year-specific site-distance variables.

However, there is a glimmer of something interesting when we also interact the site-distance variables with the latitude and longitude variables. The coefficient on site distance then becomes a linear function of the absolute location of the house. For these models, the years 1985 and 1988 develop positive and significant main distance effects, negative and marginally significant latitude*distance effects and longitude*distance effects. The implied formulas for the elasticity of housing price with respect to distance are as follows in these two years:

1985: 0.25 – 5.4 * latitude -3.2 * longitude

1988: 0.35 - 4.3 * latitude – 2.6 * longitude

Latitude increases to the north and longitude increases to the east. However, mean latitude in the sample is 42.50474 degrees and mean longitude is -71.13818. Thus, at the means of the data, the overall effect of distance on house prices is still negative, rather than positive.

9.4.4 Eagle Mine

The Eagle Mine housing sample from the Eagle County Assessor's office does not span enough distinct Census tracts for the differences in socio-demographic characteristics across these tracts to be useful in explaining the variation in housing prices. Only Census tracts 9534, 9535, 9536 and 9537 are represented in the estimating sample, and the total populations for each of these tracts were only 6162, 2480, 166 and 1134 persons at the time of the 1990 Census. If we attenuate the footprint of the data to attempt to get a better picture of the more-nearby housing price effects, we drop to just two Census tracts, which makes of the Census data perfectly collinear. In the spirit of the models used for the other sites, the richest Eagle mine estimating model would thus be just:

$$(9.10) \qquad LSPRICE_{it} = \ln(P_t) + (\beta_{10t})LDIST_{it} + \beta_2 A_{iT} + (\beta_{40})D_{iT} + \varepsilon_{it}$$

However, there is more information that can be brought into play in this case. Eagle River flows NNW through the mine site. Several kilometers downstream from the mine site, it is joined by Gore Creek, which flows in from the direction of Vail. The houses in our sample are split between those lying on the Eagle River, downstream of the Eagle Mine site, and on Gore Creek, which is not affected by the mine site. Thus, we differentiate between houses in these two groups, using a set of time-specific dummy variables for houses located downstream of the mine site on Eagle River, rather than Gore Creek, $DOWNSTR_{it}$. We will also interact these timewise dummy variables with the distances from the Eagle Mine site, $LDIST_{it}$ to yield a richest model of the form:

$$LSPRICE_{it} = \ln(P_t) + (\beta_{10t})LDIST_{it} + \gamma_{1t}DOWNSTR_{it} + \gamma_{2t}DOWNSTR_{it} \cdot LDIST_{it} + \beta_2 A_{2T} + \beta_{40} D_{iT} + \varepsilon_{it} \tag{9.11}$$

This functional form allows the effect of proximity to the mine to depend on distance in the following way:

$$\frac{\partial LSPRICE_{it}}{\partial LDIST_{it}} = \beta_{10t} + \gamma_{2t}DOWNSTR_{it} \tag{9.12}$$

The elasticity of selling prices with respect to distance from the Eagle Mine site will be just β_{10t} in year t for houses on Gore Creek. For houses on the Eagle River, downstream of the mine site, the elasticity of selling prices will be $\beta_{10t} + \gamma_{2t}$. If the estimated parameter γ_{2t} in year t is insignificantly different from zero, being downstream of the mine does not affect the elasticity of selling price with respect to distance. If β_{10t} is zero and γ_{2t} is positive, then there is no premium from being further from the mine site if the house is not downstream from the mine on Eagle River, but there is a distance effect if the house is downstream.

In the housing data for this site, there are insufficient numbers of observations to permit entirely separate distance coefficients to be estimated for each individual year. We retain the yearly dummy variables to control for area-wide increases in housing prices in each year, but we constrain the distance and downstream effects to be constant across roughly three-year intervals. To conform with some of the main benchmark years in the site's history, and to create sufficient observations while aggregating as little as possible, we hold the downstream and distance effects constant across the following sets of years: 1976-1979, 1980-1982, 1983-1985, 1986-1988, 1989-1991, 1992-1994, 1995-1997, and 1998-1999.

The site was listed on the NPL in 1986 and a remediation plan was approved in 1988, so there would have been much publicity in the area in the 1986-1988 period. 1996 saw an agreement between the agencies involved and the responsible party to evaluate and possiblely construct a groundwater extraction system, although the capping of the main tailings pile was completed in 1997. This discussion might also have created awareness of the problem in the 1995-1997 period. In 1999, state and federal authorities formally sought to change the cleanup agreement to include pumping of groundwater to keep it from filling the mine and complicating treatment of contaminated water from the mine. The lead-up to this re-opening of the agreement might be expected to influence housing prices in the 1998-99 period.

Empirical results for the distance coefficients are presented in Table 9.12, with complete results relegated to Appendix D.

9.4.4.1 Model 1: No Control for Other Distances

As usual, Model 1 considers distance effects over time, controlling for structural attributes of the dwelling and general appreciation in housing prices, but not for any other distances. This model suggests that distance from the mine site mattered little to housing prices along Gore Creek, but did affect housing prices downstream from the mine along the Eagle River in some years. House prices increased with distance from the mine along the Eagle River in the 1976-1979 period, and in the 1986-1988 period. In 1992-1994, it seems that there were distance effects along Gore Creek, but not along the Eagle River. This is difficult to explain. Thus we consider a richer model, which also controls for other distances that may affect housing prices.

9.4.4.2 Model 2: Controlling for Other Distances

We include in Model 2 the logarithms of distance to the Vail ski area, distance to the nearest recreational area (golf course or country club), distance to the nearest railroad, and distance to the nearest river. The coefficients on the distances to each of these features bears the expected sign and all are statistically significant. The Vail ski area is an amenity, with housing prices decreasing as one moves away from it. Likewise, golf courses and country clubs are amenities, as are rivers. In contrast, proximity to a railway is a disamenity. Housing prices rise as one moves away from the railroad.

Table 9.12 Eagle Mine

	Model 1		Model 3	
	Coefficient	t-statistic	Coefficient	t-statistic
ldis79	-.181	(-.57)	-.3849	(-.96)
ldis82	-.3655	(-1.35)	-.4108	(-1.47)
ldis85	-.007467	(-.02)	.1481	(.37)
ldis88	-.1457	(-.7)	-.216	(-.93)
ldis91	.1182	(.7)	.002615	(.01)
ldis94	.4586	(2.66)***	.3133	(1.5)
ldis97	.05625	(.62)	-.1811	(-1.06)
ldis99	.1029	(1.2)	-.0487	(-.27)
downldist79	6.481	(5.56)***	5.702	(4.57)***
downldist82	.9653	(1.22)	1.172	(1.47)
downldist85	-1.42	(-1.73)*	-1.084	(-1.21)
downldist88	1.716	(2.11)**	2.599	(3.01)***
downldist91	-.5503	(-.89)	.4107	(.5)
structure	yes		yes	
other distances	no		yes	
years	yes		yes	

In this model, there are no individually statistically significant distance effects for houses along Gore Creek, which are not likely to be exposed to any contamination from the Eagle River. Downstream, however, there are significant positive distance effects in each of four different time intervals. The largest effect appears to be in the 1976-1979 period, before the site was listed on the NPL. If we knew more about accessibility of residential areas downstream area in this period, it might be possible to say more about this observation. This area, further away from Vail, may have been less accessible in that time period. Significant distance effects appear next in the 1986-1988 interval, during which the site was proposed for the NPL and the remediation plan was approved. This would have been a period of high publicity. The next discernible effect came between 1995-1997. This is when the groundwater flooding problem became apparent and the government agencies involved began to consider groundwater extraction in order to reduce the amount of contaminated water that had to be treated. A further effect is apparent in 1998-1999 housing prices. In this period, the EPA formally proposed a change to the prior agreement concerning remediation plans. It is not surprising that houses downstream of the site might reflect this concern in their selling prices.

9.4.4.3 Models with Lot size Interaction Terms

Appendix D also details a set of models where the context of the dwelling, as opposed to its attributes, affects not the unit price of the house, but the price per square foot of the land that it occupies. We include both the usual lot size independent distance effects, and an interaction term with lot size that allows us to see whether lot size affects the size of the premium for distance from the site. Our models show that there are no strongly significant effects of lot size on the "other distances." If anything, the premium for being closer to the Vail ski area or the local recreation areas (golf and country clubs) is enhanced when lot sizes are larger. (Lot sizes in this model are normalized to one to permit evaluation of compound coefficients at mean lot size.) However, the premium for being further downstream of the Eagle Mine site, now observed for the 1976-1979, 1986-1988 periods and the 1989-1991 periods, is positive. For the first period it increases with lot size, but for the two later periods the premium diminishes with lot size.

The positive effects of greater distance observed for the last two periods in Model 2 above disappear when we move to this more complex model. In this model, however, two downstream simple dummy variables disappear due to multicollinearity and their effects are absorbed by some of the interaction terms.

9.5 Synthesis and Conclusions

This research contributes four additional case studies to the literature on the time-varying effects of localized environmental risks on housing prices. Over the relatively long time horizons involved in Superfund identification and remediation processes, we find that the apparent time patterns in proximity effects on housing prices seem to be confounded by systematic changes in neighborhood composition in the vicinity of these sites. There is some evidence that housing tenure patterns and the housing stock near the site are also altered by the process.

A "reduced form" type specification where individual house selling prices are modeled as depending only upon structural variables, an area-wide price index for housing, and proximity to a Superfund site interacted with time dummies will indeed document observed patterns in housing prices during a Superfund identification and remediation process. However, such a reduced form cannot distinguish between the effect of perceived risk at each distance and the effects of changing socio-demographic or housing stock variables at each distance. To isolate the effects of perceived risk, one must control for these other effects, but at the same time, recognize that these other changes are not exogenous.

The implicit experiment imbedded in an estimated distance effect is a change in the risk associated with increased distance from the site. At a great enough distance, the risk is presumed to go to zero, and so should the property value differential. When, over a long time horizon, property value distance profiles do not return to a zero slope when the risk is reduced essentially to zero, neighborhood change is a potential explanation for persistent price differentials with distance. It is not at all possible to conclude that perceived risk does not respond to cleanup.

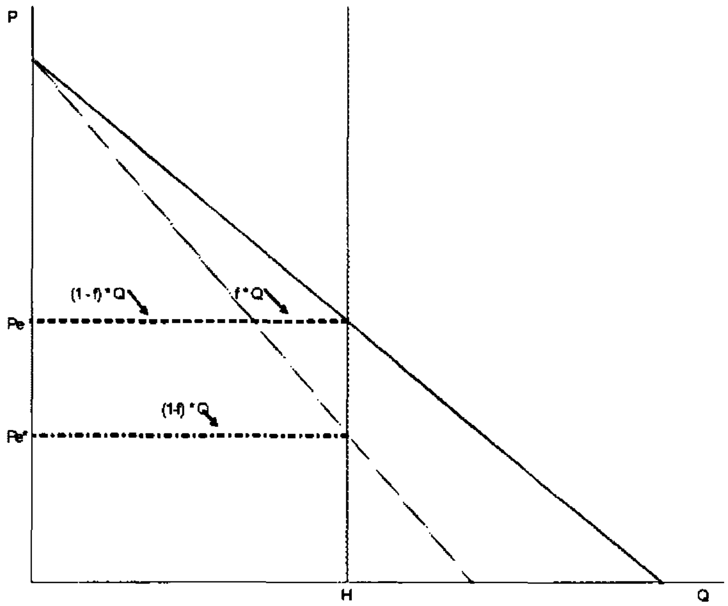
In some cases, especially the Woburn case, we find that controlling for timewise variation in neighborhood characteristics such as gender, ethnicity, the age distribution, family structures and housing tenure reveals very little in the way of a remaining distance profile, so that any inferences about persistent risk perceptions are difficult to make.

Chapter 10

Conclusion: Stigma and Property Values

The possibility that stigma may cause large losses in property values has been noted by other researchers (e.g., Dale et al., 1999; Adams and Cantor, 2001) and the EPA (Harris, 2004). In contrast to the hedonic approach (Rosen, 1974; and for application to hazardous sites see Bartik, 1998; Harris, 2004; Harrison and Stock, 1984; Ketkar, 1992; Kolhase, 1991; Mendelsohn, et al., 1992; Michaels and Smith, 1990; etc.) where risk is treated as one of many attributes that contribute to a determination of sale price, stigma is likely to effect property values in a rather different and more direct manner. Upon learning of the contamination potentially affecting their community, some current home owners may simply be unwilling to continue to live in their home, and likewise, potential buyers will be unwilling to consider buying a home in that community. If some owners and buyers have lexicographic preferences, the standard hedonic model fails since it relies on a tradeoff between risk and home prices. Rather, shunning by both current owners and potential home buyers will reduce the total demand for housing for a neighborhood near a site as shown in Figure 10.1. Imagine that the total demand for homes in a particular fully built-out neighborhood with H existing homes is Q(P) where Q is the number of desired homes, P is the sale price, and quantity demanded falls with price, $Q' < 0$. If, for example, homes were sold in a competitive uniform price auction, the equilibrium price, P_e, is obtained by solving H=Q(P), so $P_e=Q^{-1}(H)$. Now consider the case where a fraction f of home buyers and owners shun a neighborhood because of a nearby Superfund site. The usual hedonic model cannot handle this phenomenon because the hedonic price adjustment for these individuals, either through very high subjective risk beliefs (assuming conventional values of statistical life) or shunning would give homes a risk deficit greater than or equal to the value of the home. In other words, in either case the perceived costs of staying in the home are greater than the entire value of the home and the observed behavior would be identical. This implies that fraction f of current owners will sell and that the number of potential buyers will be reduced by fraction f as well. As shown in Figure 10.1, since we have defined total demand for the neighborhood to include current owners, the equilibrium price will now be determined by the solving $H=(1-f)Q(P)$, so $P_e^*=Q^{-1}(H/(1-f))$ and $P_e^* < P_e$ for $f > 0$. If f falls with distance from the site, as is likely since perceptual cues decline with distance, then property values will rise with distance, *ceteris paribus*. Of course, relative demand for housing that is more distant from the site will increase, but presumably this increase in demand will fall on a much larger group of homes, resulting in a negligible increase in prices of homes farther from the site.

Figure 10.1 The Effect of Stigma on Equilibrium Housing Prices

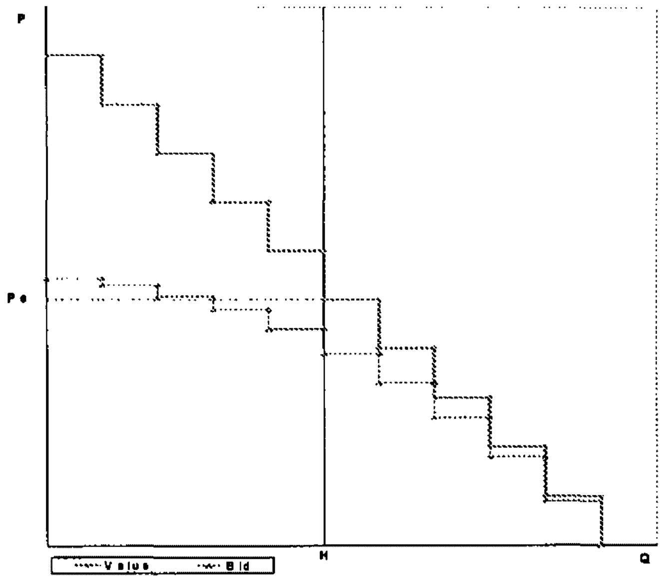


The next question is, since a hedonic analysis is used to incorporate normal attributes for predicting property prices, how can downward sloping demand be incorporated into the analysis? The answer proposed here is that hedonic models predict an average price based on home and community attributes, but do not take into account individual buyer characteristics, including bidding errors, which will affect the willingness to pay for homes in a particular area. So, for example, relative to a predicted hedonic price, P_h, one particular individual will be willing to pay more because grandmother happens to live in the neighborhood and another particular individual will be willing to pay less because of a random error in bidding strategy. Clearly no hedonic market can exist for such attributes since they are buyer specific, and these sale price deviations will appear as part of the error term in the estimated hedonic equation. Thus, for homes with a particular set of hedonic attributes in a homogenous neighborhood with a mean sale price of P_h, there exists an array of values for homes among potential buyers, V, with a cumulative distribution function of Q(V). Presumably, the H buyers with the highest individual values will own homes in the area.

To further understand the property value market, we model the market itself as a discriminative auction to account for the fact that identical homes in the same neighborhood can, in fact, sell for different prices depending on unobserved individual buyer errors and other attributes (see Cox et al, 1984, for a discussion of the relevant theory and an experimental test of this auction). Approximating the property value market with an appropriate auction where multiple buyers compete for available homes solves the potential problem associated with modeling real estate sales as bilateral negotiations where some sellers potentially have no value. Rather, in a discriminative auction other potential buyers provide competition that maintains the price at a higher level than that which would be predicted by bilateral negotiation. The properties of a discriminative auction are well understood, and this auction provides a reasonable approximation of the real estate market under the special circumstances where homes near a site are stigmatized.

As previously discussed, sellers in our model may have little or no value for the homes they are selling since they shun the site. Thus, any price they can get for the home is acceptable. This corresponds to an auction situation where buyers bid on H homes put up for sale, and the H bidders with highest bids obtain the homes for the prices bid. Figure 10.2 shows this market in the context of total demand where all homes in a neighborhood are potentially up for sale. Note that the bids in a discriminative auction (shown as the lower step function) fall below the true values (upper step function). Note also, that compared to the price that would be obtained in a uniform price auction giving a price, P_e, in a discriminative auction there is a distribution of bids and sale prices around the equilibrium price, since buyers pay accepted bid prices. In a discriminative auction, it is well known that if buyers are risk neutral, the average of the accepted bids will equal the uniform price, so revenue neutrality exists in theory between uniform price and discriminative auctions. Note also that risk aversion will increase bids in a discriminative auction and bring them closer to true values because buyers trade off the gain in consumer surplus of a lower accepted bid against the reduced probability of having their lower bid accepted. The lower bid curve shown in Figure 10.2 assumes risk neutrality and plausibly provides a lower bound for bids in a real estate market.

Figure 10.2 Discriminative Auction Market



With these concepts in mind, we can then turn to the hedonic model used to estimate property values at each of our study sites described in Chapters 8 and 9. The hedonic model estimated to explain property values uses a logarithmic specification and takes the form:

(10.1) $$SPRICE_{it} = P_t DIST_{it}^{b_{1t}} e^{b_2 A_{iT}} e^{b_3 S_{it}} e^{b_4 D_{iT}} e^{\varepsilon_{it}}$$

Here, P_t is an area-wide price index for owner-occupied housing in year t, $DIST_{it}$ is the distance of each dwelling from the Superfund site in question. The coefficient associated with this variable will be allowed to differ across years by interacting the constant distance measure with yearly dummy variables. The vector A_{iT} is property attributes and S_{it} is a vector of (interpolated) time-varying characteristics of the Census tract in which the dwelling is located, and D_{iT} is a vector of the logarithms of the distances from the dwelling to a potentially relevant set of other spatially differentiated local amenities or disamenities, calculated at time T, the end of the sample period, rather than contemporaneously.

Taking the logarithms of both sides of the equation yields a version of this model that is appropriate for estimation:

(10.2) $$LSPRICE_{it} = \ln P_t + b_{1t} LDIST_{it} + b_{2t} A_{iT} + b_{3t} S_{it} + b_{4t} D_{iT} + \varepsilon_{it}$$

where $LSPRICE_{it}$ denotes the logarithm of the observed selling price, $\ln P_t$ will be captured as an intercept for the first year in the sample and a set of intercept shifters activated by year dummy variables. The variables of key interest are the $LDIST_{it}$, which consist of a vector of logged distances from the dwelling to the Superfund site interacted with yearly dummies in order to permit year-varying elasticities of housing prices with respect to distance to the site. Geographic Information Systems techniques were used to measure distances from the homes to the closest Superfund site in the specific year, t, that the sales price was observed and the distance to other local amenities or disamenities as they existed in year T.

As discussed previously, n obvious disadvantage of our sample described in previous chapters is that in all of our data sets we only observe selling prices for the most recent sale of a house. If a house is in an area where turnover is high, there will be more recent sales and fewer earlier sales. For analytical purposes, it would be preferable to have data on all sales in all years and selling price in those years, but such data do not exist. Data could be purchased from Experian every year, if a future study could be anticipated, but retrospectively, the data are not available. The data are collected primarily for current marketing purposes and records are updated without saving their previous values. Historical modeling is not a use anticipated by the providers of the data. Consequently, there may be some systematic sampling. We observe earlier transactions prices only for houses which are still occupied by the owners who purchased them at that earlier date. We do not observe many early transactions prices for houses in neighborhoods where there has been a lot of turnover. It must be a maintained hypothesis that rates of turnover are uncorrelated with identification and cleanup of Superfund sites. This may be a strenuous assumption, but there are few alternatives. So it will be necessary to speculate upon the types of biases this non-random selection is likely to produce in the effects of distance from a Superfund site on housing transactions prices.

However, a distinct advantage exists of only having one observation for each home in the sample. By only having one observation per house and controlling for area-wide price index with dummy variables, we ensure that each observation is independent. Therefore, the coefficient b_{1t} (the effect of distance from the Superfund site on property values) can be observed over time by looking at the hedonic estimates for each year over the 20-30 years of observations that have been obtained for each of the sites. To dampen noise, we average b_{1t} the coefficients over three-year intervals. To get time trends in property values as affected by the site, we normalize both by the initial three-year period property value effect, t=0, and by distance. Thus, we ask the question, at a minimum distance from the site, $DIST_{min}$, how do property values compare to price at distance $DIST_{max}$ (the boundary of the available data), which was chosen to be sufficiently far away such that no effects of the site should be present, and to the magnitude of this effect in the initial period. The relative property value effect, normalized by base period and by property values at a large distance is defined as

$$R_t = \left(\frac{DIST_{min}}{DIST_{max}} \right)^{b_{1t} - b_{10}} \qquad (10.3)$$

Thus, the index for each site starts at 1.0 (or 100% in the figures below) and either decreases or increases in successive three-year periods from this value. Table 10.1 presents the results for each of the case studies.

As can be seen in the Figures 10.3, 10.4 and 10.5 presented below, relative property values of the three metropolitan case studies (OII in Los Angeles, Industri-Plex and Wells G&H in Woburn, and Montclair, New Jersey) tend to follow an overall declining trend consistent with the notion of progressive stigmatization of the site as suggested by arguments from psychology. This result is in contrast to a number of earlier studies that examined property values over shorter time periods (Carroll et al., 1996; Kiel, 1995; Kiel and Zabel, 2001).

Table 10.1 Distance Coefficients

	Time period	Avg. Distance Coefficient	Normalized Value
OII Landfill	1970-1972	-0.133	100.00%
	1973-1975	-0.136	100.79%
	1976-1978	-0.086	86.25%
	1979-1981	-0.099	89.65%
	1982-1984	-0.015	68.94%
	1985-1987	-0.039	74.28%
	1988-1990	0.013	63.03%
	1991-1993	0.015	62.65%
	1994-1996	0.015	62.65%
	1997-1999	0.027	60.46%
Montclair (Outside)	1987-1989	-0.022	100.00%
	1990-1992	0.009	90.65%
	1993-1995	0.031	84.81%
	1996-1997	0.064	76.51%
Montclair (Inside)	1987-1989	0.102	100.0%
	1990-1992	0.174	92.9%
	1993-1995	0.094	100.8%
	1996-1997	0.191	91.1%
Woburn	1978-1979	-0.166	100.00%
	1980-1982	-0.115	87.96%
	1983-1985	-0.154	97.01%
	1986-1988	-0.157	97.85%
	1989-1991	-0.134	92.35%
	1992-1994	-0.111	87.12%
	1995-1997	-0.106	86.04%
Eagle	1976-1982	-0.814	100.00%
	1983-1988	2.134	83.88%
	1989-1994	4.815	71.48%
	1995-1999	1.966	84.72%

Figure 10.3 Relative Property Value over Time for OII Landfill, California

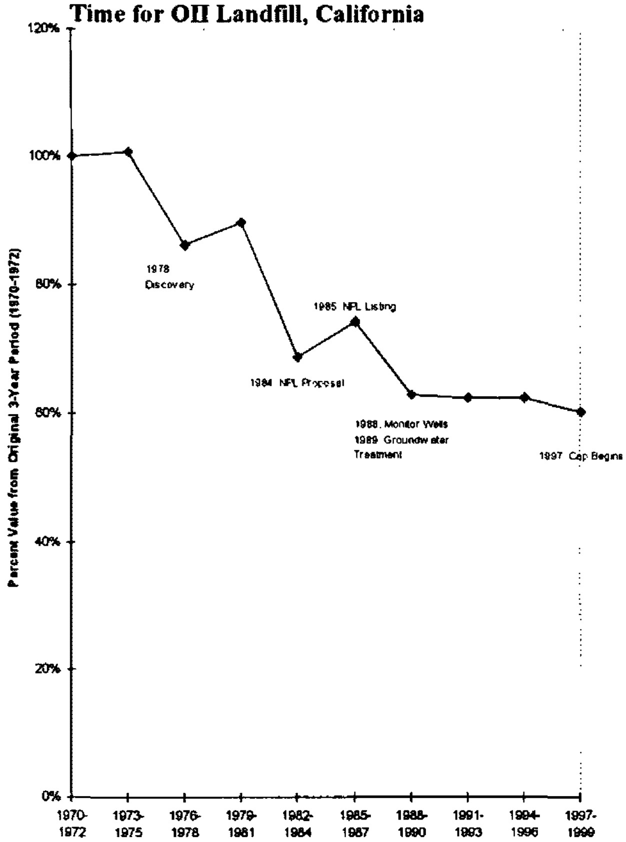


Figure 10.4 Relative Property Value over Time for Montclair, New Jersey (outside of area)

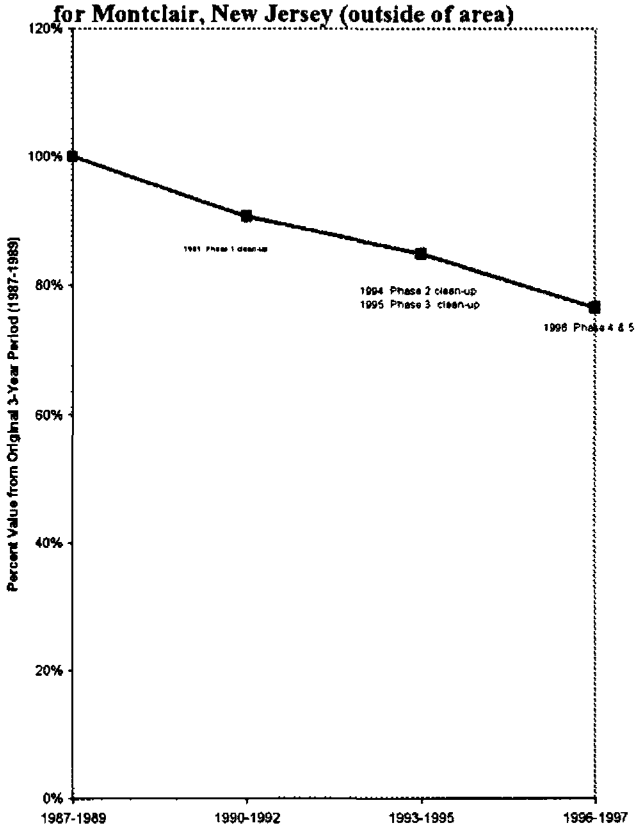
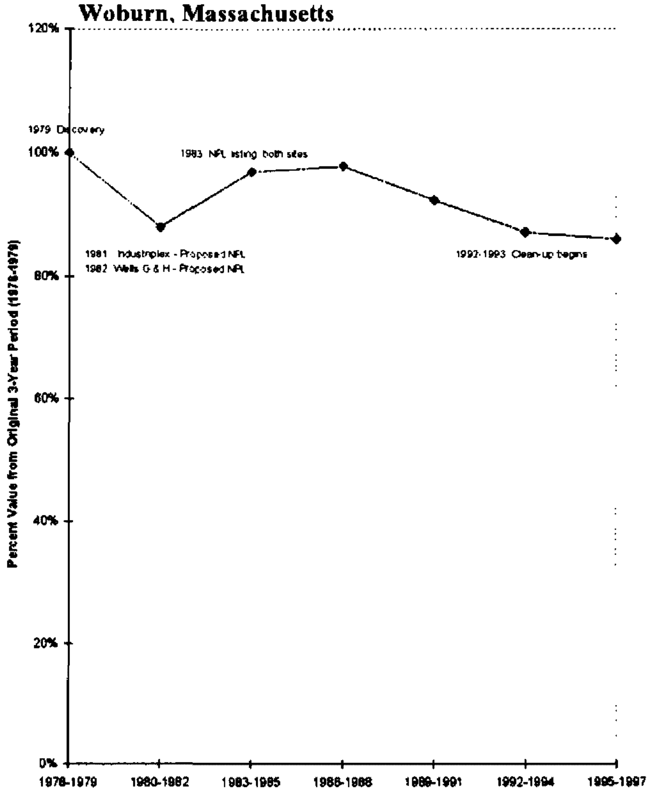


Figure 10.5 Relative Property Value over Time for Woburn, Massachusetts



What explains the long term downward trends observed in relative property values shown in Figures 10.3-10.5? If the trend is driven by f, the fraction of home owners and potential buyers who shun homes near the site, a model of the determination of f over time is needed. From the discussion of the psychology of risk perception and stigma, the determination of the fraction of shunners will be driven by media attention and perceptual cues resulting from activity at the site, which are in turn driven by "events" such as EPA announcements, discovery, NPL-listing, and cleanup. Thus, it is plausible that the percentage change between periods in the fraction of the population who shun the site is a linear function of events of type j occurring during the prior interval, characterized by the discrete dummy variable (or index summarizing a number of dummy variables), $E_{j,t-1}$, thus

(10.4) $$f_t - f_{t-1} = \alpha + \sum_j \beta_j E_{j,t-1}$$

So, in a period with no events, $E_{j,t-1} = 0\ \forall j$, we hypothesize that α is negative and f will decline, thereby raising home values, because some people who know about the site will leave the area (perhaps because of job opportunities elsewhere) and some new potential buyers will move into the area who will have no awareness of the site. Other events, such as cleanup activities, might, (a) raise awareness and thereby increase the fraction of the population who shun the site, or alternatively, (b) reduce the fraction of shunners by convincing people who know about the site that it is now safe. This latter possibility is unlikely in that the notion that, "once contaminated, always contaminated" is part of the psychology of stigmatization. Note, also, that changes in perceived risk for those who may not shun the site will likely follow a similar model.

There is no available data on f, so the model specified above cannot be estimated directly. However, if one assumes a constant elasticity of demand, $\eta<0$, and risk neutrality, a simple transformation exists between f_t and R_t as defined above: $f_t = 1 - R_t^{-\eta}$. Thus, the equation describing movement in f_t can be rewritten as:

(10.5) $$R_t^{-\eta} - R_{t-1}^{-\eta} = -(\alpha + \sum_j \beta_i E_{j,t-1})$$

To employ this transformation we need to know the relevant elasticities of demand that depend. Since we do not have this information, we assume that the elasticities are all -1.0, consistent with a linear approximation of the relationship between f and the change in R. over time.

Table 10.2 Number and Description of Events

	Number of Events			
Event Type	**OII**	**Montclair**	**Woburn**	**TOTAL**
EPA Action	11	3	14	**28**
State Government Action	6	1	4	**11**
Local Government Action	10	1	0	**11**
Public Action	2	1	9	**12**
Potentially Responsible Party Action	7	0	0	**7**
Remediation Action	6	4	3	**13**
EPA Announcement	12	3	8	**23**
Site Incident	5	2	12	**19**
TOTAL	**59**	**15**	**50**	**124**

Table 10.2 presents a psychological model using the data shown in Figures 10.3, 10.4, and 10.5 of relative property values over time for the three metropolitan sites. Note, as mentioned earlier, Eagle Mine was excluded from this analysis because the socio-demographic information for the homes were unavailable. Since all of the home sale observations were independent, a simple linear regression could be used with 18 observations of changes in relative property value ($R_t^{-\eta} - R_{t-1}^{-\eta}$) over the three-year periods for the three sites. For Discovery, NPL Listing, and the Beginning of Major Phases of Cleanup, dummy variables were used. The variable "Events" was derived by summing the number of major announcements and actions described in EPA published reports for the relevant three-year interval for each of the three case

studies (Table 10.4). Note that such events will be highly correlated with and drive important perceptual cues defined in Chapter 7 such as noise, odor, truck traffic, visible on site activity, and media coverage. Events are defined as follows:

- **EPA Action** – Includes site investigations, orders, notifications/decisions, remediation, legal actions, and regulations by the EPA.

- **State Government Action** – Includes site investigations, orders, resolutions, remediation, lawsuits, reports, and regulations by state agencies.

- **Local Government Action** – Includes site investigations, orders, resolutions, remediation, lawsuits, reports, and regulations by local cities, county, and school districts.

- **Public Action** – Include the creation of public interest groups, major meetings and protests, lawsuits by the residents, and the hiring of technical advisors for the community.

- **Potentially Responsible Parties Action** – Include site operation and closure, committees formed, and lawsuits by PRPs.

- **Remediation Action** – Includes containment of contaminations, remediation efforts and site improvements.

- **EPA Announcement** – Includes official Consent Decrees, Record of Decisions (RODs), and announcements of settlements with PRPs.

- **Site Incident** – Includes general site facts, reports and studies regarding the contaminants and occurrences at the site.

The analysis across the three sites shows that discovery, cleanup itself, and the number of events all negatively affect property values by drawing attention to the site and possibly increasing the number of owners and potential buyers who shun the site thereafter (Table 10.3). Thus, the effect of any events, publicity or site information, good or bad, appears to increase the fraction of the current home owners and potential buyers that stigmatize and consequently shun the communities neighboring the sites. In other words, at least within the observed period of the studies, all news is bad news and causes relatively permanent property value losses as an increasing fraction of original owners leave and more potential buyers shun the site. The only good news in the study is that property values did significantly recover for a short period after sites were listed on the NPL. But, it is likely that as soon as it was realized that EPA could not immediately clean up the sites, the process of stigmatization began with consequent reduction in property values. Given the small sample size, it is remarkable that all of these coefficients are significant at better than the 1% level.

Table 10.3 Psychological Model, Dependent Variable $R_t - R_{t-1}$

Model	B	t	p
(Constant)	0.078	3.578	0.003
Discovery	-0.160	-4.493	0.001
NPL – Listing	0.105	4.097	0.001
Clean-up Begins	-0.096	-4.753	0.001
Number of Events	-0.016	-6.156	0.000

N=18
$R^2 = 0.855$

Rather than property losses reversing immediately once cleanup begins, we see no permanent recovery in property values within the time period of our data and speculate that recovery will only occur as the local population gradually moves away, events cease, and perceptual cues and media attention disappear, so more buyers are uninformed. Note that McClelland et al. (1990) found that most buyers were uninformed in spite of reporting requirements. The positive intercept in the psychological model (significant at the 5% level) indicates that property values will increase at a linear rate of about 12% every three-years if no actions are taken and no news is generated by the site. Thus, at OII one could expect a complete recovery in about a decade if no news is generated from the site and recovery might occur in about half that time for the other sites.

The sites excluded from the model are also of some independent interest. First, although Eagle Mine (see Figure 10.7) has very different characteristics from the three sites discussed above, it shows a similar pattern in that relative property values decline for most of the period analyzed. Given the small amount of data available along the Eagle River, we are forced to use six-year rather than three-year periods for the analysis but do confirm the general pattern shown above. Second, the "inside" Montclair property value estimates do not use distance as an explanatory variable since the homes themselves are within the Superfund site. Yearly dummy variables averaged over the same three-year intervals used in the outside-Montclair analysis show that, unsurprisingly, cleanup itself does have a positive impact on property values (Figure 10.6). Third, another interesting result in the property value studies is the effect of including socio-demographic variables. As shown in Figure 10.8, these make a large difference in the magnitude of property losses at the Woburn site. Negative socio-demographic trends, that may be the result of the progressive stigmatization of the site, also take a substantial toll on property values (that are not included in the psychological model), but possibly should be included in any damage assessment. These results suggest a different trend than observed by Kiel and Zabel (2001) which did not account for these socio-demographic affects.

Since economic benefits are based on discounted present value, the benefits of delayed cleanup for homes surrounding sites are likely to be negligible where cleanup takes 20 years and another 5-10 years may be needed after cleanup is complete for property values to recover. The principal policy conclusion becomes evident from the results of the psychological model which suggest that the promise of a prompt cleanup raises property values, while an increase in the number of events that are the root causes of perceptual cues and media attention decreases property values. Thus, an expedited cleanup should occur as quickly as possible after a site has been determined to be hazardous and this cleanup should be conducted in a way that does not arouse excessive attention. Otherwise the neighborhoods surrounding the site will likely be stigmatized resulting in quasi-permanent economic damages.

Figure 10.6 Relative Property Value over Time for Montclair, New Jersey (inside of area)

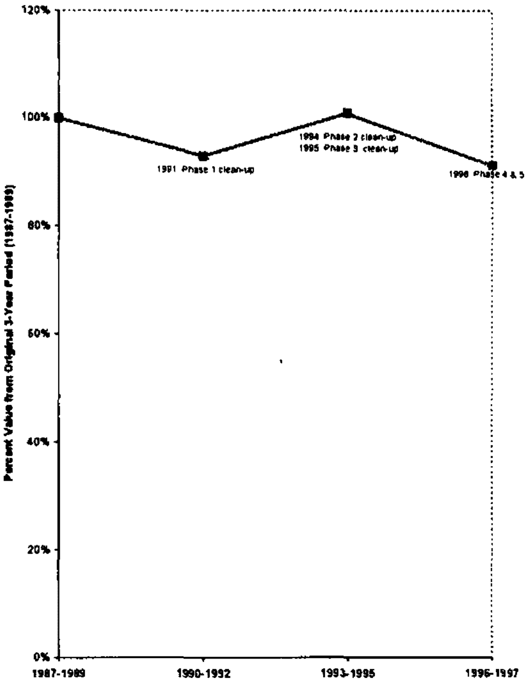


Figure 10.7 Relative Property Value over Time for Eagle Mine, Colorado

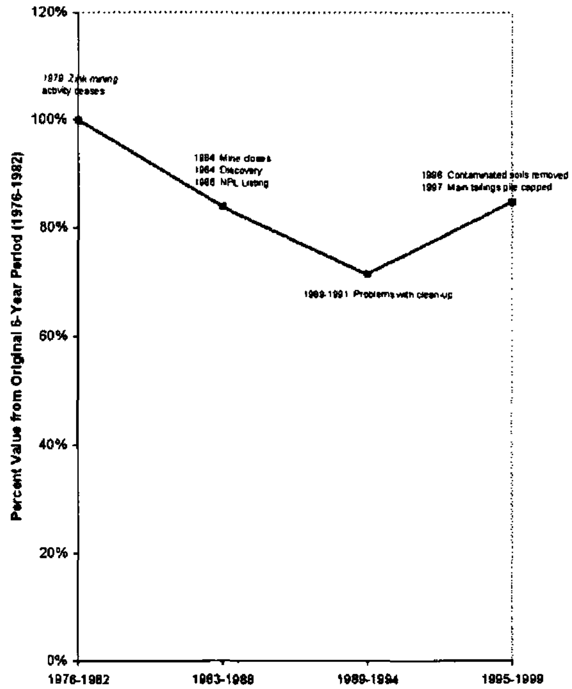
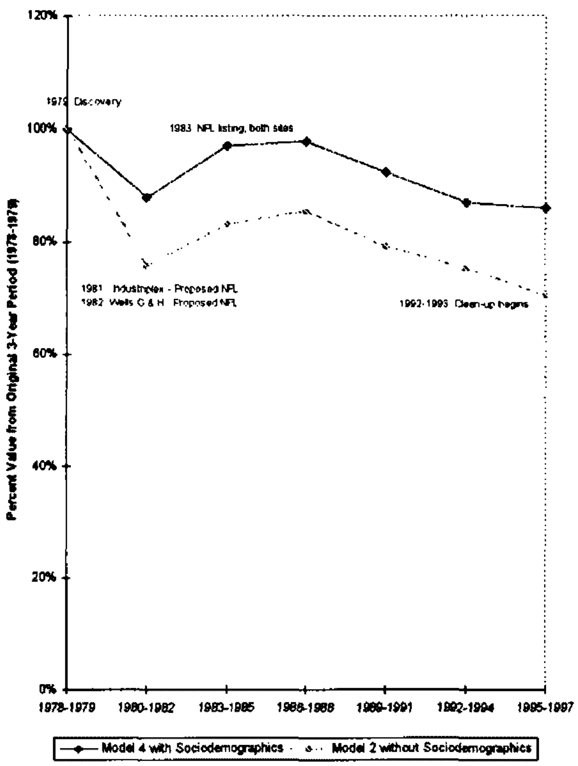
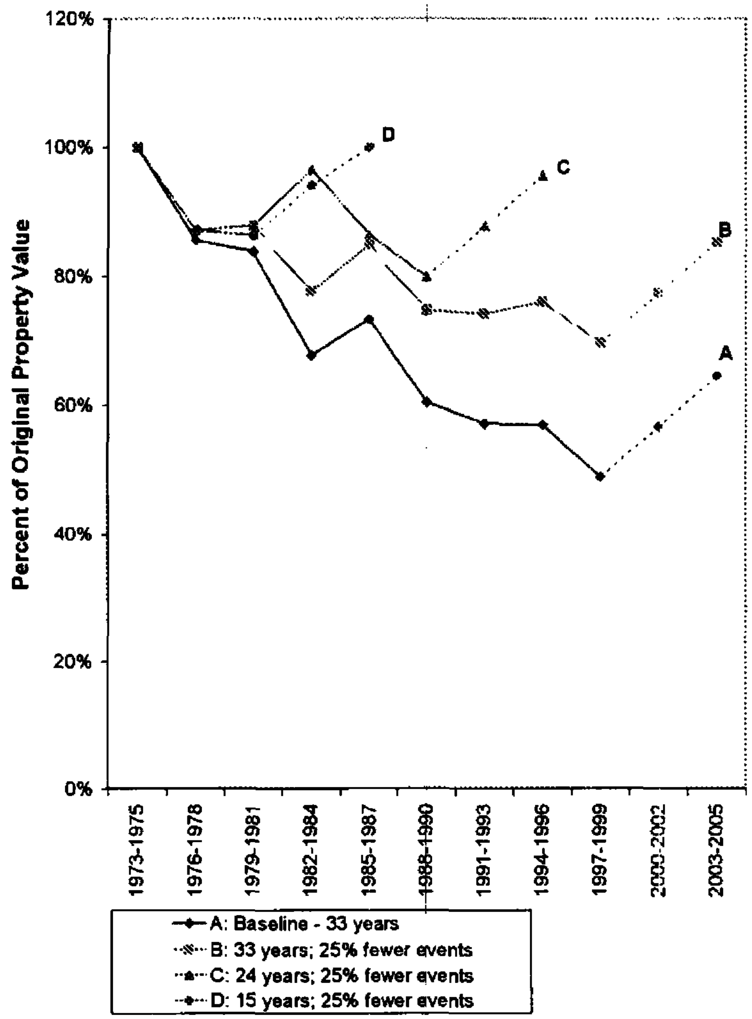


Figure 10.8 Relative Property Value over Time for Woburn, Massachusetts with and without socio-demographic variables



Using the history of the OII and the corresponding events and dates in a simulation, the potential benefits of these policies becomes evident (Figure 10.9).

Figure 10.9 Policy Simulations using the OII Landfill History



As shown in Table 10.4, this simulation considers four different scenarios and includes an extrapolation of a recovery in property values after cleanup is complete where there are no further events. Given the legislative history of Superfund, some of these scenarios are clearly fanciful, but the results are nevertheless suggestive as to what potential benefits could be obtained by expediting the cleanup process and reducing the number of events that drive perceptual cues, media attention, and social amplification. These results support several of the suggestions made by Kunreuther and Slovic (Chapter 21, 2001) for reducing stigma. In particular, they suggest prevention of the occurrence of stigmatizing events and the reduction of the number of stigmatizing messages and thus reducing social amplification.

Table 10.4 Cleanup Scenarios

	Time Horizon	Events	Discovery	NPL Listing	Cleanup time periods	Recovery time periods	Final % of Original Value
Scenario A	33 years	All	1978	1985	1988-1990 & 1997-1999	2002-2005	64.5%
Scenario B	33 years	25% Fewer	1978	1985	1988-1990 & 1997-1999	2002-2005	85.2%
Scenario C	24 years	25% Fewer	1978	1982	1985-1987 & 1988-1990	1990-1995	95.6%
Scenario D	15 years	25% Fewer	1978	1979	1979-1981	1982-1987	100.0%

Note that these results directly contrast with those of Gayer, Hamilton and Viscusi (2000) and Gayer and Viscusi (2002) who argue that media attention supports learning that leads to a lowering of public risk perceptions more consistent with scientific evidence for smaller sites. No credible evidence supports a significant long-term health risk to residents living near OII (McClelland et al. 1990). Yet the actual property value losses are enormous. One difference is that this study focuses on prominent sites while the two studies cited above focused on less prominent sites. Note that most potential benefits from cleanup are likely to come from prominent sites.

It is interesting to note that Carol Browner did in fact institute reforms to USEPA policy in 1995 to at least partly attempt to avoid the pattern shown in this study. EPA began to work with PRPs in an attempt to negotiate sufficient cleanup at potential Superfund sites to avoid having sites listed on the NPL. These reforms may, in fact, have represented an optimal response given the difficulty stigma presents for neighborhoods surrounding Superfund sites. It should also be noted that the enormously costly process of litigation and delayed cleanup that has occurred under the Superfund program has provided strong incentives for industry to avoid creating new hazardous waste sites. However, for residents living near very large Superfund sites, as they have often stated, the program has failed in spite of EPA's best efforts. In this regard, it should be noted that when CERCLA was passed, little or none of the work in psychology necessary to understand the phenomena described here had been completed. In fact, much of the relevant work was motivated by Superfund sites and other hazardous facilities.

This study raises several questions for future research. First, are smaller sites truly different as the work by Gayer, Hamilton and Viscusi suggests? Second, although the psychological model developed here is statistically significant, it is based on data from just three sites. Additional work to incorporate both larger sites, as well as smaller sites, and additional explanatory variables would be worthwhile in our judgment. Finally, more research to understand and prevent stigmatization is warranted.

Chapter 11

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150. http://www.epa.gov/superfund/pics/.

151. http://www.epa.gov/region01/superfund/sites/wellsgh/photo.html.

152. http://www.epa.gov/region02/superfnd/site_sum/0201290c.htm (September 14, 1999).

153. http://www.epa/gov/region07/programs/nplfacts/TOC.html#missouri.

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Appendix A – Montclair Radium Sites

Contents:

Chapter 1 Criteria for exclusion from raw sample

For Montclair, we drop observations for which

- Sale price is greater than $2 million or missing
- House has more than four floors
- Land area is greater than 75,000 square feet or missing
- The street address given places them outside the census tracts in which they are supposed to lie (assumed typographical errors in addresses)
- The address could not be geolocated using GIS software
- The sale year is prior to 1987 or after 1997
- An assessors estimate of the value of improvements is missing

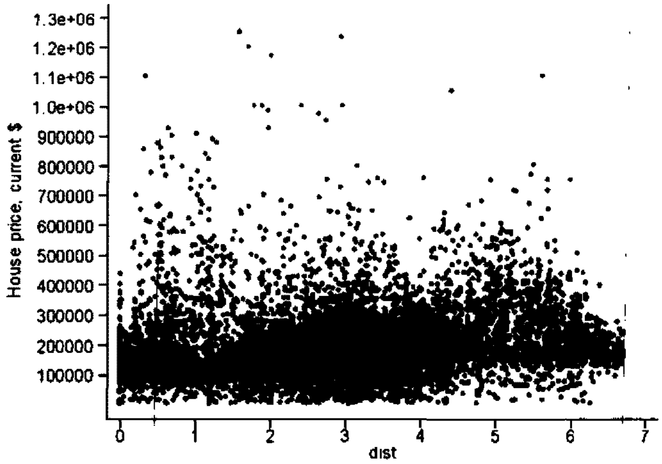
Chapter 2 Annual counts in sample

year	Freq.	Percent	Cum.
87	490	4.10	4.10
88	798	6.68	10.79
89	814	6.82	17.60
90	887	7.43	25.03
91	1030	8.63	33.66
92	1152	9.65	43.31
93	1348	11.29	54.60
94	1505	12.60	67.20
95	1425	11.93	79.14
96	1665	13.94	93.08
97	826	6.92	100.00
Total	11940	100.00	

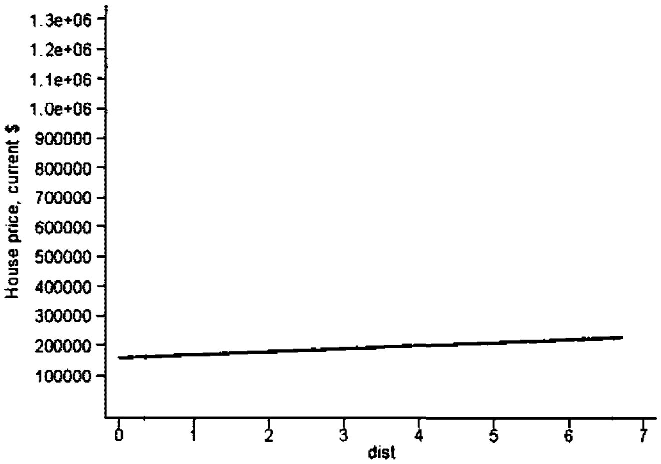
Chapter 3 Descriptive statistics

3.1 Housing prices and distances from site

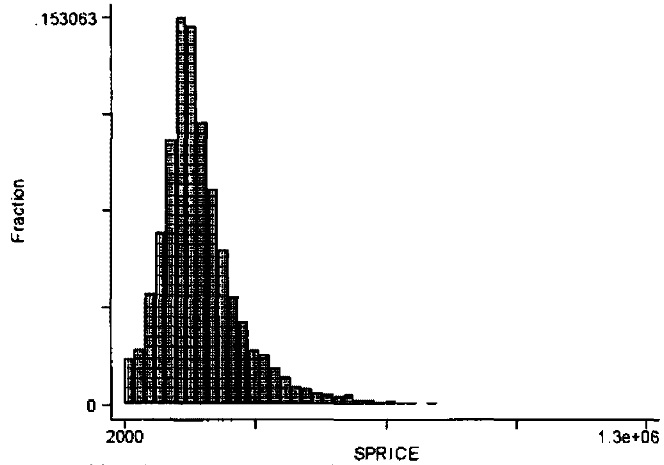
Variable	Obs	Mean	Std. Dev.	Min	Max
dist	11940	2.958726	1.653603	0	6.716527
sprice	11940	188345.9	108008.5	2000	1250000



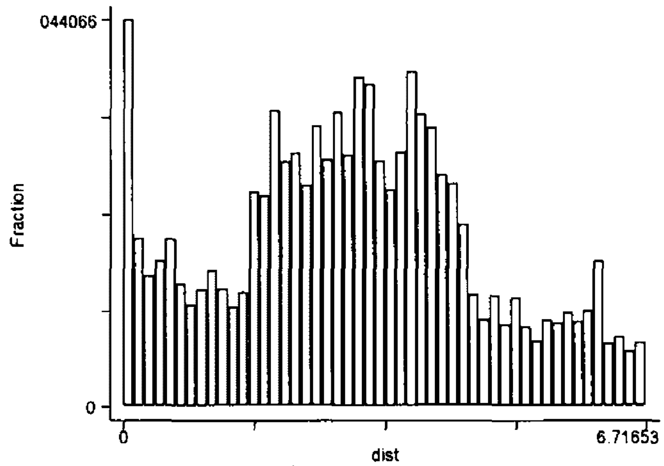
Distance from nearest Montclair site (km)



Distance from nearest Montclair site (km)



Marginal distribution of house prices: Montclair



Marginal distribution of distances: Montclair

3.2 Structural variables

Variable	Obs	Mean	Std. Dev.	Min	Max
knowflr	11940	.8752931	.3304001	0	1
flocrs	11940	1.448936	.7510819	0	4
limpval	11940	10.96357	.7406981	8.006368	13.61376
ageknown	11940	.4040201	.4907219	0	1
age20	11940	.0040201	.0632793	0	1
age30	11940	.0117253	.1076512	0	1
age40	11940	.0323283	.1768779	0	1
age50	11940	.0330821	.1788584	0	1
age60	11940	.0324958	.1773202	0	1
age70	11940	.0932161	.2907472	0	1
age70plus	11940	.1913735	.3933989	0	1
lotsize	11940	1.001101	.907426	.0009748	8.068128

3.3 Census tract attributes

Variable	Obs	Mean	Std. Dev.	Min	Max
pfemales	11940	.5312597	.0137262	.4782994	.600673
pblack	11940	.1981348	.2875085	.0009183	.9759917
pother	11940	.0856179	.0566641	.0120837	.3222607
page_under5	11940	.0658442	.0109725	.0337553	.1124166
page_5_29	11940	.3131265	.0482451	.2308882	.4530005
page_65_up	11940	.1546853	.0437867	.0421896	.251818
pmarhh_chd	11940	.2536222	.0729032	.0747633	.4308186
pmhh_child	11940	.0133316	.0100036	.0012361	.054559
pfhh_child	11940	.0617661	.053228	.0167364	.2973308
pvacant	11940	.0365	.0238177	.0095438	.1516945
prenter_occ	11940	.3480293	.2366121	.0275876	.91541

3.4 Other distances

Distance variable	Description
d_summits	Distance from the nearest summit of land. There are three small summits in the relevant geographic area, and none of them are very high. Only two of these are inside the sample area.
d_school	Distance from the nearest school. There are several dozen schools within the sample area.
d_retail	Distance to the nearest retail center. There are two major locations for retail centers, and each of these is to the northwest, outside the sample area. (Essex Mall, Hudson Mall, The Mall at Short Hills, and Wayne Town Center are presently active. We do not have historical data concerning their level of activity in the period 1987-97.)
d_hospital	Distance to the nearest hospital. There are 7 hospitals either within or near the sample area.
d_church	Distance from the nearest church. There are 17 churches either within or adjacent to the sample area.
d_cemetery	Distance to the nearest cemetery. There are nine cemeteries either within or adjacent to the sample area.
d_railroad	Railroads run through the eastern portion of our sample area. (GTW and NS are the owners of these railways).
d_njrds	Distance from the closest main New Jersey roads. This includes Interstate 280 and the Garden State Parkway, if they happen to be the nearest main roads (which they usually will not be).
d_i280	Distance from Interstate 280, [an east-west] freeway that runs entirely outside the sample area, to the [north]. The coefficient on this variable is a proximity effect in addition to proximity from the nearest main roads, d_njrds.
d_gspkwy	Distance from the Garden State Parkway, [a north-south] freeway that runs entirely outside thw sample area, to the [west]. The

	coefficient on this variable is a proximity effect in addition to proximity from the nearest main roads, d_njrds.
d_parks	Distance from the nearest park. There are about 23 park areas that could be the nearest park for houses in the sample.
d_mjwater	Distance from the nearest body of water. There are no significant bodies of water in the sample area. The Pompton River runs to the north and to the east of the sample area, and the Cedar Grove and Great Notch reservoirs lie to the north, in adjacent zip codes.
d_colleges	Distance from the nearest college or university. Upsala College and Bloomfield College lie inside the sample area. Seton Hall lies in an adjacent zip code to the south. NJ Institute of Technology and Rutgers campuses lie to the southeast, Caldwell College to the west, and Montclair State is adjacent to the northern perimeter of our sample.
d_cclubs	Distance to the nearest country club. There are ten country clubs with significant amounts of land within the sample area, mostly in the West Orange and Bloomfield zip codes.
d_airports	Distance from the nearest airport. Essex County airport lies to the northwest of the sample area. It is a smaller regional airport with two runways. Newark International airport about equidistant from the center of our sample area, but to the southeast. None of the main runways of either of these two airports would produce flight paths that intersect the sample area.
d_newark_i	Distance from Newark International Airport. This distance will be correlated with the distance from other disamenities (or amenities) associated with the location of the airport.

Variable	Obs	Mean	Std. Dev.	Min	Max
d_summits	11940	3679.74	1617.095	281.3663	7515.158
d_school	11940	547.4059	391.6714	12.21375	2300.027
d_retail	11940	8348.043	1928.518	3757.655	11851.8
d_hospital	11940	2269.5	1182.129	65.12099	5554.716
d_church	11940	1220.129	603.5879	10.8354	3225.218
d_cemetery	11940	1865.784	1097.649	64.37774	4720.175
d_railroad	11940	1122.886	946.2423	.3640983	4178.208
d_njrds	11940	158.9385	140.2323	.0163899	936.6699
d_i280	11940	3291.807	2224.808	3.563274	8773.392
d_gspkwy	11940	2767.276	2050.373	6.289956	7662.895
d_parks	11940	773.363	493.792	.0404199	2549.764
d_mjwater	11940	4557.648	1739.214	394.7092	8069.31
d_colleges	11940	2197.54	1074.472	1	5100.181
d_cclubs	11940	1531.028	1095.087	.0299353	5288.419
d_airports	11940	8096.859	1477.857	3930.727	10653.95
d_newark_i	11940	11529.63	2697.796	5343.567	16899.11

Chapter 4 Collinearities

4.1 Time patterns in average site distances in sample

Regression with robust standard errors

Number of obs	=	11940
F(10, 11929)	=	3.94
Prob > F	=	0.0000
R-squared	=	0.0026
Root MSE	=	.91947

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year88	-.2077507	.0468216	-4.44	0.000	-.2995286	-.1159729
year89	-.2492569	.0474433	-5.25	0.000	-.3422535	-.1562604
year90	-.1644464	.0450486	-3.65	0.000	-.2527489	-.0761439
year91	-.1574261	.0448733	-3.51	0.000	-.245385	-.0694672
year92	-.1746706	.043588	-4.01	0.000	-.2601102	-.0892309
year93	-.2351696	.0434252	-5.42	0.000	-.3202901	-.1500491
year94	-.2040609	.0420796	-4.85	0.000	-.2865438	-.1215779
year95	-.1721154	.0417705	-4.12	0.000	-.2539925	-.0902384
year96	-.1787973	.0405406	-4.41	0.000	-.2582636	-.0993311
year97	-.1899618	.0445582	-4.26	0.000	-.2773031	-.1026205
_cons	1.015294	.0339832	29.88	0.000	.9486813	1.081907

4.2 Time trend in average lot sizes

Regression with robust standard errors

Number of obs	=	11940
F(10, 11929)	=	3.02
Prob > F	=	0.0008
R-squared	=	0.0021
Root MSE	=	.90684

lotsize	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year88	.1030169	.0454197	2.27	0.023	.013987	.1920469
year89	.1249482	.0478034	2.61	0.009	.0312457	.2186506
year90	.1082126	.0461802	2.34	0.019	.0176918	.1987333
year91	.1178118	.0424183	2.78	0.005	.034665	.2009586
year92	.1766366	.0439886	4.02	0.000	.0904117	.2628615
year93	.1886342	.0419542	4.50	0.000	.1063971	.2708713
year94	.1402731	.0392404	3.57	0.000	.0633555	.2171908
year95	.123381	.0397198	3.11	0.002	.0455238	.2012383
year96	.1520162	.0399157	3.81	0.000	.0737749	.2302574
year97	.0667246	.0440867	1.51	0.130	-.0196926	.1531418
_cons	.8709363	.0327428	26.60	0.000	.806755	.9351176

4.3 Distance to site vs. structural variables

Regression with robust standard errors

Number of obs	=	11940
F(12, 11927)	=	73.27
Prob > F	=	0.0000
R-squared	=	0.0614

Root MSE = .89201

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	.5621402	.0368365	15.26	0.000	.4899347	.6343457
floors	-.1351645	.0151117	-8.94	0.000	-.1647859	-.1055431
limpval	.1153885	.009619	12.00	0.000	.0965336	.1342433
ageknown	-.0110498	.0803332	-0.14	0.891	-.1685159	.1464163
age20	.1802057	.124023	1.45	0.146	-.0628995	.4233109
age30	-.0183933	.1036304	-0.18	0.859	-.2215257	.184739
age40	.3357685	.0903477	3.72	0.000	.1586722	.5128647
age50	.4380861	.0925754	4.73	0.000	.2566231	.619549
age60	.5016029	.0866531	5.79	0.000	.3317487	.671457
age70	.1647473	.0850763	1.94	0.053	-.0020162	.3315108
age70plus	-.0327322	.0824492	-0.40	0.691	-.1943459	.1288816
lotsize	.0468758	.0090222	5.20	0.000	.0291908	.0645608
_cons	-.8240943	.1079984	-7.63	0.000	-1.035789	-.6123997

4.4 Distance to site vs. Census tract attributes

Regression with robust standard errors

Number of obs = 11940
F(11, 11928) = 312.02
Prob > F = 0.0000
R-squared = 0.1783
Root MSE = .8346

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
pfemales	4.607242	.9148456	5.04	0.000	2.813995	6.400488
pblack	-1.051875	.0813007	-12.94	0.000	-1.211237	-.892512
pother	-3.264204	.2138823	-15.26	0.000	-3.683448	-2.844959
page_under5	1.089476	1.250295	0.87	0.384	-1.361306	3.540259
page_5_29	-5.142977	.4941953	-10.41	0.000	-6.11168	-4.174273
page_65_up	-3.173556	.4744836	-6.69	0.000	-4.103621	-2.243491
pmarhh_chd	.7647791	.2641258	2.90	0.004	.2470496	1.282509
pmhh_child	-23.87896	2.266044	-10.54	0.000	-28.32078	-19.43715
pfhh_child	10.31201	.6031825	17.10	0.000	9.129675	11.49435
pvacant	2.370267	.3116062	7.61	0.000	1.759468	2.981065
prenter_occ	-.8083711	.0882834	-9.16	0.000	-.9814209	-.6353214
_cons	.5829649	.4528341	1.29	0.198	-.3046637	1.470594

4.5 Distance to site vs. other distances

Regression with robust standard errors

Number of obs = 11940
F(16, 11923) = 767.69
Prob > F = 0.0000
R-squared = 0.5011
Root MSE = .65044

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ld_summits	.5830631	.0225069	25.91	0.000	.5389459	.6271802
ld_school	.0040095	.0093627	0.43	0.668	-.014343	.022362
ld_retail	-.8080889	.0934561	-8.65	0.000	-.991278	-.6248998
ld_hospital	.1947804	.0111483	17.47	0.000	.172928	.2166328
ld_church	-.1235253	.0108221	-11.41	0.000	-.1447384	-.1023122
ld_cemetery	.5175188	.0170457	30.36	0.000	.4841064	.5509313
ld_railroad	-.0674414	.007	-9.63	0.000	-.0811625	-.0537204
ld_njrds	.0003375	.0046745	0.07	0.942	-.0088253	.0095002
ld_i280	.1589406	.00833	19.08	0.000	.1426124	.1752687
ld_gspkwy	.083741	.0099501	8.42	0.000	.0642371	.1032449
ld_parks	.0631714	.0073117	8.64	0.000	.0488392	.0775036
ld_mjwater	-.9691344	.027243	-35.57	0.000	-1.022535	-.9157337
ld_colleges	.2875994	.0143331	20.07	0.000	.2595042	.3156945
ld_cclubs	-.2339437	.0124952	-18.72	0.000	-.2584362	-.2094511
ld_airports	-.2033038	.0631761	-3.22	0.001	-.3271393	-.0794682
ld_newark_i	-1.141372	.071517	-15.96	0.000	-1.281557	-1.001187
_cons	17.13824	1.199418	14.29	0.000	14.78718	19.48929

Chapter 5 Trends in the distance gradient

These models use individual houses as observations. We associate with each house the proportion of each group in the Census tract that contains the house. The right-hand side variables are the measured distance of the house itself from the Woburn site, a time trend, starting at 1 in the first period of the data, and an interaction term between distance and time. The simple trend picks up the trend over time in the concentration of the group in question throughout the sample area. The "ldisw" variable, distance to the nearer of the Wells G&H sites or the Industri-Plex site, picks up any baseline distance gradient in the concentration of the group in question as a function of distance from the nearest Superfund site. The key variable is the interaction term, which tells how the distance gradient is shifting over time. If the distance gradient is becoming either less positive or more negative, the concentration of the group in question nearer the Superfund site is growing, relative to the concentration further away.

5.1 Structural variables

There are very few available structural variables for each house. In lieu of a longer list of structural variables, we employ the current assessed value of improvements as a proxy for housing quality. It is not reasonable to assess how these values change with the time of sale of the house. Given the paucity of data on housing attributes for the Montclair sample, we cannot conclude much about the condition of the housing stock over time.

5.1.1 Floors known?

```
Regression with robust standard errors                 Number of obs =   11940
                                                       F(  5, 11934) =   41.15
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.0222
                                                       Root MSE      =  .32679
```

knowflr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
inside	-.0771242	.0547582	-1.41	0.159	-.1844592	.0302108

	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0641301	.0090269	7.10	0.000	.0464359	.0818243
trend	-.001299	.0017916	-0.73	0.468	-.0048108	.0022128
insidey	-.0065508	.0090075	-0.73	0.467	-.0242069	.0111053
ldisty	-.0032718	.0014203	-2.30	0.021	-.0060559	-.0004877
_cons	.8472986	.0114769	73.83	0.000	.824802	.8697951

5.1.2 Floors

Regression with robust standard errors

Number of obs = 11940
F(5, 11934) = 7.90
Prob > F = 0.0000
R-squared = 0.0040
Root MSE = .74973

floors	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
inside	-.2215466	.1054497	-2.10	0.036	-.4282452	-.0148481
ldist	.0477309	.0190507	2.51	0.012	.0103885	.0850734
trend	.0020551	.0037851	0.54	0.587	-.0053644	.0094746
insidey	-.0016867	.0172702	-0.10	0.922	-.0355391	.0321657
ldisty	-.0028708	.0029731	-0.97	0.334	-.0086987	.002957
_cons	1.416048	.0243248	58.21	0.000	1.368367	1.463729

5.1.3 Age known?

Regression with robust standard errors

Number of obs = 11940
F(5, 11934) = 40.13
Prob > F = 0.0000
R-squared = 0.0155
Root MSE = .48699

ageknown	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
inside	.0129883	.0659437	0.20	0.844	-.1162722	.1422488
ldist	.0898056	.01086	8.27	0.000	.0685183	.1110929
trend	-.0010347	.0021129	-0.49	0.624	-.0051763	.0031069
insidey	-.000424	.010727	-0.04	0.968	-.0214506	.0206026
ldisty	-.0045979	.001698	-2.71	0.007	-.0079263	-.0012696
_cons	.356786	.013576	26.28	0.000	.3301749	.3833972

5.1.4 Age

Regression with robust standard errors

Number of obs = 4824
F(5, 4818) = 53.85
Prob > F = 0.0000
R-squared = 0.0607
Root MSE = 22.792

age	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
inside	-13.64081	6.437296	-2.12	0.034	-26.26085	-1.020772
insidey	.1463102	1.092536	0.13	0.893	-1.99556	2.28818
ldist	-6.439359	1.063588	-6.05	0.000	-8.524478	-4.35424
ldisty	.2577415	.1603724	1.61	0.108	-.0566617	.5721446
trend	1.03418	.2088739	4.95	0.000	.624692	1.443668
_cons	67.0986	1.389429	48.29	0.000	64.37468	69.82251

5.1.5 Lotsize

Regression with robust standard errors

Number of obs = 11940
F(5, 11934) = 24.43
Prob > F = 0.0000
R-squared = 0.0043
Root MSE = .90567

lotsize	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
inside	-.2707097	.0593119	-4.56	0.000	-.3869706	-.1544488
ldist	.0504139	.017611	2.86	0.004	.0158933	.0849344
trend	.0039132	.0039827	0.98	0.326	-.0038936	.01172
insidey	.015799	.0112238	1.41	0.159	-.0062015	.0377996
ldisty	.0002315	.0027266	0.08	0.932	-.0051132	.0055762
_cons	.9397404	.0261798	35.90	0.000	.8884236	.9910571

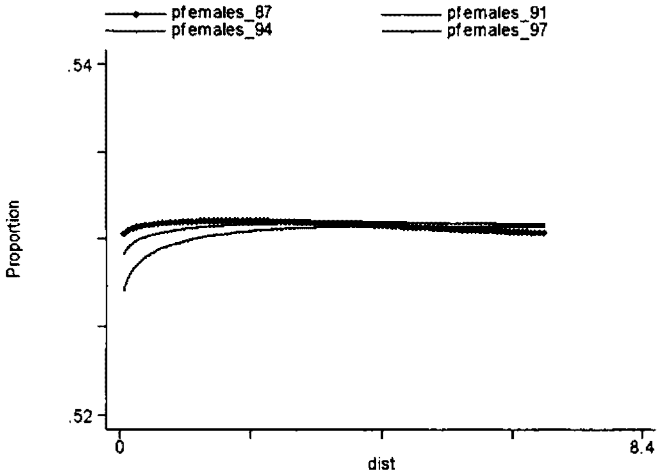
5.2 Census tract attributes

5.2.1 Females

Regression with robust standard errors

Number of obs = 11940
F(5, 11934) = 6.34
Prob > F = 0.0000
R-squared = 0.0016
Root MSE = .01372

pfemales	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0004869	.0004075	-1.19	0.232	-.0012857	.0003119
trend	-.0001192	.0000789	-1.51	0.131	-.0002739	.0000355
ldisty	.0000813	.0000612	1.33	0.184	-.0000387	.0002012
inside	-.0070261	.0014803	-4.75	0.000	-.0099278	-.0041244
insidey	.00078	.0002652	2.94	0.003	.0002601	.0012999
_cons	.5320221	.00053	1003.79	0.000	.5309832	.533061



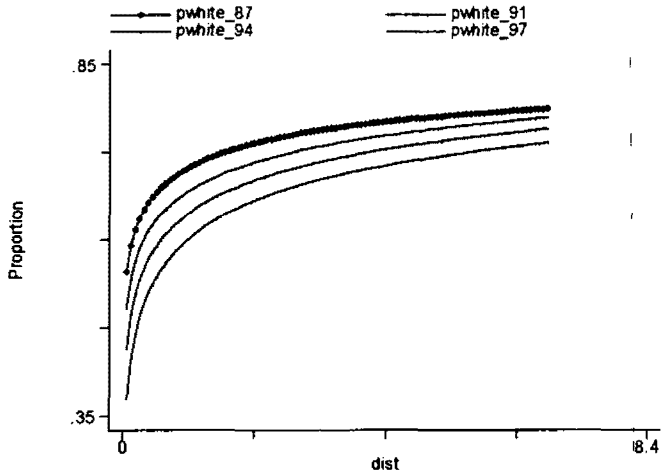
Fitted pfemales by distance from nearest Montclair site (km)

5.2.2 Whites

Regression with robust standard errors

Number of obs	= 11940
F(5, 11934)	= 127.80
Prob > F	= 0.0000
R-squared	= 0.0462
Root MSE	= .26929

pwhite	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0416303	.0061867	6.73	0.000	.0295033	.0537572
trend	-.0102532	.0013299	-7.71	0.000	-.0128601	-.0076463
ldisty	.0028637	.0009531	3.00	0.003	.0009954	.004732
inside	.1553385	.0225094	6.90	0.000	.1112165	.1994605
insidey	-.0171576	.0044719	-3.84	0.000	-.025923	-.0083921
_cons	.7254027	.0086937	83.44	0.000	.7083617	.7424438



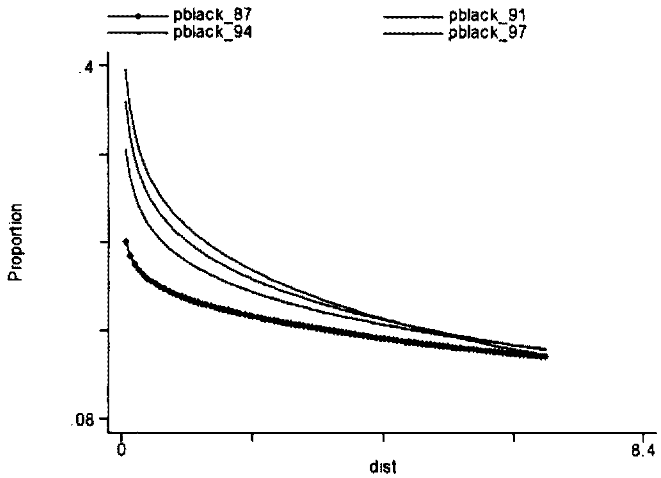
Fitted pwhite by distance from nearest Montclair site (km)

5.2.3 Blacks

Regression with robust standard errors

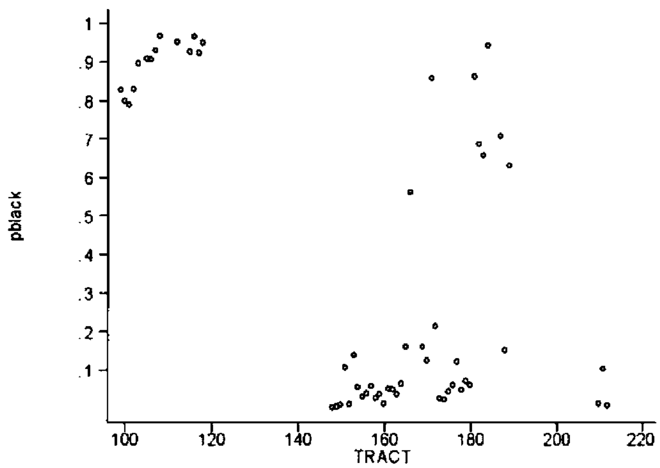
Number of obs	=	11940
F(5, 11934)	=	85.98
Prob > F	=	0.0000
R-squared	=	0.0246
Root MSE	=	.284

pblack	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0253767	.0064643	-3.93	0.000	-.0380477	-.0127057
trend	.0066725	.0013978	4.77	0.000	.0039326	.0094124
ldisty	-.0033634	.0009932	-3.39	0.001	-.0053102	-.0014167
inside	-.1937636	.0216261	-8.96	0.000	-.2361543	-.1513729
insidey	.0184994	.0044745	4.13	0.000	.0097286	.0272703
_cons	.1989742	.0091774	21.68	0.000	.180985	.2169634

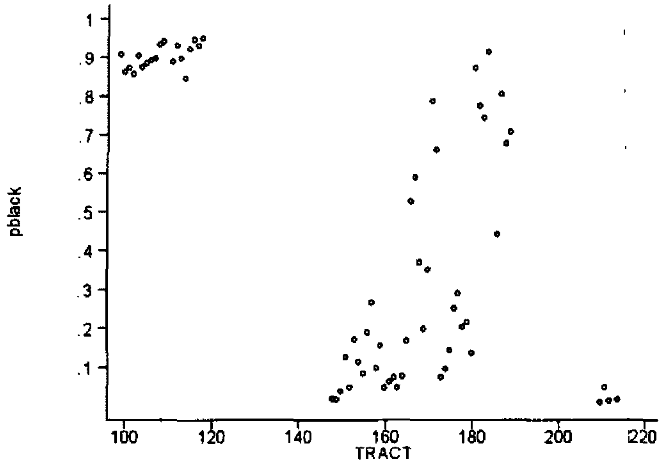


Fitted pblack by distance from nearest Montclair site (km)

We note that some census tracts in the Montclair area were predominantly white and others were predominantly black in data interpolated for 1987. For 1997, it is clear that some of these communities are becoming much more integrated, but others remain segretaged.



Percent black by census tract: Montclair 1987



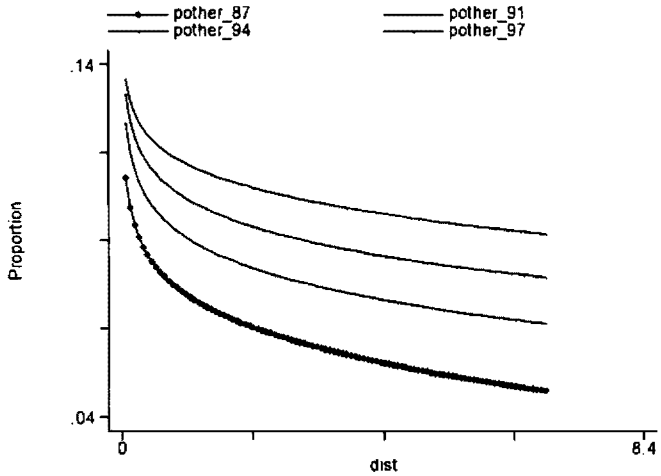
Percent black by census tract: Montclair 1997

5.2.4 Other ethnic groups

Regression with robust standard errors

Number of obs	=	11940
F(5, 11934)	=	269.55
Prob > F	=	0.0000
R-squared	=	0.0948
Root MSE	=	.05392

pother	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0150917	.001525	-9.90	0.000	-.0180809	-.0121024
trend	.0036705	.0002875	12.77	0.000	.0031071	.004234
ldisty	.0003952	.0002132	1.85	0.064	-.0000227	.0008132
inside	.0369728	.0095714	3.86	0.000	.0182112	.0557344
insidey	-.0013925	.0013491	-1.03	0.302	-.0040369	.0012519
_cons	.074682	.0020093	37.17	0.000	.0707435	.0786205



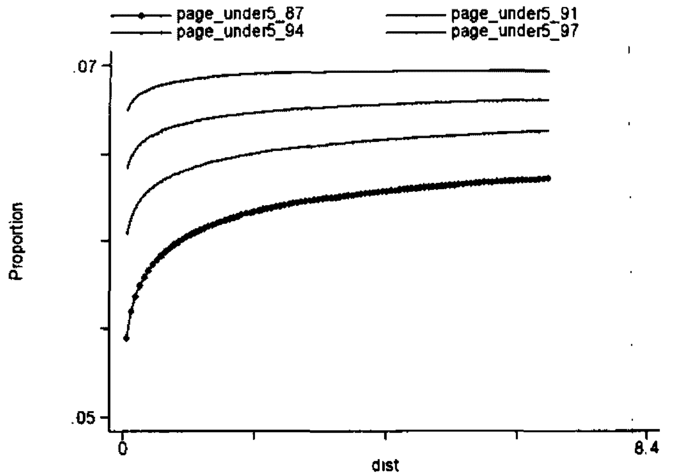
Fitted pother by distance from nearest Montclair site (km)

5.2.5 Children under 5

Regression with robust standard errors

Number of obs	= 11940
F(5, 11934)	= 119.51
Prob > F	= 0.0000
R-squared	= 0.0500
Root MSE	= .0107

page_under5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0018929	.0002475	7.65	0.000	.0014079	.002378
trend	.0008964	.0000495	18.12	0.000	.0007994	.0009934
ldisty	-.000146	.0000367	-3.98	0.000	-.0002179	-.0000741
inside	-.0009087	.001223	-0.74	0.458	-.003306	.0014887
insidey	-.0000739	.0001942	-0.38	0.703	-.0004545	.0003067
_cons	.0598658	.0003327	179.92	0.000	.0592136	.060518



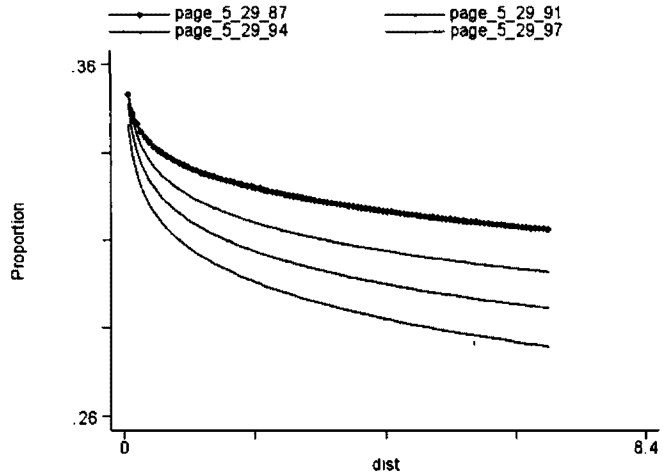
itted page_under5 by distance from nearest Montclair site (kr

5.2.6 Persons between 5 and 29

Regression with robust standard errors

Number of obs = 11940
F(5, 11934) = 187.85
Prob > F = 0.0000
R-squared = 0.0795
Root MSE = .0463

page_5_29	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0089331	.0011781	-7.58	0.000	-.0112425	-.0066238
trend	-.0022751	.0002302	-9.88	0.000	-.0027262	-.0018239
ldisty	-.0005365	.0001789	-3.00	0.003	-.0008872	-.0001858
inside	-.002263	.0046821	-0.48	0.629	-.0114407	.0069148
insidey	.0012068	.0007183	1.68	0.093	-.0002013	.0026148
_cons	.3359905	.0015184	221.27	0.000	.3330141	.3389669



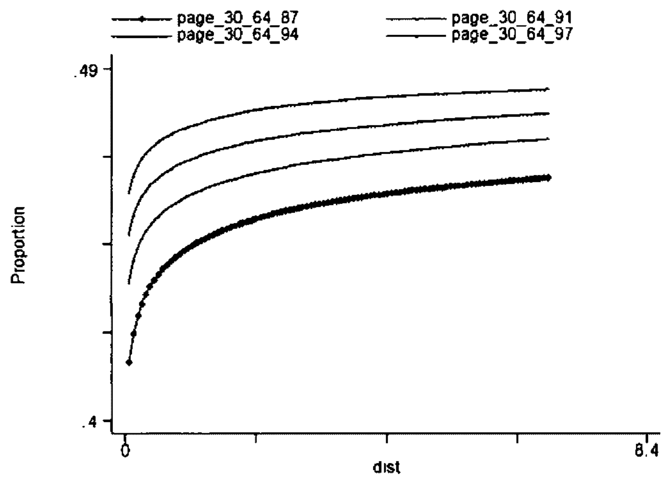
Fitted page_5_29 by distance from nearest Montclair site (km)

5.2.7 Persons between 30 and 64

Regression with robust standard errors

Number of obs	=	11940
F(5, 11934)	=	242.79
Prob > F	=	0.0000
R-squared	=	0.1034
Root MSE	=	.03069

page_30_64	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.009835	.000888	11.08	0.000	.0080944	.0115755
trend	.0031315	.00017	18.42	0.000	.0027983	.0034647
ldisty	-.000451	.0001355	-3.33	0.001	-.0007166	-.0001854
inside	-.0015717	.004051	-0.39	0.698	-.0095122	.0063688
insidey	-.0007805	.0006714	-1.16	0.245	-.0020965	.0005354
_cons	.4425372	.0011031	401.18	0.000	.4403749	.4446994



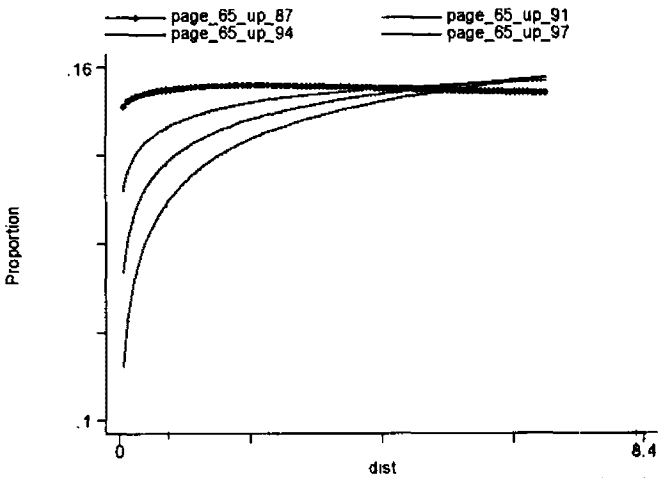
·itted page_30_64 by distance from nearest Montclair site (km

5.2.8 Persons 65 and older

Regression with robust standard errors

Number of obs	=	11940
F(5, 11934)	=	35.27
Prob > F	=	0.0000
R-squared	=	0.0144
Root MSE	=	.04348

page_65_up	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0016329	.0011066	-1.48	0.140	-.0038019	.0005362
trend	-.001663	.0002146	-7.75	0.000	-.0020836	-.0012424
ldisty	.001029	.0001688	6.10	0.000	.0006982	.0013599
inside	.0032911	.0047883	0.69	0.492	-.0060948	.0126769
insidey	-.000403	.00071	-0.57	0.570	-.0017947	.0009887
_cons	.1606655	.0014503	110.78	0.000	.1578226	.1635084



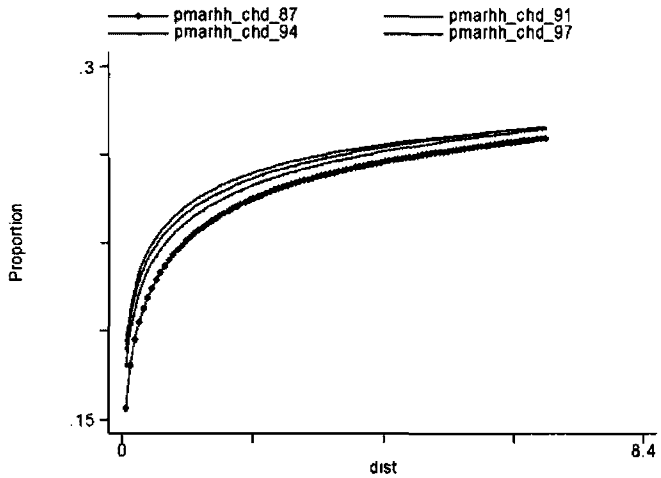
Fitted page_65_up by distance from nearest Montclair site (km

5.2.9 Married heads of household

Regression with robust standard errors

Number of obs	=	11940
F(5, 11934)	=	148.78
Prob > F	=	0.0000
R-squared	=	0.0703
Root MSE	=	.07031

pmarhh_chd	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0239196	.0018363	13.03	0.000	.0203203	.027519
trend	.0015687	.0003609	4.35	0.000	.0008613	.0022761
ldisty	-.0005364	.0002992	-1.79	0.073	-.001123	.0000501
inside	.0078763	.0075662	1.04	0.298	-.0069546	.0227072
insidey	.0002539	.0013898	0.18	0.855	-.0024703	.0029781
_cons	.2271155	.0021676	104.78	0.000	.2228655	.2313644



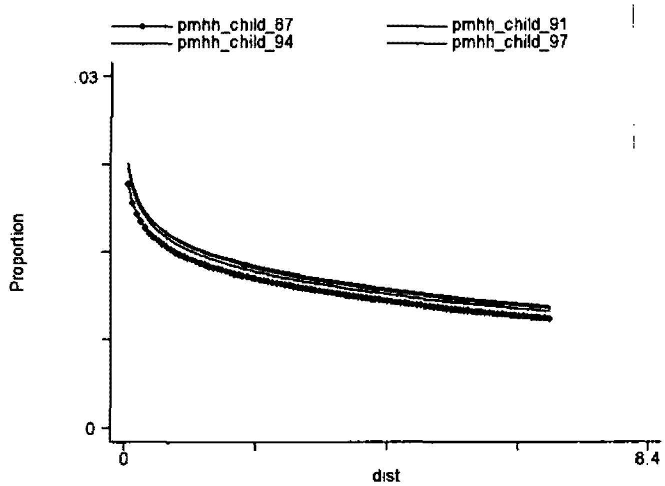
'itted pmarhh_chd by distance from nearest Montclair site (km

5.2.10 Male-headed of household with children

Regression with robust standard errors

Number of obs	= 11940
F(5, 11934)	= 122.95
Prob > F	= 0.0000
R-squared	= 0.0677
Root MSE	= .00966

pmhh_child	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0028063	.0002924	-9.60	0.000	-.0033795	-.0022331
trend	.0001108	.0000555	2.00	0.046	2.07e-06	.0002196
ldisty	-2.45e-06	.000042	-0.06	0.953	-.0000848	.0000799
inside	-.0047882	.0011136	-4.30	0.000	-.0069711	-.0026053
insidey	.0002933	.0001744	1.68	0.093	-.0000486	.0006352
_cons	.0151105	.0003873	39.01	0.000	.0143512	.0158697



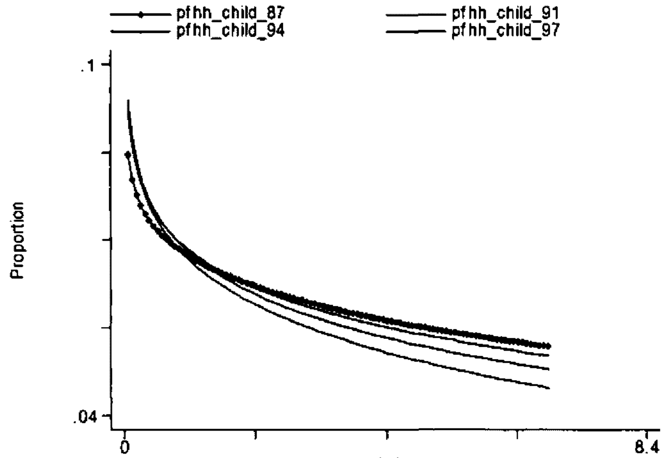
Fitted pmhh_child by distance from nearest Montclair site (km

5.2.11 Female-headed households with children

Regression with robust standard errors

Number of obs	=	11940
F(5, 11934)	=	89.64
Prob > F	=	0.0000
R-squared	=	0.0290
Root MSE	=	.05246

pfhh_child	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0078861	.0011973	-6.59	0.000	-.0102329	-.0055392
trend	-.0000687	.0002414	-0.28	0.776	-.0005419	.0004045
ldisty	-.0003317	.0001748	-1.90	0.058	-.0006743	.0000109
inside	-.0179512	.005672	-3.16	0.002	-.0290693	-.0068331
insidey	.002167	.0008539	2.54	0.011	.0004932	.0038408
_cons	.0704102	.0016435	42.84	0.000	.0671887	.0736317

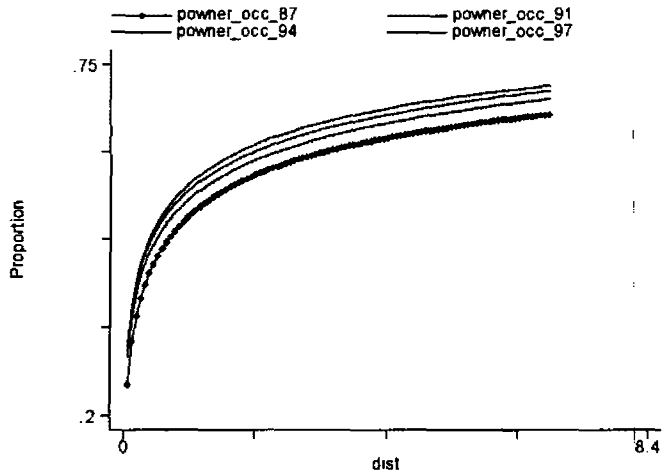


Fitted pfhh_child by distance from nearest Montclair site (km)

5.2.12 Owner-occupancy

```
Regression with robust standard errors               Number of obs =   11940
                                                      F(  5, 11934) =  207.33
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.0975
                                                      Root MSE      =  .23883
```

powner_occ	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0857379	.0068471	12.52	0.000	.0723165	.0991593
trend	.0050299	.0012501	4.02	0.000	.0025794	.0074803
ldisty	-.0002585	.0010134	-0.26	0.799	-.0022448	.0017278
inside	.0196921	.0333814	0.59	0.555	-.0457409	.0851252
insidey	-.0023418	.0051767	-0.45	0.651	-.012489	.0078054
_cons	.516553	.008328	62.03	0.000	.5002288	.5328771

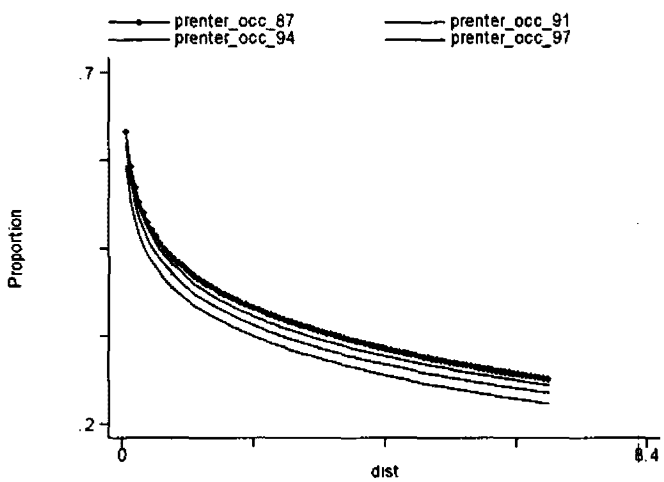


Fitted powner_occ by distance from nearest Montclair site (km

5.2.13 Renter-occupancy

```
Regression with robust standard errors               Number of obs =   11940
                                                     F(  5, 11934) =  213.39
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.1006
                                                     Root MSE      =  .22444
```

prenter_occ	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0827912	.0064599	-12.82	0.000	-.0954536	-.0701288
trend	-.0042791	.0011782	-3.63	0.000	-.0065885	-.0019696
ldisty	.0003412	.0009554	0.36	0.721	-.0015315	.002214
inside	-.0187592	.0315779	-0.59	0.552	-.0806571	.0431387
insidey	.0025831	.0049126	0.53	0.599	-.0070465	.0122126
_cons	.4397649	.0078506	56.02	0.000	.4243764	.4551535



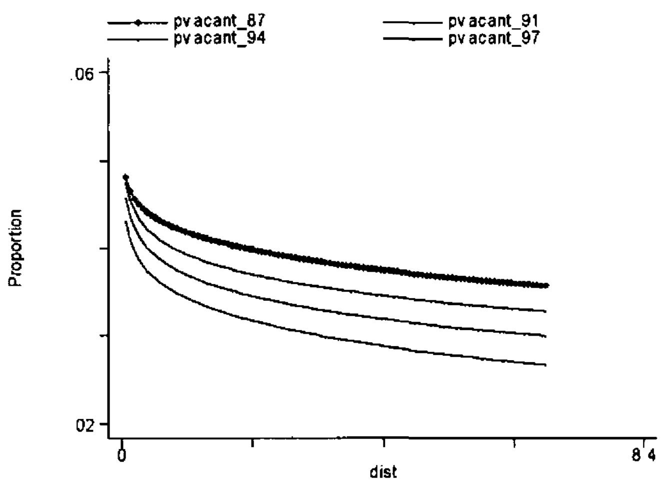
Fitted prenter_occ by distance from nearest Montclair site (km

5.2.14 Vacancy rates

Regression with robust standard errors

Number of obs	=	11940
F(5, 11934)	=	84.03
Prob > F	=	0.0000
R-squared	=	0.0268
Root MSE	=	.0235

pvacant	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0029473	.0005111	-5.77	0.000	-.0039492	-.0019454
trend	-.0007481	.0000914	-8.18	0.000	-.0009273	-.0005689
ldisty	-.0000826	.0000747	-1.11	0.269	-.0002291	.0000638
inside	-.0009375	.0034032	-0.28	0.783	-.0076083	.0057333
insidey	-.0002405	.0004838	-0.50	0.619	-.0011889	.0007079
_cons	.0436624	.0006134	71.18	0.000	.04246	.0448648



Fitted pvacant by distance from nearest Montclair site (km)

Chapter 6 Complete regression results – No lot size interactions

6.1 Just structural characteristics and year dummies

Regression with robust standard errors

Number of obs	=	11940
F(44, 11895)	=	169.26
Prob > F	=	0.0000
R-squared	=	0.4645
Root MSE	=	.45092

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.2462875	.0210282	-11.71	0.000	-.2875061	-.2050688

floors	.0681763	.0096046	7.10	0.000	.0493497	.087003
limpval	.5031077	.0086643	58.07	0.000	.4861244	.5200911
ageknown	-.2537312	.0644329	-3.94	0.000	-.3800303	-.1274321
age20	.0065962	.0957836	0.07	0.945	-.1811553	.1943476
age30	.0495509	.0821105	0.60	0.546	-.111399	.2105008
age40	.3073881	.0686384	4.48	0.000	.1728456	.4419306
age50	.2960261	.0666708	4.44	0.000	.1653403	.4267118
age60	.3650611	.0664993	5.49	0.000	.2347116	.4954106
age70	.2700766	.0657613	4.11	0.000	.1411736	.3989795
age70plus	.2313834	.065123	3.55	0.000	.1037317	.359035
lotsize	.0788871	.0065051	12.13	0.000	.066136	.0916383
inside87	-.0657024	.1603274	-0.41	0.682	-.3799702	.2485654
inside88	-.1609055	.1739843	-0.92	0.355	-.5019432	.1801322
inside89	-.0995028	.0447094	-2.23	0.026	-.1871405	-.0118651
inside90	-.0265615	.0470461	-0.56	0.572	-.1187795	.0656565
inside91	-.5115417	.2246727	-2.28	0.023	-.9519369	-.0711465
inside92	-.0895896	.0845382	-1.06	0.289	-.2552983	.0761192
inside93	-.238346	.1188784	-2.00	0.045	-.4713672	-.0053249
inside94	-.0617714	.0391401	-1.58	0.115	-.1384925	.0149497
inside95	-.05908	.0443651	-1.33	0.183	-.1460428	.0278828
inside96	-.1324379	.0683929	-1.94	0.053	-.2664991	.0016233
inside97	-.1898961	.1928148	-0.98	0.325	-.5678446	.1880524
ldis87	-.0218912	.0260457	-0.84	0.401	-.0729451	.0291627
ldis88	.0396776	.0216239	1.83	0.067	-.0027087	.0820639
ldis89	.0087154	.009982	0.87	0.383	-.0108509	.0282817
ldis90	.034921	.0133111	2.62	0.009	.0088292	.0610129
ldis91	.0453182	.0119244	3.80	0.000	.0219446	.0686919
ldis92	.0368011	.0121178	3.04	0.002	.0130482	.060554
ldis93	.0340323	.0091016	3.74	0.000	.0161917	.0518729
ldis94	.0592907	.0141601	4.19	0.000	.0315345	.0870469
ldis95	.0550966	.0103257	5.34	0.000	.0348566	.0753367
ldis96	.0495602	.0111017	4.46	0.000	.027799	.0713214
ldis97	.0953849	.0169856	5.62	0.000	.0620903	.1286795
year88	.1179787	.0440608	2.68	0.007	.0316123	.204345
year89	.2189199	.0368393	5.94	0.000	.1467088	.291131
year90	.1273144	.0387591	3.28	0.001	.0513402	.2032886
year91	.0349477	.0381631	0.92	0.360	-.0398582	.1097536
year92	.0380014	.0381022	1.00	0.319	-.0366851	.1126879
year93	.0406369	.036685	1.11	0.268	-.0312717	.1125454
year94	.0428305	.0381448	1.12	0.262	-.0319396	.1176005
year95	.0546726	.0366021	1.49	0.135	-.0170735	.1264187
year96	.0227944	.0375643	0.61	0.544	-.0508378	.0964266
year97	-.0727253	.0421038	-1.73	0.084	-.1552556	.009805
_cons	6.424755	.1016539	63.20	0.000	6.225497	6.624013

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific coefficient on INSIDE simultaneously zero	0.0084	
All year-specific coefficients on INSIDE the same	0.5731	NO
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0005	

6.2 Including Census tract attributes

Regression with robust standard errors			
	Number of obs	=	11940
	F(55, 11884)	=	161.68
	Prob > F	=	0.0000
	R-squared	=	0.4936
	Root MSE	=	.4387

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.1688066	.0213291	-7.91	0.000	-.2106152	-.126998
floors	.0784902	.0095354	8.23	0.000	.0597992	.0971813
limpval	.4750606	.0124775	38.07	0.000	.4506026	.4995186
ageknown	-.1790821	.0583229	-3.07	0.002	-.2934045	-.0647598
age20	-.036708	.0862812	-0.43	0.671	-.2058332	.1324172
age30	-.0301581	.0767926	-0.39	0.695	-.1806842	.120368
age40	.1971785	.0624207	3.16	0.002	.0748236	.3195334
age50	.1909351	.0603937	3.16	0.002	.0725536	.3093165
age60	.2689345	.0599962	4.48	0.000	.1513322	.3865369
age70	.1945324	.0589539	3.30	0.001	.0789731	.3100917
age70plus	.1718968	.0581463	2.96	0.003	.0579205	.2858731
lotsize	.0650683	.0065243	9.97	0.000	.0522796	.0778571
inside87	-.0615138	.1626518	-0.38	0.705	-.3803379	.2573104
inside88	-.1262801	.18143	-0.70	0.486	-.4819126	.2293524
inside89	-.0722595	.0531107	-1.36	0.174	-.1763651	.0318461
inside90	.0401207	.0527627	0.76	0.447	-.0633029	.1435443
inside91	-.4604077	.219591	-2.10	0.036	-.890842	-.0299734
inside92	-.0240486	.0838429	-0.29	0.774	-.1883944	.1402973
inside93	-.1377516	.1221886	-1.13	0.260	-.3772613	.1017581
inside94	-.0458004	.0359584	-1.27	0.203	-.1162847	.0246839
inside95	-.0421126	.0442928	-0.95	0.342	-.1289338	.0447086
inside96	-.1386125	.0664374	-2.09	0.037	-.2688407	-.0083843
inside97	-.2050098	.1863174	-1.10	0.271	-.5702223	.1602028
ldis87	-.0620205	.0263429	-2.35	0.019	-.1136569	-.0103841
ldis88	.0141716	.0201659	0.70	0.482	-.0253568	.0537001
ldis89	-.0233212	.0099723	-2.34	0.019	-.0428685	-.0037739
ldis90	-.0007486	.0123961	-0.06	0.952	-.0250469	.0235498
ldis91	.0212482	.0116264	1.83	0.068	-.0015415	.0440379
ldis92	.0087746	.0109771	0.80	0.424	-.0127423	.0302914
ldis93	.010319	.00869	1.19	0.235	-.0067147	.0273528
ldis94	.0394947	.0144622	2.73	0.006	.0111463	.0678431
ldis95	.0315719	.0100001	3.16	0.002	.0119701	.0511737
ldis96	.0336331	.010753	3.13	0.002	.0125555	.0547106
ldis97	.0899648	.0171062	5.26	0.000	.0564338	.1234958
pfemales	.2013268	.6286908	0.32	0.749	-1.03101	1.433664
pblack	.6770098	.0586664	11.54	0.000	.5620141	.7920055
pother	.5524539	.1250948	4.42	0.000	.3072476	.7976602
page_under5	2.670647	.8953561	2.98	0.003	.9156029	4.425692
page_5_29	-1.220749	.2574557	-4.74	0.000	-1.725404	-.7160935
page_65_up	-.79264	.3140823	-2.52	0.012	-1.408293	-.1769874
pmarhh_chd	1.341849	.2016146	6.66	0.000	.9466511	1.737046
pmhh_child	-.9407862	1.298238	-0.72	0.469	-3.485546	1.603973
pfhh_child	-3.579822	.4373976	-8.18	0.000	-4.437193	-2.722451

pvacant	.9293185	.266194	3.49	0.000	.4075347	1.451102
prenter_occ	.1776243	.0565873	3.14	0.002	.066704	.2885446
year88	.0904015	.0430697	2.10	0.036	.0059778	.1748252
year89	.1801503	.0364891	4.94	0.000	.1086257	.251675
year90	.0879317	.0382724	2.30	0.022	.0129115	.1629519
year91	-.0093839	.0380023	-0.25	0.805	-.0838746	.0651069
year92	-.0222978	.0377707	-0.59	0.555	-.0963345	.051739
year93	-.0277583	.0370234	-0.75	0.453	-.1003302	.0448137
year94	-.0532313	.0388661	-1.37	0.171	-.1294152	.0229527
year95	-.053087	.037926	-1.40	0.162	-.1274281	.021254
year96	-.1113112	.0393976	-2.83	0.005	-.1885369	-.0340854
year97	-.2126013	.043806	-4.85	0.000	-.2984682	-.1267344
_cons	6.59805	.3058625	21.57	0.000	5.99351	7.197591

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific coefficient on INSIDE simultaneously zero	0.1124	NO
All year-specific coefficients on INSIDE the same	0.4442	NO
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0000	
All Census tract characteristic effects simultaneously zero	0.0000	

6.3 Including other distances

Regression with robust standard errors

Number of obs = 11940
F(60, 11879) = 143.60
Prob > F = 0.0000
R-squared = 0.4943
Root MSE = .43846

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.2362626	.0227698	-10.38	0.000	-.2808951	-.1916301
floors	.0433051	.0102288	4.23	0.000	.023255	.0633553
limpval	.4977374	.0104624	47.57	0.000	.4772294	.5182453
ageknown	-.1995411	.0607206	-3.29	0.001	-.3185635	-.0805188
age20	-.0030888	.0903818	-0.03	0.973	-.1802519	.1740743
age30	.0294952	.0763365	0.39	0.699	-.1201369	.1791273
age40	.2355597	.0644895	3.65	0.000	.1091497	.3619697
age50	.2290158	.0625756	3.66	0.000	.1063574	.3516742
age60	.3014699	.0623585	4.83	0.000	.1792369	.4237028
age70	.2375039	.0613852	3.87	0.000	.1171789	.3578289
age70plus	.1937161	.0606292	3.20	0.001	.074873	.3125593
lotsize	.0688024	.0065148	10.56	0.000	.0560324	.0815723

inside87	-.090702	.1621694	-0.56	0.576	-.4085806	.2271766
inside88	-.2015083	.1755523	-1.15	0.251	-.5456195	.1426028
inside89	-.1028902	.0494611	-2.08	0.038	-.1998422	-.0059383
inside90	-.0304311	.0456801	-0.67	0.505	-.1199715	.0591093
inside91	-.5174714	.2262181	-2.29	0.022	-.960896	-.0740469
inside92	-.101642	.0914085	-1.11	0.266	-.2808177	.0775336
inside93	-.2407762	.1189361	-2.02	0.043	-.4739103	-.007642
inside94	-.0393263	.045037	-0.87	0.383	-.1276061	.0489536
inside95	-.0660106	.0490507	-1.35	0.178	-.1621579	.0301367
inside96	-.1309708	.066828	-1.96	0.050	-.2619646	.000023
inside97	-.2459959	.2036548	-1.21	0.227	-.6451926	.1532009
ldis87	-.0316554	.0254472	-1.24	0.214	-.081536	.0182252
ldis88	.0374025	.0212966	1.76	0.079	-.0043423	.0791473
ldis89	-.0036091	.010969	-0.33	0.742	-.0251101	.0178918
ldis90	.0271119	.0138659	1.96	0.051	-.0000676	.0542913
ldis91	.0341177	.0122519	2.78	0.005	.010102	.0581334
ldis92	.028539	.0122753	2.32	0.020	.0044774	.0526006
ldis93	.0274066	.0095124	2.88	0.004	.0087608	.0460524
ldis94	.0488147	.0147332	3.31	0.001	.0199352	.0776943
ldis95	.0451795	.0110321	4.10	0.000	.0235547	.0668042
ldis96	.0413617	.0115783	3.57	0.000	.0186664	.064057
ldis97	.0838871	.0168984	4.96	0.000	.0507636	.1170107
ld_summits	.0460893	.0166768	2.76	0.006	.0134	.0787786
ld_school	.0119404	.0068243	1.75	0.080	-.0014363	.0253171
ld_retail	.6365502	.080798	7.88	0.000	.4781729	.7949276
ld_hospital	.0692428	.0094811	7.30	0.000	.0506583	.0878273
ld_church	-.0020441	.0086553	-0.24	0.813	-.01901	.0149217
ld_cemetery	-.0242507	.0097184	-2.50	0.013	-.0433004	-.005201
ld_railroad	.0061729	.0067071	0.92	0.357	-.0069741	.01932
ld_njrds	.030119	.0034949	8.62	0.000	.0232683	.0369696
ld_i280	.012097	.0073877	1.64	0.102	-.0023841	.0265781
ld_gspkwy	.1202201	.0124874	9.63	0.000	.0957426	.1446975
ld_parks	-.0175926	.0046738	-3.76	0.000	-.026754	-.0084312
ld_mjwater	.1307918	.0201436	6.49	0.000	.0913071	.1702765
ld_colleges	-.073431	.0117811	-6.23	0.000	-.0965238	-.0503382
ld_cclubs	.0075314	.005722	1.32	0.188	-.0036846	.0187474
ld_airports	-.566893	.0512933	-11.05	0.000	-.6674362	-.4663497
ld_newark_i	.3909264	.0527823	7.41	0.000	.2874645	.4943884
year88	.1147391	.0433964	2.64	0.008	.029675	.1998033
year89	.2172775	.0364684	5.96	0.000	.1457935	.2887614
year90	.108937	.0385283	2.83	0.005	.0334151	.1844588
year91	.0285168	.0377344	0.76	0.450	-.0454487	.1024824
year92	.0230723	.0374975	0.62	0.538	-.0504289	.0965736
year93	.0347034	.0361729	0.96	0.337	-.0362014	.1056083
year94	.0390628	.0376351	1.04	0.299	-.0347081	.1128336
year95	.0456108	.0361571	1.26	0.207	-.0252631	.1164846
year96	.0165675	.0371395	0.45	0.656	-.056232	.0893671
year97	-.0642	.0418882	-1.53	0.125	-.1463077	.0179077
_cons	-.1845058	.9263968	-0.20	0.842	-2.000395	1.631383

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	

All year-specific coefficient on INSIDE simultaneously zero	0.0209	
All year-specific coefficients on INSIDE the same	0.4535	NO
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0003	
All other distance effects simultaneously zero	0.0000	

6.4 Including both other distances and tract attributes

```
Regression with robust standard errors                Number of obs =   11940
                                                      F( 71, 11868) =  137.29
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.5124
                                                      Root MSE      =  .43073
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.1481448	.023507	-6.30	0.000	-.1942224	-.1020672
floors	.0408979	.0102978	3.97	0.000	.0207124	.0610833
limpval	.4976241	.013299	37.42	0.000	.4715558	.5236924
ageknown	-.1293435	.0557219	-2.32	0.020	-.2385675	-.0201194
age20	-.0363002	.0836071	-0.43	0.664	-.2001837	.1275834
age30	-.0468389	.0720979	-0.65	0.516	-.1881627	.0944849
age40	.1572034	.0592558	2.65	0.008	.0410524	.2733544
age50	.1650789	.0572808	2.88	0.004	.0527991	.2773587
age60	.2469087	.0568836	4.34	0.000	.1354075	.3584099
age70	.1769108	.0558059	3.17	0.002	.0675222	.2862995
age70plus	.1420149	.0548805	2.59	0.010	.0344402	.2495896
lotsize	.0594497	.0064778	9.18	0.000	.0467522	.0721472
inside87	-.0622082	.1630904	-0.38	0.703	-.3818921	.2574757
inside88	-.1821917	.1812667	-1.01	0.315	-.5375042	.1731207
inside89	-.0619429	.0564081	-1.10	0.272	-.1725119	.0486262
inside90	.0103467	.0557159	0.19	0.853	-.0988656	.1195589
inside91	-.4785792	.2246065	-2.13	0.033	-.9188448	-.0383136
inside92	-.0525078	.0908439	-0.58	0.563	-.2305767	.1255612
inside93	-.180911	.1219092	-1.48	0.138	-.419873	.0580511
inside94	-.040997	.0420785	-0.97	0.330	-.1234778	.0414839
inside95	-.0592325	.0521817	-1.14	0.256	-.1615173	.0430522
inside96	-.13893	.0693742	-2.00	0.045	-.2749148	-.0029451
inside97	-.2430417	.1980546	-1.23	0.220	-.6312613	.1451778
ldis87	-.0622194	.0259862	-2.39	0.017	-.1131565	-.0112822
ldis88	.0220357	.0201606	1.09	0.274	-.0174824	.0615538
ldis89	-.026132	.0113241	-2.31	0.021	-.0483291	-.003935
ldis90	-.0010604	.0134562	-0.08	0.937	-.0274367	.0253159
ldis91	.0190349	.0121289	1.57	0.117	-.0047396	.0428095
ldis92	.0104912	.0117362	0.89	0.371	-.0125137	.0334962
ldis93	.0146733	.0092452	1.59	0.113	-.0034438	.0327954
ldis94	.04154	.0151521	2.74	0.006	.0118333	.0712407
ldis95	.0364873	.0108252	3.37	0.001	.0152632	.0577064
ldis96	.037389	.0114299	3.27	0.001	.0149814	.0597935
ldis97	.0906506	.0168807	5.37	0.000	.0575616	.1237395

ld_summits	.0419269	.0174385	2.40	0.016	.0077445	.0761093
ld_school	.0066978	.0069586	0.96	0.336	-.0069421	.0203377
ld_retail	.2545124	.0881352	2.89	0.004	.081753	.4272719
ld_hospital	.0424212	.0098504	4.31	0.000	.0231128	.0617296
ld_church	.0104202	.0089931	1.16	0.247	-.0072079	.0280482
ld_cemetery	-.0192373	.0099644	-1.93	0.054	-.038769	.0002945
ld_railroad	-.0016612	.0068	-0.24	0.807	-.0149903	.0116679
ld_njrds	.0270853	.0035152	7.71	0.000	.020195	.0339756
ld_i280	-.005972	.0078289	-0.76	0.446	-.021318	.009374
ld_gspkwy	.0739805	.013462	5.50	0.000	.0475928	.1003683
ld_parks	-.0083094	.0046428	-1.79	0.074	-.01741	.0007912
ld_mjwater	.1070762	.0213203	5.02	0.000	.065285	.1488674
ld_colleges	-.0233721	.0118601	-1.97	0.049	-.0466198	-.0001244
ld_cclubs	.0099117	.0058941	1.68	0.093	-.0016418	.0214652
ld_airports	-.4220757	.05471	-7.71	0.000	-.5293164	-.3148351
ld_newark_i	.1830018	.0576743	3.17	0.002	.0699507	.2960528
pfemales	.454854	.6400132	0.71	0.477	-.7996767	1.709385
pblack	.6873239	.0628156	10.94	0.000	.5641951	.8104527
pother	.9665518	.1326575	7.29	0.000	.7065213	1.226582
page_under5	1.77971	.9829002	1.81	0.070	-.1469349	3.706356
page_5_29	-.8105554	.2867132	-2.83	0.005	-1.37256	-.2485505
page_65_up	-1.335181	.3309936	-4.03	0.000	-1.983982	-.6863791
pmarhh_chd	1.075264	.243632	4.41	0.000	.597705	1.552822
pmhh_child	-1.687813	1.299352	-1.30	0.194	-4.234756	.8591301
pfhh_child	-3.47872	.4418469	-7.87	0.000	-4.344812	-2.612628
pvacant	.4643934	.2714068	1.71	0.087	-.0676085	.9963952
prenter_ccc	.1652722	.063607	2.60	0.009	.040592	.2899524
year88	.0862001	.042869	2.01	0.044	.0021699	.1702303
year89	.1781898	.0365535	4.87	0.000	.106539	.2498406
year90	.0761685	.038544	1.98	0.048	.000616	.151721
year91	-.0161497	.0378644	-0.43	0.670	-.0903701	.0580707
year92	-.0337583	.0377255	-0.89	0.371	-.1077065	.0401899
year93	-.0344591	.0370058	-0.93	0.352	-.1069965	.0380783
year94	-.061627	.0388062	-1.59	0.112	-.1376935	.0144395
year95	-.0677887	.0378429	-1.79	0.073	-.141967	.0063897
year96	-.1212633	.0397723	-3.05	0.002	-.1992235	-.0433032
year97	-.2137039	.0440602	-4.85	0.000	-.3000692	-.1273387
_cons	4.130283	1.088149	3.80	0.000	1.997333	6.263234

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific coefficient on INSIDE simultaneously zero	0.1400	NO
All year-specific coefficients on INSIDE the same	0.5290	NO
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0000	
All other distance effects simultaneously zero	0.0000	
All Census tract characteristic effects simultaneously zero	0.0000	

Chapter 7 Complete regression results – With lot size interactions

7.1 Just structural characteristics and year dummies

```
Regression with robust standard errors                 Number of obs =   11940
                                                       F( 56, 11873) =  119.00
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.4674
                                                       Root MSE      =   .4501
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.2461375	.0210599	-11.69	0.000	-.2874184	-.2048566
floors	.0684279	.0095993	7.13	0.000	.0496118	.0872441
limpval	.5027855	.0086359	58.22	0.000	.4858577	.5197133
ageknown	-.2661599	.0645674	-4.12	0.000	-.3927226	-.1395972
age20	.0199907	.0954586	0.21	0.834	-.1671238	.2071053
age30	.0603632	.0815477	0.74	0.459	-.0994836	.22021
age40	.3243822	.0684936	4.74	0.000	.1901236	.4586408
age50	.31029	.0669149	4.64	0.000	.1791258	.4414542
age60	.3760878	.0665557	5.65	0.000	.2456276	.5065479
age70	.2808749	.0658646	4.26	0.000	.1517696	.4099803
age70plus	.2433283	.0652726	3.73	0.000	.1153832	.3712733
lotsize	.0925949	.0086944	10.65	0.000	.0755525	.1096374
inside87	1.20434	.7655295	1.57	0.116	-.2962227	2.704904
inside88	-.2893118	.2491193	-1.16	0.246	-.7776264	.1990029
inside89	-.1560025	.071952	-2.17	0.030	-.2970401	-.0149648
inside90	.0324357	.0631234	0.51	0.607	-.0912964	.1561678
inside91	-.8025834	.3186441	-2.52	0.012	-1.427178	-.1779887
inside92	.1341343	.120401	1.11	0.265	-.1018713	.3701399
inside93	-.4907818	.2521055	-1.95	0.052	-.9849499	.0033863
inside94	.08437	.0802709	1.05	0.293	-.0729741	.2417142
inside95	-.0118645	.1420805	-0.08	0.933	-.2903655	.2666365
inside96	.0253598	.089303	0.28	0.776	-.1496887	.2004084
inside97	.1994603	.3223943	0.62	0.536	-.4324852	.8314059
vinside87	-2.031502	1.352263	-1.50	0.133	-4.682158	.6191541
vinside88	.2353674	.3331005	0.71	0.480	-.4175641	.8882989
vinside89	.0843223	.0518359	1.63	0.104	-.0172846	.1859291
vinside90	-.0855838	.0713869	-1.20	0.231	-.2255139	.0543462
vinside91	.4007411	.192845	2.08	0.038	.0227333	.778749
vinside92	-.2877699	.2157495	-1.33	0.182	-.7106742	.1351345
vinside93	.2283016	.1382501	1.65	0.099	-.0426913	.4992944
vinside94	-.2021044	.097027	-2.08	0.037	-.3922932	-.0119155
vinside95	-.0783487	.2558219	-0.31	0.759	-.5798015	.4231041
vinside96	-.1842632	.0995791	-1.85	0.064	-.3794545	.0109282
vinside97	-.5096444	.5947695	-0.86	0.392	-1.67549	.6562013
ldis87	-.0452699	.0338335	-1.34	0.181	-.1115891	.0210493
ldis88	.0292719	.0281842	1.04	0.299	-.0259737	.0845175
ldis89	.0400567	.0157842	2.54	0.011	.009117	.0709964
ldis90	.055396	.0197471	2.81	0.005	.0166884	.0941036
ldis91	.0662461	.0183999	3.60	0.000	.0301793	.1023129
ldis92	.0532288	.0186971	2.85	0.004	.0165794	.0898782

ldis93	.0779527	.0157865	4.94	0.000	.0470086	.1088967
ldis94	.0548778	.0208902	2.63	0.009	.0139297	.095826
ldis95	.0652971	.0184302	3.54	0.000	.0291709	.1014232
ldis96	.078968	.0173553	4.55	0.000	.0449488	.1129872
ldis97	.0681285	.0296495	2.30	0.022	.0100106	.1262464
vldis87	.0271892	.0290303	0.94	0.349	-.0297149	.0840934
vldis88	.010517	.0198821	0.53	0.597	-.0284553	.0494892
vldis89	-.0330968	.0129333	-2.56	0.011	-.0584482	-.0077453
vldis90	-.0258729	.0177825	-1.45	0.146	-.0607295	.0089838
vldis91	-.0239932	.0164347	-1.46	0.144	-.0562079	.0082216
vldis92	-.0194233	.0170738	-1.14	0.255	-.0528907	.0140441
vldis93	-.047743	.0151712	-3.15	0.002	-.077481	-.018005
vldis94	.0040406	.0155776	0.26	0.795	-.0264941	.0345752
vldis95	-.0125951	.0252384	-0.50	0.618	-.0620665	.0368764
vldis96	-.034393	.0154318	-2.23	0.026	-.0646419	-.0041441
vldis97	.029776	.0269676	1.10	0.270	-.0230849	.0826368
year88	.1182232	.0446438	2.65	0.008	.0307141	.2057322
year89	.2210754	.0374153	5.91	0.000	.1477353	.2944154
year90	.1333214	.0395382	3.37	0.001	.0558201	.2108227
year91	.0392233	.0388796	1.01	0.313	-.036987	.1154336
year92	.0426791	.0388566	1.10	0.272	-.0334861	.1188444
year93	.0466048	.037367	1.25	0.212	-.0266406	.1198502
year94	.0432732	.0386575	1.12	0.263	-.0325018	.1190482
year95	.0580416	.0377463	1.54	0.124	-.0159474	.1320305
year96	.0302123	.0382153	0.79	0.429	-.044696	.1051206
year97	-.0719657	.0426243	-1.69	0.091	-.1555163	.0115849
_cons	6.413598	.1015964	63.13	0.000	6.214452	6.612743

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific coefficient on INSIDE simultaneously zero	0.0326	
All lotsize-independent year-specific coefficients on INSIDE the same	0.0216	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.1086	
All lotsize-independent year-specific slope on LDIST the same		
All lotsize-dependent year-specific coefficient on INSIDE simultaneously zero	0.0153	
All lotsize-dependent year-specific coefficients on INSIDE the same	0.0099	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0033	
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.0703	

7.2 Including Census tract attributes

Regression with robust standard errors

Number of obs	=	11940
F(88, 11851)	=	118.41
Prob > F	=	0.0000
R-squared	=	0.5042
Root MSE	=	.43469

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.1555917	.0212656	-7.32	0.000	-.1972758	-.1139077
floors	.0799018	.0093892	8.51	0.000	.0614975	.0983062
limpval	.4513043	.0128258	35.19	0.000	.4261636	.4764451
ageknown	-.1667545	.0604198	-2.76	0.006	-.2851871	-.0483219
age20	-.0547812	.0889524	-0.62	0.538	-.2291425	.1195801
age30	-.0460286	.077327	-0.60	0.552	-.1976022	.1055451
age40	.1732292	.0637876	2.72	0.007	.048195	.2982633
age50	.1754747	.0623812	2.81	0.005	.0531972	.2977522
age60	.2577204	.0619217	4.16	0.000	.1363437	.3790972
age70	.184442	.06094	3.03	0.002	.0649896	.3038944
age70plus	.1503967	.0600749	2.50	0.012	.0326401	.2681533
lotsize	1.898886	.4284057	4.43	0.000	1.05914	2.738631
inside87	1.327893	.7613485	1.74	0.081	-.1644749	2.820261
inside88	-.3140372	.2556629	-1.23	0.219	-.8151784	.187104
inside89	-.0911767	.0836671	-1.09	0.276	-.255178	.0728246
inside90	.0757837	.0729481	1.04	0.299	-.0672065	.2187739
inside91	-.7538822	.3153482	-2.39	0.017	-1.372016	-.1357479
inside92	.1987656	.1203457	1.65	0.099	-.0371317	.4346629
inside93	-.4435937	.2426716	-1.83	0.068	-.9192699	.0320825
inside94	.1083205	.0790341	1.37	0.171	-.0465992	.2632403
inside95	-.0132165	.1424972	-0.09	0.926	-.2925343	.2661013
inside96	.0473243	.0878266	0.54	0.590	-.1248303	.2194789
inside97	.1772172	.3288637	0.54	0.590	-.4674096	.8218439
vinside87	-2.210784	1.353887	-1.63	0.103	-4.864624	.4430563
vinside88	.3521088	.3457122	1.02	0.308	-.3255439	1.029761
vinside89	.0055091	.0687858	0.08	0.936	-.1293224	.1403406
vinside90	-.0702629	.1051623	-0.67	0.504	-.2763983	.1358724
vinside91	.4089645	.194346	2.10	0.035	.0280145	.7899146
vinside92	-.3187379	.2174231	-1.47	0.143	-.7449728	.107397
vinside93	.2367958	.1396171	1.70	0.090	-.0368765	.5104682
vinside94	-.2102388	.1017983	-2.07	0.039	-.4097803	-.0106974
vinside95	-.0281995	.2625748	-0.11	0.914	-.5428891	.4864901
vinside96	-.2273566	.1052115	-2.16	0.031	-.4335884	-.0211249
vinside97	-.4909729	.604846	-0.81	0.417	-1.67657	.6946245
ldis87	-.0667347	.0336392	-1.98	0.047	-.1326729	-.0007964
ldis88	.0016666	.0266233	0.06	0.950	-.0505196	.0538527
ldis89	.0133427	.0166562	0.80	0.423	-.0193062	.0459916
ldis90	.0206669	.0179299	1.15	0.249	-.0144786	.0558125
ldis91	.0508369	.0178128	2.85	0.004	.0159209	.0857528
ldis92	.0248532	.01726	1.44	0.150	-.0089792	.0586856
ldis93	.0521144	.0154312	3.38	0.001	.0218667	.0823621
ldis94	.0498406	.0211036	2.36	0.018	.0084741	.0912071
ldis95	.045747	.0209164	2.19	0.029	.0047474	.0867466
ldis96	.0713424	.0176271	4.05	0.000	.0367904	.1058943

ldis97	.0853133	.0309396	2.76	0.006	.0246666	.14596
vldis87	.0027051	.0286978	0.09	0.925	-.0535473	.0589575
vldis88	.0135	.0198033	0.68	0.495	-.0253177	.0523176
vldis89	-.036293	.0154413	-2.35	0.019	-.0665606	-.0060254
vldis90	-.0295837	.0168912	-1.75	0.080	-.0626932	.0035258
vldis91	-.0350836	.0164293	-2.14	0.033	-.0672877	-.0028795
vldis92	-.0210323	.0168683	-1.25	0.212	-.0540969	.0120324
vldis93	-.0449558	.0155513	-2.89	0.004	-.075439	-.0144726
vldis94	-.0173126	.0158303	-1.09	0.274	-.0483426	.0137173
vldis95	-.0218964	.0308617	-0.71	0.478	-.0823905	.0385977
vldis96	-.0478982	.0170374	-2.81	0.005	-.0812943	-.014502
vldis97	.0002769	.0285389	0.01	0.992	-.0556641	.0562178
pfemales	3.638995	.9776639	3.72	0.000	1.722613	5.555377
pblack	.5734917	.0784868	7.31	0.000	.4196446	.7273388
pother	.2065206	.1902086	1.09	0.278	-.1663195	.5793607
page_under5	1.657506	1.442782	1.15	0.251	-1.170584	4.485597
page_5_29	-1.163295	.4363086	-2.67	0.008	-2.018531	-.3080584
page_65_up	-1.359091	.4858882	-2.80	0.005	-2.311512	-.4066707
pmarhh_chd	.65092	.3487365	1.87	0.062	-.0326608	1.334501
pmhh_child	1.162086	2.290889	0.51	0.612	-3.328433	5.652604
pfhh_child	-4.248994	.7425809	-5.72	0.000	-5.704574	-2.793413
pvacant	.7488725	.5147228	1.45	0.146	-.2600688	1.757814
prenter_occ	.0053371	.0965389	0.06	0.956	-.1838949	.1945691
vpfemales	-4.575072	.9002597	-5.08	0.000	-6.339729	-2.810415
vpblack	.0309887	.0706607	0.44	0.661	-.1075178	.1694952
vpother	.2929666	.147287	1.99	0.047	.0042599	.5816733
vpage_under5	-.4123094	1.104866	-0.37	0.709	-2.578029	1.75341
vpage_5_29	.1748894	.3880707	0.45	0.652	-.5857929	.9355716
vpage_65_up	1.137465	.4297104	2.65	0.008	.2951622	1.979768
vpmarhh_chd	1.089086	.2997905	3.63	0.000	.5014475	1.676725
vpmhh_child	-3.252622	2.244686	-1.45	0.147	-7.652574	1.14733
vpfhh_child	1.517444	.8471985	1.79	0.073	-.1432044	3.178092
vpvacant	.0602551	.5079868	0.12	0.906	-.9354823	1.055993
vprenter_occ	.2529799	.0917453	2.76	0.006	.0731441	.4328157
year88	.0911239	.0432864	2.11	0.035	.0062754	.1759724
year89	.1851009	.0368067	5.03	0.000	.1129538	.257248
year90	.1015647	.0385181	2.64	0.008	.0260629	.1770665
year91	.0000576	.0383678	0.00	0.999	-.0751495	.0752647
year92	-.0109949	.0381852	-0.29	0.773	-.0858442	.0638543
year93	-.0168257	.0373153	-0.45	0.652	-.0899698	.0563184
year94	-.0349802	.038968	-0.90	0.369	-.1113638	.0414035
year95	-.0295593	.039832	-0.74	0.458	-.1076366	.048518
year96	-.0798571	.039797	-2.01	0.045	-.1578658	-.0018484
year97	-.1876873	.0440181	-4.26	0.000	-.27397	-.1014045
_cons	5.40201	.4651399	11.61	0.000	4.490259	6.31376

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific coefficient on INSIDE simultaneously zero	0.0331	
All lotsize-independent year-specific coefficients on INSIDE the	0.0258	

same		
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.0000	
All lotsize-independent year-specific slope on LDIST the same	0.0120	
All lotsize-independent Census tract characteristic effects simultaneously zero	0.0000	
All lotsize-dependent year-specific coefficient on INSIDE simultaneously zero	0.0145	
All lotsize-dependent year-specific coefficients on INSIDE the same	0.0143	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0050	
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.2525	NO
All lotsize-dependent Census tract characteristic effects simultaneously zero (on vX Census tract variables)	0.0030	

7.3 Including other distances

```
Regression with robust standard errors                 Number of obs =   11940
                                                       F( 98, 11841) =  102.65
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5067
                                                       Root MSE      =  .43377
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.2287369	.0222194	-10.29	0.000	-.2722906	-.1851833
floors	.0386152	.0103033	3.75	0.000	.018419	.0588114
limpval	.4813311	.0113756	42.31	0.000	.459033	.5036292
ageknown	-.2347059	.0631998	-3.71	0.000	-.358588	-.1108239
age20	.0510878	.0911383	0.56	0.575	-.1275582	.2297339
age30	.0663445	.0767563	0.86	0.387	-.0841105	.2167995
age40	.2449608	.0664987	3.68	0.000	.1146124	.3753093
age50	.246457	.065636	3.75	0.000	.1177956	.3751144
age60	.3300137	.0648841	5.09	0.000	.2028301	.4571972
age70	.2690778	.0639952	4.20	0.000	.1436367	.3945189
age70plus	.2177839	.0633959	3.44	0.001	.0935175	.3420503
lotsize	5.198291	2.090635	2.49	0.013	1.100303	9.296279
inside87	1.312467	.7447861	1.76	0.078	-.1474363	2.77237
inside88	-.2723894	.2503217	-1.09	0.277	-.7630611	.2182823
inside89	-.144157	.0806899	-1.79	0.074	-.3023225	.0140084
inside90	.0898942	.0801202	1.11	0.267	-.0681545	.2459429
inside91	-.8317921	.3199761	-2.60	0.009	-1.458998	-.2045864

inside92	.1736454	.125308	1.39	0.166	-.0719788	.4192696
inside93	-.4005431	.2437214	-1.64	0.100	-.8782772	.077191
inside94	.1252535	.091058	1.38	0.169	-.0532352	.3037422
inside95	.0354209	.1787843	0.20	0.843	-.3150258	.3858675
inside96	.0681992	.0913403	0.75	0.455	-.1108427	.2472412
inside97	.2350139	.3245386	0.72	0.469	-.4011351	.8711629
vinside87	-2.241971	1.317233	-1.70	0.089	-4.823963	.3400214
vinside88	.1582947	.3332254	0.48	0.635	-.4948818	.8114712
vinside89	.0673108	.0794468	0.85	0.397	-.088418	.2230396
vinside90	-.152343	.0794524	-1.92	0.055	-.3080826	.0033967
vinside91	.4513601	.196025	2.30	0.021	.0671188	.8356013
vinside92	-.3377249	.2224905	-1.52	0.129	-.7738429	.0983931
vinside93	.1407771	.1316803	1.07	0.285	-.1173379	.3988921
vinside94	-.2234914	.1167025	-1.92	0.056	-.4522474	.0052646
vinside95	-.1399916	.328934	-0.43	0.670	-.7847562	.5047731
vinside96	-.2391652	.110798	-2.16	0.031	-.4563475	-.0219829
vinside97	-.5979581	.6008897	-1.00	0.320	-1.775801	.5798846
ldis87	-.0685386	.0332642	-2.06	0.039	-.133742	-.0033352
ldis88	.0163296	.0276973	0.59	0.555	-.0379617	.0706209
ldis89	.0180767	.0160616	1.13	0.260	-.0134066	.0495601
ldis90	.0113164	.0197947	0.57	0.568	-.0274845	.0501174
ldis91	.03852	.0178379	2.16	0.031	.0035547	.0734852
ldis92	.027194	.0185139	1.47	0.142	-.0090964	.0634844
ldis93	.0444265	.0160717	2.76	0.006	.0129233	.0759296
ldis94	.0296375	.0217526	1.36	0.173	-.013001	.0722761
ldis95	.027221	.0198239	1.37	0.170	-.011637	.0660791
ldis96	.0478906	.0179807	2.66	0.008	.0126455	.0831356
ldis97	.0589567	.0287878	2.05	0.041	.0025279	.1153854
vldis87	.0345949	.0300081	1.15	0.249	-.0242259	.0934157
vldis88	.0215694	.0206786	1.04	0.297	-.0189641	.0621029
vldis89	-.0218843	.0131949	-1.66	0.097	-.0477484	.0039798
vldis90	.0163058	.0180541	0.90	0.366	-.0190831	.0516948
vldis91	-.0060064	.0159728	-0.38	0.707	-.0373157	.0253029
vldis92	-.0006561	.0177764	-0.04	0.971	-.0355008	.0341887
vldis93	-.0184821	.0160643	-1.15	0.250	-.0499707	.0130064
vldis94	.0178603	.0170651	1.05	0.295	-.0155901	.0513108
vldis95	.0179614	.0277529	0.65	0.518	-.0364388	.0723616
vldis96	-.0109826	.0165121	-0.67	0.506	-.043349	.0213839
vldis97	.027111	.0267199	1.01	0.310	-.0252644	.0794864
ld_summits	.0373709	.029433	1.27	0.204	-.0203226	.0950644
ld_school	.0365305	.0116968	3.12	0.002	.0136029	.0594581
ld_retail	.8859575	.1729206	5.12	0.000	.5470046	1.22491
ld_hospital	.1218503	.0145481	8.38	0.000	.0933336	.1503669
ld_church	.0163629	.0143884	1.14	0.255	-.0118407	.0445664
ld_cemetery	-.0137802	.016551	-0.83	0.405	-.0462229	.0186625
ld_railroad	-.0294455	.0105898	-2.78	0.005	-.0502033	-.0086877
ld_njrds	.0063738	.0056671	1.12	0.261	-.0047347	.0174824
ld_i280	-.00512	.013585	-0.38	0.706	-.0317489	.0215089
ld_gspkwy	.171849	.023189	7.41	0.000	.1263947	.2173033
ld_parks	.0139228	.0083375	1.67	0.095	-.0024199	.0302656
ld_mjwater	.1372817	.0370056	3.71	0.000	.0647447	.2098187
ld_colleges	-.0785524	.0237257	-3.31	0.001	-.1250586	-.0320462
ld_cclubs	.0009817	.0082758	0.12	0.906	-.0152402	.0172037
ld_airports	-.7112129	.1201315	-5.92	0.000	-.9466904	-.4757354
ld_newark_i	.5865961	.1197834	4.90	0.000	.3518008	.8213913
vld_summits	.0160069	.0258883	0.62	0.536	-.0347383	.0667522

vld_school	-.0186214	.0095079	-1.96	0.050	-.0372584	.0000155
vld_retail	-.3242198	.169203	-1.92	0.055	-.6558855	.0074458
vld_hospital	-.067021	.0146772	-4.57	0.000	-.0957908	-.0382512
vld_church	-.0139537	.0114934	-1.21	0.225	-.0364827	.0085753
vld_cemetery	-.0117227	.0151627	-0.77	0.439	-.0414442	.0179987
vld_railroad	.0408327	.0088443	4.62	0.000	.0234964	.0581691
vld_njrds	.023313	.0045355	5.14	0.000	.0144227	.0322033
vld_i280	.0165044	.0117868	1.40	0.161	-.0065997	.0396086
vld_gspkwy	-.0748724	.0267435	-2.80	0.005	-.1272939	-.0224508
vld_parks	-.0272249	.007566	-3.60	0.000	-.0420555	-.0123942
vld_mjwater	-.0417069	.0349399	-1.19	0.233	-.1101948	.0267809
vld_colleges	.0249413	.0238649	1.05	0.296	-.0218377	.0717204
vld_cclubs	-.0003378	.0040357	-0.08	0.933	-.0082484	.0075729
vld_airports	.1606291	.1102629	1.46	0.145	-.0555042	.3767624
vld_newark_i	-.2736858	.1249954	-2.19	0.029	-.5186973	-.0286743
year88	.1048026	.0438016	2.39	0.017	.0189442	.190661
year89	.206907	.0368331	5.62	0.000	.1347081	.2791059
year90	.1027585	.0391785	2.62	0.009	.0259622	.1795549
year91	.0220043	.0383307	0.57	0.566	-.0531302	.0971387
year92	.0142346	.038081	0.37	0.709	-.0604104	.0888796
year93	.027096	.0367563	0.74	0.461	-.0449525	.0991445
year94	.0276894	.0379951	0.73	0.466	-.0467873	.102166
year95	.0386965	.0369751	1.05	0.295	-.0337807	.1111737
year96	.0107121	.0376805	0.28	0.776	-.0631479	.0845721
year97	-.0767808	.042187	-1.82	0.069	-.1594743	.0059127
_cons	-3.550678	1.89115	-1.88	0.060	-7.257642	.156287

Hypothesis	**P-value of F-test**	**Reject?**
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific coefficient on INSIDE simultaneously zero	0.0190	
All lotsize-independent year-specific coefficients on INSIDE the same	0.0130	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.0092	
All lotsize-independent year-specific slope on LDIST the same	0.1169	NO
All lotsize-independent other distance effects simultaneously zero	0.0000	
All lotsize-dependent year-specific coefficient on INSIDE simultaneously zero	0.0385	
All lotsize-dependent year-specific coefficients on INSIDE the same	0.0119	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.1252	NO
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.1312	NO

All lotsize-dependent other distance effects simultaneously zero (on vX "other distance" variables)	0.0000

7.4 Including both other distances and tract attributes

```
Regression with robust standard errors               Number of obs =   11940
                                                     F(120, 11819) =  101.32
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.5295
                                                     Root MSE      =  .42402
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
knowflr	-.1388045	.0234666	-5.91	0.000	-.1848029	-.092806
floors	.0468302	.0101169	4.63	0.000	.0269994	.0666611
limpval	.4685191	.0140783	33.28	0.000	.4409233	.496115
ageknown	-.1020435	.0599523	-1.70	0.089	-.2195598	.0154728
age20	-.0367788	.0867948	-0.42	0.672	-.206911	.1333533
age30	-.056402	.0740602	-0.76	0.446	-.2015722	.0887681
age40	.1163051	.0631492	1.84	0.066	-.0074776	.2400879
age50	.1307326	.061948	2.11	0.035	.0093044	.2521609
age60	.2194256	.0613041	3.58	0.000	.0992594	.3395918
age70	.1489352	.0603619	2.47	0.014	.030616	.2672545
age70plus	.1039544	.059647	1.74	0.081	-.0129635	.2208724
lotsize	11.05272	2.183822	5.06	0.000	6.772071	15.33337
inside87	1.320297	.7673162	1.72	0.085	-.1837694	2.824363
inside88	-.2130517	.2620469	-0.81	0.416	-.7267068	.3006035
inside89	-.0562239	.10345	-0.54	0.587	-.2590029	.1465552
inside90	.1149565	.081788	1.41	0.160	-.0453615	.2752745
inside91	-.7884622	.3218548	-2.45	0.014	-1.419351	-.1575737
inside92	.2425379	.1279812	1.90	0.058	-.0083264	.4934022
inside93	-.3638381	.2431987	-1.50	0.135	-.8405476	.1128714
inside94	.147494	.0946385	1.56	0.119	-.0380132	.3330011
inside95	.0013879	.1543916	0.01	0.993	-.3012451	.3040208
inside96	.0359847	.1000822	0.36	0.719	-.1601929	.2321623
inside97	.1947032	.3393725	0.57	0.566	-.4705227	.8599291
vinside87	-2.194676	1.362436	-1.61	0.107	-4.865275	.475923
vinside88	.1110547	.3607654	0.31	0.758	-.5961049	.8182143
vinside89	.0022437	.1253706	0.02	0.986	-.2435032	.2479907
vinside90	-.1618678	.0959758	-1.69	0.092	-.3499962	.0262606
vinside91	.450845	.2013335	2.24	0.025	.0561982	.8454917
vinside92	-.3932505	.2273961	-1.73	0.084	-.8389844	.0524834
vinside93	.137383	.1375244	1.00	0.318	-.1321875	.4069536
vinside94	-.237142	.1286066	-1.84	0.065	-.4892321	.0149481
vinside95	-.0520266	.2792381	-0.19	0.852	-.5993793	.495326
vinside96	-.1943162	.1277085	-1.52	0.128	-.444646	.0560135
vinside97	-.5286984	.6271795	-0.84	0.399	-1.758074	.7006768
ldis87	-.0870175	.033402	-2.61	0.009	-.1524909	-.0215441
ldis88	-.0069996	.0266664	-0.26	0.793	-.0592702	.0452709
ldis89	-.0097467	.0182342	-0.53	0.593	-.0454887	.0259953
ldis90	-.0262071	.0197768	-1.33	0.185	-.064973	.0125587

ldis91	.0236279	.0191811	1.23	0.218	-.0139703	.061226
ldis92	.0033196	.0186659	0.18	0.859	-.0332686	.0399079
ldis93	.0325805	.0165168	1.97	0.049	.0002048	.0649562
ldis94	.0231713	.0227175	1.02	0.308	-.0213588	.0677014
ldis95	.0156275	.0209928	0.74	0.457	-.0255219	.0567768
ldis96	.0440892	.0195189	2.26	0.024	.0058289	.0823494
ldis97	.0669015	.0301052	2.22	0.026	.0078905	.1259126
vldis87	.0219704	.0292732	0.75	0.453	-.0354098	.0793507
vldis88	.0340216	.0204872	1.66	0.097	-.0061367	.0741799
vldis89	-.0131749	.0173746	-0.76	0.448	-.047232	.0208822
vldis90	.0251521	.0195516	1.29	0.198	-.0131723	.0634765
vldis91	-.0048707	.0192534	-0.25	0.800	-.0426106	.0328692
vldis92	.0063697	.0190284	0.33	0.738	-.030929	.0436684
vldis93	-.0170301	.0172687	-0.99	0.324	-.0508796	.0168193
vldis94	.0160286	.0185496	0.86	0.388	-.0203317	.0523888
vldis95	.0153054	.0301445	0.51	0.612	-.0437329	.0743936
vldis96	-.0163576	.020216	-0.81	0.418	-.0559343	.023269
vldis97	.0180802	.0288953	0.63	0.532	-.0385595	.0747198
ld_summits	.0658995	.0301136	2.19	0.029	.0068718	.1249272
ld_school	.038532	.0120029	3.21	0.001	.0150043	.0620598
ld_retail	.3609476	.1826239	1.98	0.048	.0029747	.7189204
ld_hospital	.0708335	.0158687	4.46	0.000	.0397282	.1019388
ld_church	.0125312	.0150399	0.83	0.405	-.0169495	.0420119
ld_cemetery	-.0016792	.017265	-0.10	0.923	-.0355214	.032163
ld_railroad	-.0296702	.0106432	-2.79	0.005	-.0505327	-.0088077
ld_njrds	.0048456	.0056867	0.85	0.394	-.0063013	.0159924
ld_i280	.0136775	.0145797	0.94	0.348	-.0149012	.0422562
ld_gspkwy	.109992	.0240495	4.57	0.000	.062851	.1571329
ld_parks	.0157448	.0076826	2.05	0.040	.0006857	.0308039
ld_mjwater	.1177259	.0383034	3.07	0.002	.0426449	.1928069
ld_colleges	-.0120485	.0226507	-0.53	0.595	-.0564475	.0323505
ld_cclubs	.0004339	.0087763	0.05	0.961	-.0167691	.0176368
ld_airports	-.3845297	.1326254	-2.90	0.004	-.6444974	-.124562
ld_newark_i	.4456733	.1218155	3.66	0.000	.2068948	.6844517
vld_summits	-.0298753	.0247342	-1.21	0.227	-.0783584	.0186078
vld_school	-.0294116	.0095838	-3.07	0.002	-.0481975	-.0106258
vld_retail	-.2153227	.1699369	-1.27	0.205	-.548427	.1177816
vld_hospital	-.0559326	.0145134	-3.85	0.000	-.0843813	-.0274839
vld_church	.0038147	.0122057	0.31	0.755	-.0201104	.0277398
vld_cemetery	-.0241847	.0163083	-1.48	0.138	-.0561516	.0077822
vld_railroad	.036741	.0084999	4.32	0.000	.0200799	.0534021
vld_njrds	.0235222	.0046235	5.09	0.000	.0144593	.0325851
vld_i280	-.0355665	.0123809	-2.87	0.004	-.0598351	-.011298
vld_gspkwy	-.0504349	.0268557	-1.88	0.060	-.1030764	.0022067
vld_parks	-.0203045	.0067555	-3.01	0.003	-.0335463	-.0070627
vld_mjwater	-.1098461	.0374935	-2.93	0.003	-.1833396	-.0363527
vld_colleges	.0071572	.0217797	0.33	0.742	-.0355345	.049849
vld_cclubs	.0008703	.0049006	0.18	0.859	-.0087356	.0104762
vld_airports	-.0649777	.1225234	-0.53	0.596	-.3051438	.1751883
vld_newark_i	-.552884	.1222448	-4.52	0.000	-.792504	-.3132641
pfemales	2.946455	1.009645	2.92	0.004	.9673843	4.925526
pblack	.6455517	.0912565	7.07	0.000	.4666738	.8244295
pother	.5025801	.2143407	2.34	0.019	.0824369	.9227232
page_under5	1.104882	1.544262	0.72	0.474	-1.922126	4.131889
page_5_29	-.8263215	.4643796	-1.78	0.075	-1.736582	.0839389
page_65_up	-2.008093	.5136042	-3.91	0.000	-3.014842	-1.001344
pmarhh_chd	-.0910406	.4179533	-0.22	0.828	-.910298	.7282168

pmhh_child	.5381206	2.239511	0.24	0.810	-3.85169	4.927932
pfhh_child	-4.029349	.7243345	-5.56	0.000	-5.449164	-2.609534
pvacant	.4903542	.5223224	0.94	0.348	-.5334836	1.514192
prenter_occ	-.0574815	.1097548	-0.52	0.600	-.272619	.1576561
vpfemales	-3.239823	.9289654	-3.49	0.000	-5.060748	-1.418897
vpblack	-.111944	.0852464	-1.31	0.189	-.279041	.0551529
vpother	.5074429	.184935	2.74	0.006	.1449398	.8699459
vpage_under5	-1.070621	1.285217	-0.83	0.405	-3.589858	1.448616
vpage_5_29	.06907	.4157292	0.17	0.868	-.7458276	.8839676
vpage_65_up	1.263968	.4582809	2.76	0.006	.3656619	2.162274
vpmarhh_chd	1.677632	.3684749	4.55	0.000	.9553604	2.399903
vpmhh_child	-2.802156	2.123441	-1.32	0.187	-6.964451	1.360139
vpfhh_child	1.604859	.7723147	2.08	0.038	.0909948	3.118723
vpvacant	-.526921	.5277025	-1.00	0.318	-1.561305	.5074629
vprenter_occ	.3158721	.102198	3.09	0.002	.1155471	.516197
year88	.0756214	.0430731	1.76	0.079	-.0088088	.1600517
year89	.1722892	.0368321	4.68	0.000	.1000922	.2444863
year90	.0830788	.0388464	2.14	0.032	.0069334	.1592243
year91	-.0165673	.0383278	-0.43	0.666	-.0916962	.0585616
year92	-.0324988	.038089	-0.85	0.394	-.1071596	.0421619
year93	-.0345966	.037293	-0.93	0.354	-.1076971	.0385038
year94	-.0563537	.0390625	-1.44	0.149	-.1329226	.0202151
year95	-.0525721	.0389484	-1.35	0.177	-.1289175	.0237733
year96	-.0994709	.0403243	-2.47	0.014	-.1785132	-.0204285
year97	-.2015484	.0442536	-4.55	0.000	-.2882928	-.1148041
_cons	-1.241569	2.044169	-0.61	0.544	-5.248477	2.765339

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific coefficient on INSIDE simultaneously zero	0.0376	
All lotsize-independent year-specific coefficients on INSIDE the same	0.0427	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.0042	
All lotsize-independent year-specific slope on LDIST the same	0.0040	
All lotsize-independent other distance effects simultaneously zero	0.0000	
All lotsize-independent Census tract characteristic effects simultaneously zero	0.0000	
All lotsize-dependent year-specific coefficient on INSIDE simultaneously zero	0.0355	
All lotsize-dependent year-specific coefficients on INSIDE the same	0.0478	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.2052	NO
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.1606	NO
All lotsize-dependent other distance effects simultaneously zero (on vX "other distance" variables)	0.0000	
All lotsize-dependent Census tract characteristic effects simultaneously zero (on vX Census tract variables)	0.0000	

Appendix B – OII Landfill Site

Contents:

Chapter 1 Criteria for Exclusion from Raw Samples

For OII, we drop observations for all the same reasons as Montclair. For OII, however, there are many more structural characteristics of the house available, and we prefer to use these to control for structural differences. For OII, we drop observations for which

- no data are available concerning the year the dwelling was built, which is used to determine its age at the time of the last sale.
- Number of floors exceeds four
- Square footage of the dwelling is missing
- Number of bedrooms or bathrooms is missing, or number of full baths is greater than five
- Presence or absence of a fireplace is not recorded
- Square footage of dwelling exceeds 5000.
- Lotsize is greater than 25,000 square feet (e.g. 250' x 100')

Chapter 2 Annual counts in sample

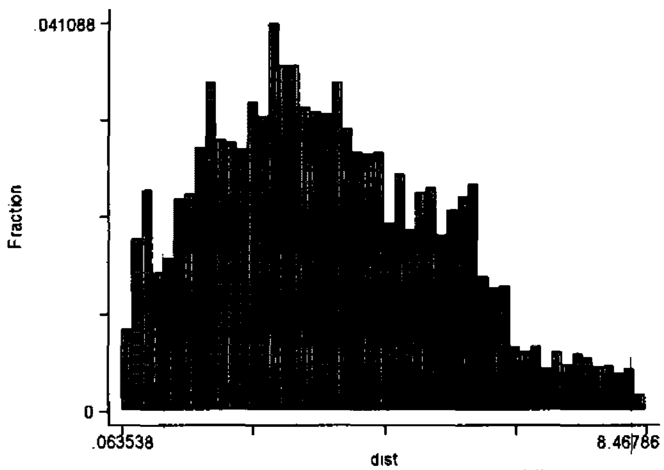
year	Freq.	Percent	Cum.
70	99	1.07	1.07
71	138	1.50	2.57
72	189	2.05	4.62
73	203	2.20	6.83
74	201	2.18	9.01
75	209	2.27	11.28
76	242	2.63	13.91
77	259	2.81	16.72
78	225	2.44	19.16
79	228	2.48	21.64
80	130	1.41	23.05
81	82	0.89	23.94
82	98	1.06	25.00
83	166	1.80	26.80
84	200	2.17	28.98
85	229	2.49	31.46
86	303	3.29	34.75
87	382	4.15	38.90
88	415	4.51	43.40
89	398	4.32	47.73
90	331	3.59	51.32
91	343	3.72	55.04
92	312	3.39	58.43
93	364	3.95	62.38
94	432	4.69	67.07
95	396	4.30	71.37
96	467	5.07	76.44
97	484	5.25	81.70
98	745	8.09	89.78
99	941	10.22	100.00

Total	9211	100.00

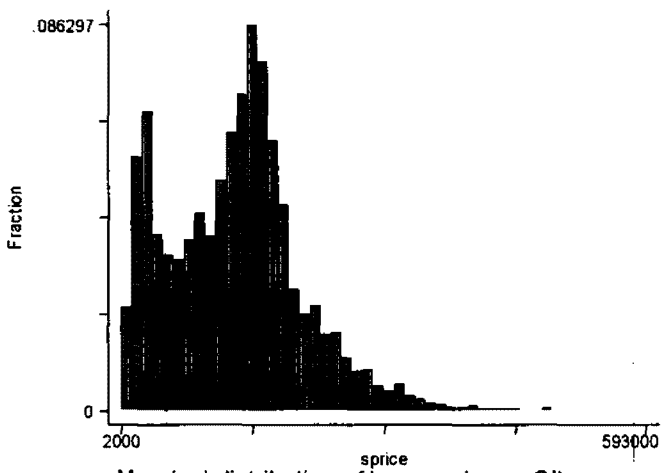
Chapter 3 Descriptive statistics

3.1 Housing prices and distances from the site

Variable	Obs	Mean	Std. Dev.	Min	Max
dist	9211	3.367053	1.853798	.0635377	8.467858
sprice	9211	130252.1	75643.73	2000	593000



Marginal distribution of distances: OII



Marginal distribution of house prices: OII

3.2 Structural variables

Variable	Obs	Mean	Std. Dev.	Min	Max

notold	9211	.9997829	.0147346	0	1
age	9211	32.53849	18.62063	0	91
age2	9211	1405.443	1293.041	0	8281
sqft	9211	1.373521	.4950583	.3	4.8
sqft2	9211	2.131615	1.739636	.09	23.04
bedrms	9211	2.903811	.8580447	1	7
bthrms	9211	1.912116	.8345881	1	5
sqftbed	9211	4.256291	2.66714	.3	27
sqftbth	9211	2.884616	2.1323	.3	19.2
fplace	9211	.396591	.4892163	0	1
knowflr	9211	.8059928	.3954559	0	1
floors	9211	.9280751	.5609922	0	3
lotsize	9211	1	.4556344	.1294409	4.045029

3.2.1 R^2 for auxiliary regressions among variables

3.3 Census tract attributes

Variable	Obs	Mean	Std. Dev.	Min	Max
pfemales	9211	.5118072	.0118325	.4678834	.5899951
pblack	9211	.0059348	.0054257	0	.0882786
pother	9211	.5082869	.1999439	.003553	.8814761
page_under5	9211	.078255	.0177446	.0382657	.136191
page_5_29	9211	.4069791	.0487373	.2603768	.5292445
page_65_up	9211	.1073373	.0394719	.0255308	.2438971
pmarhh_chd	9211	.3142498	.0640051	.1093058	.5365998
pmhh_child	9211	.0258387	.0166391	0	.1202512
pfhh_child	9211	.0784943	.0324638	0	.1863905
pvacant	9211	.0296959	.0137419	0	.1009516
prenter_occ	9211	.3972171	.1705825	.090209	.7281437

3.3.1 R^2 for auxiliary regressions among variables

3.4 Other distances

Distance variable	Description (in kilometers)
d_school	Distance to nearest school. There are dozens of schools in the sample area.
d_retail	Distance to nearest retail center. Montebello Mall lies about three-quarters of a mile to the east of the eastern edge of the site.
d_hospital	Distance to nearest hospital. There are four hospitals that lie within the boundaries of our sample area, and a further 12 lying just outside the sample area that will sometimes be the nearest hospital to some houses in our sample.

d_church	Distance to nearest church. Only Saint Alphonsus Catholic Church lies in our sample area, in the western portion. There are no other churches within the sample area, but there are dozens of religious facilities clustered in each of three areas, one starting about a mile to the southwest, one starting about two miles to the southeast of the sample area, and one starting about a mile to the northeast.
d_cemetery	Distance to nearest cemetery. Resurrection Cemetery lies just to the north of the landfill site. Savannah Cemetery lies in the Northeast Corner, and there are no less than six cemeteries at the western extreme of our sample area. Ten other cemeteries, outside the sample area, may serve as the closest cemetery to some houses in the sample.
d_i5	Distance to Interstate 5 freeway. The Golden State Freeway runs just outside the southwestern perimeter of our sample area, forming this boundary.
d_i605	Distance to Interstate 605 freeway. This freeway forms the southeastern boundary of our sample area.
d_i10	Distance to Interstate 10 freeway. The San Bernardino Freeway runs along the northern edge of our sample, except for a subset of houses in one Census tract that spans the freeway.
d_railroad	Distance to nearest railroad. A dense array of railroad tracks occupies an area 7 miles east-west by 2.5 miles north-south adjacent to the southwest portion of our sample area. Railroad tracks border our sample area to the north and the southeast, and three east-west lines cut through the sample area at different latitudes, but none of these lines approaches more closely than about 1.4 miles from the landfill site.
d_s60	Distance to state route 60 (Pomona Freeway). This freeway runs east-west, spitting the landfill site into its northern and southern portions and splitting our sample of houses roughly in half as well.
d_rivers	Distance to nearest minor river or streambed. There are few natural rivers in Southern California. The Alhambra, Rubio, and Eaton Wash features cut through the northeastern corner of our sample area, and the Whittier Narrows dam creates some water features. See d_mjwater for substantial waterways.
d_cards	Distance to nearest road (CA roads feature). In addition to the freeways for which distances are also included individually, this group of features includes about 7 major roads running east-west and about 7 major roads running north-south through the sample area.
d_whittiern	Distance to Whittier Narrows recreation area. This is a large recreation area sitting to the east of our sample area, roughly 2.5 miles by 1 miles in size, but not completely contiguous. It lies about another ¾ of a mile further to the east of the landfill site than the Montebello Mall.

d_parks	Distance to nearest park. There are roughly two dozen small parks within the boundaries of our sample area, and more just to the outside of the area which may be the closest parks to some houses in the sample.
d_mjwater	Distance to nearest major body of water. The San Gabriel River corresponds geographically to the I-605 Freeway in this area, so it will be extremely unlikely that we can distinguish between the effects of this freeway and the effects of this River. However, this category of features also includes the Rio Hondo River, which parallels the San Gabriel River about 1.75 miles to the northwest. The Los Angeles River lies at least a mile outside our sample area, to the west and southwest
d_csula	Distance to the campus of the California State University at LA. This major public urban university lies just outside the northwest corner of our sample area.
d_cclubs	Distance to nearest country club/golf course. There are four golf or country clubs within our sample area, and another three outside the boundary that may serve as the closest facilities.

Variable	Obs	Mean	Std. Dev.	Min	Max
d_school	9211	.4695382	.2278552	.0210058	1.570117
d_retail	9211	4.546856	1.95908	.3162922	9.420857
d_hospital	9211	1.849731	.7941503	.0317994	3.996492
d_church	9211	3.041624	1.283886	.0635077	6.233308
d_cemetery	9211	2.535859	1.04748	.0507924	4.412509
d_i5	9211	5.223122	2.794447	.1060339	12.28935
d_i605	9211	5.256435	2.773785	.2184427	11.02538
d_i10	9211	4.678754	3.495584	.0385008	13.30645
d_railroad	9211	1.333081	.9336122	.0020506	3.661991
d_s60	9211	2.973134	2.092419	.0089229	9.187186
d_rivers	9211	2.762804	1.824602	.0013621	7.937554
d_cards	9211	.2527654	.1971348	6.50e-07	1.167369
d_whittiern	9211	4.498945	2.148109	.2511083	9.383685
d_parks	9211	.6886061	.397285	3.90e-07	1.988177
d_mjwater	9211	2.407134	1.820432	.0022402	7.016768
d_csula	9211	7.118163	3.014083	.483409	13.94009
d_cclubs	9211	2.250993	1.238161	.0000936	5.479274

3.4.1 R^2 for auxiliary regressions among variables

Chapter 4 Collinearities

4.1 Time patterns in average site distances in sample

```
Regression with robust standard errors               Number of obs =    9211
                                                     F( 29,   9181) =    1.94
                                                     Prob > F      =  0.0019
```

```
R-squared     =  0.0073
Root MSE      =  .74534
```

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year71	.0317235	.0883472	0.36	0.720	-.1414566	.2049035
year72	.0859397	.0840058	1.02	0.306	-.0787304	.2506098
year73	.0032975	.0832593	0.04	0.968	-.1599092	.1665042
year74	.0767495	.0816442	0.94	0.347	-.0832913	.2367903
year75	-.0758499	.0897324	-0.85	0.398	-.2517154	.1000456
year76	-.1300573	.0956679	-1.36	0.174	-.3175376	.057473
year77	-.170214	.0909799	-1.87	0.061	-.3485547	.0081268
year78	-.1477047	.0908943	-1.63	0.104	-.3258776	.0304683
year79	-.0895337	.0866816	-1.03	0.302	-.2594489	.0803815
year80	-.1115134	.108103	-1.03	0.302	-.3234194	.1003926
year81	.0920412	.0962669	0.96	0.339	-.0966633	.2807457
year82	.0197791	.0995868	0.20	0.843	-.1754332	.2149914
year83	-.0919169	.094225	-0.98	0.329	-.2766189	.0927851
year84	-.0593357	.0850137	-0.70	0.485	-.2259814	.10731
year85	.1188389	.0812613	1.46	0.144	-.0404513	.278129
year86	.0284096	.0817358	0.35	0.728	-.1318109	.18863
year87	.0622672	.0768907	0.81	0.418	-.0884556	.2129901
year88	.0567704	.076419	0.74	0.458	-.0930278	.2065686
year89	-.0147613	.0794248	-0.19	0.853	-.1704516	.140929
year90	-.030246	.0805885	-0.38	0.707	-.1882174	.1277253
year91	-.0163818	.0783395	-0.21	0.834	-.1699447	.1371811
year92	.0391751	.0799508	0.49	0.624	-.1175462	.1958964
year93	.0579568	.0783126	0.74	0.459	-.0955534	.211467
year94	.0318384	.0759538	0.42	0.675	-.1170479	.1807246
year95	-.0086662	.0774514	-0.11	0.911	-.1604981	.1431557
year96	.0268945	.0771292	0.35	0.727	-.1242958	.1780848
year97	.0447263	.0746531	0.60	0.549	-.1016104	.191063
year98	.0191487	.0737975	0.26	0.795	-.1255108	.1638083
year99	.0230723	.0723098	0.32	0.750	-.118671	.1648156
_cons	1.000204	.0686039	14.58	0.000	.8657255	1.134683

4.2 Time trend in average lot sizes

```
Regression with robust standard errors          Number of obs =    9211
                                                F( 29,  9181) =    5.56
                                                Prob > F      =  0.0000
                                                R-squared     =  0.0154
                                                Root MSE      =  .45283
```

lotsize	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year71	.0370856	.0443437	0.84	0.403	-.0498378	.1240091
year72	.0581753	.0442895	1.31	0.189	-.0286421	.1449926
year73	.0158991	.0432329	0.37	0.713	-.0688469	.1006451
year74	.0344922	.044767	0.77	0.441	-.0532611	.1222456
year75	.0970377	.0457635	2.12	0.034	.007331	.1867444
year76	-.0073695	.0428059	-0.17	0.863	-.0912786	.0765397
year77	.0048223	.0424023	0.11	0.909	-.0782955	.0879401
year78	.0659691	.0476268	1.39	0.166	-.02739	.1593283
year79	-.0026365	.0466992	-0.06	0.955	-.0941773	.0889044

year80	-.0004551	.0624263	-0.01	0.994	-.1228245	.1219143
year81	-.0857179	.0482712	-1.78	0.076	-.1803402	.0089043
year82	-.0294701	.0702935	-0.42	0.675	-.167261	.1083208
year83	-.0527158	.0476387	-1.11	0.269	-.1460982	.0406665
year84	-.0916612	.0454278	-2.02	0.044	-.1807098	-.0026126
year85	.0041223	.0458008	0.09	0.928	-.0856575	.093902
year86	-.0403184	.0432267	-0.93	0.351	-.1250523	.0444154
year87	-.0925032	.0403962	-2.29	0.022	-.1716887	-.0133177
year88	-.0485246	.041859	-1.16	0.246	-.1305775	.0335282
year89	-.0928938	.0403567	-2.30	0.021	-.1720018	-.0137858
year90	-.1342887	.041311	-3.25	0.001	-.2152675	-.0533099
year91	-.113602	.0424817	-2.67	0.008	-.1968756	-.0303283
year92	-.1057711	.0424013	-2.49	0.013	-.188887	-.0226551
year93	-.0716032	.0421767	-1.70	0.090	-.1542789	.0110726
year94	-.0892971	.0395896	-2.26	0.024	-.1669016	-.0116926
year95	-.0976527	.0407658	-2.40	0.017	-.1775628	-.0177426
year96	-.1178293	.0400843	-2.94	0.003	-.1964035	-.0392551
year97	-.0796451	.0416097	-1.91	0.056	-.1612094	.0019193
year98	-.0983243	.0387418	-2.54	0.011	-.174267	-.0223817
year99	-.0897773	.0378823	-2.37	0.018	-.1640351	-.0155196
_cons	1.059879	.0343544	30.85	0.000	.9925371	1.127222

4.3 Distance to site vs. structural variables

Regression with robust standard errors

Number of obs	=	9211
F(13, 9197)	=	125.27
Prob > F	=	0.0000
R-squared	=	0.2048
Root MSE	=	.66652

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	-1.164896	.1586876	-7.34	0.000	-1.475959	-.8538331
age	.0169089	.0014887	11.36	0.000	.0139908	.019827
age2	-.0001336	.000018	-7.42	0.000	-.0001689	-.0000983
sqft	-.2965837	.0615899	-4.82	0.000	-.4173135	-.1758538
sqft2	.102883	.0165969	6.20	0.000	.0703691	.1353969
bedrms	.1511174	.0313248	4.82	0.000	.0897138	.212521
bthrms	-.0651158	.0364991	-1.78	0.074	-.1366621	.0064306
sqftbed	-.0620597	.019966	-3.11	0.002	-.1011975	-.0229219
sqftoth	.0075439	.0236997	0.32	0.750	-.0389128	.0540005
fplace	-.1613489	.0164944	-9.78	0.000	-.1936816	-.1290163
knowflr	.3965481	.0462004	8.58	0.000	.305985	.4871112
floors	-.4768071	.0336819	-14.16	0.000	-.5428308	-.4107833
lotsize	.0003271	.0178777	0.02	0.985	-.0347173	.0353714
_cons	2.108913	.1713417	12.31	0.000	1.773045	2.444781

4.4 Distance to site vs. Census tract attributes

Regression with robust standard errors

Number of obs	=	9211
F(11, 9199)	=	227.77
Prob > F	=	0.0000
R-squared	=	0.2171

Root MSE = .66128

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
pfemales	-3.289739	.9466478	-3.48	0.001	-5.145379	-1.434099
pblack	6.708423	1.635602	4.10	0.000	3.502228	9.914566
pother	.6246435	.070074	8.91	0.000	.4872828	.7620041
page_under5	22.60372	1.054946	21.43	0.000	20.53358	24.67165
page_5_29	4.512753	.5028299	8.97	0.000	3.527095	5.498411
page_65_up	10.09821	.4471518	22.58	0.000	9.221597	10.97473
pmarhh_chd	1.996988	.188402	10.60	0.000	1.627579	2.366298
pmhh_child	-11.40863	.5669918	-20.12	0.000	-12.52006	-10.2972
pfhh_child	-2.727324	.3696495	-7.38	0.000	-3.451919	-2.002728
pvacant	-7.573115	.6748127	-11.22	0.000	-8.895898	-6.250332
prenter_occ	-.7672199	.0758307	-10.12	0.000	-.9158649	-.6185748
_cons	-1.948006	.5272493	-3.69	0.000	-2.981532	-.9144807

4.5 Distance to site vs. other distances

Regression with robust standard errors

Number of obs = 9211
F(17, 9193) = 1793.39
Prob > F = 0.0000
R-squared = 0.8109
Root MSE = .32513

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ld_school	-.1822357	.0083541	-21.81	0.000	-.1986117	-.1658598
ld_retail	1.186024	.0340795	34.80	0.000	1.119221	1.252828
ld_hospital	-.1399455	.0073205	-19.12	0.000	-.1542952	-.1255957
ld_church	-.3041922	.0135102	-22.52	0.000	-.3306752	-.2777092
ld_cemetery	-.0447594	.0072388	-6.18	0.000	-.0589491	-.0305698
ld_i5	-.135625	.0069391	-19.55	0.000	-.1492271	-.1220229
ld_i605	-.1456176	.0098454	-14.79	0.000	-.1649168	-.1263184
ld_i10	.0109707	.0067179	1.63	0.102	-.0021979	.0241394
ld_railroad	-.0655516	.0038653	-16.96	0.000	-.0731284	-.0579748
ld_s60	.2688995	.0127635	21.07	0.000	.2438801	.2939188
ld_rivers	-.0012389	.0067469	-0.18	0.854	-.0144642	.0119865
ld_cards	-.0202639	.0016522	-12.26	0.000	-.0235027	-.0170252
ld_whittiern	-.8163222	.028066	-29.09	0.000	-.8713379	-.7613066
ld_parks	-.0039177	.0027232	-1.44	0.150	-.0092557	.0014203
ld_mjwater	-.0689012	.005308	-12.98	0.000	-.079306	-.0584964
ld_csula	-.4005061	.0137442	-29.14	0.000	-.4274478	-.3735644
ld_cclubs	-.0368624	.0064279	-5.73	0.000	-.0494625	-.0242622
_cons	1.6459	.0636562	25.86	0.000	1.521119	1.77068

Chapter 5 Trends in the distance gradient

These models use individual houses as observations. We associate with each house the proportion of each group in the Census tract that contains the house. The right-hand side variables are the measured distance of the house itself from the OII landfill site, a time trend, and an interaction term between distance and time. The simple trend picks up the trend over time in the concentration of the group in question throughout the sample area. The "ldist" variable, distance to the boundary of the landfill site, picks up any baseline distance gradient in the concentration of the group in question as a function of distance from the site. The key variable is the interaction term, which tells how the distance gradient is shifting over time. If the distance gradient is becoming either less positive or more negative, the concentration of the group in question nearer the Superfund site is growing, relative to the concentration further away.

5.1 Structural variables

5.1.1 Built post-1900

Regression with robust standard errors

Number of obs	=	9211
F(3, 9207)	=	0.67
Prob > F	=	0.5726
R-squared	=	0.0002
Root MSE	=	.01474

notold	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.000214	.0003268	-0.65	0.513	-.0008547	.0004266
ldisty	-1.50e-06	.0000179	-0.08	0.933	-.0000365	.0000335
trend	6.72e-06	4.95e-06	1.36	0.175	-2.99e-06	.0000164
_cons	.9999013	.0000736	.	0.000	.999757	1.000046

5.1.2 Age if built post-1900

Regression with robust standard errors

Number of obs	=	9211
F(3, 9207)	=	1546.57
Prob > F	=	0.0000
R-squared	=	0.2226
Root MSE	=	16.421

age	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	7.436829	.3076385	24.17	0.000	6.83379	8.039869
ldisty	-.0009755	.016739	-0.06	0.954	-.0337876	.0318366
trend	.7720479	.0229092	33.70	0.000	.7271408	.816955
_cons	10.7639	.407078	26.44	0.000	9.965937	11.56186

5.1.3 Square footage

Regression with robust standard errors

Number of obs	=	9211
F(3, 9207)	=	210.03
Prob > F	=	0.0000
R-squared	=	0.0653
Root MSE	=	.4787

	Robust

sqft	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.1779509	.0146573	-12.14	0.000	-.2066825	-.1492192
ldisty	.0007751	.0007512	1.03	0.302	-.0006974	.0022476
trend	-.0038883	.0009721	-4.00	0.000	-.0057938	-.0019829
_cons	1.609737	.019037	84.56	0.000	1.57242	1.647053

5.1.4 Bedrooms

Regression with robust standard errors

Number of obs =	9211
F(3, 9207) =	112.74
Prob > F =	0.0000
R-squared =	0.0356
Root MSE =	.84276

bedrms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.2387678	.0264259	-9.04	0.000	-.2905684	-.1869672
ldisty	.0020337	.0013125	1.55	0.121	-.0005391	.0046064
trend	-.007976	.0016546	-4.82	0.000	-.0112194	-.0047326
_cons	3.253231	.0331528	98.13	0.000	3.188244	3.318218

5.1.5 Bathrooms

Regression with robust standard errors

Number of obs =	9211
F(3, 9207) =	382.90
Prob > F =	0.0000
R-squared =	0.0953
Root MSE =	.79396

bthrms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.3548969	.0224883	-15.78	0.000	-.398979	-.3108149
ldisty	.0006031	.0011436	0.53	0.598	-.0016337	.0028449
trend	.0024499	.0014982	1.64	0.102	-.000487	.0053868
_cons	2.211612	.0295537	74.83	0.000	2.15368	2.269544

5.1.6 Fireplace(s)?

Regression with robust standard errors

Number of obs =	9211
F(3, 9207) =	252.56
Prob > F =	0.0000
R-squared =	0.0626
Root MSE =	.47374

| Robust

fplace	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.1819811	.0131149	-13.88	0.000	-.2076891	-.156273
ldisty	.0022162	.0006919	3.20	0.001	.00086	.0035725
trend	-.0086033	.0008755	-9.83	0.000	-.0103195	-.0068871
_cons	.6971983	.0165422	42.15	0.000	.664772	.7296246

5.1.7 Floors recorded?

Regression with robust standard errors

Number of obs = 9211
F(3, 9207) = 97.87
Prob > F = 0.0000
R-squared = 0.0217
Root MSE = .3912

knowflr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0554189	.0092847	-5.97	0.000	-.0736189	-.0372188
ldisty	.002548	.0005351	4.76	0.000	.0014991	.0035968
trend	-.0089382	.0006572	-13.60	0.000	-.0102265	-.00765
_cons	.9794968	.0107698	90.95	0.000	.9583857	1.000608

5.1.8 Floors

Regression with robust standard errors

Number of obs = 9211
F(3, 9207) = 191.70
Prob > F = 0.0000
R-squared = 0.0640
Root MSE = .54283

floors	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.2379908	.0169375	-14.05	0.000	-.271192	-.2047896
ldisty	.0038295	.0009294	4.12	0.000	.0020076	.0056515
trend	-.0101069	.0012234	-8.26	0.000	-.012505	-.0077088
_cons	1.282427	.0221347	57.94	0.000	1.239038	1.325816

5.1.9 Lotsize

Regression with robust standard errors

Number of obs = 9211
F(3, 9207) = 41.13
Prob > F = 0.0000
R-squared = 0.0126
Root MSE = .45282

	Robust

lotsize	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
ldist	-.0303502	.0126484	-2.40	0.016	-.0551439	-.0055565
ldisty	.0026144	.0006575	3.98	0.000	.0013256	.0039033
trend	-.0080879	.0008551	-9.46	0.000	-.0097641	-.0064118
_cons	1.131305	.0162807	69.49	0.000	1.099391	1.163219

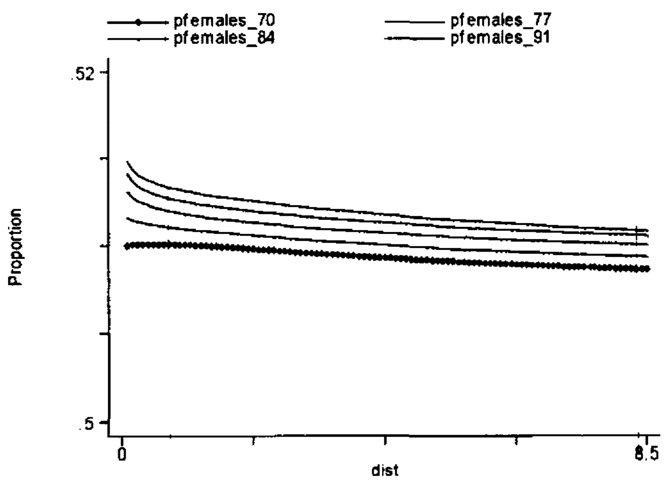
5.2 Census tract attributes

5.2.1 Females

Regression with robust standard errors

Number of obs	=	9211
F(3, 9207)	=	20.26
Prob > F	=	0.0000
R-squared	=	0.0063
Root MSE	=	.0118

pfemales	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
ldist	-.0005075	.0003176	-1.60	0.110	-.00113	.0001149
trend	.0001003	.0000197	5.09	0.000	.0000617	.0001389
ldisty	-.0000198	.0000155	-1.27	0.203	-.0000502	.0000107
_cons	.5108283	.0003917	1303.98	0.000	.5100604	.5115962



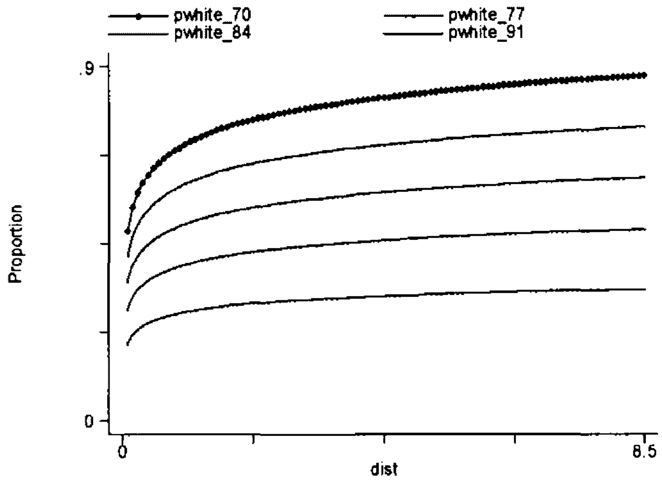
Fitted pfemales by distance from Oil site (km)

5.2.2 Whites

Regression with robust standard errors

Number of obs	=	9211
F(3, 9207)	=	4210.76
Prob > F	=	0.0000
R-squared	=	0.5570
Root MSE	=	.13148

pwhite	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0830403	.0033537	24.76	0.000	.0764663	.0896142
trend	-.0147613	.0002263	-65.24	0.000	-.0152048	-.0143177
ldisty	-.0018906	.0001748	-10.81	0.000	-.0022333	-.0015479
_cons	.7094765	.0042602	166.54	0.000	.7011256	.7178273



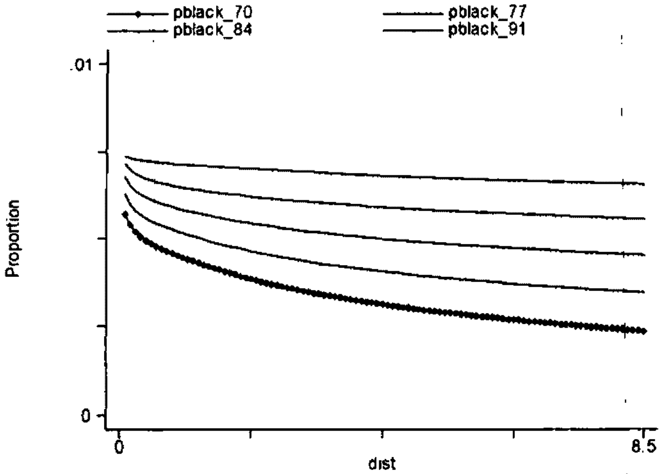
Fitted pwhite by distance from OII site (km)

5.2.3 Blacks

Regression with robust standard errors

Number of obs	=	9211
F(3, 9207)	=	121.95
Prob > F	=	0.0000
R-squared	=	0.0329
Root MSE	=	.00534

pblack	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0007855	.0001735	-4.53	0.000	-.0011256	-.0004455
trend	.0000888	5.59e-06	15.88	0.000	.0000779	.0000998
ldisty	.000019	7.39e-06	2.57	0.010	4.49e-06	.0000335
_cons	.0047176	.0001203	39.22	0.000	.0044818	.0049533



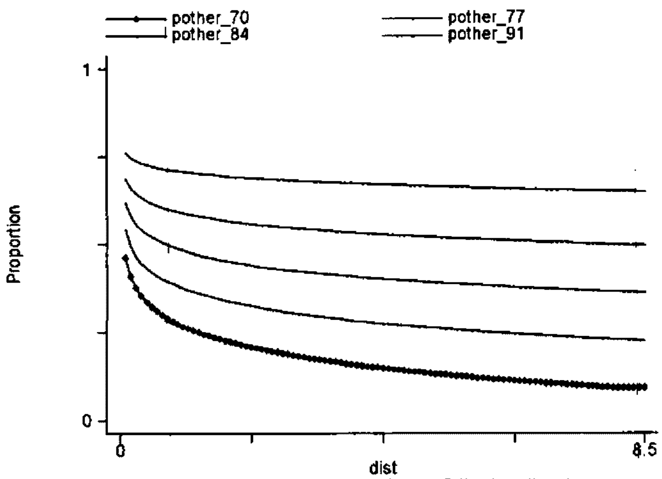
Fitted pblack by distance from OII site (km)

5.2.4 Other ethnic groups

Regression with robust standard errors

Number of obs = 9211
F(3, 9207) = 4321.06
Prob > F = 0.0000
R-squared = 0.5660
Root MSE = .13174

pother	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
ldist	-.0850076	.0034053	-24.96	0.000	-.0916828	-.0783324
trend	.014992	.0002305	65.03	0.000	.0145401	.0154439
ldisty	.0020202	.0001769	11.42	0.000	.0016734	.002367
_cons	.277383	.0043922	63.15	0.000	.2687734	.2859927

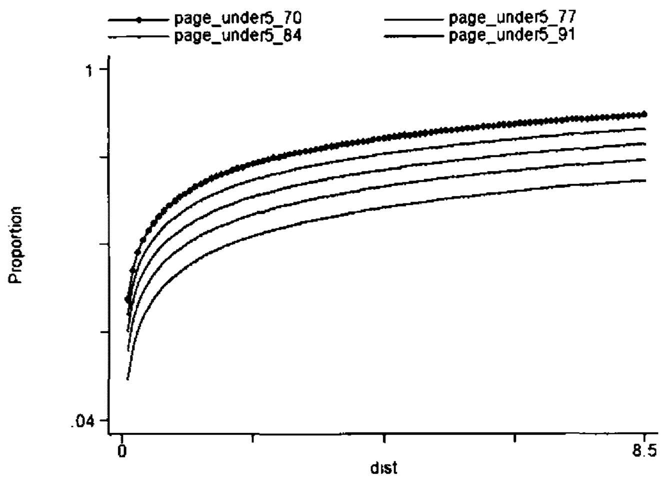


Fitted pother by distance from OII site (km)

5.2.5 Children under 5

```
Regression with robust standard errors                Number of obs =    9211
                                                      F(  3,   9207) =  510.68
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.1224
                                                      Root MSE      =  .01663
```

page_under5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0063994	.0005023	12.74	0.000	.0054147	.0073841
trend	-.0004558	.0000322	-14.14	0.000	-.000519	-.0003927
ldisty	.0000226	.0000246	0.92	0.357	-.0000256	.0000708
_cons	.0798627	.0006704	119.14	0.000	.0785487	.0811768

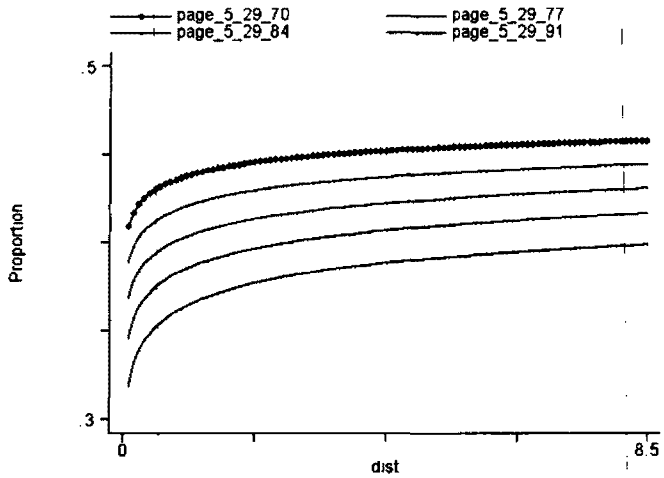


Fitted page_under5 by distance from Oil site (km)

5.2.6 Persons between 5 and 29

```
Regression with robust standard errors                Number of obs =    9211
                                                      F(  3,   9207) =  894.76
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.2081
                                                      Root MSE      =  .04338
```

page_5_29	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.009715	.0010478	9.27	0.000	.0076612	.0117689
trend	-.0025506	.0000747	-34.15	0.000	-.002697	-.0024042
ldisty	.0002393	.0000569	4.20	0.000	.0001277	.0003508
_cons	.4400477	.0014033	313.59	0.000	.4372969	.4427984



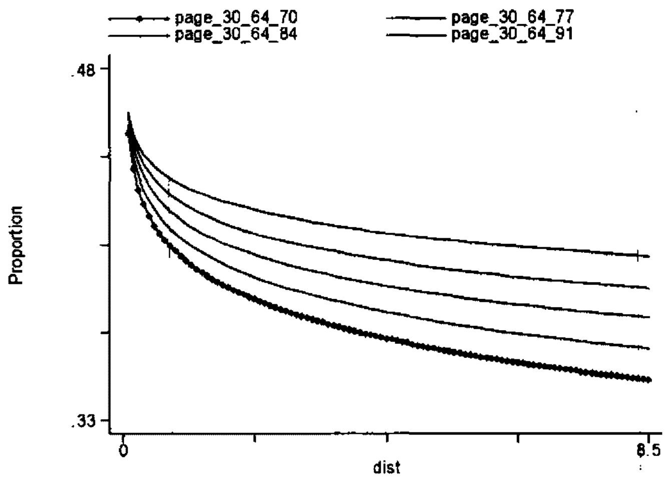
Fitted page_5_29 by distance from OII site (km)

5.2.7 Persons between 30 and 64

Regression with robust standard errors

Number of obs	=	9211
F(3, 9207)	=	750.46
Prob > F	=	0.0000
R-squared	=	0.1712
Root MSE	=	.03882

page_30_64	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	-.0240991	.001275	-18.90	0.000	-.0265984	-.0215998
trend	.0010147	.0000782	12.97	0.000	.0008614	.0011681
ldisty	.0003549	.0000582	6.10	0.000	.0002403	.000469
_cons	.401974	.0017344	231.77	0.000	.3985742	.4053737

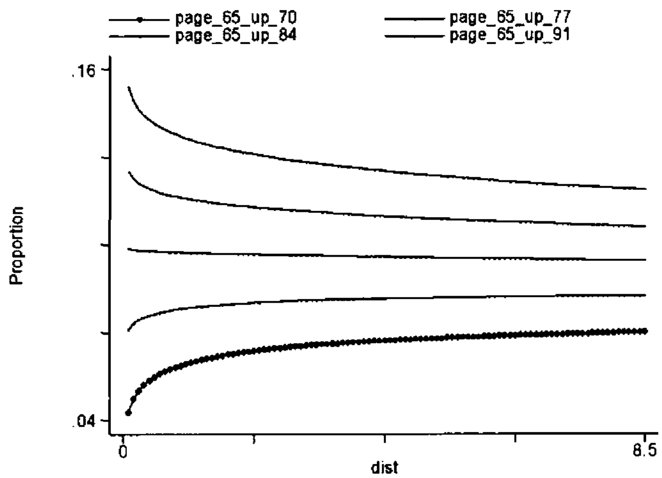


Fitted page_30_64 by distance from OII site (km)

5.2.8 Persons 65 and older

```
Regression with robust standard errors                 Number of obs =    9211
                                                       F(  3,  9207) =  981.78
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2373
                                                       Root MSE      =  .03448

------------------------------------------------------------------------------
             |               Robust
  page_65_up |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ldist |   .0053883     .00078     6.91   0.000     .0038593    .0069172
       trend |   .0026715   .0000628    42.54   0.000     .0025484    .0027946
      ldisty |  -.0004772   .0000461   -10.35   0.000    -.0005676   -.0003869
       _cons |    .061345   .0010659    57.55   0.000     .0592556    .0634343
------------------------------------------------------------------------------
```

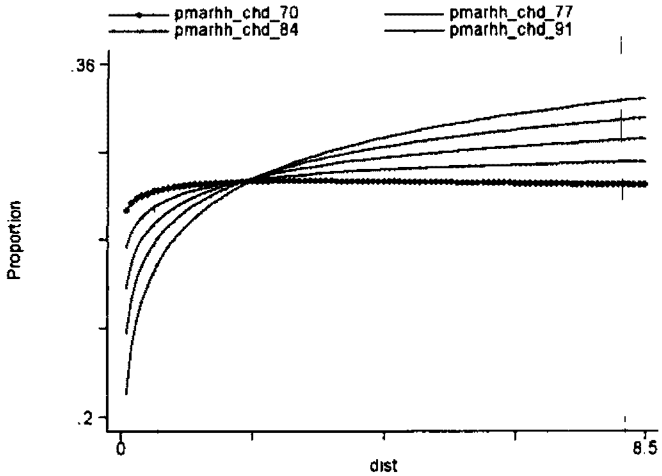


Fitted page_65_up by distance from Oll site (km)

5.2.9 Married heads of household

```
Regression with robust standard errors                 Number of obs =    9211
                                                       F(  3,  9207) =  231.93
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.0505
                                                       Root MSE      =  .06238

------------------------------------------------------------------------------
             |               Robust
  pmarhh_chd |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ldist |   .0007957    .002086     0.38   0.703    -.0032933    .0048848
       trend |  -.0007432   .0001309    -5.68   0.000    -.0009998   -.0004866
      ldisty |   .0009305   .0000997     9.33   0.000     .0007351    .0011259
       _cons |   .3097138   .0026691   116.04   0.000     .3044818    .3149458
------------------------------------------------------------------------------
```



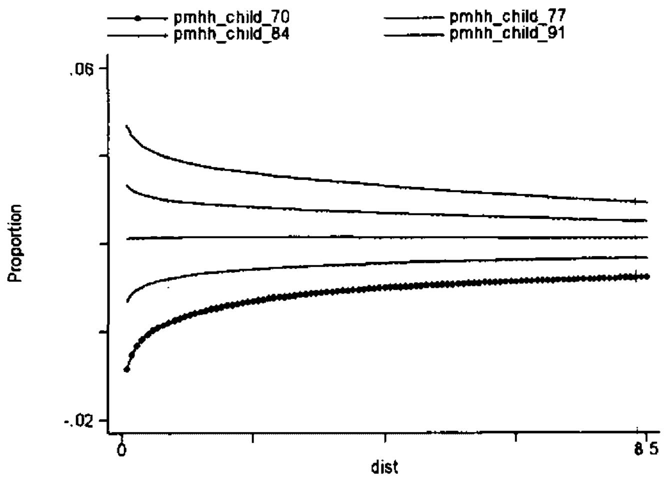
Fitted pmarhh_chd by distance from Oil site (km)

5.2.10 Male-headed of household with children

Regression with robust standard errors

Number of obs = 9211
F(3, 9207) = 1268.58
Prob > F = 0.0000
R-squared = 0.2514
Root MSE = .0144

pmhh_child	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0040426	.0004067	9.94	0.000	.0032452	.0048399
trend	.0012375	.0000488	25.38	0.000	.0011419	.0013331
ldisty	-.0002995	.0000355	-8.45	0.000	-.000369	-.00023
_cons	.0044591	.0005502	8.10	0.000	.0033805	.0055377



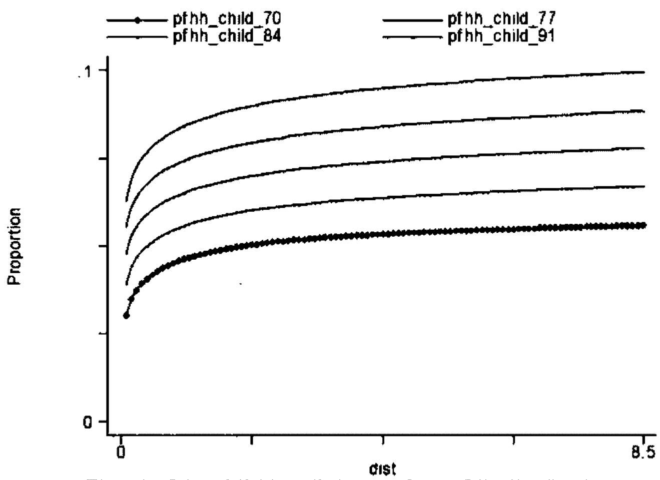
Fitted pmhh_child by distance from Oil site (km)

5.2.11 Female-headed households with children

Regression with robust standard errors

Number of obs =	9211
F(3, 9207) =	582.34
Prob > F =	0.0000
R-squared =	0.1572
Root MSE =	.02981

pfhh_child	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0048499	.0008863	5.47	C.000	.0031125	.0065873
trend	.0012721	.00005	25.42	0.000	.001174	.0013702
ldisty	.0000927	.000042	2.21	0.027	.0000104	.000175
_cons	.0482733	.0010703	45.10	0.000	.0461753	.0503714



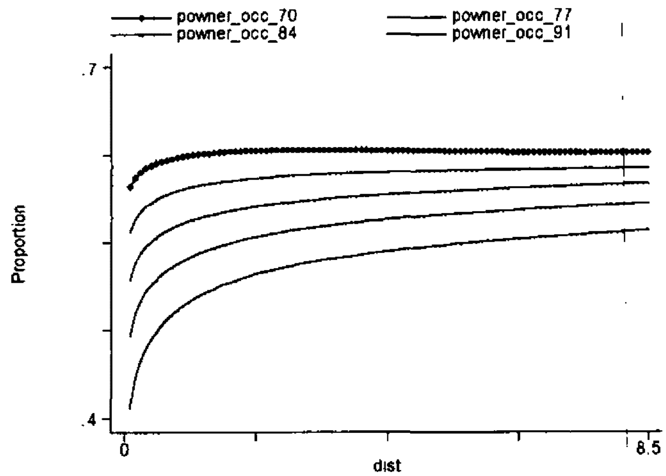
Fitted pfhh_child by distance from OII site (km)

5.2.12 Owner-occupancy

Regression with robust standard errors

Number of obs =	9211
F(3, 9207) =	143.27
Prob > F =	0.0000
R-squared =	0.0361
Root MSE =	.17435

powner_occ	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0033151	.0043922	0.75	0.450	-.0052946	.0119248
trend	-.0044307	.0002689	-16.48	0.000	-.0049578	-.0039035
ldisty	.0009346	.0002308	4.05	0.000	.0004821	.001387
_cons	.634293	.0051611	122.90	0.000	.6241761	.6444098

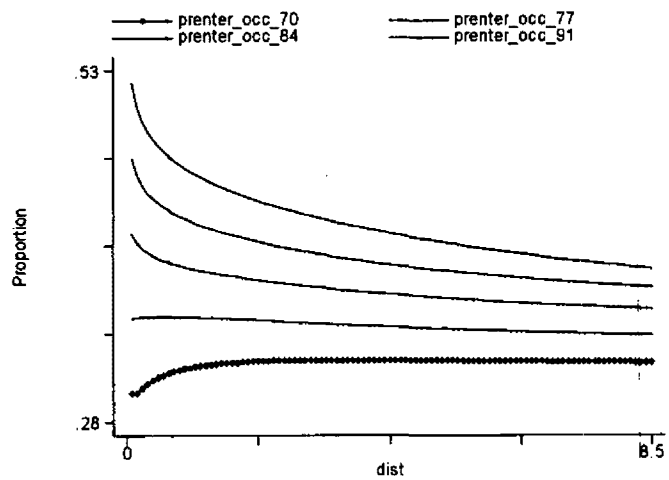


Fitted powner_occ by distance from OII site (km)

5.2.13 Renter-occupancy

```
Regression with robust standard errors               Number of obs =    9211
                                                      F(  3,  9207) =  162.12
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.0394
                                                      Root MSE      =  .16722
```

prenter_occ	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldist	.0040978	.0041508	0.99	0.324	-.0040386	.0122342
trend	.004771	.0002528	18.87	0.000	.0042754	.0052666
ldisty	-.0012124	.0002187	-5.54	0.000	-.001641	-.0007837
_cons	.3274087	.0048078	68.10	0.000	.3179843	.3368331

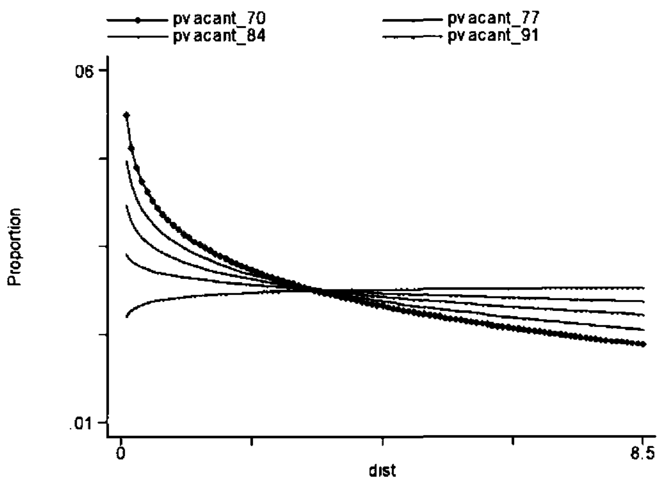


Fitted prenter_occ by distance from OII site (km)

5.2.14 Vacancy rates

```
Regression with robust standard errors                Number of obs =     9211
                                                      F(  3,   9207) =   132.89
                                                      Prob > F      =   0.0000
                                                      R-squared     =   0.0373
                                                      Root MSE      =   .01349

------------------------------------------------------------------------------
             |               Robust
     pvacant |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ldist |  -.0074489   .0003894   -19.13   0.000    -.0082122   -.0066856
       trend |   -.000332   .0000258   -12.89   0.000    -.0003825   -.0002815
     ldisty  |    .000279   .0000186    15.02   0.000     .0002426    .0003154
       _cons |   .0380797   .0005776    65.92   0.000     .0369474     .039212
------------------------------------------------------------------------------
```



Fitted pvacant by distance from OII site (km)

Chapter 6 Complete regression results – No lot size interactions

6.1 Just structural characteristics and year dummies

```
Regression with robust standard errors                Number of obs =     9211
                                                      F( 72,   9138) =   349.56
                                                      Prob > F      =   0.0000
                                                      R-squared     =   0.6916
                                                      Root MSE      =   .45753

------------------------------------------------------------------------------
             |               Robust
      lsprice|      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      notold |   .9932554   .1628348     6.10   0.000     .6740629    1.312448
         age |  -.0117411    .001059   -11.09   0.000     -.013817   -.0096653
        age2 |   .0001031   .0000131     7.84   0.000     .0000773    .0001288
        sqft |   .5206245   .0611521     8.51   0.000     .4007527    .6404963
       sqft2 |  -.0924193   .0242179    -3.82   0.000    -.1398917   -.0449468
```

bedrms	.0702122	.0283334	2.48	0.013	.0146724	.125752
bthrms	-.1172286	.0308256	-3.80	0.000	-.1776536	-.0568035
sqftbed	-.0386692	.0185536	-2.08	0.037	-.0750385	-.0023
sqftbth	.0735727	.0208992	3.52	0.000	.0326056	.1145398
fplace	.0708999	.0121874	5.82	0.000	.0470099	.0947898
knowflr	.1081705	.0331057	3.27	0.001	.0432759	.1730652
floors	-.0431627	.0208639	-2.07	0.039	-.0840606	-.0022649
lotsize	.1845719	.0149515	12.34	0.000	.1552637	.2138802
ldis70	-.0910615	.0679057	-1.34	0.180	-.2241718	.0420488
ldis71	-.1911183	.0668653	-2.86	0.004	-.3221892	-.0600474
ldis72	-.1452377	.0434544	-3.34	0.001	-.2304181	-.0600574
ldis73	-.1446323	.0348781	-4.15	0.000	-.2130012	-.0762634
ldis74	-.1543859	.0485435	-3.18	0.001	-.2495421	-.0592297
ldis75	-.133872	.0230817	-5.80	0.000	-.1791172	-.0886267
ldis76	-.0896486	.0151661	-5.91	0.000	-.1193775	-.0599197
ldis77	-.0948632	.0204214	-4.65	0.000	-.1348936	-.0548327
ldis78	-.0794666	.0176889	-4.49	0.000	-.1141408	-.0447924
ldis79	-.0210521	.040024	-0.53	0.599	-.0995081	.0574039
ldis80	-.1573536	.0415527	-3.79	0.000	-.2388062	-.0759011
ldis81	-.1388767	.1325139	-1.05	0.295	-.3986335	.1208801
ldis82	.139067	.0825229	1.69	0.092	-.0226964	.3008304
ldis83	-.1294389	.0394743	-3.28	0.001	-.2068173	-.0520604
ldis84	-.0254665	.0476241	-0.53	0.593	-.1188203	.0678874
ldis85	-.056664	.045126	-1.26	0.209	-.1451212	.0317931
ldis86	.0014281	.0319232	0.04	0.964	-.0611485	.0640047
ldis87	-.0586542	.0272223	-2.15	0.031	-.1120161	-.0052923
ldis88	-.013604	.0538295	-0.25	0.800	-.1191218	.0919139
ldis89	.0896625	.0526624	1.70	0.089	-.0135677	.1928927
ldis90	-.0356742	.0370301	-0.96	0.335	-.1082614	.0369131
ldis91	.1126622	.0625144	1.80	0.072	-.0098799	.2352044
ldis92	-.0556043	.0214439	-2.59	0.010	-.0976391	-.0135694
ldis93	-.0206699	.0220965	-0.94	0.350	-.0639841	.0226442
ldis94	-.0119439	.0194802	-0.61	0.540	-.0501294	.0262415
ldis95	.0019911	.0397644	0.05	0.960	-.075956	.0799382
ldis96	.0468581	.037562	1.25	0.212	-.0267718	.1204879
ldis97	.0606048	.0346603	1.75	0.080	-.0073371	.1285467
ldis98	-.004532	.0134719	-0.34	0.737	-.03094	.0218759
ldis99	.0254911	.0118365	2.15	0.031	.002289	.0486932
year71	.1859305	.1090268	1.71	0.088	-.0277364	.3996474
year72	.2292775	.0952193	2.41	0.016	.0426265	.4159286
year73	.391798	.0911333	4.30	0.000	.2131562	.5704397
year74	.3391404	.099699	3.40	0.001	.1437081	.5345728
year75	.562629	.0910229	6.18	0.000	.3842038	.7410541
year76	.6670246	.0890389	7.49	0.000	.4924884	.8415608
year77	.905679	.08994	10.07	0.000	.7293765	1.081982
year78	1.182555	.087627	13.50	0.000	1.010786	1.354324
year79	1.210986	.0984302	12.30	0.000	1.018041	1.403931
year80	1.296118	.0995991	13.01	0.000	1.100882	1.491355
year81	1.19299	.1745181	6.84	0.000	.850895	1.535084
year82	1.064098	.1375375	7.74	0.000	.7944933	1.333702
year83	1.551468	.0950517	16.32	0.000	1.365145	1.737791
year84	1.500138	.1030402	14.56	0.000	1.298157	1.70212
year85	1.63059	.1062313	15.35	0.000	1.422353	1.838827
year86	1.703408	.0953771	17.86	0.000	1.516448	1.890369
year87	1.889991	.0919629	20.55	0.000	1.709723	2.070259
year88	1.918535	.10588	18.12	0.000	1.710987	2.126084
year89	1.93175	.1104169	17.50	0.000	1.715308	2.148192
year90	2.179907	.0997584	21.85	0.000	1.984359	2.375456
year91	2.086958	.1128417	18.49	0.000	1.865763	2.308153

year92	2.349472	.0886803	26.49	0.000	2.175639	2.523305
year93	2.251859	.0904794	24.89	0.000	2.074499	2.429219
year94	2.238253	.0886592	25.25	0.000	2.064461	2.412045
year95	2.13355	.098177	21.73	0.000	1.941101	2.325999
year96	2.116251	.098453	21.50	0.000	1.923261	2.309241
year97	2.051297	.0981948	20.89	0.000	1.858813	2.243781
year98	2.1765	.0876417	24.83	0.000	2.004703	2.348298
year99	2.227537	.087748	25.39	0.000	2.055531	2.399542
_cons	8.267537	.1923249	42.99	0.000	7.890537	8.644536

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0000	

6.2 Including Census tract attributes

```
Regression with robust standard errors                 Number of obs =     9211
                                                       F( 83,   9127) =   328.50
                                                       Prob > F       =   0.0000
                                                       R-squared      =   0.6997
                                                       Root MSE       =   .45174
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notcld	.9311328	.2032774	4.58	0.000	.5326636	1.329602
age	-.0139166	.0011205	-12.42	0.000	-.016113	-.0117203
age2	.0001407	.0000145	9.71	0.000	.0001123	.0001692
sqft	.4534617	.0613922	7.39	0.000	.3331193	.573804
sqft2	-.0770347	.0239452	-3.22	0.001	-.1239726	-.0300968
bedrms	.0683652	.0281657	2.43	0.015	.013154	.1235763
bthrms	-.1222492	.0309686	-3.95	0.000	-.1829546	-.0615439
sqftbed	-.0352978	.0183522	-1.92	0.054	-.0712723	.0006766
sqftbth	.06746	.0208661	3.23	0.001	.0265578	.1083622
fplace	.0460746	.012244	3.76	0.000	.0220736	.0700757
knowflr	.0915762	.0328087	2.79	0.005	.0272639	.1558886
floors	-.0295288	.0208388	-1.42	0.157	-.0703775	.01132
lotsize	.1828214	.0150136	12.18	0.000	.1533914	.2122515
ldis70	-.0700751	.0707616	-0.99	0.322	-.2087836	.0686335
ldis71	-.1529778	.0672047	-2.28	0.023	-.2847141	-.0212415
ldis72	-.1290165	.0436163	-2.96	0.003	-.2145141	-.0435188
ldis73	-.1135123	.0357361	-3.18	0.001	-.1835631	-.0434615
ldis74	-.1352636	.0486705	-2.78	0.005	-.2306686	-.0398586
ldis75	-.1043923	.0233475	-4.47	0.000	-.1501587	-.0586258
ldis76	-.068202	.0158228	-4.31	0.000	-.0992183	-.0371856
ldis77	-.0724416	.0197573	-3.67	0.000	-.1111704	-.0337129
ldis78	-.0589154	.0176079	-3.35	0.001	-.0934309	-.0243999
ldis79	.0009394	.0401474	0.02	0.981	-.0777585	.0796374
ldis80	-.147009	.0413456	-3.56	0.000	-.2280556	-.0659624

ldis81	-.104919	.1317158	-0.80	0.426	-.3631116	.1532735
ldis82	.1326908	.0851089	1.56	0.119	-.0341417	.2995233
ldis83	-.1165535	.0390932	-2.98	0.003	-.193185	-.039922
ldis84	-.0091316	.0472946	-0.19	0.847	-.1019396	.0835764
ldis85	-.0381543	.0447816	-0.85	0.394	-.1259663	.0495976
ldis86	.0134244	.0313907	0.43	0.669	-.0481084	.0749572
ldis87	-.0420247	.0268712	-1.56	0.118	-.0946983	.0106489
ldis88	.0005704	.0537216	0.01	0.992	-.1047358	.1058767
ldis89	.1019377	.0515777	1.98	0.048	.0008338	.2030416
ldis90	-.0163981	.036353	-0.45	0.652	-.0876581	.0548619
ldis91	.1236039	.0632254	1.95	0.051	-.0003321	.2475398
ldis92	-.0376243	.0208478	-1.80	0.071	-.0784906	.003242
ldis93	-.0055244	.0218501	-0.25	0.800	-.0483555	.0373066
ldis94	.0101151	.0188412	0.54	0.591	-.0268178	.047048
ldis95	.0168815	.0397943	0.42	0.671	-.0611242	.0948873
ldis96	.0603449	.0361389	1.67	0.095	-.0104954	.1311851
ldis97	.087042	.0339601	2.56	0.010	.0204726	.1536114
ldis98	.009177	.0127379	0.72	0.471	-.0157922	.0341462
ldis99	.02755	.012406	2.22	0.026	.0032315	.0518684
pfemales	2.747538	.7050241	3.90	0.000	1.365532	4.129543
pblack	-1.852562	1.552152	-1.19	0.233	-4.895127	1.190003
pother	-.0160533	.0617295	-0.26	0.795	-.137057	.1049504
page_under5	-2.690753	.8482998	-3.17	0.002	-4.353611	-1.027896
page_5_29	-.2775036	.4197039	-0.66	0.509	-1.100217	.54521
page_65_up	-.4607948	.366569	-1.26	0.209	-1.179352	.2577625
pmarhh_chd	-.3810539	.2313454	-1.65	0.100	-.8345427	.0724349
pmhh_child	-.8717908	.3919165	-2.22	0.026	-1.640035	-.1035467
pfhh_child	.3196293	.4317667	0.74	0.459	-.5267301	1.165989
pvacant	.350096	.5082449	0.69	0.491	-.6461778	1.34637
prenter_occ	.0058759	.0578392	0.10	0.919	-.1075019	.1192538
year71	.1545344	.1121572	1.38	0.168	-.0653187	.3743876
year72	.2277507	.0984653	2.31	0.021	.0347367	.4207647
year73	.3767912	.0960932	3.92	0.000	.188427	.5651555
year74	.3498717	.105628	3.31	0.001	.1428172	.5569261
year75	.5612083	.0989128	5.67	0.000	.367317	.7550997
year76	.673521	.0993022	6.78	0.000	.4788665	.8681756
year77	.9169083	.102101	8.98	0.000	.7167675	1.117049
year78	1.192805	.1023776	11.65	0.000	.9921225	1.393488
year79	1.233654	.1123752	10.98	0.000	1.013374	1.453935
year80	1.337426	.1123766	11.90	0.000	1.117143	1.55771
year81	1.185371	.1808823	6.55	0.000	.8308014	1.539941
year82	1.096352	.1523085	7.20	0.000	.7977936	1.394911
year83	1.586889	.1105634	14.35	0.000	1.37016	1.803618
year84	1.524242	.1178005	12.94	0.000	1.293327	1.755158
year85	1.653669	.1224609	13.50	0.000	1.413618	1.893719
year86	1.722433	.1123297	15.33	0.000	1.502242	1.942625
year87	1.914389	.1105949	17.31	0.000	1.697598	2.13118
year88	1.950266	.1233513	15.81	0.000	1.70347	2.192062
year89	1.964867	.1225789	16.03	0.000	1.724585	2.205149
year90	2.206596	.119912	18.40	0.000	1.971542	2.441651
year91	2.117776	.1311657	16.15	0.000	1.860662	2.37489
year92	2.367988	.1072584	22.08	0.000	2.157737	2.578238
year93	2.271292	.1095807	20.73	0.000	2.056489	2.486094
year94	2.237837	.1071719	20.88	0.000	2.027756	2.447918
year95	2.135686	.1174229	18.19	0.000	1.90551	2.365861
year96	2.123062	.1137846	18.66	0.000	1.900019	2.346105
year97	2.03405	.1151111	17.67	0.000	1.808407	2.259694
year98	2.169597	.1055907	20.55	0.000	1.962615	2.376578
year99	2.22936	.1068837	20.86	0.000	2.019844	2.438876

```
       _cons |   7.501291   .4593048    16.33   0.000     6.600951    8.401631
------------------------------------------------------------------------------
```

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0000	
All Census tract characteristic effects simultaneously zero	0.0000	

6.3 Including other distances

```
Regression with robust standard errors                 Number of obs =    9211
                                                       F( 89,  9121) =  295.22
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.6983
                                                       Root MSE      =  .45296

------------------------------------------------------------------------------
             |               Robust
     lsprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      notold |   1.001211   .1977214     5.06   0.000     .6136332     1.38879
         age |  -.0130169   .0011016   -11.82   0.000    -.0151762   -.0108575
        age2 |   .0001135   .0000139     8.18   0.000     .0000863    .0001408
        sqft |   .4567512   .0604111     7.56   0.000     .3383319    .5751705
       sqft2 |   -.077342   .0233334    -3.31   0.001    -.1230808   -.0316032
      bedrms |   .0698487   .0281143     2.48   0.013     .0147384     .124959
      bthrms |  -.1118675   .0306591    -3.65   0.000    -.1719662   -.0517687
     sqftbed |  -.0363684   .0183891    -1.98   0.048    -.0724151   -.0003217
     sqftbth |   .0640609   .0206107     3.11   0.002     .0236593    .1044624
      fplace |    .060934   .0121563     5.01   0.000     .0371049    .0847631
    knowflr |   .0898725   .0330778     2.72   0.007     .0250325    .1547125
      floors |  -.0234684    .020879    -1.12   0.261    -.0643959    .0174591
     lotsize |   .1839993   .0152313    12.08   0.000     .1541426    .2138559

      ldis70 |  -.1273846   .0742849    -1.71   0.086    -.2729995    .0182304
      ldis71 |  -.2088247   .0700265    -2.98   0.003    -.3460924    -.071557
      ldis72 |  -.1767336   .0463757    -3.81   0.000    -.2676403   -.0858269
      ldis73 |  -.1642089   .0393582    -4.17   0.000    -.2413597   -.0870581
      ldis74 |  -.1841929   .0525649    -3.50   0.000    -.2872319   -.0811539
      ldis75 |  -.1461116   .0263498    -5.55   0.000    -.1977632     -.09446
      ldis76 |  -.1182289   .0192548    -6.14   0.000    -.1559726   -.0804853
      ldis77 |  -.1214819    .023741    -5.12   0.000    -.1680195   -.0749442
      ldis78 |  -.0968739   .0222307    -4.36   0.000     -.140451   -.0532968
      ldis79 |  -.0487484   .0431883    -1.13   0.259    -.1334072    .0359105
      ldis80 |  -.1826636   .0425788    -4.29   0.000    -.2661275   -.0991996
      ldis81 |  -.1628725   .1332603    -1.22   0.222    -.4240926    .0983476
      ldis82 |   .1040464    .089668     1.16   0.246     -.071723    .2798158
      ldis83 |  -.1617318    .042452    -3.81   0.000    -.2449473   -.0785163
      ldis84 |  -.0593314   .0505849    -1.17   0.241    -.1584891    .0398263
      ldis85 |  -.0878825   .0475759    -1.85   0.065    -.1811419    .0053769
```

ldis86	-.0369571	.0350382	-1.05	0.292	-.1056399	.0317257
ldis87	-.089046	.031852	-2.80	0.005	-.151483	-.0266091
ldis88	-.0460065	.0568567	-0.81	0.418	-.1574583	.0654453
ldis89	.0510108	.0495855	1.03	0.304	-.0461878	.1482094
ldis90	-.0736167	.038476	-1.91	0.056	-.1490382	.0018048
ldis91	.076444	.0687475	1.11	0.266	-.0583166	.2112046
ldis92	-.0848735	.0261137	-3.25	0.001	-.1360622	-.0336848
ldis93	-.0528936	.0272822	-1.94	0.053	-.1063729	.0005856
ldis94	-.0433073	.0249046	-1.74	0.082	-.0921258	.0055113
ldis95	-.0316994	.0437923	-0.72	0.469	-.1175421	.0541433
ldis96	.014926	.040119	0.37	0.710	-.0637163	.0935682
ldis97	.0356117	.037133	0.96	0.338	-.0371773	.1084007
ldis98	-.0343556	.0195687	-1.76	0.079	-.0727147	.0040036
ldis99	-.0149839	.0200047	-0.75	0.454	-.0541976	.0242298
ld_school	.007193	.0091592	0.79	0.432	-.0107611	.0251471
ld_retail	.0476416	.0380076	1.25	0.210	-.0268619	.1221451
ld_hospital	-.0142779	.0110092	-1.30	0.195	-.0358584	.0073026
ld_church	-.0327921	.0158547	-2.07	0.039	-.0638708	-.0017134
ld_cemetery	.0634055	.0130525	4.86	0.000	.0378196	.0889913
ld_i5	.0569511	.0155329	3.67	0.000	.0265031	.0873991
ld_i605	.0598053	.0154894	3.86	0.000	.0294425	.0901681
ld_i10	-.0318407	.0112692	-2.83	0.005	-.0539309	-.0097504
ld_railroad	.0261523	.0074647	3.50	0.000	.0115198	.0407849
ld_s60	.0105443	.0131657	0.80	0.423	-.0152634	.036352
ld_rivers	.0263751	.0125085	2.11	0.035	.0018556	.0508946
ld_cards	.0163784	.002612	6.27	0.000	.0112582	.0214986
ld_whittiern	.0725796	.0366962	1.98	0.048	.0006467	.1445124
ld_parks	-.0062075	.0048469	-1.28	0.200	-.0157086	.0032936
ld_mjwater	-.0137087	.0100736	-1.36	0.174	-.0334551	.0060378
ld_csula	.1005911	.0283902	3.54	0.000	.04494	.1562423
ld_cclubs	-.0249674	.0111858	-2.23	0.026	-.0468941	-.0030407
year71	.1550973	.1147808	1.35	0.177	-.0698987	.3800934
year72	.2168663	.100495	2.16	0.031	.0198736	.4138589
year73	.3770868	.0971175	3.88	0.000	.1867147	.5674588
year74	.3377187	.105214	3.21	0.001	.1314758	.5439616
year75	.5337655	.0971142	5.50	0.000	.3433999	.7241311
year76	.6657166	.0955676	6.97	0.000	.4783826	.8530505
year77	.8984543	.0957098	9.39	0.000	.7108417	1.086067
year78	1.159694	.0939853	12.34	0.000	.9754614	1.343926
year79	1.204526	.1041701	11.56	0.000	1.000329	1.408723
year80	1.295781	.1046955	12.38	0.000	1.090555	1.501008
year81	1.181369	.1760032	6.71	0.000	.8363637	1.526375
year82	1.05688	.1470438	7.19	0.000	.7686409	1.345118
year83	1.554778	.1010053	15.39	0.000	1.356785	1.752771
year84	1.498359	.1084669	13.81	0.000	1.28574	1.710979
year85	1.623616	.1107628	14.66	0.000	1.406496	1.840736
year86	1.706289	.1003312	17.01	0.000	1.509618	1.902961
year87	1.887947	.0973966	19.38	0.000	1.697028	2.078866
year88	1.917709	.1110131	17.27	0.000	1.700099	2.13532
year89	1.941076	.1152451	16.84	0.000	1.715169	2.166982
year90	2.19021	.1047923	20.90	0.000	1.984793	2.395626
year91	2.087404	.1178713	17.71	0.000	1.85535	2.318458
year92	2.34227	.0944174	24.81	0.000	2.157191	2.527349
year93	2.246327	.0963544	23.31	0.000	2.057451	2.435204
year94	2.230809	.0945247	23.60	0.000	2.04552	2.416099
year95	2.135439	.1038255	20.57	0.000	1.931918	2.33896
year96	2.115704	.1033699	20.47	0.000	1.913076	2.318332
year97	2.045975	.103889	19.69	0.000	1.842329	2.24962
year98	2.178776	.0936741	23.26	0.000	1.995154	2.362399

	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
year99	2.239947	.0935955	23.93	0.000	2.056479	2.423416
_cons	7.920597	.2422357	32.70	0.000	7.445761	8.395433

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0000	
All other distance effects simultaneously zero	0.0000	

6.4 Including both other distances and tract attributes

```
Regression with robust standard errors               Number of obs =    9211
                                                     F(100,   9110) =  282.52
                                                     Prob > F      =  0.0000
                                                     R-squared     =  0.7021
                                                     Root MSE      =  .45036
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.950083	.2208615	4.30	0.000	.517145	1.383021
age	-.0144509	.0011484	-12.58	0.000	-.0167019	-.0121999
age2	.0001413	.0000149	9.52	0.000	.0001122	.0001704
sqft	.4376641	.0607247	7.21	0.000	.31863	.5566982
sqft2	-.0711489	.0232073	-3.07	0.002	-.1166404	-.0256574
bedrms	.0666789	.0278111	2.40	0.017	.0121628	.1211949
bthrms	-.1108145	.0309102	-3.59	0.000	-.1714053	-.0502236
sqftbed	-.0348318	.0181468	-1.92	0.055	-.0704036	.00074
sqftbth	.0610939	.0207373	2.95	0.003	.0204442	.1017436
fplace	.0460638	.0123143	3.74	0.000	.021925	.0702026
knowflr	.0709631	.0329042	2.16	0.031	.0064635	.1354628
floors	-.0176153	.0207367	-0.85	0.396	-.0582638	.0230333
lotsize	.1772867	.0150858	11.75	0.000	.1477152	.2068581
ldis70	-.0874608	.074724	-1.17	0.242	-.2339366	.059015
ldis71	-.1681922	.0703947	-2.39	0.017	-.3061815	-.0302028
ldis72	-.1442436	.0475576	-3.03	0.002	-.2374672	-.0510201
ldis73	-.1307234	.0400035	-3.27	0.001	-.2091393	-.0523075
ldis74	-.1532548	.053254	-2.88	0.004	-.2576445	-.0488651
ldis75	-.1233935	.0281761	-4.38	0.000	-.1786249	-.0681621
ldis76	-.0919088	.0207793	-4.42	0.000	-.1326409	-.0511767
ldis77	-.0926112	.0251135	-3.69	0.000	-.1418393	-.0433831
ldis78	-.0743741	.0240642	-3.09	0.002	-.1215453	-.0272029
ldis79	-.0174455	.0436411	-0.40	0.689	-.1029918	.0681008
ldis80	-.1583898	.0433717	-3.65	0.000	-.243408	-.0733716
ldis81	-.1199943	.1351424	-0.89	0.375	-.3849037	.1449152
ldis82	.1175408	.0892852	1.32	0.188	-.0574781	.2925598
ldis83	-.1318143	.0425484	-3.10	0.002	-.2152186	-.0484099

ldis84	-.0311296	.0510418	-0.61	0.542	-.131183	.0689237
ldis85	-.0564328	.0476447	-1.18	0.236	-.1493272	.0369616
ldis86	-.0055914	.035916	-0.16	0.876	-.0759948	.0648119
ldis87	-.0545578	.0325945	-1.67	0.094	-.1181504	.0093348
ldis88	-.0131781	.0572352	-0.23	0.818	-.1253719	.0990158
ldis89	.0864298	.0497325	1.74	0.082	-.011057	.1839166
ldis90	-.033315	.0386042	-0.86	0.388	-.1089879	.0423579
ldis91	.1109849	.0687847	1.61	0.107	-.0233486	.2458184
ldis92	-.0472435	.0270797	-1.74	0.081	-.1003259	.0058388
ldis93	-.0180475	.0280293	-0.64	0.520	-.0729911	.0368962
ldis94	-.0038159	.0256759	-0.15	0.882	-.0541464	.0465146
ldis95	.0035955	.0440419	0.08	0.935	-.0827366	.0899276
ldis96	.0459027	.0405971	1.13	0.258	-.0336766	.1254821
ldis97	.0734012	.0371506	1.98	0.048	.0005776	.1462248
ldis98	-.0040276	.0203746	-0.20	0.843	-.0439664	.0359113
ldis99	.0101689	.0211885	0.48	0.631	-.0313653	.0517031
pfemales	1.64439	.7910702	2.08	0.038	.0937146	3.195065
pblack	-.6662112	1.855665	-0.36	0.720	-4.30373	2.971308
pother	-.166078	.0879576	-1.89	0.059	-.3384948	.0063387
page_under5	-2.453882	.9112003	-2.69	0.007	-4.240039	-.6677252
page_5_29	.2766206	.4944557	0.56	0.576	-.6926234	1.245865
page_65_up	-.0038523	.4456985	-0.01	0.993	-.8775214	.8698167
pmarhh_chd	-.3355717	.2471527	-1.36	0.175	-.8200465	.1489031
pmhh_child	-.371012	.4212083	-0.88	0.378	-1.196675	.4546508
pfhh_child	-.1698681	.4980972	-0.34	0.733	-1.14625	.8065141
pvacant	.4702613	.5623476	0.84	0.403	-.6320662	1.572589
prenter_occ	-.1179529	.0662052	-1.78	0.075	-.2477299	.0118241
ld_school	.0105924	.0094185	1.12	0.261	-.00787	.0290549
ld_retail	-.0014982	.0402856	-0.04	0.970	-.0804671	.0774707
ld_hospital	.0026951	.0113842	0.24	0.813	-.0196204	.0250106
ld_church	-.0171211	.0164738	-1.04	0.299	-.0494134	.0151712
ld_cemetery	.0242556	.015568	1.56	0.119	-.0062612	.0547724
ld_i5	-.0028033	.0176145	-0.16	0.874	-.0373316	.031725
ld_i605	.0702899	.0227337	3.09	0.002	.0257267	.1148531
ld_i10	-.040326	.0129888	-3.10	0.002	-.065787	-.014865
ld_railroad	.0097142	.0078631	1.24	0.217	-.0056991	.0251276
ld_s60	.0071373	.0145953	0.49	0.625	-.0214729	.0357474
ld_rivers	.0427592	.0134791	3.17	0.002	.016337	.0691814
ld_cards	.0158738	.0026404	6.01	0.000	.010698	.0210495
ld_whittiern	.0150716	.0401881	0.38	0.708	-.0637062	.0938493
ld_parks	-.0046835	.0049686	-0.94	0.346	-.0144231	.005056
ld_mjwater	-.0172807	.0111405	-1.55	0.121	-.0391186	.0045571
ld_csula	.0823504	.0356364	2.31	0.021	.012495	.1522058
ld_cclubs	-.0122514	.0116803	-1.05	0.294	-.0351474	.0106445
year71	.1588892	.1141079	1.39	0.164	-.064788	.3825663
year72	.2353756	.0995915	2.36	0.018	.0401539	.4305974
year73	.4002081	.0976332	4.10	0.000	.2088251	.5915911
year74	.3827154	.1078895	3.55	0.000	.1712279	.594203
year75	.5991426	.1029001	5.82	0.000	.3974354	.8008498
year76	.7303127	.1043307	7.00	0.000	.5258011	.9348243
year77	.9775283	.1078208	9.07	0.000	.7661754	1.188881
year78	1.251705	.1091715	11.47	0.000	1.037704	1.465706
year79	1.298517	.1193009	10.88	0.000	1.06466	1.532373
year80	1.40171	.1192476	11.75	0.000	1.167957	1.635462
year81	1.256444	.1872487	6.71	0.000	.8893941	1.623493
year82	1.163924	.1587979	7.33	0.000	.8526443	1.475203
year83	1.659741	.1185764	14.00	0.000	1.427305	1.892178
year84	1.603451	.125548	12.77	0.000	1.357349	1.849554

year85	1.735558	.1302581	13.32	0.000	1.480223	1.990893
year86	1.812839	.1205921	15.03	0.000	1.576452	2.049227
year87	2.005389	.1199308	16.72	0.000	1.770298	2.24048
year88	2.044687	.1317092	15.52	0.000	1.786508	2.302867
year89	2.063719	.1330474	15.51	0.000	1.802916	2.324522
year90	2.309781	.1294271	17.85	0.000	2.056075	2.563487
year91	2.214955	.1391015	15.92	0.000	1.942285	2.487625
year92	2.462505	.1178963	20.89	0.000	2.231402	2.693608
year93	2.36903	.120211	19.71	0.000	2.13339	2.604671
year94	2.342507	.1175678	19.92	0.000	2.112048	2.572966
year95	2.246307	.1272988	17.65	0.000	1.996773	2.495841
year96	2.235956	.1239523	18.04	0.000	1.992982	2.478931
year97	2.150304	.1258222	17.09	0.000	1.903664	2.396943
year98	2.291612	.1171559	19.56	0.000	2.06196	2.521264
year99	2.358637	.1181444	19.96	0.000	2.127048	2.590227
_cons	7.635599	.487419	15.67	0.000	6.680148	8.591049

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0000	
All other distance effects simultaneously zero	0.0000	
All Census tract characteristic effects simultaneously zero	0.0000	

Chapter 7 Complete regression results – With lot size interactions

7.1 Just structural characteristics and year dummies

```
Regression with robust standard errors                Number of obs =     9211
                                                      F(102,  9108) =   260.26
                                                      Prob > F      =   0.0000
                                                      R-squared     =   0.6943
                                                      Root MSE      =   .45625
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.9988356	.1701005	5.87	0.000	.6654003	1.332271
age	-.0116319	.0010565	-11.01	0.000	-.0137029	-.009561
age2	.0001005	.0000132	7.61	0.000	.0000747	.0001264
sqft	.5209625	.0610285	8.54	0.000	.401333	.6405921
sqft2	-.0943504	.0239555	-3.94	0.000	-.1413086	-.0473923
bedrms	.0622435	.0282524	2.20	0.028	.0068625	.1176246
bthrms	-.1142465	.0311376	-3.67	0.000	-.1752831	-.0532099
sqftbed	-.0343525	.0185268	-1.85	0.064	-.0706693	.0019643
sqftbth	.0699198	.0211335	3.31	0.001	.0284935	.1113461

fplace	.0697511	.0121702	5.73	0.000	.0458947	.0936076
knowflr	.1009321	.0332847	3.03	0.002	.0356865	.1661777
floors	-.0382573	.0208782	-1.83	0.067	-.0791833	.0026686
lotsize	.2435989	.0258695	9.42	0.000	.1928838	.294309
ldis70	-.2699964	.1477605	-1.83	0.068	-.5596401	.0196474
ldis71	-.1484632	.1242143	-1.20	0.232	-.3919511	.0950248
ldis72	-.0258969	.0931448	-0.28	0.781	-.2084816	.1566877
ldis73	-.076537	.0841739	-0.91	0.363	-.2415368	.0884628
ldis74	-.1172235	.0895338	-1.31	0.190	-.2927298	.0582827
ldis75	-.0053131	.0619588	-0.09	0.932	-.1267664	.1161401
ldis76	-.1384437	.0458815	-3.02	0.003	-.2283818	-.0485056
ldis77	-.0923926	.0413224	-2.24	0.025	-.1733938	-.0113913
ldis78	.0181055	.0441523	0.41	0.682	-.068443	.1046539
ldis79	-.0274318	.0817553	-0.34	0.737	-.1876906	.1328269
ldis80	-.1004064	.0776648	-1.29	0.196	-.2526469	.0518341
ldis81	.3078565	.2808649	1.10	0.273	-.2427017	.8584146
ldis82	.2359055	.1239274	1.90	0.057	-.00702	.4788309
ldis83	-.0705092	.0952766	-0.74	0.459	-.2572727	.1162543
ldis84	.1435025	.0898464	1.60	0.110	-.0326165	.3196216
ldis85	.0627717	.0706398	0.89	0.374	-.075698	.2012415
ldis86	.1827039	.1023375	1.79	0.074	-.0179006	.3833085
ldis87	-.0971432	.049881	-1.95	0.052	-.1949212	.0006347
ldis88	-.0517317	.0791622	-0.65	0.513	-.2069074	.1034441
ldis89	.1526253	.0757524	2.01	0.044	.0041337	.3011169
ldis90	.1069724	.0996711	1.07	0.283	-.0884052	.3023501
ldis91	.3504297	.1040185	3.37	0.001	.1465301	.5543294
ldis92	-.0094538	.0462287	-0.20	0.838	-.1000724	.0811649
ldis93	.0096591	.0405834	0.24	0.812	-.0698935	.0892117
ldis94	-.0234191	.048441	-0.48	0.629	-.1183742	.0715361
ldis95	.1405376	.0563654	2.49	0.013	.0300488	.2510263
ldis96	.1152141	.0705214	1.63	0.102	-.0230237	.253452
ldis97	.099792	.0505463	1.97	0.048	.00071	.198874
ldis98	.0343551	.0320405	1.07	0.284	-.0284515	.0971616
ldis99	.0396528	.0248585	1.60	0.111	-.0090754	.088381
vldis70	.1846888	.134578	1.37	0.170	-.0791142	.4484918
vldis71	-.0395453	.084321	-0.47	0.639	-.2048335	.1257429
vldis72	-.1149431	.0808118	-1.42	0.155	-.2733523	.0434662
vldis73	-.0611215	.080204	-0.76	0.446	-.2183393	.0960963
vldis74	-.0303966	.0685864	-0.44	0.658	-.1648413	.104048
vldis75	-.1061756	.0471282	-2.25	0.024	-.1985574	-.0137938
vldis76	.0476323	.0439517	1.08	0.279	-.0385229	.1337874
vldis77	-.0046285	.0313049	-0.15	0.882	-.0659931	.0567362
vldis78	-.088997	.043431	-2.05	0.040	-.1741315	-.0038625
vldis79	.0053975	.066298	0.08	0.935	-.1245615	.1353566
vldis80	-.0568727	.0700676	-0.81	0.417	-.1942208	.0804755
vldis81	-.4911717	.3155184	-1.56	0.120	-1.109559	.1273153
vldis82	-.0713744	.0611182	-1.17	0.243	-.1911799	.0484311
vldis83	-.0598326	.0955887	-0.63	0.531	-.2472079	.1275427
vldis84	-.1691355	.0797681	-2.12	0.034	-.3254988	-.0127721
vldis85	-.1112468	.0433113	-2.57	0.010	-.1961467	-.026347
vldis86	-.175329	.1011475	-1.73	0.083	-.3736008	.0229428
vldis87	.0355179	.0406835	0.87	0.383	-.0442309	.1152668
vldis88	.0365849	.0634283	0.58	0.564	-.0877489	.1609187
vldis89	-.0646925	.057548	-1.12	0.261	-.1774995	.0481145
vldis90	-.152776	.111741	-1.37	0.172	-.3718135	.0662616
vldis91	-.247712	.094244	-2.63	0.009	-.4324515	-.0629726
vldis92	-.0444869	.0377843	-1.18	0.239	-.1185527	.0295789
vldis93	-.0344438	.0355211	-0.97	0.332	-.1040782	.0351805
vldis94	.0109283	.040978	0.27	0.790	-.0693978	.0912543

vldis95	-.1417644	.0536202	-2.64	0.008	-.2468721	-.0366568
vldis96	-.0709976	.0443198	-1.60	0.109	-.1578744	.0158792
vldis97	-.0419838	.0332385	-1.26	0.207	-.1071388	.0231711
vldis98	-.0399856	.028989	-1.38	0.168	-.0968105	.0168393
vldis99	-.0162408	.0233971	-0.69	0.488	-.0621045	.0296228
year71	.197388	.1101488	1.79	0.073	-.0185283	.4133044
year72	.2484049	.0970738	2.56	0.011	.0581184	.4386914
year73	.399473	.0928972	4.30	0.000	.2173737	.5815723
year74	.3445368	.1014587	3.40	0.001	.1456549	.5434186
year75	.5585659	.0930854	6.00	0.000	.3760975	.7410342
year76	.6772712	.0913233	7.42	0.000	.4982571	.8562854
year77	.9209143	.0914585	10.07	0.000	.7416352	1.100193
year78	1.192673	.0892969	13.36	0.000	1.017632	1.367715
year79	1.224925	.1003313	12.21	0.000	1.028254	1.421597
year80	1.313545	.1014507	12.95	0.000	1.114679	1.512411
year81	1.233937	.1794308	6.88	0.000	.8822121	1.585662
year82	1.053051	.1407317	7.48	0.000	.7771856	1.328917
year83	1.571066	.0965234	16.28	0.000	1.381858	1.760273
year84	1.512784	.1047431	14.44	0.000	1.307464	1.718104
year85	1.641528	.1075886	15.26	0.000	1.43063	1.852426
year86	1.722435	.0971564	17.73	0.000	1.531987	1.912884
year87	1.912529	.0935988	20.43	0.000	1.729054	2.096003
year88	1.936966	.1065382	18.18	0.000	1.728127	2.145804
year89	1.951962	.11225	17.39	0.000	1.731927	2.171997
year90	2.203294	.1008454	21.85	0.000	2.005615	2.400974
year91	2.107972	.1128124	18.69	0.000	1.886834	2.329109
year92	2.365667	.0902217	26.22	0.000	2.188812	2.542521
year93	2.274759	.0921271	24.69	0.000	2.09417	2.455349
year94	2.258287	.0902125	25.03	0.000	2.08145	2.435124
year95	2.154008	.0994145	21.67	0.000	1.959133	2.348883
year96	2.137511	.0994495	21.49	0.000	1.942568	2.332455
year97	2.073228	.0993347	20.87	0.000	1.87851	2.267947
year98	2.196374	.089126	24.64	0.000	2.021668	2.371081
year99	2.248859	.0893183	25.18	0.000	2.073775	2.423943
_cons	8.200771	.1999337	41.02	0.000	7.808856	8.592686

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.0000	
All lotsize-independent year-specific slope on LDIST the same	0.0000	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0176	
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.0342	

7.2 Including Census tract attributes

Regression with robust standard errors

Number of obs	=	9211
F(124, 9086)	=	236.96
Prob > F	=	0.0000
R-squared	=	0.7034
Root MSE	=	.45001

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.9165522	.2052025	4.47	0.000	.5143091	1.318795
age	-.0131541	.0011457	-11.48	0.000	-.0153999	-.0109083
age2	.0001286	.000015	8.58	0.000	.0000992	.000158
sqft	.4608774	.0615074	7.49	0.000	.3403309	.5814458
sqft2	-.0807706	.0235728	-3.43	0.001	-.1269786	-.0345627
bedrms	.0612303	.027982	2.19	0.029	.0063793	.1160814
bthrms	-.1176677	.0312911	-3.76	0.000	-.1790053	-.0563301
sqftbed	-.0314833	.0182654	-1.72	0.085	-.0672876	.0043209
sqftbth	.0640482	.02111	3.03	0.002	.0225678	.1054286
fplace	.0439777	.0122687	3.58	0.000	.0199282	.0680271
knowflr	.0783876	.0333356	2.35	0.019	.0130423	.1437329
floors	-.0235397	.0209715	-1.12	0.262	-.0646485	.0175691
lotsize	1.724679	.9375752	1.84	0.066	-.1131791	3.562538
ldis70	-.2826613	.156844	-1.80	0.072	-.5901109	.0247883
ldis71	-.1750469	.1380508	-1.27	0.205	-.4456576	.0955638
ldis72	-.0931239	.100128	-0.93	0.352	-.2893974	.1031495
ldis73	-.1058343	.0875336	-1.21	0.227	-.2774199	.0657513
ldis74	-.1763794	.0950248	-1.86	0.063	-.3626495	.0098907
ldis75	-.0455593	.0625504	-0.73	0.466	-.1681721	.0770536
ldis76	-.1925953	.0450261	-4.28	0.000	-.2808566	-.104334
ldis77	-.1263481	.0425396	-2.97	0.003	-.2097354	-.0429608
ldis78	-.0669384	.0443613	-1.51	0.131	-.1538965	.0200197
ldis79	-.0794996	.0835965	-0.95	0.342	-.2433675	.0843683
ldis80	-.1875689	.0822936	-2.28	0.023	-.3488827	-.026255
ldis81	.2662066	.279905	0.95	0.342	-.2824702	.8148835
ldis82	.1086019	.1269789	0.86	0.392	-.1403052	.3575091
ldis83	-.0833953	.0907232	-0.92	0.358	-.2612332	.0944425
ldis84	.0843799	.0868951	0.97	0.332	-.0855954	.2547137
ldis85	.0163124	.0699395	0.23	0.816	-.1207847	.1534096
ldis86	.1540321	.1066145	1.44	0.149	-.0549563	.3630206
ldis87	-.1310279	.0507077	-2.58	0.010	-.2304264	-.0316293
ldis88	-.0579894	.0799171	-0.73	0.468	-.2146449	.098666
ldis89	.1368076	.072131	1.90	0.058	-.0045855	.2782007
ldis90	.1163003	.0989829	1.17	0.240	-.0777285	.3103291
ldis91	.3203736	.1053835	3.04	0.002	.1137982	.5269491
ldis92	-.0127485	.0486472	-0.26	0.793	-.1081078	.0826109
ldis93	.0063002	.0384857	0.16	0.870	-.0691404	.0817409
ldis94	-.0048689	.0511578	-0.10	0.924	-.1051498	.095412
ldis95	.1548803	.0580075	2.67	0.008	.0411726	.268588
ldis96	.1441416	.0703128	2.05	0.040	.0063128	.2819705
ldis97	.1283079	.0501519	2.56	0.011	.0299988	.226617
ldis98	.0540219	.0338889	1.59	0.111	-.012408	.1204518
ldis99	.0554174	.0288101	1.92	0.054	-.0010569	.1118916
vldis70	.2118708	.1432855	1.48	0.139	-.0690011	.4927427
vldis71	.0189604	.0957227	0.20	0.843	-.1686777	.2065984
vldis72	-.0349145	.0881181	-0.40	0.692	-.2076459	.1378169
vldis73	-.0087492	.0785328	-0.11	0.911	-.1626312	.1451927

vldis74	.0373692	.0757932	0.49	0.622	-.1112026	.185941
vldis75	-.0474257	.0472024	-1.00	0.315	-.1399531	.0451016
vldis76	.1327652	.0443804	2.99	0.003	.0457696	.2197608
vldis77	.0560184	.0326274	1.72	0.086	-.0079387	.1199755
vldis78	.0095267	.0446826	0.21	0.831	-.0780612	.0971147
vldis79	.0772341	.0681129	1.13	0.257	-.0562826	.2107507
vldis80	.0474642	.0724889	0.65	0.513	-.0946304	.1895589
vldis81	-.410782	.3177079	-1.29	0.196	-1.033561	.2119969
vldis82	.0256398	.0664738	0.39	0.700	-.1046638	.1559434
vldis83	-.0260686	.0903692	-0.29	0.773	-.2032125	.1510753
vldis84	-.0900032	.0740601	-1.22	0.224	-.2351777	.0551712
vldis85	-.0464233	.0422408	-1.10	0.272	-.1292249	.0363782
vldis86	-.1323016	.1055433	-1.25	0.210	-.3391902	.074587
vldis87	.0879971	.0425103	2.07	0.038	.0046674	.1713268
vldis88	.057224	.0637339	0.90	0.369	-.0677088	.1821567
vldis89	-.033028	.0542153	-0.61	0.542	-.1393022	.0732463
vldis90	-.1389267	.1102413	-1.26	0.208	-.3550245	.0771711
vldis91	-.2024679	.0937774	-2.16	0.031	-.3862927	-.0186431
vldis92	-.0218133	.041006	-0.53	0.595	-.1021942	.0585676
vldis93	-.0139467	.0325591	-0.43	0.668	-.07777	.0498766
vldis94	.0163334	.0449405	0.36	0.716	-.07176	.1044269
vldis95	-.1395255	.0547954	-2.55	0.011	-.2469367	-.0321143
vldis96	-.0854278	.0458419	-1.86	0.062	-.1752883	.0044327
vldis97	-.0445908	.0347812	-1.28	0.200	-.1127698	.0235882
vldis98	-.0433964	.0316081	-1.37	0.170	-.1053553	.0185626
vldis99	-.0270545	.0259879	-1.04	0.298	-.0779967	.0238878
pfemales	3.93342	1.9916	1.98	0.048	.0294355	7.837405
pblack	-3.091772	2.240053	-1.38	0.168	-7.48278	1.299235
pother	-.0013977	.1657788	-0.01	0.993	-.3263614	.3235661
page_under5	-5.258563	1.906766	-2.76	0.006	-8.996253	-1.520873
page_5_29	2.75681	.9891335	2.79	0.005	.8178857	4.695734
page_65_up	.4459353	.8712632	0.51	0.609	-1.261937	2.153807
pmarhh_chd	-.5782048	.4886966	-1.18	0.237	-1.53616	.3797505
pmhh_child	-.8582164	1.040405	-0.82	0.409	-2.897644	1.181212
pfhh_child	.1185717	.8544424	0.14	0.890	-1.556328	1.793471
pvacant	1.428592	1.004489	1.42	0.155	-.5404324	3.397617
prenter_occ	-.1759728	.1486005	-1.18	0.236	-.4672631	.1153175
vpfemales	-.9480066	1.835389	-0.52	0.606	-4.545781	2.649768
vpblack	1.245737	2.104473	0.59	0.554	-2.879503	5.370977
vpother	-.0138705	.1498806	-0.09	0.926	-.3076703	.2799292
vpage_under5	1.985041	1.67961	1.18	0.237	-1.307372	5.277455
vpage_5_29	-3.098925	.8805155	-3.52	0.000	-4.824933	-1.372916
vpage_65_up	-1.057589	.7917475	-1.34	0.182	-2.609592	.4944139
vpmarhh_chd	.3038902	.4465291	0.68	0.498	-.5753278	1.183108
vpmhh_child	.0868051	1.060696	0.08	0.935	-1.992397	2.166007
vpfhh_child	.3086173	.7840376	0.39	0.694	-1.228273	1.845507
vpvacant	-1.204047	.9984558	-1.21	0.228	-3.161245	.7531509
vprenter_occ	.2321561	.1488887	1.56	0.119	-.0596993	.5240115
year71	.1646225	.1147839	1.43	0.152	-.0603798	.3896249
year72	.2426421	.1008523	2.41	0.016	.0449489	.4403353
year73	.3830431	.0988288	3.88	0.000	.1893164	.5767697
year74	.3589601	.1084108	3.31	0.001	.1464505	.5714697
year75	.5575864	.1019989	5.47	0.000	.3576456	.7575272
year76	.6507012	.1026861	6.34	0.000	.4494133	.8519891
year77	.9052132	.1048552	8.63	0.000	.6996734	1.110753
year78	1.186598	.1052646	11.27	0.000	.9802556	1.39294
year79	1.219498	.114578	10.64	0.000	.9948995	1.444097
year80	1.319258	.1150346	11.47	0.000	1.093764	1.544751

year81	1.18804	.1853593	6.41	0.000	.8245942	1.551386
year82	1.084203	.1588885	6.82	0.000	.772746	1.39566
year83	1.563661	.1131756	13.82	0.000	1.341812	1.785511
year84	1.499866	.1201688	12.48	0.000	1.264308	1.735423
year85	1.634104	.1246051	13.11	0.000	1.38985	1.878358
year86	1.706003	.1150238	14.83	0.000	1.48053	1.931476
year87	1.901796	.1133351	16.78	0.000	1.679633	2.123958
year88	1.936037	.1249827	15.49	0.000	1.691043	2.181032
year89	1.948422	.124541	15.64	0.000	1.704294	2.19255
year90	2.192643	.1221637	17.95	0.000	1.953174	2.432111
year91	2.104079	.1321843	15.92	0.000	1.844968	2.36319
year92	2.350348	.1099423	21.38	0.000	2.134837	2.56586
year93	2.261341	.1121414	20.17	0.000	2.041519	2.481163
year94	2.226663	.1099758	20.25	0.000	2.011086	2.442241
year95	2.124498	.1196479	17.76	0.000	1.889961	2.359035
year96	2.111936	.1167747	18.09	0.000	1.883031	2.34084
year97	2.028976	.1176057	17.25	0.000	1.798443	2.25951
year98	2.158611	.1083457	19.92	0.000	1.946229	2.370993
year99	2.219835	.1097631	20.22	0.000	2.004675	2.434996
_cons	5.889568	1.063314	5.54	0.000	3.805234	7.973902

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.0000	
All lotsize-independent year-specific slope on LDIST the same	0.0000	
All lotsize-independent Census tract characteristic effects simultaneously zero	0.0003	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0139	
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.0102	
All lotsize-dependent Census tract characteristic effects simultaneously zero (on vX Census tract variables)	0.0000	

7.3 Including other distances

```
Regression with robust standard errors                Number of obs =    9211
                                                      F(136,  9074) =  207.46
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.7022
                                                      Root MSE      =  .45117
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	1.01078	.1963429	5.15	0.000	.6259035	1.395656
age	-.0130358	.0011239	-11.60	0.000	-.0152389	-.0108326
age2	.0001119	.0000141	7.93	0.000	.0000842	.0001396
sqft	.448072	.060142	7.45	0.000	.3301802	.5659638
sqft2	-.0731531	.0228597	-3.20	0.001	-.1179634	-.0283429
bedrms	.0623636	.027589	2.26	0.024	.0082829	.1164442
bthrms	-.0943	.0316053	-2.98	0.003	-.1562535	-.0323465
sqftbed	-.0324151	.0180257	-1.80	0.072	-.0677495	.0029194
sqftbth	.053809	.0212689	2.53	0.011	.0121172	.0955008
fplace	.0601806	.0122113	4.93	0.000	.0362437	.0841175
knowflr	.0754882	.0333205	2.27	0.024	.0101724	.140804
floors	-.0168327	.0209767	-0.80	0.422	-.0579517	.0242863
lotsize	.3340394	.262537	1.27	0.203	-.1805923	.8486711
ldis70	-.2855172	.1559739	-1.83	0.067	-.5912612	.0202268
ldis71	-.1822907	.1391968	-1.31	0.190	-.4551479	.0905665
ldis72	-.0960865	.102256	-0.94	0.347	-.2965313	.1043584
ldis73	-.0849355	.0859546	-0.99	0.323	-.253426	.0835549
ldis74	-.1939962	.1008932	-1.92	0.055	-.3917697	.0037773
ldis75	-.045649	.0742886	-0.61	0.539	-.1912713	.0999734
ldis76	-.1905804	.0618659	-3.08	0.002	-.3118515	-.0693094
ldis77	-.1348433	.0611903	-2.20	0.028	-.2547901	-.0148965
ldis78	-.0348141	.0616751	-0.56	0.572	-.1557112	.086083
ldis79	-.0699274	.0937735	-0.75	0.456	-.2537446	.1138898
ldis80	-.1598652	.0895759	-1.78	0.074	-.3354542	.0157238
ldis81	.2933968	.2913203	1.01	0.314	-.2776567	.8644503
ldis82	.1516452	.1423548	1.07	0.287	-.1274024	.4306928
ldis83	-.0831549	.0962946	-0.86	0.388	-.2719141	.1056043
ldis84	.0528265	.1002795	0.53	0.598	-.1437439	.2493968
ldis85	-.00965	.0858904	-0.11	0.911	-.1780145	.1587146
ldis86	.113026	.1135165	1.00	0.319	-.109492	.335544
ldis87	-.1757187	.0711654	-2.47	0.014	-.3152189	-.0362185
ldis88	-.1172299	.0919078	-1.28	0.202	-.29739	.0629301
ldis89	.0820262	.0807829	1.02	0.310	-.0763266	.2403789
ldis90	.0690992	.102748	0.67	0.501	-.1323099	.2705084
ldis91	.2787667	.1197444	2.33	0.020	.0440408	.5134927
ldis92	-.0863779	.0642588	-1.34	0.179	-.2123396	.0395837
ldis93	-.0708935	.060235	-1.18	0.239	-.1889677	.0471807
ldis94	-.0874664	.068083	-1.28	0.199	-.2209245	.0459917
ldis95	.0827853	.0740736	1.12	0.264	-.0624157	.2279863
ldis96	.0352414	.0841704	0.42	0.675	-.1297516	.2002343
ldis97	.0427095	.0654582	0.65	0.514	-.0856032	.1710223
ldis98	-.0333816	.0538653	-0.62	0.535	-.1389698	.0722066
ldis99	-.0347635	.0509786	-0.68	0.495	-.134693	.0651661
vldis70	.1553786	.1409644	1.10	0.270	-.1209433	.4317006
vldis71	-.0266688	.1023727	-0.26	0.794	-.2273423	.1740047
vldis72	-.0822359	.0878412	-0.94	0.349	-.2544245	.0899528
vldis73	-.0880326	.0772817	-1.14	0.255	-.2395222	.0634569
vldis74	.0107562	.080406	0.13	0.894	-.1468577	.1683702
vldis75	-.0949748	.0580861	-1.64	0.102	-.2088366	.0188871
vldis76	.0751702	.0612246	1.23	0.220	-.0448439	.1951843
vldis77	.0088869	.0536453	0.17	0.868	-.0962701	.1140438
vldis78	-.0631169	.0584521	-1.08	0.280	-.1776962	.0514624
vldis79	.0169076	.0794405	0.21	0.831	-.1388138	.1726289
vldis80	-.0308488	.0799577	-0.39	0.700	-.187584	.1258863
vldis81	-.5124926	.3266528	-1.57	0.117	-1.152806	.1278204
vldis82	-.0499772	.076536	-0.65	0.514	-.2000051	.1000506

vldis83	-.0801731	.0925115	-0.87	0.386	-.2615165	.1011702
vldis84	-.1189987	.0874959	-1.36	0.174	-.2905104	.052513
vldis85	-.0774273	.061781	-1.25	0.210	-.1985319	.0436774
vldis86	-.1491694	.1117435	-1.33	0.182	-.3682119	.0698731
vldis87	.0847634	.0622988	1.36	0.174	-.0373563	.206883
vldis88	.0582239	.0755884	0.77	0.441	-.0899463	.2063941
vldis89	-.0361026	.0695848	-0.52	0.604	-.1725044	.1002992
vldis90	-.1617859	.1117712	-1.45	0.148	-.3808826	.0573107
vldis91	-.2141515	.1028371	-2.08	0.037	-.4157354	-.0125675
vldis92	-.0017229	.0550318	-0.03	0.975	-.1095975	.1061518
vldis93	.0170388	.0528479	0.32	0.747	-.086555	.1206326
vldis94	.034036	.0592979	0.57	0.566	-.0822013	.1502732
vldis95	-.1217679	.0673704	-1.81	0.071	-.2538292	.0102934
vldis96	-.0242093	.0616169	-0.39	0.694	-.1449922	.0965737
vldis97	-.0132117	.0524804	-0.25	0.801	-.1160852	.0896617
vldis98	-.0070486	.0488948	-0.14	0.885	-.1028935	.0887962
vldis99	.0147186	.0459458	0.32	0.749	-.0753456	.1047828
ld_school	.05885	.0229996	2.56	0.011	.0137655	.1039345
ld_retail	.2128186	.0907346	2.35	0.019	.0349582	.3906789
ld_hospital	.0100744	.0252366	0.40	0.690	-.0393951	.0595438
ld_church	.0692553	.0514981	1.34	0.179	-.0316925	.1702031
ld_cemetery	.1146278	.0348863	3.29	0.001	.0462428	.1830128
ld_i5	-.0408457	.0460772	-0.89	0.375	-.1311674	.0494761
ld_i605	.0089587	.0408476	0.22	0.826	-.0711118	.0890293
ld_i10	-.090095	.0331572	-2.72	0.007	-.1550906	-.0250995
ld_railroad	.0742574	.0225946	3.29	0.001	.0299668	.1185479
ld_s60	-.0254397	.0363207	-0.70	0.484	-.0966365	.0457571
ld_rivers	-.0022064	.0348716	-0.06	0.950	-.0705625	.0661498
ld_cards	.0239115	.0046567	5.13	0.000	.0147833	.0330396
ld_whittiern	.0164331	.0923855	0.18	0.859	-.1646634	.1975296
ld_parks	.0085618	.0158883	0.54	0.590	-.0225829	.0397065
ld_mjwater	.0235234	.0221965	1.06	0.289	-.0199867	.0670335
ld_csula	.2097668	.0690151	3.04	0.002	.0744817	.345052
ld_cclubs	-.047513	.0154859	-3.07	0.002	-.0778688	-.0171572
vld_school	-.0536148	.0227146	-2.36	0.018	-.0981404	-.0090891
vld_retail	-.1630339	.0806322	-2.02	0.043	-.3210913	-.0049766
vld_hospital	-.0306094	.0236917	-1.29	0.196	-.0770504	.0158317
vld_church	-.1054151	.0574642	-1.83	0.067	-.2180579	.0072276
vld_cemetery	-.0500317	.0338297	-1.48	0.139	-.1163455	.0162821
vld_i5	.0955708	.0464238	2.06	0.040	.0045697	.1865719
vld_i605	.0487181	.0403704	1.21	0.228	-.030417	.1278531
vld_i10	.0535919	.0320213	1.67	0.094	-.0091771	.1163608
vld_railroad	-.0491097	.0223083	-2.20	0.028	-.092839	-.0053804
vld_s60	.0354948	.0370346	0.96	0.338	-.0371014	.108091
vld_rivers	.0326098	.0348624	0.94	0.350	-.0357284	.100948
vld_cards	-.008712	.005189	-1.68	0.093	-.0188835	.0014596
vld_whitti~n	.0473927	.0874666	0.54	0.588	-.1240615	.2188469
vld_parks	-.0138063	.0167664	-0.82	0.410	-.0466722	.0190597
vld_mjwater	-.0349612	.0186473	-1.87	0.061	-.0715141	.0015918
vld_csula	-.1055273	.0651511	-1.62	0.105	-.233238	.0221835
vld_cclubs	.025362	.0174375	1.45	0.146	-.0088194	.0595433
year71	.1631364	.1156831	1.41	0.159	-.0636286	.3899014
year72	.23412	.1019729	2.30	0.022	.0342301	.4340099
year73	.3935531	.0982892	4.00	0.000	.2008842	.586222
year74	.3445819	.1061608	3.25	0.001	.1364827	.552681
year75	.5432421	.0985958	5.51	0.000	.3499722	.736512
year76	.6636308	.0974931	6.81	0.000	.4725223	.8547392

year77	.9082953	.096925	9.37	0.000	.7183004	1.09829
year78	1.17338	.0950978	12.34	0.000	.986967	1.359793
year79	1.216334	.1052138	11.56	0.000	1.010091	1.422577
year80	1.313444	.106073	12.38	0.000	1.105517	1.521371
year81	1.223729	.1815608	6.74	0.000	.8678288	1.579629
year82	1.075728	.1550198	6.94	0.000	.7718546	1.379602
year83	1.567677	.1019548	15.38	0.000	1.367823	1.767532
year84	1.513282	.1098191	13.78	0.000	1.298012	1.728552
year85	1.635502	.1120046	14.60	0.000	1.415948	1.855056
year86	1.72384	.1017301	16.95	0.000	1.524426	1.923254
year87	1.90264	.0985698	19.30	0.000	1.709421	2.095859
year88	1.941813	.1102744	17.61	0.000	1.725651	2.157976
year89	1.955631	.1168134	16.74	0.000	1.726651	2.184612
year90	2.213139	.1058574	20.91	0.000	2.005634	2.420643
year91	2.105524	.1181024	17.83	0.000	1.874016	2.337031
year92	2.36137	.09562	24.70	0.000	2.173934	2.548807
year93	2.259504	.0977135	23.12	0.000	2.067963	2.451044
year94	2.254821	.0956137	23.58	0.000	2.067396	2.442245
year95	2.156261	.1048449	20.57	0.000	1.950742	2.361781
year96	2.132398	.1042553	20.45	0.000	1.928034	2.336762
year97	2.064529	.1045225	19.75	0.000	1.859641	2.269417
year98	2.200241	.0949103	23.18	0.000	2.014195	2.386287
year99	2.260399	.09494	23.81	0.000	2.074295	2.446502
_cons	7.777638	.336108	23.14	0.000	7.11879	8.436485

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.0000	
All lotsize-independent year-specific slope on LDIST the same	0.0001	
All lotsize-independent other distance effects simultaneously zero	0.0000	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0182	
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.0138	
All lotsize-dependent other distance effects simultaneously zero (on vX "other distance" variables)	0.0006	

7.4 Including both other distances and tract attributes

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Regression with robust standard errors                Number of obs =    9211
                                                      F(158,  9052) =  193.83
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.7072
                                                      Root MSE      =  .44791
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.9396044	.22867	4.11	0.000	.4913596	1.387849
age	-.0139859	.0012051	-11.61	0.000	-.0163481	-.0116237
age2	.000133	.0000155	8.56	0.000	.0001026	.0001635
sqft	.430146	.0606969	7.09	0.000	.3111663	.5491257
sqft2	-.0648951	.0230478	-2.82	0.005	-.110074	-.0197162
bedrms	.0609665	.0274557	2.22	0.026	.0071471	.114786
bthrms	-.0878012	.0317455	-2.77	0.006	-.1500295	-.025573
sqftbed	-.032318	.0179173	-1.80	0.071	-.06744	.0028039
sqftbth	.0485406	.0213351	2.28	0.023	.0067189	.0903622
fplace	.0442048	.0123183	3.59	0.000	.0200582	.0683514
knowflr	.0454479	.0335581	1.35	0.176	-.0203336	.1112293
floors	-.0057551	.0210582	-0.27	0.785	-.0470339	.0355238
lotsize	2.133716	.9663641	2.21	0.027	.2394244	4.028008
ldis70	-.2892864	.1646555	-1.76	0.079	-.6120483	.0334755
ldis71	-.1591525	.1528035	-1.04	0.298	-.4586819	.140377
ldis72	-.0979634	.1151836	-0.85	0.395	-.3237493	.1278225
ldis73	-.0864205	.0988882	-0.87	0.382	-.2802637	.1074227
ldis74	-.207558	.108093	-1.92	0.055	-.4194446	.0043287
ldis75	-.0710578	.0798885	-0.89	0.374	-.2276572	.0855416
ldis76	-.2315977	.0630613	-3.67	0.000	-.355212	-.1079833
ldis77	-.1678442	.0666591	-2.52	0.012	-.2985112	-.0371773
ldis78	-.1049015	.0641114	-1.64	0.102	-.2305743	.0207713
ldis79	-.1102457	.0948561	-1.16	0.245	-.2961852	.0756938
ldis80	-.2105626	.0949694	-2.22	0.027	-.3967241	-.0244011
ldis81	.264586	.2906608	0.91	0.363	-.3051748	.8343468
ldis82	.0688614	.1424117	0.48	0.629	-.2102979	.3480206
ldis83	-.0962069	.0983969	-0.98	0.328	-.2890871	.0966732
ldis84	-.0059556	.1036861	-0.06	0.954	-.2092037	.1972925
ldis85	-.0265716	.0876936	-0.30	0.762	-.1984708	.1453276
ldis86	.1158008	.1149114	1.01	0.314	-.1094514	.3410531
ldis87	-.1703324	.0757173	-2.25	0.024	-.3187555	-.0219094
ldis88	-.1055557	.0968463	-1.09	0.276	-.2953963	.084285
ldis89	.0958057	.0829579	1.15	0.248	-.0668106	.2584219
ldis90	.0990395	.1041006	0.95	0.341	-.1050213	.3031002
ldis91	.2746674	.1204551	2.28	0.023	.0385482	.5107866
ldis92	-.0511714	.0713483	-0.72	0.473	-.1910302	.0886874
ldis93	-.0388498	.0675568	-0.58	0.565	-.1712763	.0935768
ldis94	-.0349283	.0747392	-0.47	0.640	-.181434	.1115774
ldis95	.1349149	.0806216	1.67	0.094	-.0231217	.2929514
ldis96	.1012796	.0908195	1.12	0.265	-.0767472	.2793063
ldis97	.1109927	.0724285	1.53	0.125	-.0309836	.252969
ldis98	.0320976	.0625171	0.51	0.608	-.09045	.1546452
ldis99	.0370807	.0609756	0.61	0.543	-.0824452	.1566066
vldis70	.2051993	.1498543	1.37	0.171	-.0885491	.4989476
vldis71	-.0077163	.1104356	-0.07	0.944	-.2241951	.2087625
vldis72	-.0461071	.1014559	-0.45	0.650	-.2449835	.1527694
vldis73	-.0479757	.0874913	-0.55	0.583	-.2194783	.1235269
vldis74	.0565544	.0877758	0.64	0.519	-.115506	.2286148
vldis75	-.0427771	.0638557	-0.67	0.503	-.1679488	.0823946
vldis76	.1501732	.0637333	2.36	0.018	.0252415	.2751048
vldis77	.0781389	.0605014	1.29	0.197	-.0404574	.1967353
vldis78	.0301396	.0634212	0.48	0.635	-.0941803	.1544594
vldis79	.0848537	.0809932	1.05	0.295	-.0739113	.2436187
vldis80	.0557155	.0852435	0.65	0.513	-.111381	.2228119

vldis81	-.4229702	.3271879	-1.29	0.196	-1.064332	.2183921
vldis82	.0395891	.0843534	0.47	0.639	-.1257625	.2049407
vldis83	-.0242993	.095707	-0.25	0.800	-.2119066	.163308
vldis84	-.0281755	.0894657	-0.31	0.753	-.2035484	.1471975
vldis85	-.0189046	.0639991	-0.30	0.768	-.1443574	.1065482
vldis86	-.1135712	.1123787	-1.01	0.312	-.3338589	.1067164
vldis87	.1174411	.0677692	1.73	0.083	-.0154018	.2502841
vldis88	.085962	.0808687	1.06	0.288	-.0725589	.244483
vldis89	-.0075404	.0730036	-0.10	0.918	-.1506439	.1355631
vldis90	-.1447628	.1130671	-1.28	0.200	-.3664	.0768743
vldis91	-.1698419	.1028258	-1.65	0.099	-.3714038	.0317199
vldis92	.0038675	.0629433	0.06	0.951	-.1195156	.1272507
vldis93	.0211849	.0620146	0.34	0.733	-.1003778	.1427476
vldis94	.0269625	.0673223	0.40	0.689	-.1050044	.1589295
vldis95	-.1380712	.0757118	-1.82	0.068	-.2864834	.0103409
vldis96	-.0579474	.0691739	-0.84	0.402	-.1935439	.077649
vldis97	-.0434914	.0619631	-0.70	0.483	-.1649531	.0779703
vldis98	-.0393046	.0581896	-0.68	0.499	-.1533694	.0747602
vldis99	-.0304552	.0561175	-0.54	0.587	-.1404583	.0795478
ld_school	.076556	.0238608	3.21	0.001	.0297834	.1233285
ld_retail	.1410083	.0959807	1.47	0.142	-.0471355	.3291521
ld_hospital	.0038849	.0270081	0.14	0.886	-.0490572	.0568269
ld_church	.0567614	.0533221	1.06	0.287	-.047762	.1612849
ld_cemetery	.0943059	.039173	2.41	0.016	.0175179	.1710939
ld_i5	-.0496932	.0504129	-0.99	0.324	-.148514	.0491275
ld_i605	.0515217	.0561445	0.92	0.359	-.0585342	.1615777
ld_i10	-.1494311	.0381768	-3.91	0.000	-.2242663	-.074596
ld_railroad	.062625	.0234534	2.67	0.008	.0166511	.1085989
ld_s60	-.0233059	.0411942	-0.57	0.572	-.1040559	.0574441
ld_rivers	.044171	.037762	1.17	0.242	-.0298511	.118193
ld_cards	.0277618	.0048259	5.75	0.000	.0183019	.0372217
ld_whittiern	-.010857	.0959999	-0.11	0.910	-.1990384	.1773244
ld_parks	.00142	.0153337	0.09	0.926	-.0286375	.0314774
ld_mjwater	.0452407	.0247954	1.82	0.068	-.0033638	.0938452
ld_csula	.2458509	.0796422	3.09	0.002	.0897342	.4019675
ld_cclubs	-.033089	.018603	-1.78	0.075	-.0695551	.0033771
vld_school	-.067924	.0237941	-2.85	0.004	-.1145658	-.0212822
vld_retail	-.1492354	.0838446	-1.78	0.075	-.3135897	.0151189
vld_hospital	-.0070525	.0252526	-0.28	0.780	-.0565533	.0424484
vld_church	-.0767225	.0596684	-1.29	0.199	-.1936861	.0402411
vld_cemetery	-.0649201	.0365769	-1.77	0.076	-.1366192	.006779
vld_i5	.0454289	.0506654	0.90	0.370	-.0538867	.1447445
vld_i605	.0169224	.0562335	0.30	0.763	-.093308	.1271527
vld_i10	.1035502	.0358445	2.89	0.004	.0332868	.1738135
vld_railroad	-.0513127	.0233714	-2.20	0.028	-.0971259	-.0054996
vld_s60	.0354789	.0422519	0.84	0.401	-.0473444	.1183021
vld_rivers	.0042554	.037204	0.11	0.909	-.0686729	.0771837
vld_cards	-.0144015	.0054509	-2.64	0.008	-.0250864	-.0037165
vld_whitti~n	.0146674	.0886792	0.17	0.869	-.1591639	.1884987
vld_parks	-.0053955	.0160706	-0.34	0.737	-.0368975	.0261064
vld_mjwater	-.0571488	.0212625	-2.69	0.007	-.0988281	-.0154696
vld_csula	-.154431	.0743566	-2.08	0.038	-.3001868	-.0086752
vld_cclubs	.0228168	.0219965	1.04	0.300	-.0203014	.065935
pfemales	3.149603	2.153247	1.46	0.144	-1.071249	7.370454
pblack	-1.893343	2.643731	-0.72	0.474	-7.075653	3.288968
pother	-.281395	.2120095	-1.33	0.184	-.6969816	.1341917
page_under5	-4.450687	2.176282	-2.05	0.041	-8.716692	-.1846827
page_5_29	3.058623	1.126971	2.71	0.007	.8495047	5.267741

page_65_up	.8124726	.9695418	0.84	0.402	-1.083048	2.712994
pmarhh_chd	-.6169048	.5570739	-1.11	0.268	-1.703896	.475086
pmhh_child	1.007679	1.121035	0.90	0.369	-1.189803	3.205161
pfhh_child	1.186137	1.082091	1.10	0.273	-.9350068	3.307281
pvacant	1.203104	1.174282	1.02	0.306	-1.093754	3.504962
prenter_occ	-.5469779	.1711734	-3.20	0.001	-.8825165	-.2114394
vpfemales	-1.409647	1.98081	-0.71	0.477	-5.292484	2.473189
vpblack	1.33834	2.72497	0.49	0.623	-4.003218	6.679898
vpother	.1287247	.1929762	0.67	0.505	-.2495522	.5070016
vpage_under5	1.594482	1.9326	0.83	0.409	-2.193851	5.382815
vpage_5_29	-2.909213	1.026244	-2.83	0.005	-4.920888	-.8975467
vpage_65_up	-.9587272	.8971892	-1.07	0.285	-2.717421	.7999664
vpmarhh_chd	.3787277	.5167106	0.73	0.464	-.6341419	1.391597
vpmhh_child	-1.408249	1.137144	-1.24	0.216	-3.63731	.8208107
vpfhh_child	-1.135848	1.026224	-1.11	0.268	-3.147478	.8757819
vpvacant	-.9868546	1.150016	-0.86	0.391	-3.241145	1.267436
vprenter_occ	.4592367	.1708943	2.69	0.007	.1242452	.7942292
year71	.1664823	.1162305	1.43	0.152	-.0613558	.3943204
year72	.2514694	.101474	2.48	0.013	.0525574	.4503813
year73	.4092673	.0995113	4.11	0.000	.2142027	.6043318
year74	.3848241	.1096513	3.51	0.000	.1698829	.5997654
year75	.5964986	.1050497	5.68	0.000	.3905774	.8024199
year76	.7026122	.1070529	6.56	0.000	.4927643	.9124602
year77	.9613523	.1099833	8.74	0.000	.7457601	1.176944
year78	1.247636	.1111936	11.22	0.000	1.029672	1.465601
year79	1.289347	.1206733	10.68	0.000	1.052801	1.525894
year80	1.382417	.1213021	11.40	0.000	1.144637	1.620196
year81	1.254108	.1923185	6.52	0.000	.8771202	1.631096
year82	1.159287	.16687	6.95	0.000	.8321837	1.48639
year83	1.633089	.1204857	13.55	0.000	1.396909	1.869268
year84	1.585514	.127342	12.45	0.000	1.335895	1.835133
year85	1.706921	.1324946	12.88	0.000	1.447201	1.96664
year86	1.791261	.1225671	14.61	0.000	1.551002	2.03152
year87	1.982614	.1219792	16.25	0.000	1.743507	2.221721
year88	2.028457	.1328252	15.27	0.000	1.768089	2.288824
year89	2.040198	.1340566	15.22	0.000	1.777417	2.302979
year90	2.293865	.1311888	17.49	0.000	2.036705	2.551025
year91	2.197231	.1396465	15.73	0.000	1.923492	2.47097
year92	2.443586	.1199116	20.38	0.000	2.208533	2.67864
year93	2.349368	.1218154	19.29	0.000	2.110582	2.588153
year94	2.330382	.1195678	19.49	0.000	2.096003	2.564762
year95	2.238097	.1288106	17.38	0.000	1.985599	2.490595
year96	2.220733	.127	17.49	0.000	1.971784	2.469681
year97	2.14241	.1274552	16.81	0.000	1.892569	2.392251
year98	2.282842	.1191668	19.16	0.000	2.049248	2.516436
year99	2.350785	.1204582	19.52	0.000	2.11466	2.58691
_cons	5.704457	1.097236	5.20	0.000	3.553626	7.855289

Hypothesis	**P-value of F-test**	**Reject @ 5% level?**
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.0000	
All lotsize-independent year-specific slope on LDIST the same	0.0000	

All lotsize-independent other distance effects simultaneously zero	0.0000
All lotsize-independent Census tract characteristic effects simultaneously zero	0.0000
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0105
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.0077
All lotsize-dependent other distance effects simultaneously zero (on vX "other distance" variables)	0.0001
All lotsize-dependent Census tract characteristic effects simultaneously zero (on vX Census tract variables)	0.0000

Appendix C – Woburn Sites (Wells G&H and Industri-Plex)

Contents

Chapter 1 Criteria for exclusion from raw sample

Observations are excluded from the estimating sample for the Woburn site if:

- the recorded selling price is zero or there is no record of the current assessed value of improvements for the property
- the total number of rooms exceeds 15
- the number of bedrooms is zero or greater than 8
- the house has more than four stories
- the number of baths, including fractions, exceeds 5
- the land area exceeds 75,000 square feet
- the building area exceeds 5000 square feet
- the year of the recorded sale is outside the 1978-1997 window
- the most current assessed value of the dwelling is less than $8000 (if the log of this value is less than 9; affects 10 observations)
- the recorded sale price is less than about $1100 (if the log of this value is less than 7; early house sales in this sample involve a lot of extremely low prices that are too numerous to be either coding errors or non-arm's-length sales. this criterion affects 18 observations).
- the recorded sale price is greater than $1 million (affects 5 observations)
- the census tract is number 3585 (the data contain only what appears to be 31 replications of the same transaction, at the same price, in the same year)

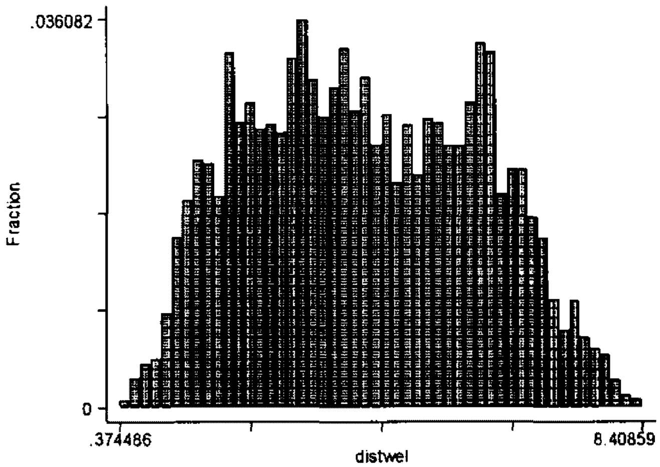
Chapter 2 Annual counts in sample

YEAR	Freq.	Percent	Cum.
78	316	2.54	2.54
79	258	2.07	4.61
80	208	1.67	6.28
81	143	1.15	7.43
82	174	1.40	8.83
83	284	2.28	11.11
84	485	3.90	15.01
85	590	4.74	19.75
86	586	4.71	24.46
87	684	5.50	29.96
88	652	5.24	35.20
89	644	5.18	40.37
90	612	4.92	45.29
91	813	6.53	51.82
92	1077	8.65	60.48
93	1195	9.60	70.08
94	1255	10.09	80.17
95	1021	8.20	88.37
96	1146	9.21	97.58
97	301	2.42	100.00

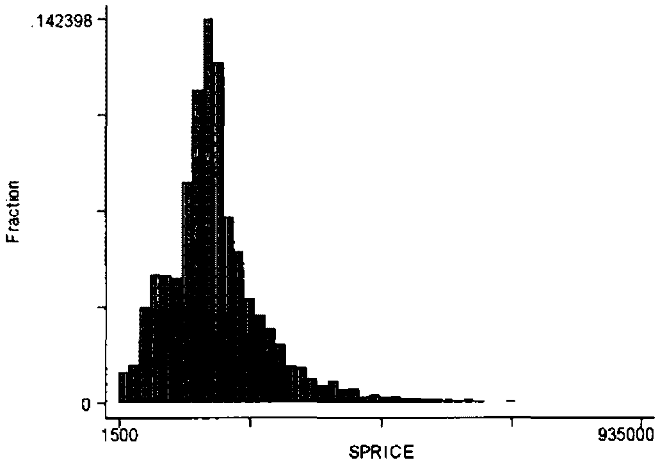
```
------------+-----------------------------------
      Total |      12444      100.00
```

Chapter 3 Descriptive statistics

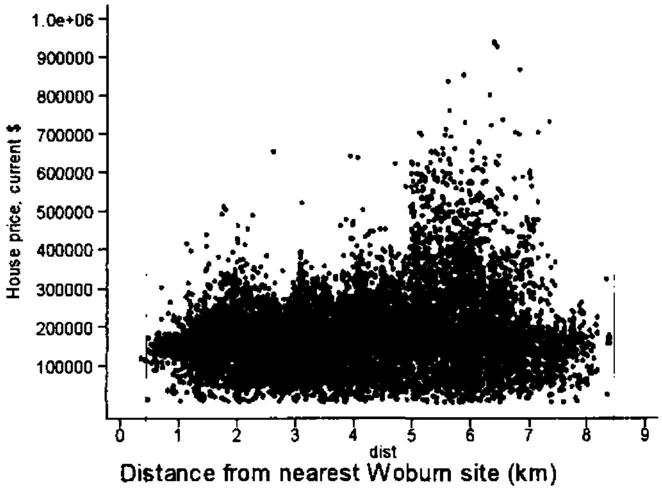
3.1 Housing prices and distances from nearest site

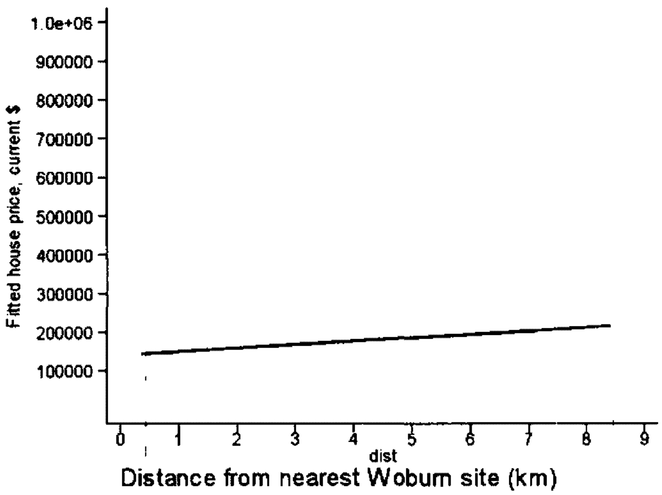


Marginal distribution of distances: Woburn



Marginal distribution of house prices: Woburn





3.2 Structural variables

Variable	Obs	Mean	Std. Dev.	Min	Max
notold	12444	.8825137	.3220119	0	1
age	12444	29.22059	24.04477	0	95
age2	12444	1431.947	1730.919	0	9025
sqft	12444	1.764122	.6879198	.408	4.981
sqft2	12444	3.585322	3.127169	.166464	24.81036
bedrms	12444	3.206606	.8423902	1	7
bthrms	12444	1.916747	.7942649	1	5
sqftbed	12444	5.994829	3.798772	.408	34.72
sqftbth	12444	3.759232	2.999084	.408	24.8
fplace	12444	.3726294	.4835241	0	1
knowflr	12444	.5279653	.4992374	0	1
floors	12444	.9040501	.9420838	0	3
lotsize	12444	1	.6488305	.0725759	4.95228

3.2.1 R2 for auxiliary regressions among these variables

Presented in order of variable list above.

.4683797170314082
.9220851573928605
.9118813156209173
.9581688612114861
.9805588416981539
.9080785263944619
.9357735922711881
.9782196655164073
.9794293001361518
.6306254215308172
.8866865498149391
.8684375445278907
.1760773201957944

3.3 Census tract attributes

Variable	Obs	Mean	Std. Dev.	Min	Max
pfemales	12444	.5163597	.0125727	.4956687	.5579294
pblack	12444	.0073106	.0067375	.0007966	.0391236
pother	12444	.0536386	.0963819	.003478	.6231612
page_under5	12444	.066371	.0140333	.0370092	.1198748
page_5_29	12444	.3474652	.050334	.2429152	.4951487
page_65_up	12444	.1266392	.0366465	.0594679	.2443653
pmarhh_chd	12444	.3083403	.0750423	.1766845	.5188977
pmhh_child	12444	.0086841	.0053786	.0034562	.0361781
pfhh_child	12444	.0464293	.0314776	.0180311	.2152134
pvacant	12444	.0306772	.0209923	.0078603	.1417197
prenter_occ	12444	.2269974	.1426593	.0308584	.656051

3.3.1 R2 for auxiliary regressions among these variables

Presented in order of variable list above.
.8333379383483428
.6423130939986187
.6499138244909342
.7940032426653801
.9540897077185154
.9312561902433929
.9694583283248606
.6241497143798369
.8195435645337803
.6963054354151017
.9587034947733537

3.4 Other distances

Distance variable	Description
d_summits	Distance from the nearest summit of land. There are about three doxen minor summits in the sample area, and none of them are very high. No house is at an altitude greater than about 3200 feet (verify units, meters?)
d_school	Distance from the nearest school. There are about 76 different schools in the sample area.
d_retail	Distance to the nearest retail center. There are no major retail centers within the sample area. (Houses in the sample are nearest to either Fresh Pond Mall, Meadow Glenn Mall, or Northshore Mall, among malls that are presently active. We do not have historical data concerning their level of activity in the period 1987-97.) All three of these centers are closer to Boston than the sample area, so the effect of this variable will partially capture proximity to Boston's central business district.
d_hospital	Distance to the nearest hospital. There are 3 hospitals inside the sample area, one in each of the three southernmost zip codes, nearest to Boston, of the seven zip codes in the sample area. Thus some of the effects of proximity to Boston's central business district will confound the effects of proximity to a hospital.
d_church	Distance from the nearest church. There are no churches at all inside the sample area. All recorded churches are much closer to Boston's city center. Thus, the effects of this variable will partially capture proximity to Boston's central business district.
d_cemetery	Distance to the nearest cemetery. There are thirteen cemeteries either within the sample area, with at least one in each of the seven zip codes.
d_railroad	Railroads cut through six of the seven zip codes in the sample area. (Burlington Northern and Union Pacific are recorded as the owners of these railroads.) There are two main routes, each running northwest out of the Boston area.
d_prinarte	"Principal arteries are defined as significant roads that are not designated as freeways. There are two basic north-south routes cutting through the sample area, other than the two freeways, which are not classed as principal arteries. [might want to drop this specially constructed variable... different intuition than ESRI variables]
d_othpriro	"Other primary roads" consists of a network of roads that criss-cross the sample area, but do no include quiet residential streets.
d_ma_rds	Distance from the closest main Massachusetts roads. This includes Interstates 93 and 95, if they happen to be the nearest main roads (which they usually will not be).
d_i95	Distance from Interstate 95, an east-west freeway that runs roughly across the center of the sample area. The coefficient on this variable is a proximity effect in addition to proximity from the nearest main

	road, d_ma_rds.
d_i93	Distance from Interstate 93, a north-south freeway that runs roughly up and down the center of the sample area. The coefficient on this variable is a proximity effect in addition to proximity from the nearest main road, d_ma_rds.
d_fp_tewma	Distance from the closest of the two flight paths associated with Tew-Mac airport, a small airport just outside the sample area, to the northwest.
d_fp_milit	Distance from the closest of the two flight paths associated with Hanscom Air Force Base, just outside the sample area to the southwest.
d_fp_logan	Distance from the one flight path associated with Logan International Airport (Boston) that cuts across the sample area. The center of the sample area is about 15 kilometers northwest of Logan Airport.
d_fp_bevmu	Distance from the one flight path for Beverly Municipal Airport, a small airport to the east of the sample area.
d_parks	Distance from the nearest park. The most extensive park areas are on the southern and southeastern boundaries of the sample area. There are only eight very small parks scattered within the sample area, other than these large parks areas in the south. Three external parks may be the closest park for some houses near the boundaries of the sample area.
d_mjwater	Distance from the nearest body of water. There are lakes associated with the major park areas on the south and south-east boundaries of the sample area, three bodies of water just north of the sample area, and two or three lakes outside parks in the southern and eastern portions of the sample area.
d_cclubs	Distance to the nearest country club. There are four country clubs inside the sample area, in the three most southern zip codes. There are two on the eastern boundary, or just outside it, and two near Hanscom Airforce Base to the southwest, but outside the sample area.
d_tewmac	Distance from Tew-Mac Airport.
d_military	Distance from Hanscom Air Force Base
d_logan	Distance from Logan International Airport.
d_bevmuni	Distance from Beverly Municipal Airport.

Variable	Obs	Mean	Std. Dev.	Min	Max
d_summits	12444	1349.167	874.0157	11.72466	4879.962
d_school	12444	681.4809	439.7627	4.349329	2660.245
d_retail	12444	11670.2	4195.242	4663.43	20922.31
d_hospital	12444	4468.638	2487.899	89.68488	10299.77
d_church	12444	12072.31	2380.219	6483.696	16487.02
d_cemetery	12444	1634.933	933.052	8.296629	4704.21
d_railroad	12444	1002.811	748.5769	.2851097	3741.38

4.3 Distance to site vs. structural variables

Regression with robust standard errors

Number of obs = 12444
F(13, 12430) = 128.97
Prob > F = 0.0000
R-squared = 0.1052
Root MSE = .4722

ldisw	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.1323117	.0175011	7.56	0.000	.0980069	.1666165
age	-.0037551	.0006524	-5.76	0.000	-.0050339	-.0024762
age2	.000026	8.29e-06	3.13	0.002	9.73e-06	.0000422
sqft	-.1913799	.0286959	-6.67	0.000	-.2476282	-.1351315
sqft2	.045791	.0087448	5.24	0.000	.0286498	.0629323
bedrms	.0395467	.0165267	2.39	0.017	.0071518	.0719415
bthrms	-.1056481	.0200206	-5.28	0.000	-.1448916	-.0664046
sqftbed	-.0236376	.0071075	-3.33	0.001	-.0375694	-.0097058
sqftbth	.0512712	.0089206	5.75	0.000	.0337855	.0687568
fplace	.2887278	.0163352	17.68	0.000	.2567083	.3207473
knowflr	-.4661392	.0289458	-16.10	0.000	-.5228775	-.409401
floors	.1183639	.0137333	8.62	0.000	.0914445	.1452834
lotsize	.0916501	.0072345	12.67	0.000	.0774693	.105831
_cons	1.406325	.0416209	33.79	0.000	1.324742	1.487909

4.4 Distance to site vs. Census tract attributes

Regression with robust standard errors

Number of obs = 12444
F(11, 12432) = 1039.33
Prob > F = 0.0000
R-squared = 0.4990
Root MSE = .3533

ldisw	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
pfemales	25.58699	.6144816	41.64	0.000	24.38251	26.79147
pblack	10.47738	1.206388	8.68	0.000	8.112675	12.84209
pother	1.900744	.3224596	5.89	0.000	1.268674	2.532815
page_under5	6.781207	.6627516	10.23	0.000	5.482111	8.080303
page_5_29	1.727713	.3253576	5.31	0.000	1.089961	2.365464
page_65_up	-9.046912	.2977327	-30.39	0.000	-9.630515	-8.46331
pmarhh_chd	-2.20178	.2470664	-8.91	0.000	-2.686069	-1.717492
pmhh_child	53.36124	1.605203	33.24	0.000	50.21479	56.50769
pfhh_child	-29.25011	.6321976	-46.27	0.000	-30.48932	-28.01091
pvacant	21.46273	.6624228	32.40	0.000	20.16428	22.76118
prenter_occ	-3.117636	.1324616	-23.54	0.000	-3.377281	-2.857991
_cons	-10.32185	.3140708	-32.86	0.000	-10.93747	-9.706219

4.5 Distance to site vs. other distances

Regression with robust standard errors

Number of obs	=	12444
F(23, 12420)	=	5527.36
Prob > F	=	0.0000
R-squared	=	0.8840
Root MSE	=	.17012

ldisw	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ld_summits	-.0370292	.0034191	-10.83	0.000	-.0437312	-.0303273
ld_school	.0324862	.0026741	12.15	0.000	.0272447	.0377278
ld_retail	1.320319	.0584987	22.57	0.000	1.205653	1.434986
ld_hospital	.1263315	.0077495	16.30	0.000	.1111412	.1415217
ld_church	-3.610246	.0514098	-70.22	0.000	-3.711017	-3.509475
ld_cemetery	.1680658	.0046991	35.77	0.000	.1588549	.1772767
ld_railroad	.0572693	.0022626	25.31	0.000	.0528342	.0617044
ld_prinarte	-.0071236	.0024505	-2.91	0.004	-.011927	-.0023203
ld_othpriro	-.0223408	.0019421	-11.50	0.000	-.0261476	-.0185341
ld_ma_roads	.0062531	.0012634	4.95	0.000	.0037766	.0087296
ld_i95	.2831022	.0074579	37.96	0.000	.2684835	.2977209
ld_i93	.1343621	.0035001	38.39	0.000	.1275013	.1412229
ld_fp_tewma	.004121	.0019537	2.11	0.035	.0002914	.0079506
ld_fp_milit	-.0357545	.0023531	-15.19	0.000	-.0403669	-.031142
ld_fp_logan	-.0042021	.0038821	-1.08	0.279	-.0118116	.0034073
ld_fp_bevmu	-.0410567	.00303	-13.55	0.000	-.046996	-.0351173
ld_parks	-.0147874	.0026756	-5.53	0.000	-.0200319	-.0095429
ld_mjwater	.0030723	.0037919	0.81	0.418	-.0043604	.010505
ld_cclubs	-.016519	.0024433	-6.76	0.000	-.0213084	-.0117297
ld_tewmac	.3481346	.0351869	9.89	0.000	.2791628	.4171064
ld_military	-1.227163	.0504958	-24.30	0.000	-1.326143	-1.128184
ld_logan	.1453099	.0573186	2.54	0.011	.0329566	.2576633
ld_bevmuni	-3.979154	.0894777	-44.47	0.000	-4.154544	-3.803764
_cons	64.21698	1.9738	32.53	0.000	60.34802	68.08593

Chapter 5 Trends in the distance gradient

These models use individual houses as observations. We associate with each house the proportion of each group in the Census tract that contains the house. The right-hand side variables are the measured distance of the house itself from the Woburn site, a time trend, starting at 1 in the first period of the data, and an interaction term between distance and time. The simple trend picks up the trend over time in the concentration of the group in question throughout the sample area. The "ldisw" variable, distance to the nearer of the Wells G&H sites or the Industri-Plex site, picks up any baseline distance gradient in the concentration of the group in question as a function of distance from the nearest Superfund site. The key variable is the interaction term, which tells how the distance gradient is shifting over time. If the distance gradient is becoming either less positive or more negative, the concentration of the group in question nearer the Superfund site is growing, relative to the concentration further away.

5.1 Structural variables

5.1.1 Built post-1900

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	41.84
Prob > F	=	0.0000
R-squared	=	0.0081
Root MSE	=	.32075

notold	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0511654	.0139318	3.67	0.000	.023857	.0784739
trend	-.0025208	.001649	-1.53	0.126	-.0057532	.0007116
ldiswy	6.06e-06	.0010607	0.01	0.995	-.0020732	.0020853
_cons	.8455241	.0216549	39.05	0.000	.803077	.8879711

5.1.2 Age if built post-1900

Regression with robust standard errors

Number of obs	=	10982
F(3, 10978)	=	211.40
Prob > F	=	0.0000
R-squared	=	0.0492
Root MSE	=	22.373

age	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	-.8602572	1.018054	-0.85	0.398	-2.855827	1.135313
trend	1.298745	.1155265	11.24	0.000	1.072292	1.525198
ldiswy	-.3173891	.0795552	-3.99	0.000	-.4733316	-.1614466
_cons	23.7504	1.495089	15.89	0.000	20.81976	26.68104

5.1.3 Square footage

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	88.66
Prob > F	=	0.0000
R-squared	=	0.0187
Root MSE	=	.68154

sqft	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.1432007	.0342994	4.18	0.000	.0759686	.2104328
trend	-.0096499	.0032731	-2.95	0.003	-.0160657	-.0032341
ldiswy	.0026118	.0025989	1.00	0.315	-.0024825	.0077061
_cons	1.651138	.0435167	37.94	0.000	1.565839	1.736438

5.1.4 Bedrooms

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 37.65
Prob > F	= 0.0000
R-squared	= 0.0088
Root MSE	= .83876

bedrms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0808946	.0417319	1.94	0.053	-.0009064	.1626956
trend	-.0136365	.0043075	-3.17	0.002	-.0220799	-.005193
ldiswy	.0042233	.0031858	1.33	0.185	-.0020214	.0104681
_cons	3.198047	.0565213	56.58	0.000	3.087257	3.308838

5.1.5 Bathrooms

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 90.71
Prob > F	= 0.0000
R-squared	= 0.0186
Root MSE	= .78693

bthrms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0593045	.0387866	1.53	0.126	-.0167232	.1353323
trend	-.0222378	.0038683	-5.75	0.000	-.0298204	-.0146553
ldiswy	.0109726	.0029239	3.75	0.000	.0052412	.0167039
_cons	1.934167	.0516204	37.47	0.000	1.832983	2.035351

5.1.6 Fireplace(s)?

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 53.76
Prob > F	= 0.0000
R-squared	= 0.0108
Root MSE	= .48095

fplace	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.1507521	.0225073	6.70	0.000	.1066343	.1948699
trend	.0145869	.0023447	6.22	0.000	.0099909	.0191829
ldiswy	-.0060986	.0017332	-3.52	0.000	-.0094958	-.0027013
_cons	.0950634	.0304548	3.12	0.002	.0353672	.1547596

5.1.7 Floors recorded?

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 164.83

Prob > F	=	0.0000
R-squared	=	0.0324
Root MSE	=	.49114

knowflr	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0950693	.0228831	4.15	0.000	.0502149	.1399238
trend	.0338765	.0023747	14.27	0.000	.0292218	.0385313
ldiswy	-.0152776	.001719	-8.89	0.000	-.0186471	-.0119081
_cons	.2355526	.0317171	7.43	0.000	.1733322	.2977229

5.1.8 Floors

Regression with robust standard errors

Number of obs	=	6570
F(3, 6566)	=	13.04
Prob > F	=	0.0000
R-squared	=	0.0063
Root MSE	=	.54328

floors	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.1396411	.0439333	3.18	0.001	.0535176	.2257646
trend	.0040315	.0046354	0.87	0.384	-.0050553	.0131183
ldiswy	-.0051249	.0032299	-1.59	0.113	-.0114565	.0012067
_cons	1.565387	.0633544	24.71	0.000	1.441191	1.689582

5.1.9 Lotsize

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	168.25
Prob > F	=	0.0000
R-squared	=	0.0373
Root MSE	=	.63668

lotsize	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.2690467	.0336682	7.99	0.000	.2030519	.3350415
trend	-.003972	.0034553	-1.15	0.250	-.0107449	.0028008
ldiswy	-.0026604	.0025702	-1.04	0.301	-.0076984	.0023775
_cons	.7361747	.0456018	16.14	0.000	.6467882	.8255612

5.2 Census tract attributes

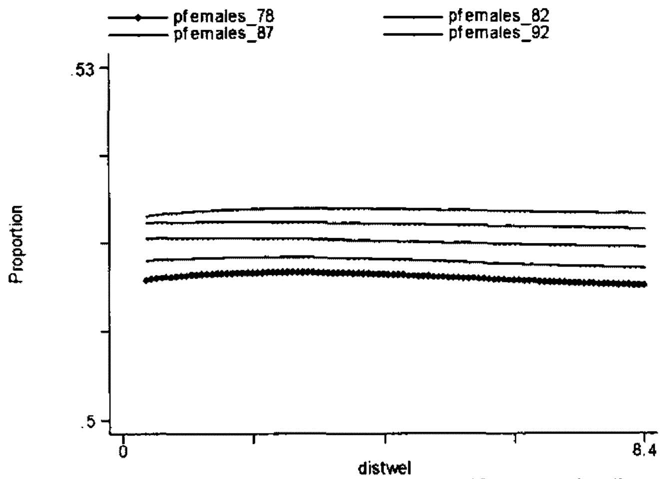
5.2.1 Females

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	61.19
Prob > F	=	0.0000

R-squared = 0.0128
Root MSE = .01249

pfemales	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	-.0007029	.0005885	-1.19	0.232	-.0018564	.0004506
trend	.0002497	.000063	3.96	0.000	.0001262	.0003731
ldiswy	.000025	.0000437	0.57	0.568	-.0000608	.0001107
_cons	.5138941	.0008457	607.67	0.000	.5122364	.5155518



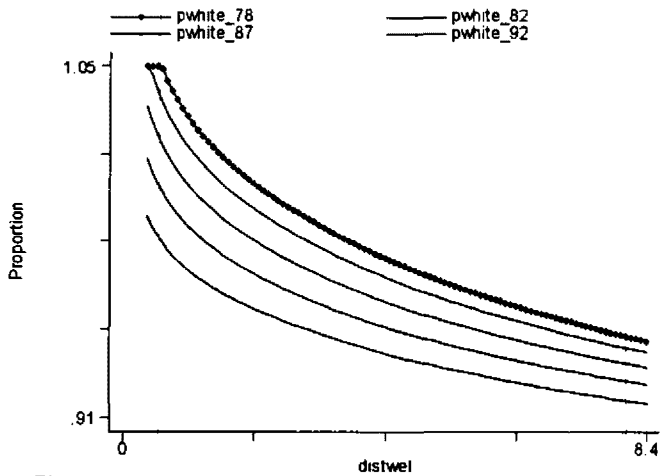
Fitted pfemales by distance from nearest Woburn site (km)

5.2.2 Whites

Regression with robust standard errors

Number of obs = 12444
F(3, 12440) = 651.79
Prob > F = 0.0000
R-squared = 0.0668
Root MSE = .06899

pwhite	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	-.0426479	.0025868	-16.49	0.000	-.0477185	-.0375773
trend	-.0033329	.00021	-15.87	0.000	-.0037444	-.0029213
ldiswy	.0009262	.0001799	5.15	0.000	.0005736	.0012788
_cons	1.036867	.0028473	364.15	0.000	1.031286	1.042449



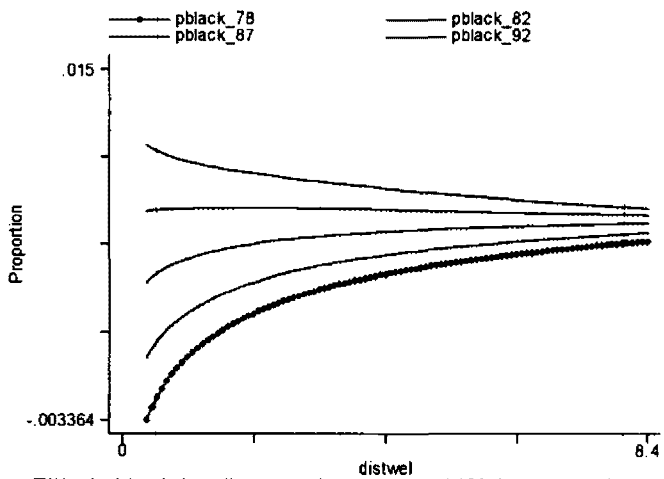
Fitted pwhite by distance from nearest Woburn site (km)

5.2.3 Blacks

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	332.76
Prob > F	=	0.0000
R-squared	=	0.0400
Root MSE	=	.0066

pblack	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0028297	.0002498	11.33	0.000	.0023399	.0033194
trend	.0005395	.0000266	20.25	0.000	.0004873	.0005917
ldiswy	-.0002135	.0000192	-11.12	0.000	-.0002511	-.0001759
_cons	.0004607	.0003257	1.41	0.157	-.0001777	.0010991



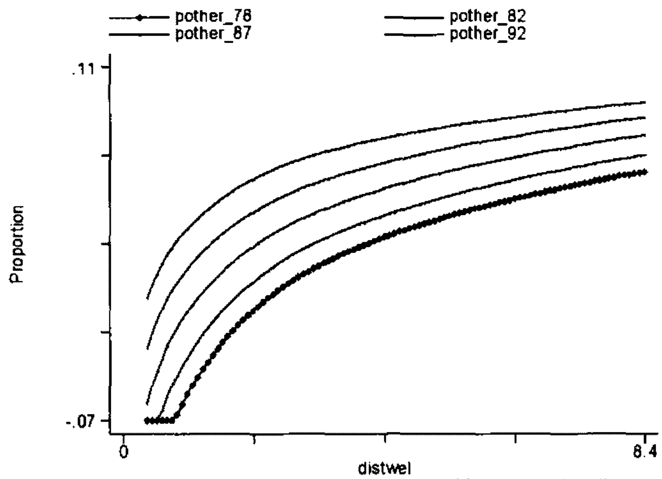
Fitted pblack by distance from nearest Woburn site (km)

5.2.4 Other ethnic groups

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	673.37
Prob > F	=	0.0000
R-squared	=	0.0594
Root MSE	=	.09349

pother	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0542575	.0034674	15.65	0.000	.0474608	.0610542
trend	.0043839	.0002694	16.28	0.000	.0038559	.0049119
ldiswy	-.0012235	.0002377	-5.15	0.000	-.0016894	-.0007576
_cons	-.0510659	.0037505	-13.62	0.000	-.0584174	-.0437144



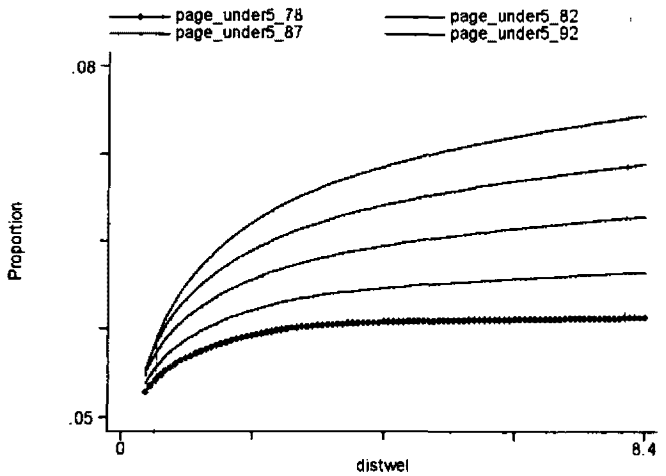
Fitted pother by distance from nearest Woburn site (km)

5.2.5 Children under 5

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	547.26
Prob > F	=	0.0000
R-squared	=	0.0856
Root MSE	=	.01342

page_under5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0016573	.0006504	2.55	0.011	.0003824	.0029322
trend	.0002899	.0000513	5.66	0.000	.0001894	.0003903
ldiswy	.0002793	.0000457	6.11	0.000	.0001897	.000369
_cons	.0563436	.0007246	77.76	0.000	.0549233	.0577639



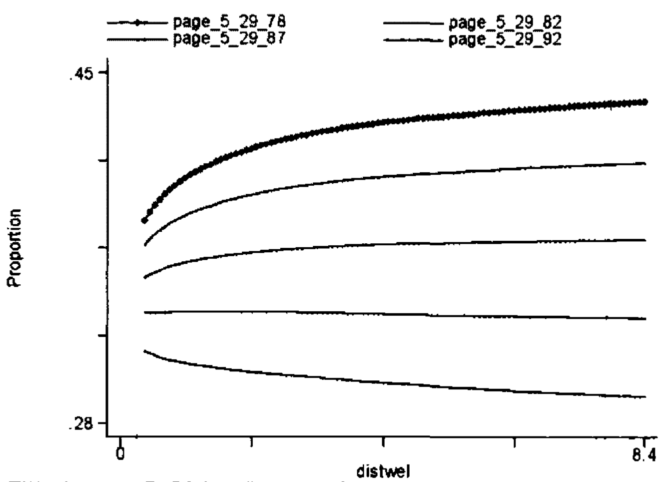
Fitted page_under5 by distance from nearest Woburn site (km

5.2.6 Persons between 5 and 29

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 4739.40
Prob > F	= 0.0000
R-squared	= 0.4156
Root MSE	= .03848

page_5_29	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0172771	.0017827	9.69	0.000	.0137827	.0207714
trend	-.0047735	.0001676	-28.49	0.000	-.0051102	-.0044451
ldiswy	-.0013235	.0001303	-10.16	0.000	-.0015789	-.0010681
_cons	.4028142	.0022685	177.57	0.000	.3983676	.4072608



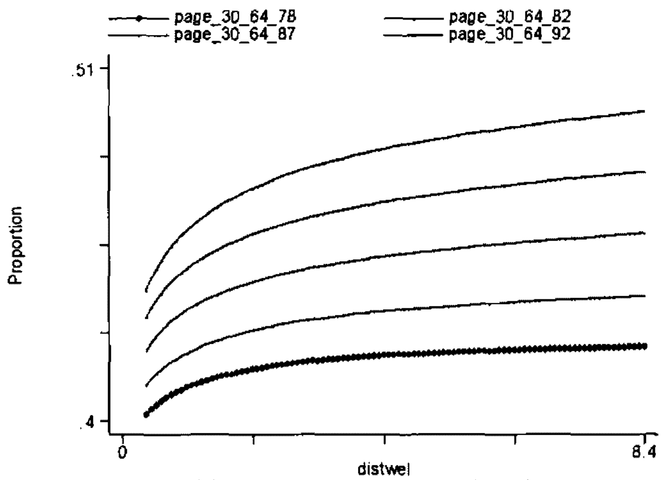
Fitted page_5_29 by distance from nearest Woburn site (km)

5.2.7 Persons between 30 and 64

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 2582.91
Prob > F	= 0.0000
R-squared	= 0.3111
Root MSE	= .02587

page_30_64	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0058642	.0013361	4.39	0.000	.0032452	.0084832
trend	.002485	.0001163	21.36	0.000	.002257	.0027131
ldiswy	.0006111	.0000905	6.75	0.000	.0004337	.0007885
_cons	.4135398	.0016854	245.37	0.000	.4102362	.4168435



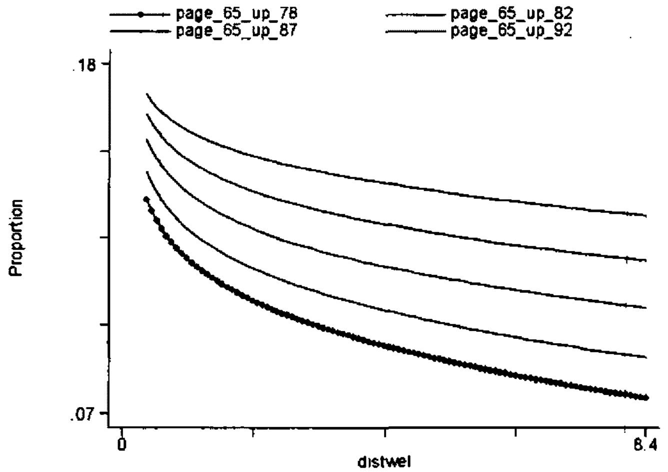
Fitted page_30_64 by distance from nearest Woburn site (km)

5.2.8 Persons 65 and older

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 988.59
Prob > F	= 0.0000
R-squared	= 0.1826
Root MSE	= .03314

page_65_up	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	-.0216667	.0015527	-13.95	0.000	-.0247101	-.0186232
trend	.0020491	.0001788	11.46	0.000	.0016986	.0023996
ldiswy	.0004368	.0001241	3.52	0.000	.0001935	.00068
_cons	.1236413	.0022441	55.10	0.000	.1192425	.12804

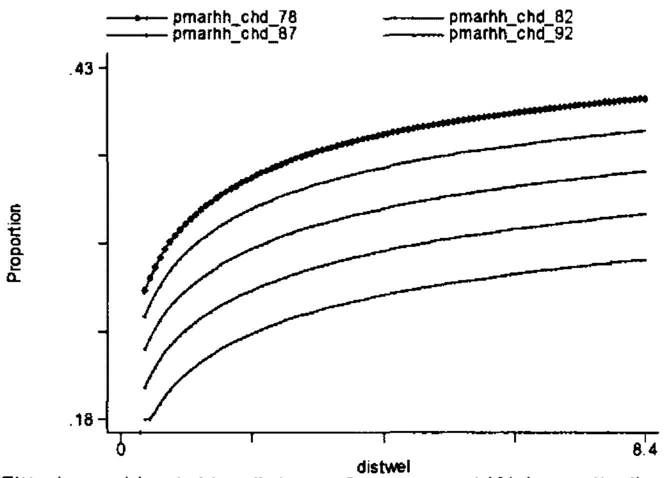


Fitted page_65_up by distance from nearest Woburn site (km)

5.2.9 Married heads of household

```
Regression with robust standard errors                 Number of obs =   12444
                                                       F(  3, 12440) = 1283.77
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2347
                                                       Root MSE      =  .06565
```

pmarhh_chd	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0410018	.0034139	12.01	0.000	.0343101	.0476936
trend	-.0058504	.0003632	-16.11	0.000	-.0065623	-.0051385
ldiswy	-.0001361	.0002568	-0.53	0.596	-.0006396	.0003673
_cons	.3268933	.0048437	67.49	0.000	.3173989	.3363877



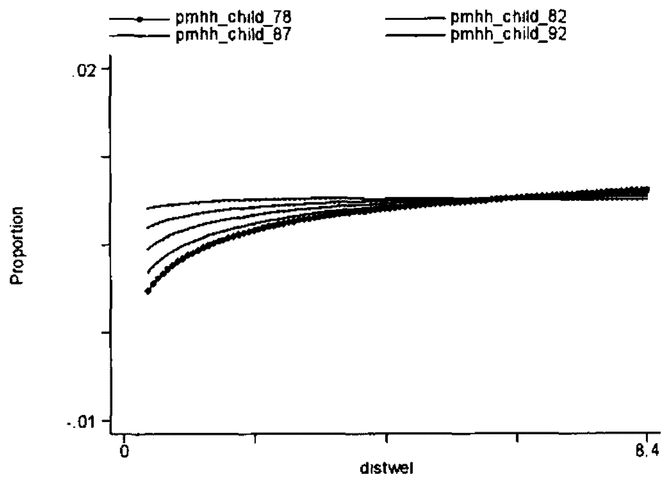
Fitted pmarhh_chd by distance from nearest Woburn site (km)

5.2.10 Male-headed of household with children

Regression with robust standard errors

Number of obs = 12444
F(3, 12440) = 129.82
Prob > F = 0.0000
R-squared = 0.0144
Root MSE = .00534

pmhh_child	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0026316	.0002132	12.34	0.000	.0022137	.0030496
trend	.0002315	.0000177	13.09	0.000	.0001968	.0002662
ldiswy	-.0001315	.0000153	-8.61	0.000	-.0001614	-.0001015
_cons	.0045081	.0002412	18.69	0.000	.0040354	.0049808



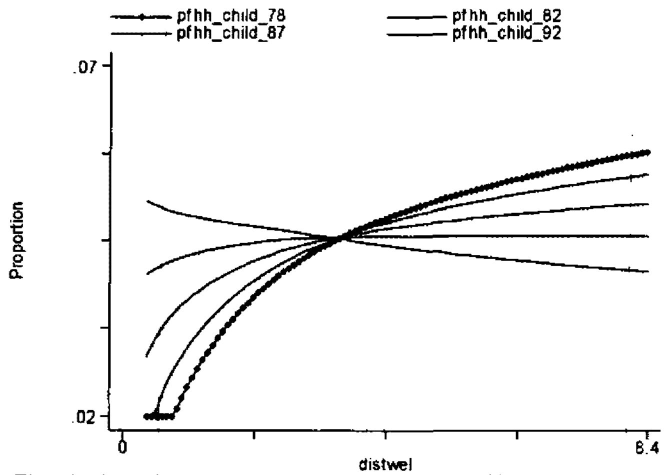
Fitted pmhh_child by distance from nearest Woburn site (km)

5.2.11 Female-headed households with children

Regression with robust standard errors

Number of obs = 12444
F(3, 12440) = 57.43
Prob > F = 0.0000
R-squared = 0.0089
Root MSE = .03134

pfhh_child	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0158892	.0012568	12.64	0.000	.0134256	.0183528
trend	.0012692	.0001026	12.38	0.000	.0010681	.0014702
ldiswy	-.0010325	.0000861	-11.99	0.000	-.0012013	-.0008637
_cons	.026495	.0014844	17.85	0.000	.0235853	.0294047



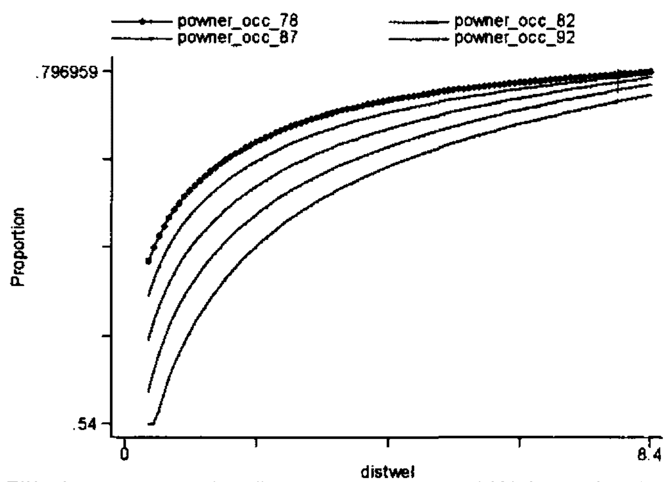
Fitted pfhh_child by distance from nearest Woburn site (km)

5.2.12 Owner-occupancy

Regression with robust standard errors

Number of obs	=	12444
F(3, 12440)	=	247.27
Prob > F	=	0.0000
R-squared	=	0.0548
Root MSE	=	.15376

powner_occ	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.0387542	.0067619	5.73	0.000	.0254998	.0520086
trend	-.0058857	.0007026	-8.38	0.000	-.0072629	-.0045085
ldiswy	.0022567	.0004911	4.60	0.000	.001294	.0032193
_cons	.7266904	.0095303	76.25	0.000	.7080095	.7453713



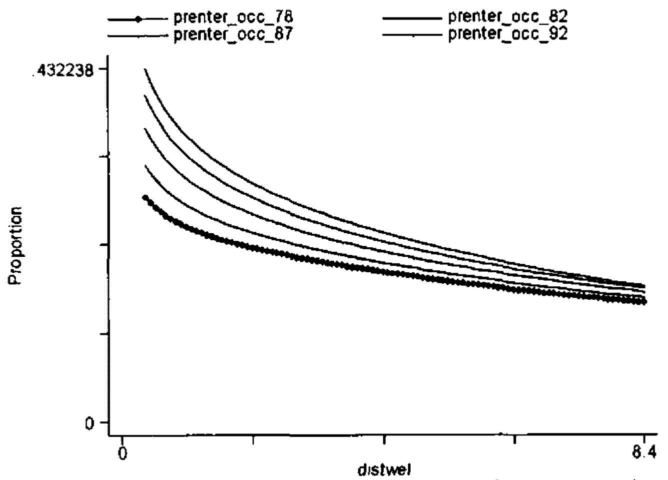
Fitted powner_occ by distance from nearest Woburn site (km)

5.2.13 Renter-occupancy

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 368.05
Prob > F	= 0.0000
R-squared	= 0.0800
Root MSE	= .13685

prenter_occ	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	-.0474617	.0061438	-7.73	0.000	-.0595044	-.035419
trend	.005599	.0006564	8.53	0.000	.0043124	.0068856
ldiswy	-.0022182	.0004497	-4.93	0.000	-.0030996	-.0013368
_cons	.25679	.0088694	28.95	0.000	.2394047	.2741754



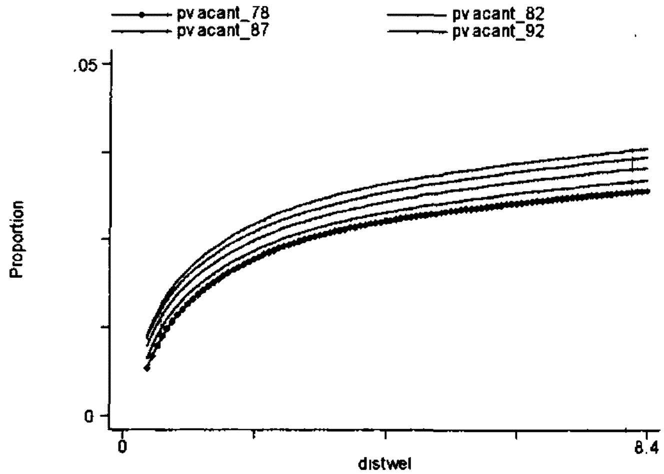
Fitted prenter_occ by distance from nearest Woburn site (km)

5.2.14 Vacancy rates

Regression with robust standard errors

Number of obs	= 12444
F(3, 12440)	= 156.39
Prob > F	= 0.0000
R-squared	= 0.0395
Root MSE	= .02058

pvacant	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ldisw	.00766	.000804	9.53	0.000	.006084	.0092359
trend	.0002288	.0000664	3.44	0.001	.0000986	.000359
ldiswy	.000031	.000056	0.55	0.580	-.0000788	.0001408
_cons	.0173909	.0009295	18.71	0.000	.0155689	.0192128



Fitted pvacant by distance from nearest Woburn site (km)

Chapter 6 Complete regression results – No lot size interactions

6.1 Just structural characteristics and year dummies

Regression with robust standard errors

Number of obs = 12444
F(52, 12391) = 248.46
Prob > F = 0.0000
R-squared = 0.4886
Root MSE = .42983

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.0489693	.0186774	2.62	0.009	.0123587	.0855799
age	.0010374	.0006339	1.64	0.102	-.0002051	.0022799
age2	-.0000112	7.92e-06	-1.42	0.157	-.0000267	4.31e-06
sqft	.2479851	.0306218	8.10	0.000	.1879617	.3080086
sqft2	-.0170873	.0100014	-1.71	0.088	-.0366917	.002517
bedrms	-.0122332	.0157373	-0.78	0.437	-.0430807	.0186143
bthrms	.1598301	.0216087	7.40	0.000	.1174738	.2021864
sqftbed	.0156497	.0077049	2.03	0.042	.0005469	.0307526
sqftbth	-.012486	.0113685	-1.10	0.272	-.0347699	.009798
fplace	.1584083	.0144585	10.96	0.000	.1300675	.1867492
knowflr	-.1482357	.0251731	-5.89	0.000	-.1975789	-.0988925
floors	.0315333	.0122127	2.58	0.010	.0075945	.0554721
lotsize	.0365814	.0070445	5.19	0.000	.0227732	.0503896
ldisw78	-.0285236	.0383282	-0.74	0.457	-.1036529	.0466057
ldisw79	-.1322543	.0741523	-1.78	0.075	-.2776043	.0130957
ldisw80	-.0005082	.0618726	-0.01	0.993	-.1217881	.1207717
ldisw81	-.0533517	.0843768	-0.63	0.527	-.2187434	.1120399
ldisw82	.0077582	.053554	0.14	0.885	-.0972159	.1127324
ldisw83	-.0978117	.0542451	-1.80	0.071	-.2041406	.0085172
ldisw84	.0443689	.0377947	1.17	0.240	-.0297145	.1184523
ldisw85	.1042162	.0440051	2.37	0.018	.0179594	.190473
ldisw86	-.0087994	.0439745	-0.20	0.841	-.0949963	.0773975
ldisw87	-.011426	.0331795	-0.34	0.731	-.076463	.0536109
ldisw88	.0430796	.0279399	1.54	0.123	-.0116868	.0978461

ldisw89	.0371748	.027407	1.36	0.175	-.0165471	.0908968
ldisw90	.0521827	.0270853	1.93	0.054	-.0009087	.1052741
ldisw91	.050278	.0285997	1.76	0.079	-.0057818	.1063379
ldisw92	.0737088	.0279899	2.63	0.008	.0188443	.1285734
ldisw93	.0793316	.0220498	3.60	0.000	.0361106	.1225527
ldisw94	.0416848	.024991	1.67	0.095	-.0073014	.090671
ldisw95	.1094682	.0248348	4.41	0.000	.0607882	.1581483
ldisw96	.1031653	.0182737	5.65	0.000	.0673459	.1389846
ldisw97	.0463116	.0362596	1.28	0.202	-.0247629	.1173861
year79	.2503722	.1048783	2.39	0.017	.0447945	.4559499
year80	.1730845	.1085707	1.59	0.111	-.0397309	.3858999
year81	.333171	.122066	2.73	0.006	.0939027	.5724393
year82	.3156999	.0983298	3.21	0.001	.1229582	.5084415
year83	.5386808	.093381	5.77	0.000	.3556396	.7217221
year84	.5379653	.0752274	7.15	0.000	.3905079	.6854228
year85	.6560054	.0852122	7.70	0.000	.4889762	.8230345
year86	1.114607	.0795717	14.01	0.000	.9586336	1.27058
year87	1.201649	.0753569	15.95	0.000	1.053938	1.349361
year88	1.164397	.0685533	16.99	0.000	1.030022	1.298772
year89	1.175654	.0699542	16.81	0.000	1.038533	1.312775
year90	1.120914	.0684935	16.37	0.000	.9866558	1.255172
year91	1.037364	.0695909	14.91	0.000	.9009554	1.173773
year92	1.002075	.0698281	14.35	0.000	.865201	1.138949
year93	1.024214	.0659142	15.54	0.000	.8950119	1.153416
year94	1.089912	.066143	16.48	0.000	.9602613	1.219562
year95	1.077126	.0672051	16.03	0.000	.9453934	1.208858
year96	1.14618	.0631965	18.14	0.000	1.022305	1.270055
year97	1.216637	.0716661	16.98	0.000	1.07616	1.357114
_cons	10.11873	.0730562	138.51	0.000	9.975527	10.26193

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0010	

6.2 Including Census tract attributes

Regression with robust standard errors

Number of obs	=	12444
F(63, 12380)	=	253.09
Prob > F	=	0.0000
R-squared	=	0.5265
Root MSE	=	.41375

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.1250637	.0186467	6.71	0.000	.0885133	.161614
age	-.0014915	.0006219	-2.40	0.016	-.0027106	-.0002724

age2	|	5.09e-06	7.65e-06	0.67	0.505	-9.90e-06	.0000201
sqft	|	.1971115	.0296864	6.64	0.000	.1389216	.2553015
sqft2	|	-.0169391	.0094491	-1.79	0.073	-.0354598	.0015835
bedrms	|	.002461	.0152669	0.16	0.872	-.0274645	.0323865
bthrms	|	.1053681	.0207582	5.08	0.000	.0646789	.1460573
sqftbed	|	.0147478	.0074223	1.99	0.047	.0001989	.0292966
sqftbth	|	-.0088652	.0108892	-0.81	0.416	-.0302078	.0124774
fplace	|	.0818046	.0138499	5.91	0.000	.0546566	.1089526
knowflr	|	-.0506454	.0274446	-1.85	0.065	-.1044411	.0031504
floors	|	.012164	.0117416	1.04	0.300	-.0108515	.0351795
lotsize	|	.0399528	.0071748	5.57	0.000	.0258891	.0540165
ldisw78	|	-.0751494	.0374318	-2.01	0.045	-.1485215	-.0017773
ldisw79	|	-.1632537	.072774	-2.24	0.025	-.3059021	-.0206053
ldisw80	|	-.0203892	.0607769	-0.34	0.737	-.1395215	.098743
ldisw81	|	-.1036433	.0833055	-1.24	0.213	-.266935	.0596485
ldisw82	|	-.0416704	.0538218	-0.77	0.439	-.1471696	.0638288
ldisw83	|	-.1412171	.0514768	-2.74	0.006	-.2421196	-.0403147
ldisw84	|	-.1057222	.0395021	-2.68	0.007	-.1831525	-.0282918
ldisw85	|	-.0289091	.0418568	-0.69	0.490	-.110955	.0531368
ldisw86	|	-.1010463	.0423291	-2.39	0.017	-.1840178	-.0180748
ldisw87	|	-.130573	.0340084	-3.84	0.000	-.1972348	-.0639113
ldisw88	|	-.0772486	.0292287	-2.64	0.008	-.1345415	-.0199557
ldisw89	|	-.083541	.0289126	-2.89	0.004	-.1402143	-.0268677
ldisw90	|	-.0732827	.0279338	-2.62	0.009	-.1280373	-.018528
ldisw91	|	-.0624389	.0284187	-2.20	0.028	-.1181439	-.006734
ldisw92	|	-.0390139	.0295106	-1.32	0.186	-.0968593	.0188315
ldisw93	|	-.0293196	.0232881	-1.26	0.208	-.0749679	.0163287
ldisw94	|	-.088817	.0255264	-3.48	0.001	-.1386527	-.0387814
ldisw95	|	-.010883	.0253123	-0.43	0.667	-.0604991	.038733
ldisw96	|	-.0126859	.019582	-0.65	0.517	-.0510696	.0256978
ldisw97	|	-.0572987	.0359245	-1.59	0.111	-.1277163	.013119
pfemales	|	5.006831	.8314503	6.02	0.000	3.377059	6.636603
pblack	|	-1.663042	1.580983	-1.05	0.293	-4.762014	1.43593
pother	|	2.064265	.4791806	4.31	0.000	1.124996	3.003533
page_under5	|	-2.822898	1.00667	-2.80	0.005	-4.795127	-.8496692
page_5_29	|	-6.98893	.5887391	-11.87	0.000	-8.14295	-5.83491
page_65_up	|	-3.650558	.4198468	-8.69	0.000	-4.473523	-2.827593
pmarhh_chd	|	1.487224	.3315558	4.49	0.000	.8373234	2.137125
pmhh_child	|	3.084206	2.517625	1.23	0.221	-1.850731	8.019144
pfhh_child	|	1.664087	.856072	1.94	0.052	-.0133479	3.342121
pvacant	|	4.66128	.7967777	5.85	0.000	3.099471	6.223088
prenter_occ	|	.0094855	.1820208	0.05	0.958	-.3473036	.3662745
year79	|	.1964707	.1018905	1.93	0.054	-.0032504	.3961919
year80	|	.0964912	.1054726	0.91	0.360	-.1102515	.3032339
year81	|	.2823778	.1204158	2.35	0.019	.0463441	.5184115
year82	|	.2492813	.0977224	2.55	0.011	.0577303	.4408323
year83	|	.4342925	.0893982	4.86	0.000	.2590581	.6095268
year84	|	.5763723	.0754589	7.64	0.000	.4284611	.7242835
year85	|	.6411623	.0813667	7.88	0.000	.481671	.8006536
year86	|	.9610217	.0779536	12.33	0.000	.8082204	1.113823
year87	|	1.069124	.0783105	13.65	0.000	.9156238	1.222625
year88	|	.9772057	.0725633	13.47	0.000	.8349704	1.119441
year89	|	.9572482	.0740356	12.93	0.000	.8121269	1.10237
year90	|	.9056303	.0727857	12.44	0.000	.7629591	1.048302
year91	|	.7918292	.0735363	10.77	0.000	.6476866	.9359718
year92	|	.7353282	.0742926	9.90	0.000	.5897032	.8809532
year93	|	.7145283	.0715639	9.98	0.000	.5742519	.8548046
year94	|	.7645767	.0724445	10.55	0.000	.6225742	.9065791
year95	|	.6921696	.0755341	9.16	0.000	.544111	.8402281
year96	|	.7058066	.0742792	9.50	0.000	.5602079	.8514053
year97	|	.725549	.0861535	8.42	0.000	.5566747	.8944233

```
     _cons |   10.36435   .4859749    21.33   0.000     9.411766    11.31694
------------------------------------------------------------------------------
```

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0000	
All year-specific slope on LDIST the same	0.0590	
All Census tract characteristic effects simultaneously zero	0.0000	

6.3 Including other distances

```
Regression with robust standard errors                 Number of obs =   12444
                                                       F( 75, 12368) =  226.64
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5346
                                                       Root MSE      =  .41041

------------------------------------------------------------------------------
           |               Robust
   lsprice |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------+------------------------------------------------------------------
    notold |   .1569426   .0196394     7.99   0.000     .1184463     .195439
       age |  -.0028662   .0006303    -4.55   0.000    -.0041017   -.0016306
      age2 |   .0000164   7.72e-06     2.12   0.034     1.26e-06    .0000315
      sqft |   .1811277   .0295521     6.13   0.000     .1232009    .2390545
     sqft2 |  -.0121392   .0093027    -1.30   0.192    -.0303739    .0060955
    bedrms |   .0081811   .0150692     0.54   0.587     -.021357    .0377192
    bthrms |   .1071896   .0205156     5.22   0.000     .0669759    .1474034
   sqftbed |   .0115474    .007288     1.58   0.113    -.0027381    .0258329
   sqftbth |  -.0125214   .0107615    -1.16   0.245    -.0336157    .0085728
    fplace |   .0874144   .0139716     6.26   0.000     .0600279    .1148009
   knowflr |  -.3360679   .0329574   -10.20   0.000    -.4006695   -.2714663
    floors |   .0150786    .012128     1.24   0.214    -.0086942    .0388514
   lotsize |   .0441894   .0073256     6.03   0.000     .0298301    .0585487

   ldisw78 |  -.0816017    .042338    -1.93   0.054    -.1645907    .0013873
   ldisw79 |  -.1858336   .0752901    -2.47   0.014    -.3334139   -.0382532
   ldisw80 |  -.0535438   .0637115    -0.84   0.401    -.1784283    .0713406
   ldisw81 |  -.1366499   .0864024    -1.58   0.114    -.3060121    .0327123
   ldisw82 |  -.0940644   .0565769    -1.66   0.096    -.2049639    .0168351
   ldisw83 |  -.1710932    .055943    -3.06   0.002    -.2807503   -.0614362
   ldisw84 |  -.1121743   .0425505    -2.64   0.008    -.1955798   -.0287687
   ldisw85 |  -.0180357   .0467954    -0.39   0.700     -.109762    .0736907
   ldisw86 |  -.1164692    .047105    -2.47   0.013    -.2088023    -.024136
   ldisw87 |  -.1179319   .0379481    -3.11   0.002    -.1923161   -.0435476
   ldisw88 |  -.0808622   .0338971    -2.39   0.017    -.1472862   -.0144381
   ldisw89 |  -.0813797    .033095    -2.46   0.014     -.146251   -.0165084
   ldisw90 |  -.0872954   .0328177    -2.66   0.008    -.1516232   -.0229675
   ldisw91 |  -.0853543   .0338196    -2.52   0.012     -.151646   -.0190626
   ldisw92 |   -.054765   .0355136    -1.54   0.123    -.1243771    .0148471
   ldisw93 |  -.0341518    .028733    -1.19   0.235    -.0904729    .0221694
   ldisw94 |  -.1061577    .029998    -3.54   0.000    -.1649585    -.047357
```

ldisw95	-.0355842	.0299655	-1.19	0.235	-.0943213	.0231529
ldisw96	-.0466305	.0254737	-1.83	0.067	-.096563	.0033019
ldisw97	-.1076644	.0385314	-2.79	0.005	-.1831919	-.032137
ld_summits	-.0128029	.0070101	-1.83	0.068	-.0265439	.000938
ld_school	-.0308617	.006655	-4.64	0.000	-.0439065	-.0178168
ld_retail	-1.445565	.1539512	-9.39	0.000	-1.747334	-1.143797
ld_hospital	.0944295	.017747	5.32	0.000	.0596426	.1292164
ld_church	.4647825	.1418528	3.28	0.001	.1867289	.7428361
ld_cemetery	-.0417228	.0088408	-4.72	0.000	-.0590521	-.0243935
ld_railroad	.0172871	.0059608	2.90	0.004	.0056029	.0289713
ld_prinarte	-.0236997	.0081087	-2.92	0.003	-.0395939	-.0078054
ld_othpriro	.0220981	.0044153	5.00	0.000	.0134134	.0307528
ld_ma_roads	.0068839	.0028982	2.38	0.018	.0012029	.0125649
ld_i95	-.0180925	.0114279	-1.58	0.113	-.0404929	.004308
ld_i93	.0377832	.007746	4.88	0.000	.0225999	.0529665
ld_fp_tewma	-.0228689	.006108	-3.74	0.000	-.0348416	-.0108963
ld_fp_milit	-.0081251	.0057943	-1.40	0.161	-.0194828	.0032327
ld_fp_logan	-.0130995	.0094828	-1.38	0.167	-.0316873	.0054883
ld_fp_bevmu	.0101688	.0075557	1.35	0.178	-.0046415	.0249791
ld_parks	-.0188613	.0075207	-2.51	0.012	-.0336029	-.0041196
ld_mjwater	-.0383665	.0106903	-3.59	0.000	-.0593212	-.0174118
ld_cclubs	-.0183595	.00524	-3.50	0.000	-.0286307	-.0080882
ld_tewmac	.1830531	.0993552	1.84	0.065	-.0116985	.3778047
ld_military	1.124274	.134809	8.34	0.000	.8600276	1.388521
ld_logan	1.681858	.1706983	9.85	0.000	1.347262	2.016453
ld_bevmuni	1.789187	.2342924	7.63	0.000	1.328937	2.247436
year79	.2456496	.0992993	2.47	0.013	.0510074	.4402918
year80	.1790832	.1038019	1.73	0.085	-.0243847	.3825512
year81	.3597841	.1195308	3.01	0.003	.1254851	.5940831
year82	.3684415	.0936482	3.93	0.000	.1848763	.5520066
year83	.5783117	.0856281	6.75	0.000	.4104673	.7461561
year84	.7248305	.0720866	10.06	0.000	.5835296	.8661314
year85	.8107206	.0795955	10.19	0.000	.6545909	.9667302
year86	1.235729	.0747583	16.53	0.000	1.089191	1.382267
year87	1.343715	.0717565	18.73	0.000	1.203061	1.484369
year88	1.322354	.0646663	20.45	0.000	1.195599	1.44911
year89	1.320379	.0676762	19.51	0.000	1.187723	1.453035
year90	1.305581	.0633565	20.61	0.000	1.181392	1.42977
year91	1.207136	.0649972	18.57	0.000	1.079731	1.33454
year92	1.161401	.0648116	17.92	0.000	1.03436	1.288442
year93	1.167479	.0626225	18.64	0.000	1.044729	1.290229
year94	1.277792	.0618888	20.65	0.000	1.15648	1.399103
year95	1.266398	.062091	20.40	0.000	1.14469	1.388106
year96	1.333023	.0581002	22.94	0.000	1.219138	1.446908
year97	1.413227	.0663079	21.31	0.000	1.283254	1.543201
_cons	-26.33767	5.550022	-4.75	0.000	-37.21657	-15.45876

Hypothesis	**P-value of F-test**	**Reject @ 5% level?**
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0098	
All year-specific slope on LDIST the same	0.1207	NO

All other distance effects simultaneously zero	0.0000

6.4 Including both other distances and tract attributes

```
Regression with robust standard errors                 Number of obs =   12444
                                                       F( 86, 12357) =  208.24
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5418
                                                       Root MSE      =  .40739
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.1644526	.0195508	8.41	0.000	.12613	.2027752
age	-.0031931	.0006327	-5.05	0.000	-.0044332	-.001953
age2	.0000183	7.72e-06	2.37	0.018	3.13e-06	.0000334
sqft	.1750219	.0293972	5.95	0.000	.1173987	.232645
sqft2	-.0129308	.0092274	-1.40	0.161	-.031018	.0051564
bedrms	.0081091	.0150001	0.54	0.589	-.0212933	.0375115
bthrms	.0974569	.0203827	4.78	0.000	.0575037	.1374102
sqftbed	.0121049	.0072525	1.67	0.095	-.0021112	.026321
sqftbth	-.0119339	.0106868	-1.12	0.264	-.0328817	.0090138
fplace	.0640722	.0136916	4.68	0.000	.0372345	.0909099
knowflr	-.2486657	.039298	-6.33	0.000	-.3256959	-.1716354
floors	.0122557	.0120643	1.02	0.310	-.0113921	.0359036
lotsize	.047623	.0073779	6.45	0.000	.0331612	.0620847
ldisw78	-.1183986	.0442745	-2.67	0.008	-.2051836	-.0316137
ldisw79	-.2127232	.0773112	-2.75	0.006	-.3642652	-.0611812
ldisw80	-.0720667	.0650719	-1.11	0.268	-.1996178	.0554844
ldisw81	-.1564728	.0874353	-1.79	0.074	-.3278596	.0149141
ldisw82	-.1156535	.0587284	-1.97	0.049	-.2307703	-.0005367
ldisw83	-.1990855	.0559997	-3.56	0.000	-.3088536	-.0893174
ldisw84	-.1771748	.0452931	-3.91	0.000	-.2659564	-.0883933
ldisw85	-.0842971	.0469693	-1.79	0.073	-.1763642	.00777
ldisw86	-.1607007	.0480024	-3.35	0.001	-.2547929	-.0666085
ldisw87	-.1774609	.0404264	-4.39	0.000	-.2567029	-.098219
ldisw88	-.1327165	.0364416	-3.64	0.000	-.2041478	-.0612852
ldisw89	-.1365158	.0355827	-3.84	0.000	-.2062635	-.066768
ldisw90	-.1376485	.0362797	-3.79	0.000	-.2087622	-.0665347
ldisw91	-.1279449	.0368466	-3.47	0.001	-.20017	-.0557198
ldisw92	-.0981975	.0384945	-2.55	0.011	-.1736527	-.0227423
ldisw93	-.0819654	.0311738	-2.63	0.009	-.143071	-.0208598
ldisw94	-.1525042	.0318486	-4.79	0.000	-.2149324	-.0900759
ldisw95	-.0810414	.0326235	-2.48	0.013	-.1449885	-.0170942
ldisw96	-.0921013	.0286108	-3.22	0.001	-.1481829	-.0360197
ldisw97	-.1447539	.0409226	-3.54	0.000	-.2249686	-.0645392
ld_summits	-.0195731	.0075343	-2.60	0.009	-.0343414	-.0048047
ld_school	-.031728	.0068727	-4.62	0.000	-.0451996	-.0182564
ld_retail	-.8727287	.1640059	-5.32	0.000	-1.194206	-.5512516
ld_hospital	.074898	.0184074	4.07	0.000	.0388167	.1109793
ld_church	-.0182594	.1565671	-0.12	0.907	-.3251553	.2886366
ld_cemetery	-.0066797	.0094331	-0.71	0.479	-.02517	.0118107
ld_railroad	.0154953	.0061249	2.53	0.011	.0034894	.0275011
ld_prinarte	-.0268746	.0083477	-3.22	0.001	-.0432374	-.0105119

ld_othpriro	.0172256	.0044938	3.83	0.000	.0084172	.0260341
ld_ma_roads	.005349	.0029124	1.84	0.066	-.0003598	.0110577
ld_i95	-.0115119	.011621	-0.99	0.322	-.0342908	.0112671
ld_i93	.0228202	.0086858	2.63	0.009	.0057947	.0398457
ld_fp_tewma	-.0088737	.0062309	-1.42	0.154	-.0210972	.0033399
ld_fp_milit	.0061882	.0059402	1.04	0.298	-.0054556	.0178319
ld_fp_logan	-.0010185	.0097232	-0.10	0.917	-.0200774	.0180404
ld_fp_bevmu	.0087479	.0076922	1.14	0.255	-.0063299	.0238258
ld_parks	-.020464	.0077396	-2.64	0.008	-.0356349	-.0052931
ld_mjwater	-.0425965	.0108006	-3.94	0.000	-.0637673	-.0214256
ld_cclubs	-.0091896	.0056494	-1.63	0.104	-.0202534	.0018841
ld_tewmac	.1059918	.1216317	0.87	0.384	-.1324254	.344409
ld_military	.4444311	.1671331	2.66	0.008	.1168242	.772038
ld_logan	1.161737	.2011811	5.77	0.000	.7673903	1.556083
ld_bevmuni	.6839151	.2874421	2.38	0.017	.1204339	1.247346
pfemales	3.422701	.9781858	3.50	0.000	1.505305	5.340098
pblack	.7426583	1.829367	0.41	0.685	-2.843186	4.328503
pother	.1730552	.5284539	0.33	0.743	-.8627967	1.208907
page_under5	-1.922992	1.15022	-1.67	0.095	-4.177602	.3316187
page_5_29	-3.006824	.7212157	-4.17	0.000	-4.420519	-1.593129
page_65_up	-.2182788	.5168144	-0.42	0.673	-1.231316	.7947579
pmarhh_chd	1.889583	.3605468	5.24	0.000	1.182855	2.59631
pmhh_child	8.428491	3.218717	2.62	0.009	2.119303	14.73768
pfhh_child	.692235	1.005446	0.69	0.491	-1.278595	2.663065
pvacant	3.04204	.8719766	3.49	0.000	1.33283	4.75125
prenter_occ	.2323277	.1902781	1.22	0.222	-.1406471	.6053025
year79	.1979666	.0994367	1.99	0.047	.0030552	.392878
year80	.1091657	.104416	1.05	0.296	-.0955058	.3138373
year81	.2954158	.1209502	2.44	0.015	.0583347	.532497
year82	.3025866	.0951893	3.18	0.001	.1160008	.4891725
year83	.510794	.0860329	5.94	0.000	.3421561	.6794319
year84	.7186159	.0741993	9.68	0.000	.5731737	.864058
year85	.7976214	.0806764	9.89	0.000	.6394831	.9557598
year86	1.16927	.0777086	15.05	0.000	1.01695	1.321591
year87	1.295141	.0789244	16.41	0.000	1.140437	1.449845
year88	1.249451	.0748807	16.69	0.000	1.102673	1.396229
year89	1.242527	.0773055	16.07	0.000	1.090996	1.394058
year90	1.220508	.0755873	16.15	0.000	1.072346	1.368671
year91	1.109959	.0766219	14.49	0.000	.9597683	1.26015
year92	1.054549	.0773724	13.63	0.000	.9028858	1.20621
year93	1.047361	.0760047	13.78	0.000	.8983803	1.196342
year94	1.137708	.0774669	14.69	0.000	.9858611	1.289555
year95	1.10167	.0795231	13.85	0.000	.9457925	1.257548
year96	1.148644	.0802195	14.32	0.000	.9914009	1.305886
year97	1.199211	.0919314	13.04	0.000	1.019011	1.379411
_cons	-5.583676	7.165651	-0.78	0.436	-19.62947	8.462119

Hypothesis	P-value of F-test	Reject @ 5% level?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.0002	
All year-specific slope on LDIST the same	0.1518	NO
All other distance effects simultaneously zero	0.0000	
All Census tract characteristic effects simultaneously zero	0.0000	

Chapter 7 Complete Regression Results – Models exploring absolute directional effects

7.1 Including latitude and longitude linear shifters

```
Regression with robust standard errors                 Number of obs =   12444
                                                       F(107, 12317) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.5457
                                                       Root MSE      =  .40634
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.1678627	.0195833	8.57	0.000	.1294764	.2062491
age	-.0032195	.0006334	-5.08	0.000	-.0044611	-.0019778
age2	.000018	7.72e-06	2.33	0.020	2.85e-06	.0000331
sqft	.172859	.0292887	5.90	0.000	.1154485	.2302695
sqft2	-.0120145	.0091985	-1.31	0.192	-.0300451	.0060161
bedrms	.0086916	.0149955	0.58	0.562	-.020702	.0380852
bthrms	.0986794	.0200734	4.92	0.000	.0593323	.1380265
sqftbed	.0117746	.0072313	1.63	0.103	-.0023998	.025949
sqftbth	-.0127978	.0105102	-1.22	0.223	-.0333993	.0078038
fplace	.0628759	.0136873	4.59	0.000	.0360467	.0897052
knowflr	-.2792558	.0419747	-6.65	0.000	-.3615327	-.1969788
floors	.0156098	.0120067	1.30	0.194	-.0079252	.0391448
lotsize	.0480764	.007399	6.50	0.000	.0335732	.0625797
ldisw78	-.0865772	.051832	-1.67	0.095	-.188176	.0150216
ldisw79	-.1705382	.0837022	-2.04	0.042	-.3346076	-.0064687
ldisw80	-.0316755	.0770966	-0.41	0.681	-.1827969	.1194459
ldisw81	-.0613865	.0820256	-0.75	0.454	-.2221696	.0993965
ldisw82	-.0615989	.0729772	-0.84	0.399	-.2046456	.0814479
ldisw83	-.1353376	.0691343	-1.96	0.050	-.2708516	.0001764
ldisw84	-.1910096	.0466888	-4.09	0.000	-.2825269	-.0994922
ldisw85	-.0655846	.0510681	-1.28	0.199	-.165686	.0345169
ldisw86	-.1230856	.0501139	-2.46	0.014	-.2213167	-.0248546
ldisw87	-.1801952	.0430095	-4.19	0.000	-.2645005	-.0958898
ldisw88	-.1482044	.0410086	-3.61	0.000	-.2285877	-.0678211
ldisw89	-.1766546	.0390364	-4.53	0.000	-.253172	-.1001373
ldisw90	-.1567063	.0387646	-4.04	0.000	-.2326909	-.0807216
ldisw91	-.1166325	.038175	-3.06	0.002	-.1914615	-.0418035
ldisw92	-.071312	.0408806	-1.74	0.081	-.1514445	.0088204
ldisw93	-.0713309	.0330487	-2.16	0.031	-.1361115	-.0065504
ldisw94	-.1246955	.0331211	-3.76	0.000	-.189618	-.0597729
ldisw95	-.0718708	.0341138	-2.11	0.035	-.1387393	-.0050024
ldisw96	-.071406	.0302158	-2.36	0.018	-.1306336	-.0121784
ldisw97	-.1210283	.0391171	-3.09	0.002	-.1977039	-.0443528
lat1_78	-9.995268	3.344724	-2.99	0.003	-16.55145	-3.439085
lat1_79	-10.90935	3.402743	-3.21	0.001	-17.57926	-4.239439
lat1_80	-11.52204	3.395527	-3.39	0.001	-18.17781	-4.866278
lat1_81	-10.50789	3.516509	-2.99	0.003	-17.40079	-3.614977
lat1_82	-10.35135	3.405715	-3.04	0.002	-17.02709	-3.67562
lat1_83	-10.53896	3.41709	-3.08	0.002	-17.23699	-3.840927

lat1_84	-10.6434	3.449506	-3.09	0.002	-17.40997	-3.88683
lat1_85	-9.367841	3.373491	-2.78	0.005	-15.98041	-2.75527
lat1_86	-10.16724	3.386186	-3.00	0.003	-16.80469	-3.529786
lat1_87	-11.01324	3.393283	-3.25	0.001	-17.6646	-4.361872
lat1_88	-10.97404	3.382271	-3.24	0.001	-17.60382	-4.344262
lat1_89	-10.80833	3.413203	-3.17	0.002	-17.49874	-4.117918
lat1_90	-10.22694	3.399883	-3.01	0.003	-16.89124	-3.562637
lat1_91	-10.15712	3.393799	-2.99	0.003	-16.8095	-3.504739
lat1_92	-10.22132	3.433291	-2.98	0.003	-16.95111	-3.491534
lat1_93	-10.33204	3.382554	-3.05	0.002	-16.96237	-3.701702
lat1_94	-9.849703	3.395069	-2.90	0.004	-16.50457	-3.194836
lat1_95	-11.05756	3.429388	-3.22	0.001	-17.77969	-4.33542
lat1_96	-10.6092	3.402488	-3.12	0.002	-17.27361	-3.939795
lat1_97	-11.4889	3.473529	-3.31	0.001	-18.29756	-4.680236
long1_78	17.07279	4.506985	3.79	0.000	8.238395	25.90719
long1_79	17.22089	4.580658	3.76	0.000	8.242081	26.1997
long1_80	17.17941	4.596946	3.74	0.000	8.16968	26.19015
long1_81	19.01076	4.703044	4.04	0.000	9.792058	28.22946
long1_82	17.58915	4.605401	3.82	0.000	8.561844	26.61646
long1_83	17.71589	4.550759	3.89	0.000	8.795691	26.63609
long1_84	15.34552	4.489626	3.42	0.001	6.545148	24.14589
long1_85	16.94392	4.50633	3.76	0.000	8.110809	25.77703
long1_86	17.2224	4.583381	3.76	0.000	8.238261	26.20655
long1_87	15.41344	4.550221	3.39	0.001	6.494297	24.33259
long1_88	14.97575	4.488746	3.34	0.001	6.177106	23.77439
long1_89	13.75165	4.531638	3.03	0.002	4.868926	22.63437
long1_90	15.26085	4.528317	3.37	0.001	6.384636	24.13706
long1_91	16.30977	4.545593	3.59	0.000	7.399698	25.21985
long1_92	16.88479	4.463558	3.78	0.000	8.135515	25.63406
long1_93	16.28274	4.502637	3.62	0.000	7.456872	25.10862
long1_94	16.98656	4.48894	3.78	0.000	8.187533	25.78558
long1_95	16.21588	4.509991	3.60	0.000	7.375596	25.05617
long1_96	16.78047	4.505312	3.72	0.000	7.949354	25.61159
long1_97	16.85655	4.597943	3.67	0.000	7.843866	25.86924
ld_summits	-.0118507	.0079568	-1.49	0.136	-.0274472	.0037458
ld_school	-.026592	.0069503	-3.83	0.000	-.0402156	-.0129684
ld_retail	-.6543589	.1651116	-3.96	0.000	-.9780035	-.3307142
ld_hospital	.096675	.0188616	5.13	0.000	.0597033	.1336467
ld_church	.1025613	.1682832	0.61	0.542	-.2273002	.4324228
ld_cemetery	-.0032877	.0094851	-0.35	0.729	-.02188	.0153046
ld_railroad	.0208018	.0062375	3.33	0.001	.0085754	.0330283
ld_prinarte	-.0237586	.0083555	-2.84	0.004	-.0401366	-.0073805
ld_othpriro	.0173061	.004495	3.85	0.000	.0084953	.0261169
ld_ma_roads	.0047173	.0029284	1.61	0.107	-.0010228	.0104573
ld_i95	-.0067621	.0117185	-0.58	0.564	-.0297323	.016208
ld_i93	.0287577	.0100969	2.85	0.004	.0089663	.0485491
ld_fp_tewma	-.0046972	.0063882	-0.74	0.462	-.0172191	.0078247
ld_fp_milit	.0070074	.0059584	1.18	0.240	-.0046721	.0186869
ld_fp_logan	-.0148987	.010372	-1.44	0.151	-.0352295	.005432
ld_fp_bevmu	.004843	.0077896	0.62	0.534	-.0104259	.0201118
ld_parks	-.0244976	.0077814	-3.15	0.002	-.0397504	-.0092448
ld_mjwater	-.0415827	.0108703	-3.83	0.000	-.0628903	-.0202751
ld_cclubs	-.0083934	.0058236	-1.44	0.150	-.0198086	.0030218
ld_tewmac	-.1159348	.1399692	-0.83	0.408	-.3902963	.1584267
ld_military	.5655227	.2230279	2.54	0.011	.128353	1.002692
ld_logan	3.225574	.5657666	5.70	0.000	2.116583	4.334565
ld_bevmuni	3.186433	.7770825	4.10	0.000	1.663229	4.709636
pfemales	3.583212	1.010342	3.55	0.000	1.602782	5.563641

pblack	2.300747	1.926858	1.19	0.232	-1.476196	6.07769
pother	-.2035338	.6165694	-0.33	0.741	-1.412106	1.005039
page_under5	-2.379441	1.228092	-1.94	0.053	-4.786693	.0278117
page_5_29	-3.303959	.7604302	-4.34	0.000	-4.794522	-1.813397
page_65_up	-.487004	.5296284	-0.92	0.358	-1.525159	.5511506
pmarhh_chd	2.057904	.4039131	5.09	0.000	1.266171	2.849637
pmhh_child	5.675075	3.46519	1.64	0.102	-1.117241	12.46739
pfhh_child	1.413925	1.11722	1.27	0.206	-.7760016	3.603852
pvacant	2.749521	.9685295	2.84	0.005	.8510516	4.647991
prenter_occ	.3964303	.2032788	1.95	0.051	-.002028	.7948886
year79	49.58279	97.17507	0.51	0.610	-140.8956	240.0611
year80	72.59571	97.0445	0.75	0.454	-117.6267	262.8181
year81	159.8673	113.6422	1.41	0.160	-62.8893	382.6239
year82	52.14509	88.58604	0.59	0.556	-121.4974	225.7876
year83	69.33264	85.05546	0.82	0.415	-97.38936	236.0547
year84	-94.32473	70.07437	-1.35	0.178	-231.6815	43.032
year85	-35.00272	73.86917	-0.47	0.636	-179.7979	109.7924
year86	19.11967	78.69384	0.24	0.808	-135.1326	173.3719
year87	-73.41773	64.69125	-1.13	0.256	-200.2227	53.38726
year88	-106.2531	65.93876	-1.61	0.107	-235.5034	22.99716
year89	-200.3425	63.34656	-3.16	0.002	-324.5117	-76.17332
year90	-117.7529	62.71998	-1.88	0.060	-240.6939	5.188062
year91	-46.24665	64.9046	-0.71	0.476	-173.4698	80.97653
year92	-2.685334	56.25792	-0.05	0.962	-112.9597	107.589
year93	-40.79697	57.63423	-0.71	0.479	-153.7691	72.17514
year94	-11.15881	59.04563	-0.19	0.850	-126.8975	104.5799
year95	-14.6607	57.22312	-0.26	0.798	-126.827	97.50557
year96	6.478051	55.69291	0.12	0.907	-102.6888	115.6449
year97	49.32666	76.23872	0.65	0.518	-100.1132	198.7665
_cons	1586.383	381.6292	4.16	0.000	838.3296	2334.436

Hypothesis	P-value of F-test	Reject @ 5% level?
All year-specific slopes on LDIST simultaneously zero	0.0002	
All year-specific slope on LDIST the same	0.0236	
All slopes to north (LAT) simultaneously zero	0.0162	
All slopes to north (LAT) equal	0.0764	NO
All slopes to east (LONG) simultaneously zero	0.0000	
All slopes to east (LONG) equal	0.0000	
All other distance effects simultaneously zero	0.0000	
All Census tract characteristic effects simultaneously zero	0.0000	

7.2 Including latitude and longitude linearly and as site distance interactions

```
Regression with robust standard errors                Number of obs =    12444
                                                      F(130, 12277) =        .
```

Prob > F	=	.
R-squared	=	0.5471
Root MSE	=	.40636

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
notold	.1693701	.0195426	8.67	0.000	.1310634	.2076767
age	-.0032359	.0006353	-5.09	0.000	-.0044312	-.0019906
age2	.0000183	7.75e-06	2.36	0.018	3.09e-06	.0000335
sqft	.1725774	.0294303	5.86	0.000	.1148895	.2302654
sqft2	-.0121996	.009235	-1.32	0.187	-.0303017	.0059025
bedrms	.0089724	.0150539	0.60	0.551	-.0205355	.0384804
bthrms	.0953513	.0201763	4.73	0.000	.0558026	.1348999
sqftbed	.0114375	.0072604	1.58	0.115	-.0027941	.0256691
sqftbth	-.0116592	.0105611	-1.10	0.270	-.0323607	.0090422
fplace	.0653969	.0136906	4.78	0.000	.0385611	.0922327
knowflr	-.2684747	.0471905	-5.69	0.000	-.3609754	-.1759739
floors	.0161969	.0120352	1.35	0.178	-.0073939	.0397877
lotsize	.0476245	.0073996	6.44	0.000	.03312	.062129
ldisw78	.235701	.1859465	1.27	0.205	-.1287833	.6001853
ldisw79	-.0187963	.2196915	-0.09	0.932	-.4494261	.4118336
ldisw80	.0799902	.2585054	0.31	0.757	-.4267209	.5867014
ldisw81	.0835096	.2606316	0.32	0.749	-.4273694	.5943885
ldisw82	.1011022	.1803859	0.56	0.575	-.2524825	.4546868
ldisw83	.23759	.1807092	1.31	0.189	-.1166284	.5918084
ldisw84	-.142172	.1961219	-0.72	0.469	-.5266018	.2422577
ldisw85	.2567009	.156646	1.64	0.101	-.0503499	.5637517
ldisw86	.0162311	.1743658	0.09	0.926	-.3255533	.3580156
ldisw87	.003416	.2015805	0.02	0.986	-.3917134	.3985455
ldisw88	.3317733	.1660725	2.00	0.046	.006245	.6573015
ldisw89	.0189916	.1252626	0.15	0.879	-.2265427	.264526
ldisw90	.0566923	.1627727	0.35	0.728	-.2623678	.3757523
ldisw91	-.103528	.1125498	-0.92	0.358	-.3241433	.1170873
ldisw92	.0375687	.1108498	0.34	0.735	-.1797124	.2548498
ldisw93	.0566083	.1405055	0.40	0.687	-.2188046	.3320212
ldisw94	-.0456962	.0987638	-0.46	0.644	-.2392889	.1478964
ldisw95	-.1295729	.1072435	-1.21	0.227	-.339787	.0806412
ldisw96	.0873205	.1022196	0.85	0.393	-.1130461	.287687
ldisw97	.1048136	.1584129	0.66	0.508	-.2057005	.4153278
lat1_78	-7.854626	8.268107	-0.95	0.342	-24.06142	8.352164
lat1_79	-4.54332	10.27744	-0.44	0.658	-24.68872	15.60208
lat1_80	-8.906506	8.753795	-1.02	0.309	-26.06532	8.252308
lat1_81	-20.31844	10.45338	-1.94	0.052	-40.80871	.171833
lat1_82	-1.710448	9.854894	-0.17	0.862	-21.02759	17.60669
lat1_83	-2.123659	9.706452	-0.22	0.827	-21.14983	16.90251
lat1_84	-10.09993	8.154696	-1.24	0.216	-26.08442	5.884554
lat1_85	4.02576	7.822169	0.51	0.607	-11.30692	19.35844
lat1_86	-3.560855	7.852957	-0.45	0.650	-18.95388	11.83217
lat1_87	-3.543371	7.77029	-0.46	0.648	-18.77436	11.68762
lat1_88	.9749088	7.107195	0.14	0.891	-12.95631	14.90613
lat1_89	-5.225542	7.317663	-0.71	0.475	-19.56931	9.118227
lat1_90	-6.751576	6.915312	-0.98	0.329	-20.30667	6.803522
lat1_91	-7.362134	6.761536	-1.09	0.276	-20.61581	5.891539
lat1_92	-5.453587	6.676022	-0.82	0.414	-18.53964	7.632465
lat1_93	-4.296164	6.787568	-0.63	0.527	-17.60087	9.008537
lat1_94	-2.785327	6.839482	-0.41	0.684	-16.19179	10.62113
lat1_95	-3.920755	6.72515	-0.58	0.560	-17.10311	9.261596

lat1_96	-4.485706	6.673725	-0.67	0.502	-17.56725	8.595844
lat1_97	-5.590626	7.382297	-0.76	0.449	-20.06109	8.879836
long1_78	18.51479	6.471835	2.86	0.004	5.828974	31.2006
long1_79	22.03932	7.146128	3.08	0.002	8.031788	36.04686
long1_80	19.8913	6.927386	2.87	0.004	6.312534	33.47007
long1_81	14.09608	7.723434	1.83	0.068	-1.043064	29.23522
long1_82	23.70465	7.210277	3.29	0.001	9.571372	37.83792
long1_83	22.75367	7.294275	3.12	0.002	8.455744	37.0516
long1_84	17.49563	6.416465	2.73	0.006	4.918345	30.07291
long1_85	24.95424	6.302712	3.96	0.000	12.59994	37.30855
long1_86	22.29309	6.140378	3.63	0.000	10.25699	34.3292
long1_87	20.75179	6.175532	3.36	0.001	8.646775	32.8568
long1_88	21.70761	5.989776	3.62	0.000	9.966709	33.44851
long1_89	18.01021	6.170309	2.92	0.004	5.91543	30.10498
long1_90	18.38307	5.88568	3.12	0.002	6.84621	29.91993
long1_91	19.77447	5.966141	3.31	0.001	8.079898	31.46905
long1_92	21.05556	5.974474	3.52	0.000	9.344649	32.76646
long1_93	21.066	5.888981	3.58	0.000	9.522668	32.60932
long1_94	22.51121	5.821359	3.87	0.000	11.10044	33.92199
long1_95	22.22124	5.795697	3.83	0.000	10.86076	33.58171
long1_96	21.51437	5.803518	3.71	0.000	10.13856	32.89018
long1_97	21.25979	5.824644	3.65	0.000	9.842573	32.67701
lat1disw78	.4577654	2.872228	0.16	0.873	-5.172252	6.087783
lat1disw79	-2.096774	4.421206	-0.47	0.635	-10.76303	6.569485
lat1disw80	-.195017	3.515421	-0.06	0.956	-7.085794	6.69576
lat1disw81	6.205866	4.423378	1.40	0.161	-2.46465	14.87638
lat1disw82	-3.248244	3.958501	-0.82	0.412	-11.00753	4.51104
lat1disw83	-2.751189	4.034986	-0.68	0.495	-10.6604	5.158018
lat1disw84	.719245	3.044232	0.24	0.813	-5.247928	6.686418
lat1disw85	-5.41568	2.780299	-1.95	0.051	-10.8655	.0341435
lat1disw86	-2.253397	2.730719	-0.83	0.409	-7.606036	3.099242
lat1disw87	-2.593667	2.579635	-1.01	0.315	-7.650156	2.462822
lat1disw88	-4.31729	2.261097	-1.91	0.056	-8.749395	.1148148
lat1disw89	-1.584891	2.36769	-0.67	0.503	-6.225935	3.056153
lat1disw90	-.4521447	2.008208	-0.23	0.822	-4.388549	3.484259
lat1disw91	-.5373405	1.921805	-0.28	0.780	-4.304381	3.2297
lat1disw92	-1.357564	2.038669	-0.67	0.505	-5.353676	2.638547
lat1disw93	-1.986987	1.8882	-1.05	0.293	-5.688156	1.714181
lat1disw94	-2.624828	1.931393	-1.36	0.174	-6.410661	1.161006
lat1disw95	-2.968697	1.970275	-1.51	0.132	-6.830747	.8933526
lat1disw96	-1.994049	1.780974	-1.12	0.263	-5.485038	1.49694
lat1disw97	-1.757131	2.209255	-0.80	0.426	-6.087617	2.573356
long1disw78	.2818642	1.714691	0.16	0.869	-3.079199	3.642928
long1disw79	-1.248972	2.641708	-0.47	0.636	-6.427135	3.92919
long1disw80	-.1127681	2.100523	-0.05	0.957	-4.230123	4.004587
long1disw81	3.714421	2.642447	1.41	0.160	-1.46519	8.894033
long1disw82	-1.937044	2.365293	-0.82	0.413	-6.57339	2.699302
long1disw83	-1.635528	2.411234	-0.68	0.498	-6.361925	3.09087
long1disw84	.4316473	1.817419	0.24	0.812	-3.13078	3.994075
long1disw85	-3.228576	1.660013	-1.94	0.052	-6.482463	.0253107
long1disw86	-1.34293	1.630995	-0.82	0.410	-4.539938	1.854077
long1disw87	-1.545273	1.539562	-1.00	0.316	-4.563056	1.472509
long1disw88	-2.569335	1.349887	-1.90	0.057	-5.215326	.076656
long1disw89	-.9422424	1.413379	-0.67	0.505	-3.712687	1.828202
long1disw90	-.2651618	1.198751	-0.22	0.825	-2.614902	2.084579
long1disw91	-.3200687	1.147467	-0.28	0.780	-2.569285	1.929147
long1disw92	-.8081924	1.217396	-0.66	0.507	-3.19448	1.578095
long1disw93	-1.183859	1.127336	-1.05	0.294	-3.393615	1.025898

longldisw94	-1.565912	1.153302	-1.36	0.175	-3.826564	.6947402
longldisw95	-1.774002	1.17629	-1.51	0.132	-4.079715	.5317118
longldisw96	-1.187466	1.063341	-1.12	0.264	-3.271781	.8968488
longldisw97	-1.044624	1.319038	-0.79	0.428	-3.630244	1.540995
ld_summits	-.0076867	.0081585	-0.94	0.346	-.0236786	.0083052
ld_school	-.0256489	.0069644	-3.68	0.000	-.0393002	-.0119976
ld_retail	-.8358928	.1881123	-4.44	0.000	-1.204623	-.4671631
ld_hospital	.0961899	.0223765	4.30	0.000	.0523284	.1400513
ld_church	.2021624	.1734784	1.17	0.244	-.1378824	.5422073
ld_cemetery	-.0020529	.0100655	-0.20	0.838	-.0217829	.0176771
ld_railroad	.0202007	.0063095	3.20	0.001	.0078332	.0325683
ld_prinarte	-.0282984	.009108	-3.11	0.002	-.0461515	-.0104452
ld_othpriro	.0187431	.0046133	4.06	0.000	.0097003	.0277859
ld_ma_roads	.0043521	.0029486	1.48	0.140	-.0014275	.0101317
ld_i95	.0198873	.0135562	1.47	0.142	-.006685	.0464596
ld_i93	.0359392	.0105477	3.41	0.001	.0152641	.0566143
ld_fp_tewma	-.0030909	.0066062	-0.47	0.640	-.0160401	.0098584
ld_fp_milit	.0075982	.0059751	1.27	0.204	-.0041139	.0193103
ld_fp_logan	-.0150445	.0105632	-1.42	0.154	-.0357501	.005661
ld_fp_bevmu	.0025637	.0078115	0.33	0.743	-.012748	.0178755
ld_parks	-.0220602	.0082728	-2.67	0.008	-.0382761	-.0058442
ld_mjwater	-.0473648	.0113291	-4.18	0.000	-.0695717	-.0251579
ld_cclubs	-.0029476	.0060042	-0.49	0.623	-.0147168	.0088216
ld_tewmac	-.1664644	.1406579	-1.18	0.237	-.442176	.1092471
ld_military	.4892863	.2390684	2.05	0.041	.0206747	.9578978
ld_logan	3.402231	.5802234	5.86	0.000	2.264902	4.53956
ld_bevmuni	3.715831	.8655053	4.29	0.000	2.019305	5.412358
pfemales	3.971701	1.0217	3.89	0.000	1.969008	5.974395
pblack	1.805294	1.979133	0.91	0.362	-2.074118	5.684706
pother	-.1301623	.6632735	-0.20	0.844	-1.430283	1.169958
page_under5	-2.669591	1.323864	-2.02	0.044	-5.264572	-.0746094
page_5_29	-3.40653	.8013081	-4.25	0.000	-4.97722	-1.83584
page_65_up	-.7613174	.5453215	-1.40	0.163	-1.830233	.3075985
pmarhh_chd	1.914783	.4488914	4.27	0.000	1.034886	2.794681
pmhh_child	4.569843	3.473691	1.32	0.188	-2.239138	11.37882
pfhh_child	1.706427	1.129584	1.51	0.131	-.5077341	3.920588
pvacant	3.377611	1.102132	3.06	0.002	1.217259	5.537963
prenter_occ	.3366676	.2238031	1.50	0.133	-.1020218	.7753569
year79	109.8418	139.0156	0.79	0.429	-162.6507	382.3344
year80	142.4608	132.3538	1.08	0.282	-116.9735	401.8951
year81	215.6738	165.234	1.31	0.192	-108.2108	539.5583
year82	107.9564	123.357	0.88	0.382	-133.8428	349.7556
year83	58.34367	110.3102	0.53	0.597	-157.8817	274.569
year84	23.28113	93.96239	0.25	0.804	-160.8999	207.4622
year85	-46.18921	101.0093	-0.46	0.647	-244.1833	151.8049
year86	87.07214	109.683	0.79	0.427	-127.9237	302.068
year87	-23.06799	96.67206	-0.24	0.811	-212.5604	166.4244
year88	-146.8431	92.81466	-1.58	0.114	-328.7745	35.08818
year89	-146.5822	91.06275	-1.61	0.107	-325.0795	31.9151
year90	-55.24889	88.11312	-0.63	0.531	-227.9644	117.4667
year91	69.32137	82.55524	0.84	0.401	-92.49988	231.1426
year92	79.37276	75.56147	1.05	0.294	-68.7396	227.4851
year93	30.95689	79.37931	0.39	0.697	-124.639	186.5528
year94	69.57374	82.25522	0.85	0.398	-91.65942	230.8069
year95	97.05387	76.72732	1.26	0.206	-53.34375	247.4515
year96	71.03207	74.44973	0.95	0.340	-74.90111	216.9652
year97	99.99672	105.9543	0.94	0.345	-107.6903	307.6838
_cons	1593.208	390.3143	4.08	0.000	828.1306	2358.285

Hypothesis	P-value of F-test	Reject @ 5% level?
All year-specific slopes on LDIST simultaneously zero	0.7466	NO
All year-specific slope on LDIST the same	0.7004	NO
All slopes to north (LAT) simultaneously zero	0.7272	NO
All slopes to north (LAT) equal	0.6967	NO
All slopes to east (LONG) simultaneously zero	0.0071	
All slopes to east (LONG) equal	0.3276	NO
All LAT*LDIST simultaneously zero	0.6290	NO
All LAT*LDIST equal	0.6915	NO
All LONG* LDIST simultaneously zero	0.6289	NO
All LONG* LDIST equal	0.6910	NO
All other distance effects simultaneously zero	0.0000	
All Census tract characteristic effects simultaneously zero	0.0000	

Appendix D – Eagle Mine Site

Contents:

Chapter 1 Criteria for exclusion from raw sample

Condominium units are retained in the Eagle Mine sample because of the shortage of dwellings within a radius of the Superfund site that could plausibly be directly affected by proximity to the site. Both single-family detached dwellings and condos are included in our sample of owner-occupied units. Given the high proportion of rental properties in the population of dwellings, this sample is systematically different from that for our other three Superfund examples. Observations are excluded from the Eagle Mine sample if:

- lot size is zero
- lot size is greater than 30000 square feet (e.g. 100 by 300 ft)
- less than 6 kilometers from the nearest portion of the Eagle Mine site (affects only nine dwellings (none condos); recorded selling prices for these nine houses vary widely, from 23,900 to 238,000).
- further than 13.5 kilometers from the site (excludes 86 dwellings, but property sales at these distances appear only in the time interval between 1984 and 1999)
- dwelling is older than 50 years (affects two outliers)
- a couple of obvious outliers that stand apart from the rest of the data: in 1978 with selling price lower than $8100; in 1999 with selling prices lower than $6000.

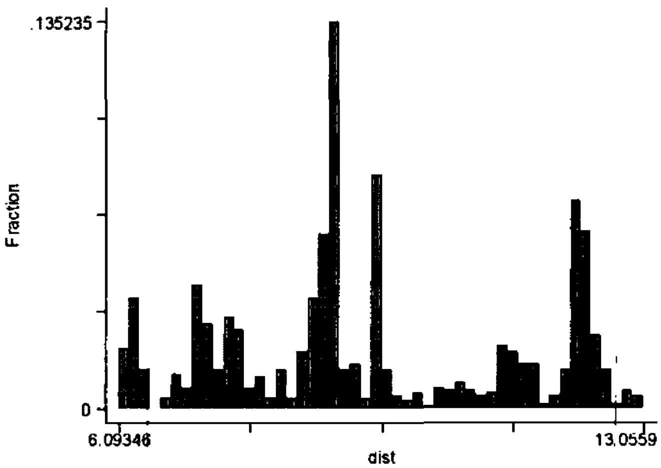
Chapter 2 Annual counts in sample

YEAR	Freq.	Percent	Cum.
76	31	2.85	2.85
77	12	1.10	3.96
78	17	1.56	5.52
79	27	2.48	8.00
80	39	3.59	11.59
81	28	2.58	14.17
82	13	1.20	15.36
83	15	1.38	16.74
84	13	1.20	17.94
85	16	1.47	19.41
86	25	2.30	21.71
87	26	2.39	24.10
88	50	4.60	28.70
89	50	4.60	33.30
90	55	5.06	38.36
91	62	5.70	44.07
92	62	5.70	49.77
93	68	6.26	56.03
94	86	7.91	63.94
95	51	4.69	68.63
96	59	5.43	74.06
97	76	6.99	81.05
98	79	7.27	88.32
99	127	11.68	100.00
Total	1087	100.00	

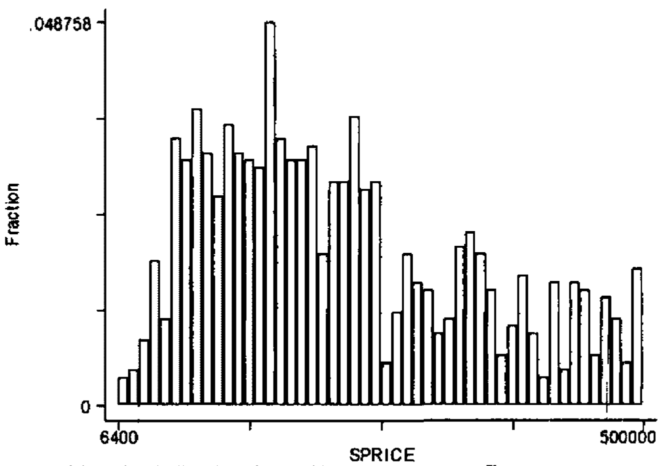
Chapter 3 Descriptive statistics

3.1 Housing prices and distances from site

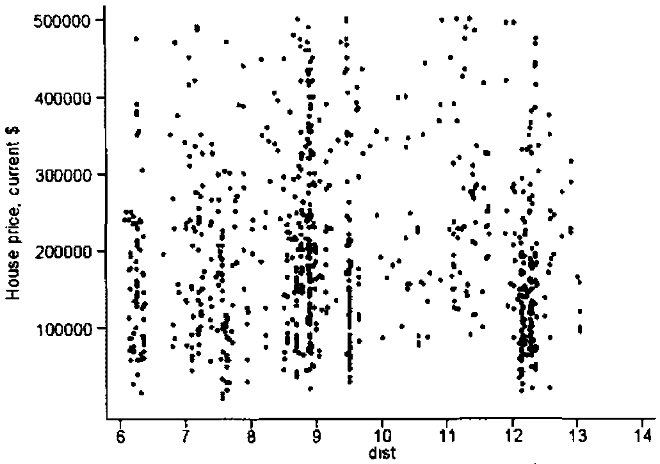
Variable	Obs	Mean	Std. Dev.	Min	Max
dist	1087	9.423684	1.929098	6.093462	13.05585
sprice	1087	215365.3	124034.4	6400	500000



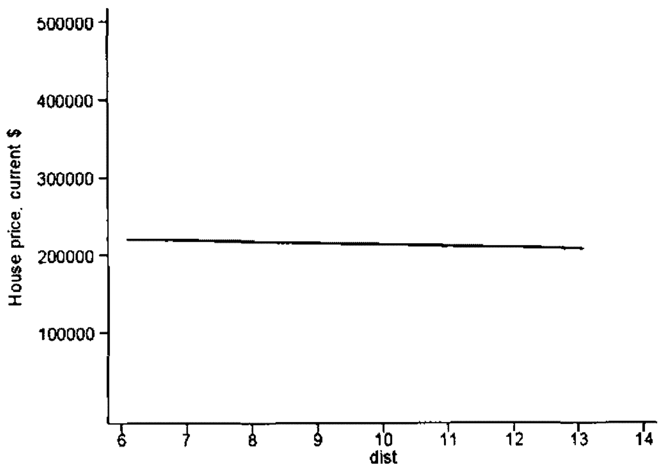
Marginal distribution of distances: Eagle Mine



Marginal distribution of house prices: Eagle Mine



Distance from nearest Eagle Mine site (km)



Distance from nearest Eagle Mine site (km)

3.2 Structural variables

Variable	Obs	Mean	Std. Dev.	Min	Max
sfd	1087	.3965041	.4893965	0	1
age	1087	13.43054	9.845643	0	36
age2	1087	258.5529	253.1993	0	1296
bedrms	1087	2.614535	.9988439	0	6
bthrms	1087	2.49494	1.044023	1	6
notwdframe	1087	.1269549	.3330757	0	1
heatelec	1087	.4912603	.5001537	0	1
constgood	1087	.2842686	.451273	0	1
constfair	1087	.2529899	.4349253	0	1
lotsize	1087	1	.9819864	.0310415	5.789237

The only structural characteristics that have exhibited different trends downstream from the Eagle mine site and nearer, as opposed to farther, from the site are the ages of dwellings and the proportion which are not wood frame structures.

3.2.1 Changing distance profiles of house age over time

In our sample, the age of houses at their last time of sale ranges only from zero to 36 years.

Regression with robust standard errors

Number of obs	=	1087
F(5, 1081)	=	237.35
Prob > F	=	0.0000
R-squared	=	0.4137
Root MSE	=	6.789

age	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
downstream	-5.117111	.3821816	-13.39	0.000	-5.867013	-4.367209
ldist	-4.566435	1.019259	-4.48	0.000	-6.566385	-2.566484
trend	-.4063416	.3277674	-1.24	0.215	-1.049474	.2367908
downstreamy	-.019133	.0585814	-0.33	0.744	-.1340792	.0958132
ldisty	.5600853	.1471051	3.81	0.000	.2714415	.8487291
_cons	20.99599	2.268103	9.26	0.000	16.5456	25.44637

Controlling for distance from the Eagle Mine site, age at time of sale for houses downstream of the Eagle Mine site (as opposed to those located on Gore Creek) has not changed over time. However, at the beginning of the sample period, houses being sold closer to the mine site are older than houses being sold at a greater distance. By the end of the sample period, many more newer houses are being sold closer to the site. Over time, the housing stock closer to the site seems to be getting newer (on average) more quickly than the housing stock in the rest of the area.

3.2.2 Changing distance profiles of framing material over time

Regression with robust standard errors

Number of obs	=	1087
F(5, 1081)	=	16.57
Prob > F	=	0.0000
R-squared	=	0.0391
Root MSE	=	.32725

notwdframe	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
downstream	-.1360607	.0172675	-7.88	0.000	-.1699422	-.1021791
ldist	-.1804713	.0463737	-3.89	0.000	-.2714639	-.0894787
trend	-.0524	.0127841	-4.10	0.000	-.0774844	-.0273155
downstreamy	.0138754	.0028731	4.83	0.000	.0082379	.0195129
ldisty	.0199838	.005445	3.67	0.000	.0092997	.0306678
_cons	.5716354	.1107124	5.16	0.000	.3543998	.788871

At the beginning of the sample period, the proportion of non-wood-frame houses was lower downstream of the mine and declined with distance from the Eagle Mine site. Over time, there was a relative increase in the proportion of non-wood-frame houses downstream of the mine and nearer the site . However, the low R-squared statistic on this model suggests that these results are not very robust. Non-wood-frame houses average only about 13% of the stock.

3.3 Census tract attributes

Census tract attributes are not employed in this analysis, since there are too few tracts in the affected area.

3.4 Other distances

Data were collected for the full set of other amenities/disamenities that have elsewhere been found to play some role in explaining housing prices. In the estimated models that we report, however, collinearity problems are so severe that we are forced to shorten the list of variables used. We eliminate variables first if the feature is located at such a great distance that it does not seem plausible that it should have any detectible effect on housing prices in this sample. This leads us to drop rivers, hospitals, and churches. Other variables are highly collinear due to the topology of the area. We are left with only the distance to the Vail ski area, the distance to Interstate 70, the distance to the nearest river, and the distance to the nearest recreational area (golf course or country club). Apparent distance effects relative to the Eagle Mine Superfund site will be unavoidably confounded with the effects of distance to the nearest cemetery, so we exclude the cemetery variable.

Distance variable	Description
d_summits	Distance from the nearest summit of land. Of course, there are many of these in Eagle County. Approximately 20 different named summits are within the Vail zip code, within which the Eagle Mine site is more or less centered.
d_rivers	Distance to the nearest river. Most houses in the sample lie close to the main branch of either the Eagle River, which flows north past the site and then west after its confluence with Gore Creek, which runs from east to west through Vail.
d_school	Distance from the nearest school. The Minturn Middle School is about 2.5 miles northwest along Eagle River from the mine site. Battle Mountain high school lies about 7.5 miles northwest of the site, near the confluence of Eagle River and Gore Creek. Lake Creek School lies further downstream on Eagle River, near the boundary of the Vail zip code area.
d_retail	Distance to the nearest retail center. Unlikely to be relevant for this sample of houses. The nearest shopping mall appears to be West Glenwood Mall, about 52 miles to the west of the site.
d_hospital	Distance to the nearest hospital. Unlikely to be relevant for this sample. Nearest hospital, Mercy Hospital, lies about 28 miles ENE of the site.
d_church	Distance from the nearest church. There appear to be no major churches anywhere with the Vail zip code area. The Saint Benedict Monastery lies about 38 miles southwest of the mine site.

d_cemetery	Distance to the nearest cemetery. The River View cemetery lies about 3.5 miles downstream (NNW) of the mine site. The Gold Park Cemetery is about 9 miles SSW of the site, and is unlikely to be relevant to explaining housing prices in our sample.
d_railroad	Railroads in the sample area follow the route of the Eagle River. The line appears to belong to the Chicago and Northwestern Railway Company (CNW), although ownership of a number of segments of lines just outside our sample area is not recorded in the GIS dataset.
d_i70	Distance from Interstate 70, [an east-west] freeway that runs through the northern third of the Vail zip code area. The coefficient on this variable is a proximity effect in addition to proximity from the nearest main roads, d_cords.
d_cords	Distance from the closest main roads. This includes I70 if it happens to be the nearest main road. The only other major roads are US Highway 6, which runs alongside I70 to the west of the confluence of the Eagle River and Gore Creek were it flow in from the direction of the Vail settlement, and US Highway 24, which runs alongside the Eagle River to its junction with I70 and US6 near the confluence of the Eagle River and Gore Creek.
d_mjwater	Distance from the nearest body of water. Four significant reservoirs are located within a radius of 18-25 miles of the mine site, but none of these is likely to have any bearing on housing prices in our sample.
d_airport	Distance from the nearest airport. Three airports lie between 29 and 24 miles of the mine site, but there is unlikely to be much of a discernible effect of proximity to these airports on housing prices in our sample.
d_recareas	Distance to the nearest Golf Club. There are three golf clubs in the Vail zip code area. All three lie in close proximity to I70. One is centered in the Vail census tract, one is slightly west of the confluence of the two rivers and the junction of US24 with the I70 freeway. The third is near the western boundary of the Vail zip code area, close to the Lake Creek School.
d_locale	Distance to different miscellaneous points of interest, such as campgrounds, ranger stations, etc. Nearest entities in this class are likely to be highly heterogeneous, so distances will not be expected to have common systematic effect on housing prices.

Variable	Obs	Mean	Std. Dev.	Min	Max
d_vail_ski	1087	5.705559	2.587591	2.77675	13.07698
d_recareas	1087	3.903944	1.7492	.5051883	6.355576
d_railroad	1087	5.778521	3.894213	.1738037	12.40084
d_rivers	1087	.1833048	.1727289	.0009171	.8601518

Chapter 4 Collinearities

4.1 Time patterns in average site distances in sample

Regression with robust standard errors

Number of obs	=	1087
F(23, 1063)	=	3.28
Prob > F	=	0.0000
R-squared	=	0.0473
Root MSE	=	.20432

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year77	.0087313	.0415166	0.21	0.833	-.0727326	.0901952
year78	-.015558	.0588126	-0.26	0.791	-.1309601	.0998441
year79	.0266883	.029099	0.92	0.359	-.0304097	.0837864
year80	.1051202	.0352026	2.99	0.003	.0360458	.1741946
year81	.2294165	.0348561	6.58	0.000	.161022	.297811
year82	.0497185	.0516654	0.96	0.336	-.0516593	.1510963
year83	.0579519	.0535447	1.08	0.279	-.0471133	.1630172
year84	.1120218	.0436912	2.56	0.010	.0262911	.1977526
year85	.0665697	.0479459	1.39	0.165	-.0275096	.160649
year86	.0461149	.0423219	1.09	0.276	-.0369289	.1291588
year87	.0490009	.0495231	0.99	0.323	-.0481734	.1461751
year88	.0749078	.0334853	2.24	0.025	.009203	.1406127
year89	.0752998	.0337427	2.23	0.026	.00909	.1415096
year90	.1068947	.0315633	3.39	0.001	.0449613	.1688281
year91	.0040524	.031803	0.13	0.899	-.0583513	.0664562
year92	.067759	.0340214	1.99	0.047	.0010023	.1345156
year93	.0525805	.0306113	1.72	0.086	-.007485	.112646
year94	.0647503	.0294466	2.20	0.028	.0069703	.1225303
year95	.1068004	.0321517	3.32	0.001	.0437124	.1698884
year96	-.000675	.0356166	-0.02	0.985	-.0705618	.0692118
year97	.0109184	.0318955	0.34	0.732	-.0516669	.0735036
year98	.0125766	.0324308	0.39	0.698	-.051059	.0762122
year99	.0590857	.0263802	2.24	0.025	.0073226	.1108489
_cons	2.167601	.0184332	117.59	0.000	2.131431	2.20377

4.2 Time trend in average lot sizes

Regression with robust standard errors

Number of obs	=	1087
F(23, 1063)	=	3.88
Prob > F	=	0.0000
R-squared	=	0.0711
Root MSE	=	.95661

lotsize	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
year77	.317916	.26954	1.18	0.238	-.2109749	.846807
year78	.5209934	.3025645	1.72	0.085	-.072698	1.114685
year79	.1706109	.2103721	0.81	0.418	-.2421808	.5834025
year80	.0681403	.1365142	0.50	0.618	-.1997275	.3360081
year81	.1000136	.1497379	0.67	0.504	-.1938018	.393829

year82	.7517196	.2941222	2.56	0.011	.1745935	1.328846
year83	.579502	.3099456	1.87	0.062	-.0286727	1.187677
year84	.3066324	.2881732	1.06	0.288	-.2588205	.8720853
year85	.3028399	.1810967	1.67	0.095	-.0525076	.6581874
year86	1.035695	.2723908	3.80	0.000	.5012108	1.57018
year87	1.139514	.2989708	3.81	0.000	.5528745	1.726154
year88	.6649398	.2087596	3.19	0.001	.2553121	1.074568
year89	.3791137	.1513063	2.51	0.012	.0822207	.6760067
year90	.5685317	.1654391	3.44	0.001	.2439074	.8931559
year91	.4324467	.1755239	2.46	0.014	.0880341	.7768593
year92	.8707075	.1940101	4.49	0.000	.4900212	1.251394
year93	.6066884	.1750321	3.47	0.001	.2632407	.9501362
year94	.719057	.1609307	4.47	0.000	.403279	1.034835
year95	.300751	.1672993	1.80	0.073	-.0275235	.6290254
year96	.3009981	.1558229	1.93	0.054	-.0047573	.6067535
year97	.3050314	.1440659	2.12	0.034	.0223456	.5877173
year98	.5701365	.1665174	3.42	0.001	.2433964	.8968766
year99	.2245463	.1223279	1.84	0.067	-.0154853	.4645778
_cons	.5374871	.1111585	4.84	0.000	.3193721	.7556022

4.3 Distance to site vs. structural variables

```
Regression with robust standard errors                 Number of obs =    1087
                                                       F( 10,  1076) =    7.97
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.0627
                                                       Root MSE      =  .20143
```

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
sfd	.062327	.0183986	3.39	0.001	.0262258	.0984282
age	-.0038515	.0022568	-1.71	0.088	-.0082798	.0005768
age2	.0000434	.0000825	0.53	0.599	-.0001186	.0002053
bedrms	-.0413248	.0100509	-4.11	0.000	-.0610463	-.0216032
bthrms	.0078928	.0099483	0.79	0.428	-.0116275	.027413
notwdframe	-.0371402	.0141457	-2.63	0.009	-.0648965	-.009384
heatelec	.0600777	.0135586	4.43	0.000	.0334733	.086682
constgood	.0326282	.0148927	2.19	0.029	.0034061	.0618503
constfair	.0336852	.0180831	1.86	0.063	-.0017969	.0691672
lotsize	.0135193	.0104568	1.29	0.196	-.0069988	.0340373
_cons	2.270167	.0307442	73.84	0.000	2.209841	2.330492

4.4 Distance to site vs. Census tract attributes

There are no census tract characteristics for this data set (insufficient numbers of tracts).

4.5 Distance to site vs. other distances

```
Regression with robust standard errors                 Number of obs =    1087
                                                       F(  4,  1082) = 1990.96
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.7795
                                                       Root MSE      =  .09743
```

ldist	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ld_vail_ski	.4150413	.008783	47.25	0.000	.3978076	.432275
ld_recareas	-.0741603	.0052133	-14.23	0.000	-.0843896	-.0639309
ld_railroad	.1467133	.0033063	44.37	0.000	.1402259	.1532007
ld_rivers	.0014111	.0028557	0.49	0.621	-.0041923	.0070145
_cons	1.433252	.0173283	82.71	0.000	1.399251	1.467253

Chapter 5 Complete regression results – No lot size interactions

5.1 Just structural characteristics and year dummies

Note that the time-differentiated "downstream" dummy variable (downstrX) and and time-differentiated log(dist) variables (ldisX) and the interactions between the downstream dummies and the log(dist) variables (downldistX) are summed across subsets of years. There was insufficient data on sales in many individual years to permit a full complement of 23 distinct yearlyy coefficients. The labeling of the combined years corresponds to the last year in the interval..

```
Regression with robust standard errors               Number of obs =    1087
                                                      F( 56,  1029) =       .
                                                      Prob > F      =       .
                                                      R-squared     =  0.6846
                                                      Root MSE      =  .38696
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
sfd	.087723	.0339329	2.59	0.010	.0211374	.1543086
age	-.002036	.0057189	-0.36	0.715	-.013308	.0091361
age2	.0000844	.0002022	0.42	0.676	-.0003123	.0004812
bedrms	.0911766	.0198941	4.58	0.000	.0521388	.1302143
bthrms	.2452747	.0204907	11.97	0.000	.2050665	.285483
notwdframe	.2857618	.0503166	5.68	0.000	.1870269	.3844967
heatelec	-.1120886	.0299623	-3.74	0.000	-.1708828	-.0532944
constgood	.2404679	.0377774	6.37	0.000	.1663384	.3145973
constfair	-.2633383	.0327453	-8.04	0.000	-.3275934	-.1990831
lotsize	-.0180865	.0218644	-0.83	0.408	-.0609904	.0248174
downstr79	-14.6678	2.620287	-5.60	0.000	-19.80951	-9.526082
downstr82	-2.451152	1.868129	-1.31	0.190	-6.116929	1.214625
downstr85	2.915498	1.881971	1.55	0.122	-.7774421	6.608437
downstr88	-4.156908	1.869033	-2.22	0.026	-7.824459	-.4893577
downstr91	1.102785	1.418707	0.78	0.437	-1.681104	3.886674
downstr94	1.29416	.8353652	1.55	0.122	-.3450539	2.933374
downstr97	-1.838408	1.394555	-1.32	0.188	-4.574904	.898088
downstr99	-1.447165	.945762	-1.53	0.126	-3.303008	.4086768
ldis79	-.1810061	.3159642	-0.57	0.567	-.8010139	.4390017
ldis82	-.3655425	.271496	-1.35	0.178	-.8982916	.1672065
ldis85	-.0074668	.3969009	-0.02	0.985	-.7862942	.7713607

ldis88	-.1457056	.2072288	-0.70	0.482	-.5523449	.2609338
ldis91	.1181851	.1689896	0.70	0.484	-.2134185	.4497887
ldis94	.4585914	.1722099	2.66	0.008	.1206687	.7965142
ldis97	.0562526	.0913914	0.62	0.538	-.1230821	.2355873
ldis99	.1029265	.0861261	1.20	0.232	-.0660765	.2719294
downldist79	6.480981	1.164892	5.56	0.000	4.195145	8.766816
downldist82	.9652991	.7914221	1.22	0.223	-.5876864	2.518285
downldist85	-1.419509	.8196063	-1.73	0.084	-3.02778	.1887814
downldist88	1.715968	.8129617	2.11	0.035	.1207159	3.31122
downldist91	-.5503184	.6185063	-0.89	0.374	-1.763996	.6633592
downldist94	-.7252007	.3532018	-2.05	0.040	-1.418279	-.0321227
downldist97	.6997834	.6091435	1.15	0.251	-.4955218	1.895089
downldist99	.5511937	.4160078	1.32	0.185	-.2651268	1.367514
year77	.0099876	.1170336	0.09	0.932	-.219664	.2396393
year78	-.4767802	.178538	-2.67	0.008	-.8271203	-.1264402
year79	.5140408	.1410527	3.64	0.000	.237257	.7908246
year80	1.085522	.9378863	1.16	0.247	-.7548665	2.92591
year81	1.106994	.946807	1.17	0.243	-.7508984	2.964887
year82	1.082301	.9894484	1.09	0.274	-.8592656	3.023868
year83	.3706013	1.163475	0.32	0.750	-1.912454	2.653657
year84	.5330833	1.135127	0.47	0.639	-1.694344	2.760511
year85	.405868	1.105695	0.37	0.714	-1.763806	2.575542
year86	.5661312	.831686	0.68	0.496	-1.065863	2.198125
year87	.4394625	.8371651	0.52	0.600	-1.203283	2.082208
year88	.323816	.82593	0.39	0.695	-1.296883	1.944515
year89	.0047135	.7938476	0.01	0.995	-1.553031	1.562458
year90	-.0944347	.7852646	-0.12	0.904	-1.635338	1.446468
year91	-.0058193	.7881901	-0.01	0.994	-1.552463	1.540824
year92	-.6572875	.7956385	-0.83	0.409	-2.218547	.9039717
year93	-.6032885	.7900044	-0.76	0.445	-2.153492	.9469151
year94	-.4135891	.7940377	-0.52	0.603	-1.971707	1.144529
year95	.6792759	.7207184	0.94	0.346	-.7349697	2.093521
year96	.6282686	.718934	0.87	0.382	-.7824756	2.039013
year97	.6077811	.7197148	0.84	0.399	-.8044952	2.020057
year98	.5657678	.719305	0.79	0.432	-.8457043	1.97724
year99	.7156931	.7223124	0.99	0.322	-.7016803	2.133067
_cons	10.83916	.7015253	15.45	0.000	9.462572	12.21574

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on DOWNSTR simultaneously zero	0.0000	
All year-specific slope on DOWNSTR the same	0.0000	
All year-specific slopes on LDIST simultaneously zero	0.1463	NO
All year-specific slope on LDIST the same	0.1995	NO
All year-specific slopes on DOWNSTR*LDIST sim. zero	0.0000	
All year-specific slope on DOWNSTR*LDIST the same	0.0000	

5.2 Including other distances

Regression with robust standard errors

Number of obs	= 1087
F(61, 1025)	= 79.20
Prob > F	= 0.0000
R-squared	= 0.7234
Root MSE	= .36307

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
sfd	.1599711	.0318435	5.02	0.000	.0974852	.2224571
age	.0008054	.0056284	0.14	0.886	-.0102392	.0118499
age2	-.0001994	.00019	-1.05	0.294	-.0005723	.0001735
bedrms	.1099823	.0192905	5.70	0.000	.0721288	.1478357
bthrms	.2132256	.0205788	10.36	0.000	.1728441	.2536071
notwdframe	.1667254	.0463674	3.60	0.000	.0757395	.2577113
heatelec	-.1032714	.0288212	-3.58	0.000	-.1598267	-.0467161
constgood	.1519202	.0363367	4.18	0.000	.0806173	.2232231
constfair	-.181157	.032681	-5.54	0.000	-.2452864	-.1170276
lotsize	-.0097934	.0245693	-0.40	0.690	-.0580053	.0384184
downstr79	-11.77349	2.833724	-4.15	0.000	-17.33405	-6.212924
downstr82	-1.828606	1.903158	-0.96	0.337	-5.563136	1.905924
downstr85	3.119721	2.065909	1.51	0.131	-.9341736	7.173616
downstr88	-5.236217	1.966144	-2.66	0.008	-9.094345	-1.378089
downstr91	-.1198468	1.887133	-0.06	0.949	-3.822931	3.583238
downstr94	-.0094171	1.036293	-0.01	0.993	-2.042916	2.024082
downstr97	-2.291988	1.216899	-1.88	0.060	-4.679886	.09591
downstr99	-2.639503	1.067854	-2.47	0.014	-4.734933	-.5440732
ldis79	-.3848692	.4002505	-0.96	0.336	-1.170273	.4005347
ldis82	-.4108056	.2797502	-1.47	0.142	-.9597541	.1381428
ldis85	.1480834	.4044314	0.37	0.714	-.6455246	.9416914
ldis88	-.2160061	.2328473	-0.93	0.354	-.6729179	.2409058
ldis91	.0026152	.2214624	0.01	0.991	-.4319563	.4371867
ldis94	.3132996	.2093543	1.50	0.135	-.0975124	.7241117
ldis97	-.181086	.1707862	-1.06	0.289	-.5162165	.1540444
ldis99	-.0486977	.178804	-0.27	0.785	-.3995614	.302166
downldist79	5.701665	1.246576	4.57	0.000	3.255534	8.147797
downldist82	1.171806	.7981178	1.47	0.142	-.394325	2.737938
downldist85	-1.083623	.8962712	-1.21	0.227	-2.842359	.675113
downldist88	2.598629	.8641985	3.01	0.003	.9028285	4.294429
downldist91	.4107277	.8277091	0.50	0.620	-1.21347	2.034926
downldist94	.2592562	.444089	0.58	0.559	-.6121712	1.130684
downldist97	1.326131	.5286867	2.51	0.012	.2886987	2.363563
downldist99	1.488794	.4788069	3.11	0.002	.5492399	2.428347
ld_vail_ski	-.6410497	.093648	-6.85	0.000	-.8248134	-.4572861
ld_recareas	-.0649664	.0316718	-2.05	0.040	-.1271153	-.0028175
ld_railroad	.2146156	.046235	4.64	0.000	.1238895	.3053418
ld_rivers	-.0287666	.0112226	-2.56	0.011	-.0507886	-.0067447
year77	.083184	.1034472	0.80	0.422	-.1198085	.2861766
year78	-.313459	.1864471	-1.68	0.093	-.6793205	.0524026
year79	.5574546	.1449649	3.85	0.000	.2729927	.8419166

```
    year80 |   .9247319   .9558066     0.97   0.334    -.9508294    2.800293
    year81 |   .9375631   .9601498     0.98   0.329    -.9465207    2.821647
    year82 |   .9351966   .9796211     0.95   0.340    -.9870954    2.857489
    year83 |  -.2396555   1.155135    -0.21   0.836    -2.506355    2.027044
    year84 |  -.0543537   1.133581    -0.05   0.962    -2.278755    2.170054
    year85 |  -.2392129   1.102717    -0.22   0.828    -2.403053    1.924627
    year86 |   .4137892   .8975717     0.46   0.645    -1.347499    2.175077
    year87 |    .378063   .8990918     0.42   0.674    -1.386208    2.142334
    year88 |   .2666087   .8914042     0.30   0.765    -1.482577    2.015794
    year89 |  -.0249318   .8844667    -0.03   0.978    -1.760504     1.71064
    year90 |  -.0754031   .8765698    -0.09   0.931    -1.795479    1.644673
    year91 |   .0135561   .8810495     0.02   0.988    -1.715311    1.742423
    year92 |  -.5351233   .8854444    -0.60   0.546    -2.272614    1.202367
    year93 |   -.495669    .881808    -0.56   0.574    -2.226024    1.234686
    year94 |  -.2744524   .8845783    -0.31   0.756    -2.010244    1.461339
    year95 |   .9902915   .8329522     1.19   0.235    -.6441949    2.624778
    year96 |   .9723515   .8320823     1.17   0.243    -.6604279    2.605131
    year97 |   .9900778   .8321521     1.19   0.234    -.6428384    2.622994
    year98 |    .775383   .8417312     0.92   0.357    -.8763302    2.427096
    year99 |   .8966721   .8443634     1.06   0.289    -.7602061     2.55355
     _cons |   11.72799   .8490379    13.81   0.000     10.06194    13.39404
------------------------------------------------------------------------------
```

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All year-specific slopes on DOWNSTR simultaneously zero	0.0000	
All year-specific slope on DOWNSTR the same	0.0001	
All year-specific slopes on LDIST simultaneously zero	0.1176	NO
All year-specific slope on LDIST the same	0.0796	NO
All year-specific slopes on DOWNSTR*LDIST sim. zero	0.0000	
All year-specific slope on DOWNSTR*LDIST the same	0.0000	
All other distance effects simultaneously zero	0.0000	

Chapter 6 Complete regression results – With lot size interactions

6.1 Just structural characteristics and year dummies

```
Regression with robust standard errors                 Number of obs =    1087
                                                       F( 75,   1007) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.7016
                                                       Root MSE      =  .38044

------------------------------------------------------------------------------
```

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
sfd	.09481	.0366988	2.58	0.010	.0227952	.1668249
age	-.0052194	.0056616	-0.92	0.357	-.0163292	.0058904
age2	.0002038	.0001956	1.04	0.298	-.00018	.0005876
bedrms	.0974357	.0205704	4.74	0.000	.05707	.1378014
bthrms	.2481431	.0214184	11.59	0.000	.2061133	.2901729
notwdframe	.2826543	.0513306	5.51	0.000	.1819271	.3833815
heatelec	-.0905038	.0301272	-3.00	0.003	-.149623	-.0313846
constgood	.2263442	.0388267	5.83	0.000	.1501537	.3025347
constfair	-.249796	.0336365	-7.43	0.000	-.3158016	-.1837903
lotsize	-.393424	.1442812	-2.73	0.007	-.6765503	-.1102977
downstr79	(dropped)					
downstr82	2.287372	5.82413	0.39	0.695	-9.141448	13.71619
downstr85	(dropped)					
downstr88	-18.89541	4.085463	-4.63	0.000	-26.9124	-10.87841
downstr91	-12.71746	6.138887	-2.07	0.039	-24.76393	-.6709796
downstr94	.4410203	1.091111	0.40	0.686	-1.700092	2.582133
downstr97	-1.990148	2.211002	-0.90	0.368	-6.328848	2.348552
downstr99	-.4148739	2.494239	-0.17	0.868	-5.309375	4.479628
ldis79	-.4815353	.3347324	-1.44	0.151	-1.138388	.1753176
ldis82	-.5486539	.2764137	-1.98	0.047	-1.091067	-.0062411
ldis85	-.2097912	.4207702	-0.50	0.618	-1.035478	.6158955
ldis88	-.2724983	.2510048	-1.09	0.278	-.7650507	.2200542
ldis91	.0572806	.2043295	0.28	0.779	-.3436798	.4582411
ldis94	.1751047	.1931204	0.91	0.365	-.2038597	.5540692
ldis97	-.1006801	.1123568	-0.90	0.370	-.3211604	.1198002
ldis99	-.0717088	.0989604	-0.72	0.469	-.2659009	.1224833
downldist79	-.0771005	.070679	-1.09	0.276	-.2157954	.0615945
downldist82	-1.025939	2.485015	-0.41	0.680	-5.90234	3.850462
downldist85	-3.621995	2.672941	-1.36	0.176	-8.867168	1.623177
downldist88	8.234722	1.802516	4.57	0.000	4.697605	11.77184
downldist91	5.444944	2.684317	2.03	0.043	.1774492	10.71244
downldist94	-.3262005	.4817548	-0.68	0.498	-1.271559	.6191578
downldist97	.7794228	.981966	0.79	0.428	-1.147511	2.706357
downldist99	.2232517	1.109803	0.20	0.841	-1.95454	2.401043
vdownstr79	-12.19815	1.884776	-6.47	0.000	-15.89669	-8.499616
vdownstr82	-6.050183	4.832214	-1.25	0.211	-15.53254	3.432179
vdownstr85	76.88201	57.30682	1.34	0.180	-35.57244	189.3365
vdownstr88	8.256142	1.746708	4.73	0.000	4.828538	11.68375
vdownstr91	11.66796	5.202168	2.24	0.025	1.459632	21.87629
vdownstr94	.5363646	.5179867	1.04	0.301	-.4800922	1.552822
vdownstr97	.180645	1.603732	0.11	0.910	-2.966395	3.327685
vdownstr99	-1.015499	1.698739	-0.60	0.550	-4.348972	2.317975
vldis79	.2339744	.0744094	3.14	0.002	.0879591	.3799897
vldis82	.1678196	.0753361	2.23	0.026	.0199859	.3156533
vldis85	.1752435	.0796416	2.20	0.028	.018961	.331526
vldis88	.1229781	.0667584	1.84	0.066	-.0080234	.2539795
vldis91	.1166426	.0689074	1.69	0.091	-.018576	.2518613
vldis94	.1832859	.0629655	2.91	0.004	.0597272	.3068443
vldis97	.1694537	.0709502	2.39	0.017	.0302266	.3086808
vldis99	.1968427	.0673798	2.92	0.004	.0646219	.3290635
vdownldist79	5.32478	.8233748	6.47	0.000	3.709053	6.940507
vdownldist82	2.527925	2.04445	1.24	0.217	-1.483945	6.539795

vdownldist85	-31.07023	23.12852	-1.34	0.179	-76.45585	14.31538
vdownldist88	-3.718982	.8020938	-4.64	0.000	-5.292949	-2.145015
vdownldist91	-5.038796	2.253747	-2.24	0.026	-9.461376	-.6162172
vdownldist94	-.2542936	.2341911	-1.09	0.278	-.713852	.2052648
vdownldist97	-.0886993	.7097366	-0.12	0.901	-1.481431	1.304033
vdownldist99	.3232028	.768681	0.42	0.674	-1.185197	1.831603
year77	-.0279239	.1078797	-0.26	0.796	-.2396186	.1837709
year78	-.555888	.1803076	-3.08	0.002	-.9097096	-.2020664
year79	.4840608	.1432401	3.38	0.001	.2029776	.765144
year80	.922831	.9737513	0.95	0.344	-.9879832	2.833645
year81	.9341329	.979137	0.95	0.340	-.9872497	2.855515
year82	.8939822	1.050655	0.85	0.395	-1.167742	2.955706
year83	.2306941	1.177666	0.20	0.845	-2.080266	2.541654
year84	.4085505	1.163137	0.35	0.725	-1.8739	2.691001
year85	.2530232	1.132406	0.22	0.823	-1.969122	2.475168
year86	.4008101	.8529452	0.47	0.639	-1.272944	2.074564
year87	.3222346	.8573298	0.38	0.707	-1.360123	2.004592
year88	.1157686	.8485191	0.14	0.892	-1.549299	1.780837
year89	-.3423158	.8283121	-0.41	0.679	-1.967731	1.2831
year90	-.4179741	.8192932	-0.51	0.610	-2.025692	1.189743
year91	-.3361387	.8230389	-0.41	0.683	-1.951206	1.278929
year92	-.661575	.8281353	-0.80	0.425	-2.286643	.9634934
year93	-.5863717	.8227413	-0.71	0.476	-2.200856	1.028112
year94	-.4200524	.8256306	-0.51	0.611	-2.040206	1.200101
year95	.4363901	.7452147	0.59	0.558	-1.025962	1.898742
year96	.3972187	.7441496	0.53	0.594	-1.063043	1.85748
year97	.3655801	.7450614	0.49	0.624	-1.096471	1.827631
year98	.3212503	.7389294	0.43	0.664	-1.129768	1.771268
year99	.4601599	.7408714	0.62	0.535	-.9936688	1.913989
_cons	11.399	.7401734	15.40	0.000	9.946539	12.85146

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific slopes on DOWNSTR simultaneously zero	0.0002	
All lotsize-independent year-specific slope on DOWNSTR the same	0.0002	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.3611	
All lotsize-independent year-specific slope on LDIST the same	0.3490	
All lotsize-independent year-specific slopes on DOWNSTR*LDIST simultaneously zero	0.0003	
All lotsize-independent year-specific slope on DOWNSTR*LDIST the same	0.0002	
All lotsize-dependent year-specific slopes on DOWNSTR	0.0000	

simultaneously zero	
All lotsize-dependent year-specific slope on DOWNSTR the same	0.0000
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0003
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.0016
All lotsize-dependent year-specific slopes on DOWNSTR*LDIST simultaneously zero (on vX ldist variables)	0.0000
All lotsize-dependent year-specific slope on DOWNSTR*LDIST the same (on vX ldist variables)	0.0000

6.2 Including other distances

Regression with robust standard errors

Number of obs	=	1087
F(83, 999)	=	.
Prob > F	=	.
R-squared	=	0.7475
Root MSE	=	.35141

lsprice	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
sfd	.1561376	.0342351	4.56	0.000	.0889566	.2233187
age	-.0016907	.0056049	-0.30	0.763	-.0126893	.0093079
age2	-.0001244	.0001868	-0.67	0.506	-.000491	.0002422
bedrms	.116823	.0197209	5.92	0.000	.0781239	.1555222
bthrms	.2148243	.0210301	10.22	0.000	.173556	.2560926
notwdframe	.134415	.0481922	2.79	0.005	.0398454	.2289845
heatelec	-.0824512	.0286962	-2.87	0.004	-.1387629	-.0261394
constgood	.1145337	.0359167	3.19	0.001	.0440529	.1850144
constfair	-.1638627	.0328503	-4.99	0.000	-.2283261	-.0993992
lotsize	-.5241875	.5693386	-0.92	0.357	-1.641424	.5930491
downstr79	(dropped)					
downstr82	4.150832	4.76774	0.87	0.384	-5.205102	13.50677
downstr85	(dropped)					
downstr88	-19.77913	4.022621	-4.92	0.000	-27.67289	-11.88538
downstr91	-18.88275	6.878922	-2.75	0.006	-32.38154	-5.383952
downstr94	-1.161994	1.940248	-0.60	0.549	-4.969424	2.645436
downstr97	-2.807719	2.226972	-1.26	0.208	-7.177799	1.562361
downstr99	-4.892306	3.04658	-1.61	0.109	-10.87074	1.086125
ldis79	-.6136583	.4881272	-1.26	0.209	-1.571531	.3442139
ldis82	-.4277661	.4383145	-0.98	0.329	-1.287889	.4323565
ldis85	.0235832	.5397856	0.04	0.965	-1.03566	1.082827
ldis88	-.3167741	.3957669	-0.80	0.424	-1.093404	.4598557
ldis91	.0119798	.3772201	0.03	0.975	-.7282548	.7522144
ldis94	.1284788	.3748758	0.34	0.732	-.6071555	.8641132
ldis97	-.2289993	.3460179	-0.66	0.508	-.9080045	.4500059
ldis99	-.1487755	.3472802	-0.43	0.668	-.8302578	.5327069

downldist79	.6424392	.1175245	5.47	0.000	.4118161	.8730623
downldist82	-1.229116	2.036985	-0.60	0.546	-5.226376	2.768145
downldist85	-4.558664	2.4115	-1.89	0.059	-9.290349	.1735218
downldist88	9.119049	1.776809	5.13	0.000	5.632342	12.60576
downldist91	8.620668	2.991758	2.88	0.004	2.749818	14.49152
downldist94	.8690293	.8645906	1.01	0.315	-.8275927	2.565651
downldist97	1.664035	.9699183	1.72	0.087	-.2392759	3.567346
downldist99	2.645432	1.358699	1.95	0.052	-.0208	5.311664
vdownstr79	-12.69702	2.128615	-5.96	0.000	-16.87409	-8.519948
vdownstr82	-7.860077	3.915284	-2.01	0.045	-15.5432	-.1769526
vdownstr85	108.1734	52.02991	2.08	0.038	6.072946	210.2739
vdownstr88	8.154826	2.126575	3.83	0.000	3.98176	12.32789
vdownstr91	15.51394	6.106109	2.54	0.011	3.531668	27.49621
vdownstr94	.7983145	1.444248	0.55	0.581	-2.035792	3.632421
vdownstr97	.0597452	1.573182	0.04	0.970	-3.027376	3.146866
vdownstr99	1.370786	2.341305	0.59	0.558	-3.223655	5.965226
vldis79	.1342792	.4226906	0.32	0.751	-.6951841	.9637425
vldis82	.0713173	.4173672	0.17	0.864	-.7476997	.8903343
vldis85	.088456	.425911	0.21	0.836	-.7473267	.9242388
vldis88	.0196382	.4218423	0.05	0.963	-.8081605	.8474369
vldis91	.0110167	.4251677	0.03	0.979	-.8233076	.845341
vldis94	.0669103	.4199073	0.16	0.873	-.7570911	.8909118
vldis97	.061494	.422089	0.15	0.884	-.7667888	.8897767
vldis99	.0676226	.4217778	0.16	0.873	-.7600494	.8952946
vdownldist79	5.310019	.9562161	5.55	0.000	3.433597	7.186442
vdownldist82	3.147268	1.649982	1.91	0.057	-.090561	6.385097
vdownldist85	-43.82669	21.01229	-2.09	0.037	-85.05998	-2.593399
vdownldist88	-3.771125	.9906189	-3.81	0.000	-5.715057	-1.827192
vdownldist91	-6.798681	2.638362	-2.58	0.010	-11.97605	-1.621313
vdownldist94	-.4721381	.6994937	-0.67	0.500	-1.844784	.9005073
vdownldist97	-.1531307	.7049515	-0.22	0.828	-1.536486	1.230225
vdownldist99	-.7944184	1.097581	-0.72	0.469	-2.948247	1.35941
ld_vail_ski	-.8855005	.1257912	-7.04	0.000	-1.132346	-.6386553
ld_recareas	-.1447152	.0632044	-2.29	0.022	-.2687437	-.0206866
ld_railroad	.2314952	.0887395	2.61	0.009	.0573581	.4056324
ld_rivers	-.0528532	.0147172	-3.59	0.000	-.0817333	-.0239731
vld_vail_ski	.2696188	.1472277	1.83	0.067	-.0192923	.5585298
vld_recareas	.0580336	.0311546	1.86	0.063	-.0031023	.1191695
vld_railroad	-.0256867	.1088857	-0.24	0.814	-.2393576	.1879843
vld_rivers	.0267628	.016317	1.64	0.101	-.0052566	.0587823
year77	.0879751	.0902128	0.98	0.330	-.0890533	.2650034
year78	-.3021502	.1947759	-1.55	0.121	-.684367	.0800667
year79	.5380431	.1521684	3.54	0.000	.2394368	.8366495
year80	.6160871	.9896216	0.62	0.534	-1.325888	2.558063
year81	.6049962	.9944454	0.61	0.543	-1.346445	2.556438
year82	.5508142	1.030322	0.53	0.593	-1.47103	2.572659
year83	-.40708	1.156329	-0.35	0.725	-2.676193	1.862033
year84	-.1249217	1.154315	-0.11	0.914	-2.390082	2.140238
year85	-.3689251	1.112378	-0.33	0.740	-2.551791	1.813941
year86	.3645976	.8911179	0.41	0.683	-1.38408	2.113275
year87	.3830043	.8937187	0.43	0.668	-1.370777	2.136785
year88	.2085509	.8858359	0.24	0.814	-1.529761	1.946863
year89	-.300348	.8858321	-0.34	0.735	-2.038653	1.437957
year90	-.3361528	.8783079	-0.38	0.702	-2.059693	1.387387
year91	-.2379597	.8819083	-0.27	0.787	-1.968565	1.492645
year92	-.4955765	.8883239	-0.56	0.577	-2.238771	1.247618

year93	-.4383989	.8846305	-0.50	0.620	-2.174346	1.297548
year94	-.2521909	.8871148	-0.28	0.776	-1.993013	1.488631
year95	.7265304	.8293872	0.88	0.381	-.9010104	2.354071
year96	.7370473	.8285022	0.89	0.374	-.8887569	2.362851
year97	.7486399	.8289987	0.90	0.367	-.8781386	2.375418
year98	.6435452	.8349206	0.77	0.441	-.9948541	2.281945
year99	.760182	.83654	0.91	0.364	-.8813951	2.401759
_cons	12.45681	.9428994	13.21	0.000	10.60652	14.3071

Hypothesis	P-value of F-test	Reject?
All structural attribute slopes simultaneously zero	0.0000	
All lotsize-independent year-specific slopes on DOWNSTR simultaneously zero	0.0000	
All lotsize-independent year-specific slope on DOWNSTR the same	0.0000	
All lotsize-independent year-specific slopes on LDIST simultaneously zero	0.3585	
All lotsize-independent year-specific slope on LDIST the same	0.2775	
All lotsize-independent year-specific slopes on DOWNSTR*LDIST simultaneously zero	0.0000	
All lotsize-independent year-specific slope on DOWNSTR*LDIST the same	0.0000	
All lotsize-independent other distance effects simultaneously zero	0.0000	
All lotsize-dependent year-specific slopes on DOWNSTR simultaneously zero	0.0000	
All lotsize-dependent year-specific slope on DOWNSTR the same	0.0000	
All lotsize-dependent year-specific slopes on LDIST simultaneously zero (on vX ldist variables)	0.0068	
All lotsize-dependent year-specific slope on LDIST the same (on vX ldist variables)	0.0041	
All lotsize-dependent year-specific slopes on DOWNSTR*LDIST simultaneously zero (on vX ldist variables)	0.0000	
All lotsize-dependent year-specific slope on DOWNSTR*LDIST the same (on vX ldist variables)	0.0000	
All lotsize-dependent other distance effects simultaneously zero (on vX "other distance" variables)	0.0012	

ECONOMIC VALUATION OF MORTALITY RISK REDUCTION

Volume II
THE EFFECTS OF AGE AND FAMILY STATUS ON THE VALUE OF STATISTICAL LIFE – EVIDENCE FROM THE AUTOMOBILE MARKET AND A NATIONAL SURVEY OF AUTOMOBILE USE

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Abstract

This study reports on a new national survey of individual automobile usage designed to provide information on automobile safety expenditures by family status and age. Noting that, for a family, the safety of an automobile is a public good, these data, when combined with an analysis of the FARS data set on fatal automobile accidents and a hedonic price function for automobiles, allows estimation of the value of statistical life for individual family members over their lifetime. The research also attempts to resolve the problem of an anomalous sign on the coefficient on fuel consumption in prior hedonic price studies of automobile safety. The principal result is that the value of statistical life remains relatively constant over the lifetime for all family members with the exception of parents with children living in the household, who have a lower value. Adults without children do not show a similar decrease in the value of statistical life. Estimates of income elasticity are also presented and a theoretical explanation for the results is provided.

Section 1
Introduction

Little work has been done either theoretically or empirically to value morbidity and mortality either for children or retired adults (for exceptions see Blomquist, et al., 1996, and Jenkins, et al. 1999). This paper attempts to address both of these issues by first presenting a theoretical model of how families value risk and then examining family automobile purchases. In particular, using a standard model of family decision-making, we show that parents may value risks to their children's lives (the model assumes two altruistic parents) through Nash cooperative bargaining to determine how much money to invest in the safety of their children. To allow empirical estimation of values, automobile safety is then shown to be a family public good, where the marginal cost of purchasing and operating a safer automobile is set equal to the usage-weighted sum of the values of statistical life (VSL) of family members. We use data on automobile purchases to estimate how much families with children spend on automobile safety, how much families with retired members and no children spend on automobile safety, and how much families without children or retired members spend on automobile safety. This not only allows estimation of an average value of a statistical life (VSL) for each type of family, but also allows estimation of an average value of a statistical life (VSL) for different age groups (children, adults and seniors) by family type and income level.

The research reported here combines primary data on automobile usage by family members with secondary data from both the automobile market and the FARS data set on automobile accidents. This allows calculation of the VSL for different family members from choices made concerning the type of vehicle and usage pattern by family members. An important issue that has clouded the potential reliability of the VSL obtained from estimated hedonic price functions for automobiles (that include risk of death) is that prior studies have shown what appears to be a positive correlation between fuel consumption and the price of automobiles rather than the expected negative correlation (people should be willing to pay less for cars with poor fuel economy). Our theoretical work in the next section provides a possible explanation that also suggests a revised estimation procedure.

The paper is organized as follows: Section 2 presents a theoretical model of family automobile purchase decisions focusing on safety, fuel usage, how safety values for each individual are determined in a family setting, and proposes a methodology for estimating the VSL of family members of different ages. Section 3 describes the survey methodology used to obtain new data on automobile usage by children, adults, and seniors. Section 4 addresses the problem of driver characteristics affecting estimates of the inherent risk of fatality of different automobiles and develops a procedure for identifying the driver independent level of risk, summarizes our empirical work estimating a hedonic price function for automobiles showing a negative correlation between risk of fatal accident and price and fuel costs, and addresses issues which arise with multiple vehicle families. Section 5 presents estimates of average implied values of life for different family groups and income levels by age as well as estimated income elasticities.

Section 2
Theoretical Issues

How willingness to pay (WTP) for health and safety may vary with the age of the person at risk is a very important policy question for which we have little well-established empirical data. Cropper and Freeman (1991) address this question with a life-cycle consumption-saving model that they apply with a quantitative example to examine how WTP for a risk reduction in the current time period can be theoretically expected to change over a person's lifetime. This model is based on the premise that a person makes consumption and saving decisions over time to maximize personal utility. Because this model is based on the premise that utility is a function of consumption, the authors note that, *if* there is additional utility derived from survival per se, then the life-cycle model provides a lower bound estimate of WTP. The quantitative example depends on assumptions regarding a lifetime pattern of earnings, endowed wealth, the rate of individual time preference, and other parameters of the model. These will all vary for different individuals, and uncertainty exists empirically about population averages for many of these factors. However, using reasonable values to calibrate the model is illustrative. Cropper and Freeman note that if consumption is constrained by income early in life, the model predicts that VSL increases with age until age 40 to 45, and declines thereafter. Shepard and Zeckhauser (1982) also illustrate this point with numerical examples for the life-cycle model. When they estimate the model with reasonably realistic parameters and assume no ability to borrow against future earnings or to purchase insurance, they find a distinct hump in the VSL function with a peak at around 40 years and dropping to about 50% of the peak by 60 years. When they allow more ability to borrow against future earnings and to purchase insurance, the function flattens and at 60 years drops only to 72% of the VSL at age 40. However, the hump shape to the VSL over a person's lifetime remains.

The conclusions reached by these theoretical analyses of the effect of age on WTP for mortality risk reduction using the life-cycle model are somewhat consistent with the empirical findings obtained by Jones-Lee et al. (1985). However, the empirical findings show that WTP varies with age much less than would be predicted by the life-cycle models. In this stated preference study, respondents gave WTP estimates for reductions in highway accident mortality risk and the answers showed a fairly flat hump-shaped relationship between VSL and age, peaking at about age 40. Although the directions of the changes in WTP with age are consistent with what the life-cycle models predict, the magnitudes of the changes are smaller. The Jones-Lee et al. results show that at age 65 the VSL is about 90% of the VSL of a 40-year-old person.

It is often suggested that WTP will be lower for the elderly than for the average adult because expected remaining years of life are fewer. This expectation is based on the presumption that WTP for one's own safety declines in proportion to the remaining life expectancy. Some analysts have suggested that effects of age on WTP might be introduced by dividing average WTP per statistical life by average expected years of life remaining (either discounted or not) to obtain WTP per year of life (Moore and Viscusi, 1988; Miller, 1989; Harrison and Nichols, 1990). Such a calculation implies very strong assumptions about the relationship between life expectancy and the utility a person derives from life; namely, that utility is a linear function of life expectancy and that the value of life year remains constant.

Determining appropriate WTP values for changes in mortality risks to children poses some particular analytical challenges. Children are not the economic decision makers whose preferences can be analyzed to determine an efficient allocation of society's resources regarding their own health and safety, so both revealed and stated preference approaches must rely on parental decisions to show what WTP for children's health and safety might be. Based on the expected relationship between WTP and expected life-years lost, it may be reasonable to assume that reductions in risks to children are valued equal to or greater than risks to adults. Blomquist, et al. (1996) support this view in their analysis of seat belt use for children. On the other hand, the life-cycle consumption-saving models show increasing WTP for risk reductions between the ages of 20 and 40, reflecting the typical pattern of increasing income and productivity during this stage of life. Extending this to children might suggest lower WTP for reducing risks to children, however, this pushes beyond the theoretical constructs of the life-cycle model regarding an individual as an economic decision maker. The only theoretical model that addresses these concerns, with respect to dependent children, has been developed by Chestnut and Schulze (1998). Their work treats the case of a family with non-paternalistic altruistic parents who engage in Nash cooperative bargaining to determine health and safety expenditures on their children and the implied VSL. We use this model as a starting point for our analysis.[1]

As indicated in the introduction, a secondary theoretical issue is that fuel consumption appears to have the wrong sign in existing hedonic price functions for automobiles that have been used to estimate the VSL (Atkinson and Halvorsen, 1990, and Dreyfus and Viscusi,1995). Atkinson and Halvorsen (1990) use the data for 112 models of new 1978 automobiles to obtain estimates of the VSL. Since the available fatality data is a function of both the inherent risk of the vehicle and the driver's characteristics, the drivers' characteristics are included in the regression as control variables. Their estimated VSL for the sample as a whole, based on willingness to pay, is $3.357 million 1986 dollars. The data used in Dreyfus and Viscusi (1995) differ from those used in earlier studies in that they reflect actual consumer automobile holdings. Dreyfus and Viscusi (1995) use the 1988 Residential Transportation Energy Consumption Survey together with data from industry sources. They generalize the standard hedonic models to recognize the role of discounting on fuel efficiency and safety. Their estimates of the implicit value of life range from $2.6 to $3.7 million. Both studies show a positive correlation between automobile price and fuel consumption.

Given the state of existing research, our first task is to develop a model that can potentially explain the positive correlation between automobile price and fuel consumption. The second task is to develop a model of the behavior of households with dependent children. This model is developed in the context of automobile safety to allow empirical estimation of the VSL for family members by age group, family status, and income group. The existing theoretical literature only considers individuals rather than families, with the exception of the work by Chestnut and Schulze mentioned above.

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[1] It should be pointed out that some interesting revealed preference empirical approaches based on a household production function framework to analyze household expenditure decisions as they relate to children's health have been attempted (Agee and Crocker, 1996; Joyce et al. 1989). These analyses infer implicit WTP for changes in children's health as revealed by expenditure decisions of the household. Limitations in available data and analytical difficulties in properly specifying and verifying modeled relationships pose challenges for this approach; however, its basis in actual household decisions and behavior is an important strength. Estimates of WTP for changes in mortality risk for children are not directly available from these two studies, but similar approaches might be applied to obtain such WTP estimates.

To begin, we address the problem of fuel consumption by considering the case of a single individual with no family who may, or may not, survive for a single period. The following notation will be useful:

c = consumption,

w = wage income,

r = risk of a fatal automobile accident per mile driven,

Π = probability of survival without automobile fatality risk,

Π -r = probability of survival with automobile fatality risk,

m = total miles driven

a = level of some other positive automobile attribute (e.g., acceleration)

P(r,a) = automobile price per mile driven (decreasing in r and increasing in a)

F*(r,a)) = fuel consumption per mile (increasing in r and a)

G = price of fuel

U(c,a,m) = strictly concave utility function.

Note: subscripts or primes denote derivatives where appropriate.

Note that we propose that the individual realizes that the fuel consumption of the car is itself a function of the attributes of the automobile. We will justify this proposal when we consider the manufacturer's decision below. Also, to abstract from the life cycle issues of owning and financing an automobile, we analyze the problem in terms of the annualized price per mile of owning the vehicle, P, without loss. In this setting, the individual must make four choices. First, the individual chooses the level of consumption, c. Second, this is traded off against the choice of automobile safety (how risky per mile a car to purchase, r) taking into account that lower r implies that both the price of the car itself over the m miles driven each year, P(r,a)m, and total cost for fuel with price per gallon G and fuel consumption F* driven m miles per year, GF*(r,a)m, are greater for a safer car since P_r, $F_r^*<0$. Third, the individual chooses the other characteristic of the car, a, realizing, for example, that increased acceleration will both increase the price of the car and increase fuel consumption since P_a, $F_a^*>0$. Fourth, the individual will choose how many miles to drive, m. The individual is assumed to maximize expected utility,

$$(\Pi - rm)U(c, a, m), \quad (1)$$

where it is assumed that the death state provides no utility because the individual has no family, subject to the budget constraint,

$$(\Pi - rm)(w-c) - P(r,a)m - GF^*(r,a)m = 0. \quad (2)$$

This budget constraint assumes that costless insurance (priced at expected value) is available both to cover the purchase price and operating costs of the automobile. Most car loans, in fact, carry life insurance for the amount of the loan, and life insurance could presumably cover other costs. The optimal choice for r, risk per mile, is determined by

$$VSL = -(P_r + GF_r^*), \quad (3)$$

where

$$VSL \equiv (U/U_c) + w - c. \quad (4)$$

Equation (4) sets the marginal increase in cost for purchasing and operating a safer car per mile equal to the VSL. The VSL is defined in (4) for the case of perfect insurance markets and is equal to the monetized value of utility, (U/U_c), which is lost in death, plus the excess of earnings over consumption. The interpretation of this relationship is much clearer in the family setting that we treat below, so we will defer discussion.

The optimal choice of the attribute, a, is determined by

$$U_a/U_c = m(P_a + GF_a^*) \quad (5)$$

which sets the marginal willingness to pay for the attribute (acceleration) equal to the incremental total cost.

The total miles driven, m, is determined by

$$U_m/U_c - rVSL - GF^* = P \tag{6}$$

so that the marginal willingness to pay for an additional mile driven, U_m/U_c, net of the risk cost of driving an additional mile, net of the cost of fuel for an additional mile, GF*, is set equal to the per mile capital cost of the car, P. It is this last condition that helps explain the peculiar result obtained in prior estimates of the hedonic price function for automobiles. All buyers have the same marginal value for improved fuel economy equal to G, the price of fuel.

Competitive automobile manufactures should attempt to minimize the cost per mile of driving their automobiles including both the capital and fuel cost per mile of automobile life given the choice of other characteristics (r and a). Thus, for any given vector of automobile characteristics, manufacturers optimize fuel economy at the fixed marginal value of G. There is no hedonic market for fuel economy *per se* because for any vector of attributes, there is only one optimal level of fuel economy, because all buyers have the same marginal valuation of fuel economy. This is unlike an other attributes, a, such as acceleration, where, for the same safety level, there are a variety of marginal values for different buyers for acceleration depending on tastes. For these attributes, makers respond by offering a variety of vehicles with the same level of risk but different levels of acceleration. In contrast, the marginal value for fuel economy is always G, so no hedonic market exists. Clearly, fuel consumption itself then becomes a function of other car attributes. This can be shown by considering the design problem of a particular manufacturer with a cost of production per mile of life for the cars that they offer of C(a,r,F). Given a particular choice of a and r by a buyer, the maker is forced by competitive pressure to minimize the total cost per mile to buyers,

$$C(a,r,F) + GF. \tag{7}$$

The condition for optimal fuel consumption in the engineering design of the vehicle is then

$$-C_F = G. \tag{8}$$

This implies that there is an optimum fuel consumption F*(a,r) for any choice by consumers of a and r and the cost function relevant for the hedonic price solution for profit maximization over a and r by the maker is C*(a,r,F*(a,r)). The maker faces a hedonic price function only defined in a and r, P(a,r), not fuel consumption which is optimized in the engineering design of the vehicle, and maximizes profits P(a,r) - C*(a,r,F*(a,r)) with respect to a, implying

$$P_a = C_a^*, \quad (9)$$

and with respect to r, implying

$$P_r = C_r^*. \quad (10)$$

So, a particular maker will pick a and r by setting marginal costs equal to the slope of the hedonic price function for r, given a, and for a, given r, implying a mix of cars with different levels of a and r available to consumers from different makers with different cost functions.

In summary, given G, the price of fuel, the choice of F will be made by the automobile maker and becomes a function of r and a, since fuel usage will be optimized by makers for any combination of these attributes chosen by consumers. Consumers and makers are faced with a hedonic price function P(r,a) which is the envelope curve of the cost tradeoffs for makers and value tradeoffs for consumers between attributes. Buyers face a pre-optimized choice of fuel consumption, F*(r,a), for each level of attributes that they choose in their purchase decision.

If these arguments are correct, then adding fuel economy as an explanatory variable in the estimated hedonic price function results in a mis-specification of the model. This mis-specification could easily result in an anomalous sign on the coefficient for fuel economy. Rather, the appropriate procedure may be to estimate F*(r,a) and P(r,a) and use (3) above to estimate the VSL for the individual from these relationships and the price of gasoline, G.

The model developed above can readily be extended to a family setting by using the Nash cooperative bargaining between parents approach employed by McElroy and Horney (1981). Following our previous work (Chestnut and Schulze, 1998), we modify the notation used above, again considering a single car family, as follows:

n = the size of the family,

$i = 1, 2, \ldots, n$ denotes individual family members,

$i = 1$ denotes the mother,

$i = 2$ denotes the father,

$i = k = 3, \ldots, n$ denotes children,

c_i = consumption of the ith family member,

w_i = wage of family member i,

r= automobile fatality risk per mile driven, the same for all family members,

Π_i = probability of survival, excluding automobile fatality risk, of i,

m = total vehicle miles driven

m_i = total miles of driving for family member i

$P(r,a)$ = automobile price per mile driven,

$F^*(r, a)$ = fuel consumption per mile driven,

$U^k(c_k,a,m_k)$ = child's utility function,

$U^i(c_i;\ldots, m_i,a,(\Pi_k - r)U^k(c_k,m_k),\ldots)$ = parent's utility function ($i = 1, 2$), and

E^i = individual expected utility in separation ($i = 1, 2$).

The family must decide how much to allocate to each family member for consumption, on the risk level of the single automobile they purchase for all, attribute a. and the number of miles driven for the car itself and each person who rides in the car. The hedonic price and fuel consumption functions for the automobile are the same as in the previous model. Utility functions of both the father and mother are assumed to depend not only on their own consumption, driving and car attribute, but also on the expected utilities of each of their children. The children's utility is assumed to be a function of their own consumption, the car attribute, and the miles they ride in the car.

Investment in the safety of their children is a public good to the parents, which is the subject of negotiation, as is the level of consumption of each. The Nash cooperative bargaining model assumes that the solution maximizes the multiplication of the increase in the expected utility of the outcome over the threat point of expected utility in separation for the mother and the father. The threat points, E^i, are assumed, in models of the family, to be a function of divorce laws, job opportunities, etc. Thus, in the Nash cooperative bargaining solution,

$$[(\Pi_1\text{-}rm_1)U^1 - E^1]\,[(\Pi_2\text{-}rm_2)U^2 - E^2], \qquad (11)$$

is maximized with respect to c_i, r, a, m, and m_i, subject to the budget constraint,

$$\sum_{i=1}^{n} (\Pi_i\text{-}rm_i)\,(w_i - c_i) - (P - GF^*)m = 0, \qquad (12)$$

and constraints on the use of the car such as,

$$m - m_i \geq 0 \qquad i = 1,\ldots\ldots, n$$

so that no individual family member can ride more miles than the car itself travels, and

$$m_1 + m_2 - m_{12} - m_k \geq 0 \qquad k = 3,\ldots\ldots, n$$

so that no child can ride more miles than the parents can collectively drive the child. Note that, to avoid pointless complication of the model, m_{12} is taken to be a constant number of miles that the parents ride together, where it is assumed that m_1, $m_2 \geq m_{12}$.

The resulting conditions for choosing the level of automobile risk and miles driven imply that the individual VSLs of family members all take the form:

$$VSL_i \equiv U^i/U^i_c + w_i - c_i \qquad i = 1,\ldots\ldots\ldots,n. \qquad (13)$$

The remarkable fact is, that, in spite of the complicated structure of the problem specified above, the implied VSL_i for each family member shown in (13) is identical in form to that for the single individual shown in (4) above. The interpretation of the VSL_i can be illustrated with the following examples. Imagine that the mother is the sole breadwinner with a stay-at-home father.

In this case, assuming that the children are young, $w_i - c_i < 0$ for the other family members and $w_m - c_m > 0$ for the mother. Thus, if the mother were to die, this would be a severe financial blow to the rest of the family and the mother's VSL would reflect this relative to the VSL of other family members. For young children it is clear that $w_k - c_k < 0$ in the short run. However, in the inter-temporal version of the model, $w_k - c_k$ is replaced by its discounted present value, which may be positive. U^i/U^i_c depends primarily on c_i in the single period model and on the lifetime consumption pattern in the full inter-temporal model. The important point is that the child's consumption depends in youth on the parents' income and wealth. Further, if parents find the value of their child's smile to be high enough, the child's consumption will be maintained by them, at a high level, leading to a high VSL. A young child's utility and the utility they derive from that happiness may also be large in the parent's view from relatively small levels of money consumption, also leading to a high VSL. These arguments suggest that the VSL of children is a purely empirical question and depends not only on their own life cycle wealth but also on their family's wealth and the beliefs of the parents regarding their children's utility.

The choice of automobile risk, r, is determined by

$$\sum_{i=1}^{n} k_i VSL_i = -(P_r + GF_r^*) \tag{14}$$

where usage weights for the vehicle for each family member are defined as $k_i = m_i/m$. Thus, the safety of the shared family vehicle is determined by a public good condition that sets the sum of the usage weighted VSLs of individual family members equal to the marginal cost of obtaining a safer automobile. The marginal cost of a safer vehicle is the slope of the hedonic price function for automobile safety, $-P_r$, plus the marginal fuel cost penalty, $-GF_r$, which, by (14), is set equal to sum of the usage weighted VSL_i for the family, $\sum_{i=1}^{n} k_i VSL_i$, to determine the choice of per mile automobile risk, r.

Thus, if we obtain predicted values for the marginal cost of reduced risk per mile ($P_r + GF_r^*$) and the share of automobile use, k_i, for each family member by age group for different households, we can use equation (14) to obtain estimates of the VSL_i. Note that equation (14) is a single equation embedded in a system of simultaneous FOC equations. To each FOC equation, we appended an additive error term. Assume that each of these error terms is independently, identically distributed over families around a mean of zero. Because m_i and m are endogenous variables in the simultaneous FOC equations, consistent estimates will not be obtained by using the method of lest squares if m_i and m are correlated with the disturbance term in equation (14). A two-stage procedure is required to obtain the consistent estimates. In the first stage, reduced-form equations for m_i and m will be estimated using appropriate exogenous variables which reflect the family characteristics. The predicted m_i and m that are uncorrelated with the residuals in equation (14) will be used as the instrumental variables for m_i and m. In the second stage, expression (14) will estimated by least squares using predicted m_i and m (which provide predicted k_i) to obtain consistent estimates of the VSL for adults, children and seniors.

The next section describes the survey methodology used to collect the necessary primary data to employ the proposed methodology.

Section 3
Survey Design and Implementation

Secondary data describing the detailed usage of vehicles by family members has been unavailable, Since such data are necessary to implement the methodology proposed in the last section for measuring the VSL of family members, a national survey was undertaken to collect data on how families choose and use automobiles, as well as on their attitudes and beliefs regarding automobile safety. This survey consisted of two parts, a telephone screening survey used to develop an appropriate sample and collect information on usage, followed by a mail survey. Both the telephone and mail surveys were extensively pre-tested and revised prior to implementing a pilot aimed at 80 households to formally test the telephone/mail survey methodology. Only small changes were made to the survey instruments following this final test. Both surveys can be found in Appendix D.

The purpose of the telephone survey was to identify appropriate households and to obtain data on automobile usage that was judged too difficult for respondents to fill out themselves in a mail survey. Note that the mail surveys were customized for each respondent and included respondent specific information on automobile make, model, and purchase price. Both the telephone and the mail survey were developed following Donald Dillman's Tailored Design Method (1999).

The telephone survey begins by indicating that the interviewer is calling on behalf of Cornell University. The first five questions determine if the interviewer and household meets the requirements for the sampling. Question 6 asks for detailed information on automobiles owned or leased by the household while Question 7 elicits information on the residents' ages and relationships. Question 8 elicits the percentage of miles that each member of the household rides in each of the three most driven cars. Needless to say, this is a difficult question and necessitated a personal telephone interview with trained interviewers. Question 9 attempts to find out whether household members typically ride in the front or back seat of the three most driven vehicles. Questions 10 to 18 collect information on the reasons and distances to various destinations that people drive their cars to help in explaining driving patterns. Question 19 recruits respondents for the follow up mail survey. Questions 20 to 27 collect socioeconomic data on respondents including income.

The cover of the mail survey booklet is titled "WHAT ARE YOUR VIEWS ON AUTO SAFETY," shows a picture of a family next to a Ford Windstar (thanks to Ford for granting permission to use the photo), and has indicates that the survey is being conducted for Cornell University in the lower left hand corner. The first page thanks the respondent for "agreeing to complete this important survey on automobile safety," and repeats the information on the most, second most and third most driven automobiles taken from the telephone survey and asks the respondent to correct any errors. Question M1 asks if the respondent has read or heard about automobile safety in the last six months. Questions M2-M6 ask about insurance and repair costs and features of each of the vehicles. The mail survey was necessary to allow collection of subjective risk information from respondents that required use of a risk ladder as a visual aid. Thus, M7 asks for a subjective risk assessment of having a fatal accident (compared to the average driver in the same type of automobile) for the respondent. M8 asks for a subjective assessment of a child's risk of dying relative to an adult's risk in a serious automobile accident. The next questions ask the respondent for their perceived risk of the safety of the vehicles that they drive. The last two pages ask a Contingent Valuation question on the value of improved automobile safety for comparison to the hedonic price estimates of the VSL to be obtained from the study.

A random digit-dialing sample of 8519 telephone numbers was obtained from Sample Survey Inc., a well-known and respected source of survey information. Although the target number of completed mail surveys was only 600, past experience has shown that random digit dialing produces a large number of non-household, disconnected, or ineligible numbers for household surveys. The telephone screening survey was implemented between July 1 and August 5, 2001 and employed a minimum of 13 attempts to reach each telephone number. The completed telephone surveys averaged 14 minutes in length. After screening out businesses and other non-household phone numbers, ineligible households such as those with more than 5 people or three automobiles (it proved impossible to design a manageable survey for such households), those with no car, etc, but including those households which were unreachable after 13 or more tries, the overall response rate was about 40% for the telephone survey as shown in

Table 3.1. This produced 1,235 completed interviews. Of these, 926 or 75% agreed to participate in the mail survey.

Table 3.1 Disposition

				Final
Total Cases (T)				8, 519
Known non-household Ineligible (A)				2, 712
	Final Disconnect			1, 302
	Final Computer Tone			423
	Business/Government			897
	Non-Residential Number			90
Known Household Ineligible (B)				1, 093
	Ineligible - > 5 people, 0 autos, > 3 autos, employer vehicle, gift vehicle, don't know make			679
	Language Barrier			414
Known Household Eligible (C)				
	I	Completed Interview		1,235
	NC	Non-Contact – Respondent not available for duration of study		45
	Refusals (R)			168
	R	SCR-Soft Mid-Interview Terminate		0
	R	SCR-hard Mid-Interview Terminate		168
Unknown Household Status (D)				3,266
	UH	No Answer/Phone Busy		1,204
	UH	Initial Disconnect/Computer Tone		9
	UO_NON_HUDI			450
	UO	Non-HUDI	Answering Machine	308
	UO	Non-HUDI	Remainder Respondent not available	86
	UO	Non-HUDI	Interviewer Reject	18
	UO	Non-HUDI	Scheduled Callback	38
	UO_HUDI			1,603
	UO	HUDI	Soft Refusal	72
	UO	HUDI	Hard Refusal, Don't know/Refuse Q1 or Q2	1,531
Total Dialed				**8,519**
Known non-household Ineligible (A)				2,712
Known household (KH) = (I + P + R + NC + B)				2,541
Unknown Household Status (D)				3,266
	Working numbers (WN) = KH + D)			5,807
	Working % (WKG) = (WN / T)			68.17%
	Non-household % = (A / T)			31.83%
Known household Ineligible (B)				1,093
	Household Eligibility Rate (NEI) = (KH – B) / KH			56.99%

Table 3.1 (Continued)	
Completed recruitment Survey (AAPOR RR4*)	39.98%
****AAPOR RR4 = I/ [I + R + NC + (WKG*NEI*UH) + (NEI * (UO_NON_HUDI + UO_HUDI))]**	

The mail survey was sent in waves from July 6, 2001 to August 6, 2001. The survey packet included a letter from Cornell University describing the importance of their response and the nature of the study, a $5 cash incentive, the 12-page survey booklet, and a post-paid return envelope. A reminder post card was mailed 7 days after each survey packet was sent thanking those who had returned their survey and reminding those that had not to please complete the survey or ask for a replacement. Two weeks after each survey packet was sent, follow-up phone calls were made to non-respondent households with more than 6 attempts, if necessary. Table 3.2 presents the response data for the telephone follow up survey. The overall response rate for completed follow-up phone calls was 78%.

Table 3.2 Response Rate Data For Follow-Up Survey

	Count	**Percent of Starting Sample**
Starting Sample	394	
Nonworking Numbers		
Disconnected	7	1.78%
Computer Tone	1	0.3%
Ineligibles		
More than 5 people	13	3.3%
No autos	5	1.3%
Adjusted Sample	368	
Refusals (R)	4	1.0%
More than 6 attempts	55	34.7%
Active sample	0	0.0%
Completed Reminder Call *(completes/adjusted sample)*	309	78.4%
Will return survey	140	45.3%
Needs survey	45	14.6%
Won't return survey	9	2.9%
Already returned survey	114	36.9%
Completed survey over the phone	1	0.3%

Note: Response rate includes pretest calling

The detailed response rate information for each wave of the mail survey by date mailed is presented in Table 3.3. The overall response rate for the mail survey was 74% with 625 completed surveys, exceeding the initial target of 600.

Table 3.3 Detailed Response Rate Information

Filename	Total Quantity	Caseid range	Date Survey Mailed	Date Postcard Mailed	Date Reminder Calls Began	Response Rate Before reminder Calls Began	Number of Completed Mailed Survey	Final Response Rate
Pretest	80	1001-1080	7/2/01	7/9/01	7/20/01	65%	64	80.0%
list7-5f.xls	98	2001-2098	7/6/01	7/13/01	7/25/01	65%	74	75.5%
list7-9f.xls	242	3001-3242	7/9/01	7/16/01	7/25/01	49%	180	74.4%
list7-11f.xls	70	4001-4070	7/11/01	7/18/01	7/31/01	64%	51	72.9%
list7-13f.xls	42	5001-5042	7/13/01	7/20/01	7/31/01	62%	31	73.8%
list7-16f.xls	58	6001-6058	7/16/01	7/23/01	7/31/01	40%	45	77.6%
list7-18f.xls	30	7001-7030	7/18/01	7/25/01	8/3/01	40%	18	60.0%
list7-20.xls	36	8001-8037	7/20/01	7/25/01	8/3/01	57%	27	75.0%
list7-23f.xls	49	9001-9049	7/23/01	7/27/01	8/3/01	49%	37	75.5%
list7-25f.xls	53	10001-10053	7/25/01	7/30/01	8/9/01	51%	39	73.6%
list7-27f.xls	72	11001-11072	7/27/01	8/1/01	8/9/01	42%	53	73.6%
list7-30f.xls	22	12001-12022	7/30/01	8/3/01	8/15/01	41%	11	50.0%
list8-1f.xls	12	13001-13012	8/1/01	8/6/01	8/15/01	33%	6	50.0%
list8-3f.xls	42	14001-14042	8/3/01	8/9/01	8/17/01	67%	36	85.7%
list8-6f.xls	20	15001-15020	8/6/01	8/13/01	8/17/01	40%	17	85.0%
TOTALS	846						625	73.9%

Section 4
Econometric Analysis

For purposes of describing the econometric analysis, we use the following notation: Let

TPM = total annual personal riding miles of the family in the automobile,

TVM=total annual driving miles of the family in the automobile, which is generally less than TPM,

M_i = total annual personal riding miles of the ith family member,

MM= total annual mother riding miles in the automobile,

FM = total annual father riding miles in the automobile,

KM = total annual children riding miles in the automobile,

$$(TPM= \Sigma_i M_i =MM+FM+KM)$$

r = average automobile inherent fatality risk per driving mile per occupant (the same for all family members),

P(r) = automobile price or capital cost per driving miles (decreasing in r),

$P(r) \times TVM$= annual automobile price or capital cost per family

F(r)= automobile fuel consumption expenses per driving mile (decreasing in r), and

$F(r) \times TVM$=annual fuel consumption expenses per family.

Using this notation, the approach used in the study to obtain the VSLs of family members requires estimation of

$$-[P'(r)+F'(r)]=\Sigma_{i=1}^{n} M_i VSL_i /TVM \qquad (15)$$

Thus, the safety of the shared family vehicle is determined by a public good condition that sets the marginal cost of obtaining a safer vehicle for the family equals to the usage-weighted average of individual family member's VSL where the weights are each family member's relative use. The marginal cost of a safer vehicle for an each occupant -P'(r) and -F'(r) can be derived from the slope of the hedonic price function HP(r,O) and hedonic fuel efficiency function HF(r,O) for automobile safety. r is still the automobile fatality risk per driving mile per occupant and O is the other automobile characteristics.

Each family will select the available automobile risk-price and risk-fuel efficiency combination that yields the maximum expected utility for the whole family. This is obtained where P(r) is tangent to the hedonic price function HP(r,O) and F(r) is tangent to the hedonic fuel efficiency function HF(r,O).The equilibrium obtains when P' (r)= HP_r and F'(r)= $-HF_r$. Hence, we can use the slope of the hedonic price and fuel efficiency functions with respect to r to get the marginal cost of obtaining a safer vehicle for each family.

By (15), the marginal cost of obtaining a safer vehicle for each family is set equal to the usage-weighted average VSL for the family, $\sum_{i=1}^{n} M_i VSL_i / TVM$, to determine the choice of automobile risk, r. If we use hedonic functions to represent the left hand side of equation (15), it reflects vehicle characteristics. The right hand side of equation (15) reflects the family characteristics. Based on this equation, the VSL for each family member can be estimated using the expected driving habits of individual family members.

4.1 Hedonic Price and Fuel Efficient Models

The first step is to obtain the marginal cost of a safer vehicle for a family owning vehicle j using hedonic models:

$$-[P'(r_j)+F'(r_j)] = -HP_{rj}(r_j,O_j)+HF_{rj}(r_j,O_j) \equiv \mathrm{St}(\mathrm{VSL}_j) \qquad (16)$$

The right hand side of equation (15) is the marginal cost of purchasing and operating a safer vehicle j, and it can also be regarded as the standard VSL for vehicle j ($\mathrm{St}(\mathrm{VSL}_j)$). Obviously, it should only depend on vehicle characteristics such as the make, model and year of a vehicle. We standardize the total annual driving mileage in each vehicle to 14000 miles. With the data on vehicle characteristics and average risk of a fatality per riding mile per occupant for different types of automobile, we can estimate hedonic indices of the purchase price and fuel efficiency for each vehicle. The standard expression for determining the marginal cost ($\mathrm{St}(\mathrm{VSL}_j)$) for any make, model and year of vehicle j from the hedonic price and fuel efficiency models is:

$$\mathrm{St}(\mathrm{VSL}_j) = -\beta_m \times \mathrm{P}_j / [\mathrm{r}_j \times 14000 \times \sum_{t=1}^{L_j} (\frac{1}{1+i})^t\ ] + \alpha_m / (r_j \times fe\_city_j) \qquad (17)$$

Where β_m is the regression coefficient for inherent vehicle risk in the hedonic price model,

P_j is the purchase price of vehicle j,

r_j is automobile fatality risk per driving mile per occupant,

i is the discount rate, set to 10 percent,

L_j is the expected vehicle life, set to Max{1,10-(purchase year_j -model year_j)}, which standardizes the age effect of a vehicle on its price,

$\mathrm{fe\_city}_j$ is the fuel efficiency in miles per dollar of gasoline for vehicle j in year 2001, (ignoring the difference in gasoline price at different locations)

α_m is the regression coefficient for inherent vehicle risk in hedonic fuel efficiency model.

Now, given information on the characteristics of each vehicle j, and estimates of β_m and α_m from the hedonic functions, we can calculate St(VSL $_j$) by Equation (17). From Equation (15), $VSL_j \equiv -(P'+F')_j = \sum_{i=1}^{n} M_{ij} VSL_{ij} / TPM_j$. If we divide people into three groups according to age: adults (16-64), seniors (>=65) and kids (0-15), the VSL for each age group in the jth vehicle is VSL_{aj}, VSL_{sj} and VSL_{kj}, respectively.

Equation (15) becomes:

St(VSL $_j$)

$=\sum_{i=1}^{n} (M_{ij} VSL_{ij} / TVM_j)$

$$=(AM_j \times VSL_{aj}/TVM_j + KM_j \times VSL_{kj}/TVM_j + SM_j \times VSL_{sj} / TVM_j) \quad (18)$$

where AM_j, KM_j and SM_j are the total riding miles of adults, kids and seniors in the jth, vehicle respectively.

4.2 Estimating the VSL for the Different Types of Families

If we assume that the VSLs of adults, kids and seniors are constant across different families, then VSL_a, VSL_k and VSL_s can be treated as parameters and estimated from Equation (18) directly. However, the VSL in different types of households will almost certainly vary. For example, an adult in a rich family is likely to have a higher VSL than one in a poor family. Thus, to estimate the VSL for different income groups the sample will be split into families with low, medium and high incomes.

Another way to remove the influence of family characteristics on VSL is to express VSL_{aj}, VSL_{kj} and VSL_{sj} as functions of family characteristics. Among all the family characteristics that might affect the VSL, income is the most important, and VSL is almost certainly positively related to the average income of a household. If EY is the average income per adult equivalent in household i, we assume VSL(i)= $\beta_i + \beta_{EY}\log(\frac{EY}{\overline{EY}})$ where $\overline{EY}$ is the average equivalent income for all households. β_i is the purified VSL for a household, and (18) becomes:

-[P'(r)+F'(r)] =

$$\beta_A \text{*AM/TVM+} \beta_K \text{*KM/TVM} + \beta_S \text{*SM/TVM} + \beta_{EY}[\log(\frac{EY}{\overline{EY}}) \text{*TPM /TVM}] \quad (19)$$

where TPM=KM+SM+AM.

The VSL for adults, seniors and kids can be estimated directly by using OLS regression. Estimated parameters β_A, β_K and β_S correspond to the average VSL for adults, seniors and kids for a household with average equivalent income $\overline{EY}$, respectively. β_{EY} measures the income effect on VSL and it can be used to calculate the income elasticity.

4.3 VSL for Families with Multiple Members and Multiple Vehicles

Assume that a multiple-vehicle family bought all vehicles owed by the family, step by step, rather than simultaneously. For example, there were no other vehicles owned by a two-vehicle family when it determined the optimal risk-usage-price-fuel efficiency combination for the first vehicle. The expected utility maximization problem faced by the family for the choice of the first vehicle is not different from the problem faced by a one-vehicle family. We can derive the same formula for VSL associated with the first vehicle as Equation (15):

$$-[P'(r1)+F'(r1)] = \sum_{i=1}^{n} M1_i VSL_i / TVM1 \qquad (20)$$

where the number "1" attached to variables represents the corresponding variables for the first vehicle. When the family determined to buy the second vehicle, the first vehicle's condition and all physical variables related with the first vehicle have been fixed and could be regarded as exogenous variables. The family chose the optimal risk-usage-price-fuel efficiency combination for the second vehicle conditional on the existing first vehicle. The expected utility maximization problem faced by the family for the second vehicle is:

$$[(\pi_m - r1MM1 - r2MM2)U^m(c_{m,}(\pi_k - r1KM1 - r2KM2)U^k(c_k, KM1 + KM2),\ldots,$$

$$MM1 + MM2) - E^m] \times [(\pi_f - r1FM1 - r2FM2)U^f(c_{f,}(\pi_k - r1KM1 - r2KM2)$$

$$U^k(c_k, KM1 + KM2),\ldots, FM1 + FM2) - E^f]$$

is maximized with respect to $M2_i$, TVM2, c_i, π_i, and r2, subject to the budget constraint,

$$\sum_{i=1}^{n}(\pi_i - r1 \times M1_i - r2 \times M2_i) \times (w_i - c_i) - P(r1) \times TVM1 - F(r1) \times TVM1$$

$$- P(r2) \times TVM2 - F(r2) \times TVM2 - H(\pi_1, \ldots, \pi_n) = 0$$

The FOCs for this problem give a result similar to Equation 15) for the second vehicle.

$$-[P'(r2)+F'(r2)] = \sum_{i=1}^{n} M2_i VSL_i / TVM2 \qquad (21)$$

This implies that if we can obtain vehicle characteristics and the family usage variables for an individual vehicle, the same procedure for estimating VSL for a one-vehicle family can be applied to a multiple-vehicle family. In our empirical work, if the family has multiple vehicles, firstly we estimate the TPM and TVM in all vehicles owned by the family. Secondly, we allocate the TPM and TVM to each vehicle j to get TPM_j and TVM_j. Thirdly, we decompose TPM_j

into AM_j, KM_j and SM_j. Finally, the VSL for adults, kids and seniors can be estimated using Equation (18) for each vehicle.

4.4 Estimating the Components of a VSL Model

In order to get a consistent estimate of VSL_{aj} from Equation (18), we need to get the appropriate measures of TVM_j, AM_j, KM_j and SM_j accounting for the fact that these variables are determined by the family (i.e. endogenous). Decisions to purchase a vehicle are made on expectations about how the vehicle will be used. The new data set collects enough information on family characteristics and how vehicles are used, to estimate the mileage variables associated with each vehicle. In addition, the risk of having a fatality, r, must be determined for each type of vehicle, and used to estimate hedonic models for the purchase price and fuel efficiency.

4.4.1 Estimates of Risk by Vehicle

When a family makes a decision to buy a new or used vehicle, the selection is based on expectations about how the vehicle will be used. The most important factors considered for the analysis are how far the vehicle is driven each year and what is the typical occupancy rate. The price of the vehicle and the fuel efficiency, the two primary economic costs to the family, will be determined by the vehicle's physical characteristics. These characteristics include the size, power, and quality of the vehicle, and most importantly for the analysis, the safety of the vehicle. The safety ratings of each type of vehicle were estimated from an earlier analysis of data on traffic fatalities (Fatal Accident Reporting Service, FARS) and vehicle ownership (National Personal Transportation Survey, NPTS). This analysis has been presented in full in a report to the EPA (Environmental Protection Agency) and a research paper.

The safety rating of a vehicle was determined by estimating the probability per thousand miles traveled of having a fatality in an accident. This safety rating was determined by the probabilities of having different types of accidents (one-vehicle, two-vehicle and multi-vehicle), and the probabilities that the occupants will survive in these accidents. All of these probabilities are functions of the vehicle's characteristics and the characteristics of the driver and the occupants. For example, heavy vehicles are relatively safe in a two-vehicle accident, but may have a relatively high probability of having a one-vehicle accident. Wearing a seatbelt is more important for survival in an accident than having an airbag. The statistical framework for the different models underlying the safety rating of a vehicle is described in Appendix A, and the estimated models and definitions of the explanatory variables are presented in Appendix B.

The safety rating of each type of vehicle is computed using the same set of characteristics for the driver and the occupants. The rationale is to standardize the effects of driving behavior. Some types of vehicle, for example, have higher probabilities of accidents because the drivers are more likely to fail tests for sobriety. Similarly, very young drivers have higher probabilities of having an accident. In general, the overall probability of having a fatality in a vehicle is proportional to the number of miles driven and the total number of occupants. The safety rating used in the hedonic models for each type of vehicle was computed under the assumption that there are two adults in each vehicle who drive 14,000 miles in a year. The effect of making this assumption is that some vehicles, which have high-observed rates of fatalities, such as pickup trucks, have lower predicted rates of fatalities. The reason is that the specified occupants are more safety conscious (e.g. by wearing seat belts) than the typical behavior of the actual occupants in the fatality data.

Using a standardized set of characteristics for the occupants is an important distinguishing feature of this analysis compared to other studies in the literature. A discussion of other studies and the estimated safety ratings from our analysis are presented in Appendix C. The safety rating of a vehicle measures the probability of having a fatality for a specified number of miles driven. This measures the value of r in the hedonic models for the price and the fuel efficiency of each type of vehicle (make, model and year). The two estimated hedonic models are also presented in Appendix C. The estimated elasticities for r used to compute the standard VSL in Equation (11) are $\alpha_m = 0.0258$ for the fuel efficiency and $\beta_m = -0.069$ for the price of the vehicle.

4.4.2 Household Types in the Survey Data

The 2001 National Auto Safety Survey (Full Scale) includes two parts: a recruitment survey and a mail survey. It obtains information on household characteristics related with the choice of automobiles and the use of automobiles, and vehicle characteristics such as the make, model, year, price and perceived risk of a fatality (i.e. safety factor).

The main characteristics of the survey data are:

- It merges information about household characteristics and vehicle characteristics into the same data set;
- It provides detailed information on the usage of different vehicles by individuals in a family. Hence, the expected total personal riding miles of a family in each vehicle (TPM), total vehicle driving miles in each vehicle (TVM) and the riding miles of each age group of family members, such as AM, SM and KM can all be estimated.
- It includes a risk ladder of different types of vehicles. The ladder assumes that each type of automobile is driven an average of 14,000 miles per year by someone with average driving ability. Since the drivers' characteristics are standardized by average driving ability, the effects of drivers' characteristics are removed and this risk ladder reflects the inherent risk associated with each type of vehicle. The risk is measured by the number of fatalities occurring in each year for every 100,000 automobiles per occupant using the models described in Section 3.1. Therefore, we can derive the automobile fatality risk per driving mile per occupant by using the formula: [risk value/(14,000 $\times$ 100,000)].

The survey covers 1147 sampled households, with no more than five family members, owning 1 vehicle, 2 vehicles or 3 vehicles. For each household, there are 349 variables, each one corresponding to a question. Only 623 households completed both surveys, and only 487 households answered all of the important questions about family member's age, total riding miles, each person's riding percentage, and the cost of gasoline. There were five households that reported at least one vehicle driven over 80,000 miles per year (the average miles driven per year for the vehicle with the highest VMT per family is less than 16,000 miles), and three households reported a vehicle with zero miles driven. These households were regarded as outliers and deleted. Therefore, the final sample had complete information about 479 families and 791 vehicles, and a description of this data set follows.

Table 4.1 Distribution of Six Types of Household (HH) by the Number of Vehicles Owned

Type of HH	1-vehicle HH	2-vehicle HH	3-vehicle HH	Total
PA HH	75	127	48	250
AK HH	29	97	29	155
SK HH	0	1	0	1
ASK HH	1	0	1	2
SA HH	6	11	2	19
PS HH	25	23	4	52
Total	136	259	84	479

Kid: 0<=age<=15

Adult: 16<=age<=64

Senior: 65<=age

PA HH: every family member is an adult

AK HH: household is composed of adults and kids

SK HH: household is composed of seniors and kids

ASK HH: household is composed of adults, seniors and kids

SA HH: household is composed of seniors and adults with at least one member younger than 60

PS HH: all family members are no less than 60 years old, and at least one member is a senior

From the Table 4.1, we can define three types of representative household that have a relatively large number of families in the sample. These are:

(1) 2-vehicle PA HH: Pure adults household with 2 vehicles;

(2) 2-vehicle AK HH: 2-vehicle household with both adults and kids;

(3) 1-vehicle PS HH: 1-vehicle household with every family member no less than 60 and at least one member is a senior.

The basic demographic characteristics of the three representative households in the survey data are listed in Table 4.2.

Table 4.2 Demographic Characteristics of Representative Households

Type of HH	Number of HH	Total Adults	Total Kids	Total seniors
2-vehicle PA HH	127	260	0	0
2-vehicle AK HH	97	206	176	0
1-vehicle PS HH	25	2	0	30

Table 4.3 Total Annual Riding Miles of the Family in Each Vehicle (TPM)

Type of HH	Number of HH	AVG(TPM1)	AVG(TPM2)	AVG(TPM3)	AVG(TPM)
1-vehicle HH	136	15256	0	0	15256
2-vehicle HH	259	23516	14756	0	19136
3-vehicle HH	84	27589	15156	6599	16448
all HH	479	21885	14854	6599	17806

AVG(TPMj)-------average TPM in the jth vehicle owned by the household (j=1, 2, 3)

AVG(TPM) -------average TPM in all vehicles owned by the household

Table 4.4 Total Annual Miles Driven per Vehicle (TVM)

Type of HH	number of HH	AVG(TVM1)	AVG(TVM2)	AVG(TVM3)	AVG(TVM)
1-vehicle HH	136	12055	0	0	12055
2-vehicle HH	259	16038	10182	0	13110
3-vehicle HH	84	18976	11510	5768	12085
all HH	479	15422	10507	5768	12666

AVG(TVMj)-------average TVM in the jth vehicle owned
by the household(j=1, 2, 3)

AVG(TVM)--------average TVM in all vehicles owned by the household

The data in Tables 4.3 and 4.4 summarize how the vehicles are used. The first vehicle in each type of household is driven more in households with more vehicles. The same relationship holds for the miles ridden and driven in the second vehicle between 2-vehicle and 3-vehicle households. This implies that one reason for buying another vehicle is to use at least one of the vehicles more intensively. However, the AVG (TPM) (average TPM per vehicle) and AVG(TVM) (average TVM per vehicle) are similar for households with 1, 2 or 3 vehicles. In other words, the total distance ridden and driven by a household is roughly proportional to the number of vehicles owned. Nevertheless, the distribution of the TPM and TVM among the first, second and third vehicles is not even. The first vehicle is always the vehicle ridden and driven most by the family. This illustrates how important the survey data were for determining how to allocate TPM and TVM to each vehicle in multi-vehicle households.

The annual average driving miles for all vehicles is 12,666 in our sample. This is slightly smaller than the average miles per year used in the risk ladder (14,000 miles per year). The ratio of AVG (TPM)/ AVG (TVM) is 1.4, implying that vehicles have a driver only for at least 60 percent of the miles driven.

Table 4.5 Household Characteristics

Type of HH	Number of HH	average household size	average number of adults	average number of adult equivalents	average household income ($)	average income per adult equivalent EY($)
1-vehicle HH	136	1.75	1.103	1.226	46213.24	39225.59
2-vehicle HH	259	2.76	1.873	1.541	67432.43	46149.25
3-vehicle HH	84	3.02	2.393	1.629	87738.1	56813.37
all HH	479	2.52	1.745	1.467	64926.47	46053.57

The demographic and income characteristics for each type of household are summarized in Table 4.5. For households with more than one member, household income is converted to income per adult equivalent using the standard weights adopted by the U.S. Bureau of the Census. The equivalence scale is based on the official weighted average poverty thresholds for 1992 (Data Source: Bureau of the Census (1993: Table A)), following the Table 3-1 of Citro and Michael (1995). The values of the equivalence scales are 1, 1.279, 1.566, 2.007, 2.323, 2.679, 3.023, 3.367 and 4.024 for family size 1, 2, 3, 4, 5, 6, 7, 8 and 9 or more, respectively. Using this measure, the income per adult equivalent is over \$39 thousand, \$46 thousand and \$57 thousand for 1-vehicle, 2-vehicle and 3-vehicle households, respectively, and the overall average is \$46 thousand.

4.4.3 Estimating How Vehicles Are Used

Given estimates of the hedonic models for the price of a vehicle and the fuel efficiency presented in Appendix C, the final component of the VSL model in Equation (18) is to estimate the mileage (TVM) and the occupancy (TPM) for each vehicle. These estimates are treated as the expected levels of use of a vehicle when it is purchased, and are, therefore, the appropriate levels to use when estimating the VSL for adults, seniors and kids. The summary of the survey data in the previous section shows strong positive relationships between the number of vehicles owned and household income and household size (see Table 4.5). In addition, the total mileage and occupancy for a household are roughly proportional to the number of vehicles owned, and the composition of a family is also a potential factor in determining how vehicles are used.

The first models of how vehicles are used by each household determine the mileage in all vehicles (TVM), the total occupancy in all the vehicles (TPM), and the proportion of miles traveled by kids. These variables are determined by the economic and demographic characteristics of each household and the number of vehicles owned. The estimated equations have the following form:

$$\log(TPM) = \alpha_0 + \Sigma_i \alpha_i A_i + e$$

$$\log(TVM) = \beta_0 + \Sigma_i \beta_i B_i + u$$

$$\log(KM/(TPM-KM)) = \gamma_0 + \Sigma_i \gamma_i C_i + v$$

Where A_i, B_i and C_i are vectors of representative measured regressors reflecting family characteristics, α_i, β_i and γ_i are the corresponding parameters and e, u and v are unobserved residuals. The least square estimates of these equations are presented in Table 4.6.

Table 4.6 Parameter Estimates for Mileage and Occupancy

(1) Parameter Estimates for log(TPM)			(2) Parameter Estimates for log(TVM)		
Variable	Parameter Estimate	t Value	Variable	Parameter Estimate	t Value
Intercept	6.53983	12.48	Intercept	6.5161	12.63
Seniorratio	-0.54969	-1.94	Seniorratio	-0.46013	-1.66
lnEY	0.25296	5.16	lnEY	0.25614	5.31
lnT	0.27909	2.58	lnT	0.06833	0.87
lnN	1.00904	9.43	lnN	1.03166	10.36
D	-0.11621	-0.38	D	-0.28313	-0.94
Dratio	1.05343	2.48	Dratio	1.07935	2.57
Kinverse	3.13611	3.08			
Square(Kinverse)	-4.11556	-2.06			

Table 4.7 Parameter Estimates for Occupancy by Kids

Parameter Estimates for log(KM/(TPM-KM))		
Variable	Parameter Estimate	t Value
Intercept	-1.43278	-1.08
lnkidnonkidratio	0.8454	6.22
lnEY	0.52692	1.58
lnN	0.04631	0.19

where: Seniorratio=(seniors)/(total family size)

lnEY=log(Average equivalent income)

lnT=log(number of household members)

lnN=log(number of vehicles owned)

D: Dummy variable for a senior household

(D=1 if the household is a senior household)

Dratio=D/(the age of the oldest person in the household-64)

Kinverse=1/(1+the age of the youngest kid in a household)

if the household has at least 1 kid

Square(Kinverse)=Square of Kinverse

lnkidratio=log((K/(T-K)), and K is the number of kids

The estimates in Table 4.6 show that both TVM and TPM are almost proportional to the numbers of vehicles (N), as expected. In contrast, the effect of household size is much smaller, particularly on TVM. Given a high enough income, most adults (and seniors) would like to have their own vehicle, and total mileage is proportional to the number of vehicles. The effect of income is inelastic, but it is clearly statistically significant.

The effects of the composition of a household require some further explanation. For total occupancy, (TPM), the positive coefficient for Kinverse (3.13611) and the negative coefficient for Square(Kinverse) (-4.11556) implies that the TPM for kids increases until the youngest kid is 2 and then decreases. The survey data indicate that average KM decreases with age. Since the TPM for "young seniors" should not drop a lot compared to adults, and the TPM for "old seniors" drops dramatically in the survey data, we include three variables: Seniorratio, D and Dratio. The coefficient for Seniorratio and D are both negative (-0.54969 and -0.11621) and the coefficient for Dratio is relatively large and positive (1.05343). Hence, if the household is a senior household (everyone is older than 60 and at least one member is a senior) and the oldest person is only 65 years old, then the total senior effect will be (-0.54969-0.11621+1.05343) > 0. In other words, for a senior household with young seniors, the TPM will be higher than it is in an adult household. Nevertheless, when a senior household is composed of "old seniors", Dratio will decrease and the TPM will also decrease as age increases. This is exactly the type of behavior observed in the survey data. The TPM for seniors does not drop in one step. It drops at ages above 65, slowly for "young seniors" and then more rapidly. One reason for the implied increase in TPM at age 65 is that these people typically have more free time for travel and are still healthy. The effects of seniors dominate the effect of household composition on TVM, and the effects of kids were not significant. In general, older seniors have lower values of both TPM and TVM, as expected.

Given predictions of TPM and TVM, it is necessary to allocate these values among adults, seniors and kids. For all adult and all senior households, there are no problems with this allocation. For mixed households with adults and seniors, the estimates in Table 3.6 imply that SM = Exp (-0.56) AM = 0.57 AM (i.e. when Seniorratio = 1), and consequently, TPM can be allocated between adults and seniors. For kids, a separate equation is estimated (see Table 4.7) for occupancy by kids. For a given household, KM increases with the number of kids and with income, but has only a small positive relationship with the number of vehicles. For a given income, the total mileage traveled by kids is not affected by the number of vehicles. For adult households, however, the total mileage traveled is twice as large in a two-vehicle household than a one-vehicle household.

The next step is to allocate TPM, TVM and KM to individual vehicles for households that own more than one vehicle. When a household makes a choice about which vehicle to drive given the estimated TVM, the main concerns affecting the choice are the vehicle's characteristics, such as its size and level of safety. Hence, the explanatory variables for the allocation will only reflect the vehicle's characteristics. We assume that the optimal vehicle characteristics for each vehicle were chosen when the vehicle was purchased. Hence the vehicle's characteristics are predetermined explanatory variables for the observed data in the survey.

For a 2-vehicle household, the dependent variables for allocating TPM, TVM and KM between the first and the second vehicle are log odds ratios:

lnTPMratio2---log(TPM in the first vehicle/TPM in the second vehicle),

lnTVMratio2---log(TVM in the first vehicle/TVM in the second vehicle),

lnKMratio2 ---log(KM in the first vehicle/KM in the second vehicle).

The explanatory variables are:

lnVehicleage1---log(the model year of the first vehicle),

lnVehicleage2---log(the model year of the second vehicle).

The least square estimates are presented in Table 4.8.

Table 4.8 Parameter Estimates for Allocating TPM, TVM and KM for a 2-Vehicle Household

Variable	TPM		TVM		KM	
	Parameter Estimate	t ratio	Parameter Estimate	t ratio	Parameter Estimate	t ratio
Intercept	367.06428	1.21	493.45121	2.01	1114.50482	0.82
lnVehicleage1	82.48443	2.31	25.33822	0.88	359.34027	2.38
lnVehicleage2	-130.71572	-5.21	-90.21446	-4.46	-506.03159	-4.87

In all three models, the coefficients have the expected signs. The proportions of TPM, TVM and KM driven in the first vehicle are higher in newer vehicles and lower if the second vehicle is newer. Given these predicted proportions, it is possible to determine TPM, TVM and KM in the first vehicle and second vehicle respectively using the observed model year of the vehicles owned by each 2-vehicle household. In other words, we can get TPM_j, TVM_j and KM_j for a 2-vehicle household. The corresponding values of SM_j are determined by the following rule for households with adults and seniors.

SM_j = [0.57*(TPM_j-KM_j)*total seniors number]/(0.57*total seniors + total adults) If the seniors are in a senior household, then SM_j=TPM_j. Note that the difference in safety between the two vehicles was not statistically significant in these models, and this variable is not reported in Table 4.8.

For a 3-vehicle household, the final model allocated the miles between the first vehicle and the other two vehicles. TPM_j, TVM_j and KM_j for the first vehicle. Efforts to model the allocation between the second and third vehicle were not successful.

lnTPMratio3---log(TPM in the first vehicle/TPM in the other two vehicles),

lnTVMratio3---log(TVM in the first vehicle/TVM in the other two vehicles),

lnKMratio3---log(KM in the first vehicle/KM in the other two vehicles).

The logarithm of model year of each vehicle are explanatory variables and a new variable, which is lnriskratio---log(minimum risk rate among the three vehicles/the risk rate of the first vehicle). This new variable measures the relative risk of the first vehicle when one of the other vehicles is safer (ratio $\leq$ 1). A bigger ratio implies a safer first vehicle. Therefore, positive coefficients for lnriskratio are expected. The least square estimates of the models are given in Table 4.9.

Table 4.9 Parameter Estimates for Allocating TPM and KM to the First Vehicle in a 3-Vehicle Household

Variable	TPM		TVM		KM	
	Parameter Estimate	t ratio	Parameter Estimate	t ratio	Parameter Estimate	t ratio
Intercept	557.82765	1.72	279.86044	0.91	552.07303	0.31
lnVehicleage1	43.30447	1.16	70.2771	1.99	606.17145	2.62
lnVehicleage2	-79.85588	-3.65	-80.21175	-3.87	-557.17158	-2.96
lnVehicleage3	-36.84872	-1.92	-26.92953	-1.49	-121.61599	-0.9
lnriskratio	0.38974	1.97	0.31179	1.67	3.1269	2.71

The positive coefficients for the model year of the first vehicle and the negative coefficients for the other two vehicles are consistent with our expectations. In addition, the risk coefficients have the expected positive sign. This model allocates TPM, TVM and KM between the first vehicle and the other two vehicles.

There are no formal models for explaining the allocation of miles between the second and third vehicles. From the Tables 4.3 and 4.4, the average TPM in the third vehicle is approximately 44% of that in the second vehicle, and the average TVM in the third vehicle is approximately 50% of that in the second vehicle. Therefore, the following rule is used to allocate the miles between the second and third vehicles:

TPM in the third vehicle =0.44*TPM in the second vehicle

TVM in the third vehicle =0.5*TVM in the second vehicle

KM in the third vehicle = 0.44*KM in the second vehicle

Finally, the same rule for determining the allocation between AM and SM described for two vehicle households is used for households with both adults and seniors, and three vehicles. Combining all of the vehicles in this section gives estimates of the mileage traveled by adults, seniors and kids in each vehicle, and TVM for each vehicle.

Section 5

Conclusions: Estimates of Average VSL By Group and Income Level

Three typical family groups own most of the total 783 vehicles:

1) PA: pure adults family (424 vehicles);

2) AK: family with both kids and adults (267 vehicles);

3) PS: pure senior family (57 vehicles).

To address possible income effects on the VSL, we divide each type of family into three types according to per capita income, low income, middle income and high income. Specifically, income type is defined as:

Low income family: Per Capita Income<=$15000;

Middle income family: $15000<Per Capita Income<=$37500;

High income family: Per Capita Income>$37500.

Three no intercept OLS regressions were run, one for each of three family groups. (If we run regressions with intercepts, the intercepts are insignificant). The estimated results without intercepts are shown in the following table.

Table 5.1 Estimated VSL for Families

Family Type	Income Type	Sample Size	Person Type*	VSL (million)	t value
PA	Low	67	Adult low	6.81	9.37
	Middle	188	Adult middle	6.07	13.63
	High	169	Adult high	7.27	14.88
AK	Low	133	Adult low	3.36	8.36
			Kid low	2.54	3.64
	Middle	120	Adult middle	3.79	8.96
			Kid middle	5.12	6.46
	High	14	Adult high	-	-
			Kid high	-	-
PS	Low	9	Senior low	7.67	4.60
	Middle	31	Senior middle	8.42	6.85
	High	17	Senior high	8.25	3.35

Note:

1. *Person Type is Defined as:
   Adult low: adults from low-income families;
   Adult middle: adults from middle-income families;
   Adult high: adults from high-income families;
   Kid low: kids from low-income families;
   Kid middle: kids from middle-income families;
   Kid high: kids from high-income families;
   Senior low: seniors from low-income families;
   Senior middle: seniors from middle-income families;
   Senior high: seniors from high-income families.
2. - means insufficient sample size to obtain reliable estimates.

Since the average ages for adults, seniors and kids in our data set are 39.8, 74.2 and 7.8 respectively, the VSL for each group can be interpreted as the VSL for that group at the average group age.

The estimated results are inconsistent with discounted present value of life-year model. Seniors are more valuable than adults in all families for any of the income levels. For families with both adults and kids, the VSL of kids is higher than that of adults in the middle-income family, but lower in low income families.

An alternative procedure is to estimate VSL in a pooled model that assumes identical VSLs across family types by age group.

From our theoretical model, the VSL can be estimated according to equation:

$$-[P'(r)+F'(r)]*TVM = [VSL(A)*AM+VSL(K)*KM+VSL(S)*SM]+(y-\bar{y})*TP$$

Using this approach, (which also allows calculation of income elasticities) the VSL for different age groups for individuals of average income and driving miles is shown in the following table.

Table 5.2 Income Elasticity Estimates

Family Type	Sample Size	Per Capita Income	Person	VSL* (million)	t value	β_{EY}	t value	elasticity
PA	424	40776	Adult	6.67	22.28	18.19	2.05	0.111
AK	267	18709	Adult	3.59	12.25	0.62	-0.02	-0.003
AK	267	18709	Kid	3.64	6.80	65.08	1.14	0.335
PS	57	26462	Senior	8.18	8.97	7.97	0.14	0.026

Comparing the estimated VSL between tables 5.2 and 5.1, the difference is not surprising. The VSL estimated here (pool model) is for people from a standardized household with average driving miles, occupancy and income. The VSL estimated previously (three group model) refers to people with average income only and differing average driving miles and occupancy.

The average estimated income elasticity for the VSL for each group is:

ε_{income}(for adults)=0.14

ε_{income}(for kids)=0.13, and

ε_{income}(for seniors)=0.11

These results provide estimates of income elasticity for each age group that is smaller than Blomquist's estimates of about 0.3.

The estimated VSL from both the group and pooled model show that seniors have the highest value among all age groups, given the same income. Moreover, the relative value of kids' VSL compared to adults depends on income class in the first model and is slightly higher in the second estimate than adults' VSL. The overall pattern is somewhat inconsistent with the discounted present value of life-year model, which suggests that VSL at age t is equal to the value of a life-year times the discounted present value of remaining years of life at age t. Because the average ages for adults, seniors and kids in our data set is 39.8, 74.2 and 7.8 respectively, we would expect the VSL for kids is to be somewhat lower than for adults. Similarly, the VSL for seniors should also be lower than for adults according to discounted present value of life-year model. However, since the VSL for kids depends on parents' tastes and preferences and may not be stationary over the life cycle, the discounted present value of life year model may well be misleading.

However, it should be noted that the analysis so far has omitted an important effect that has not previously been considered, fragility. For estimating the hedonic models, we use a standardized or inherent automobile risk ladder for each occupant in the vehicle that removes the effects of drivers' and occupants' characteristics on the risk. In other words, we assume that each occupant in the same vehicle has the same risk rate. However, seniors are, on average, more fragile than adults and kids are, on average, less fragile than adults. The effect of perceived fragility is that seniors will regard themselves more risky than adults in the same vehicle and will be induced to buy a less risky (more expensive) vehicle even if their VSL is the identical. Therefore, the fragility unadjusted VSL estimates obtained above may well over-estimate the actual VSL for seniors. The same logic implies that the fragility unadjusted VSL obtained above underestimates the actual VSL for kids since they are less fragile than adults in accidents (except for infants). If we express fragility unadjusted VSL as VSL1 and fragility adjusted VSL as VSL2, then the following relationship holds between VSL1 and VSL2 for people from PA and PS households:

$$VSL2(a)PA=VSL1(a)PA*r/r(a)$$

$$VSL2(s)PS=VSL1(s)PS*r/r(s)$$

Where r is the average driver value used in the standardized automobile risk ladder we used in hedonic models, r(a) is the risk for adults and r(s) is the risk for seniors, if we assume an adult at average age is an average driver, then r is equal to r(a). Hence, VSL2(a)PA equals VSL1(a)PA, i.e. the fragility adjusted VSL for adults from PA household is the same as the fragility unadjusted value. From the survey data, people's perception of the likelihood of a 70-year-old person dying compared to an average adult when involved in a serious accident is about 39% higher. For households earning the average income, VSL1(a)PA and VSL1(s)PS are 6.62 and 8.44 respectively. If we consider the fragility effect on VSL, fragility adjusted VSL (VSL2) of seniors from pure senior households will be less than that of adults from pure adults households by 8.3%. Because the fragility adjusted VSL of adults from PA household, VSL2(a)PA, is 6.62, the fragility adjusted VSL of seniors from PS household, VSL2(s)PS, is 6.07.

For the AK family, it is more complicated to adjust VSL by fragility because the household's real risk is an appropriate weighed average risk with both kids and adults. To simplify problem, we still assume VSL2(k)AK=VSL1(k)AK*r/r(k). For children, the survey data shows that the perception of the likelihood of a 8-year-old child dying compared to an average adult when involved in a serious accident is about 12% lower. VSL1(k)AK is 3.63, therefore the fragility adjusted VSL for kids, VSL2(k)AK, is 4.13.

The fragility adjusted VSL shows that, for the average household in the sample, kids are more valuable than adults in a family with both kids and adults. We compare the VSL for seniors from pure senior family with adults from pure adults family in order to remove the overestimated income effect from adults in AK family. Seniors' VSL is 6.07 which is less than adults' VSL 6.62. Thus, our results are now much more consistent with the simple discounted present value of life years approach when we include the effect of fragility on the VSL. However, parents have a relatively low VSL which may simply reflect imperfect capital markets and the cost of children, factors not considered in the discounted present value of life years approach.

Table 5.3 lists both the fragility unadjusted and adjusted VSLs for people from different family groups.

Table 5.3 Fragility Adjusted VSL ($million) by Family Group

Age Group	Fragility Unadjusted VSL	Fragility Adjusted VSL
Kids(AK)	3.63	4.13
Adults(AK)	3.72	3.72
Adults(PA)	6.62	6.62
Seniors(PS)	8.44	6.07

Similarly we can adjust for fragility in estimating the VSL using the pooled model. The fragility-adjusted VSLs obtained from the pooled model are consistent with the discounted present value of life years model.

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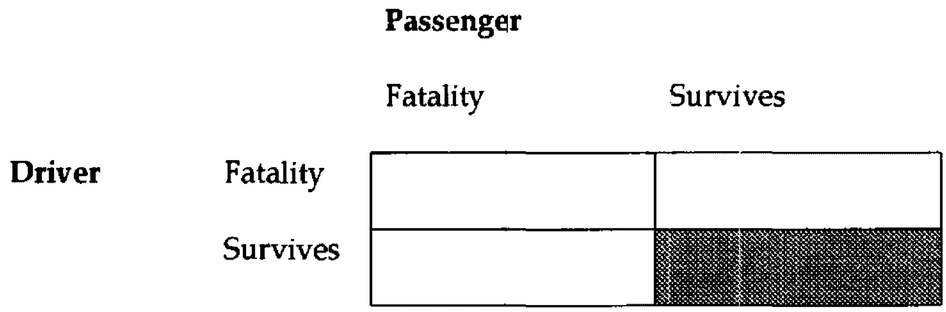
Appendix A

The Statistical Framework for Modeling Automobile Fatalities

The basic data on fatalities in automobile accidents provide a census of accidents with at least one fatality. Hence, the probability of an accident being included in the data set depends on the number of individuals involved in an accident as well as the characteristics of the vehicles and driving behavior (e.g. the use of seat belts). This can be illustrated by the following examples for a one-vehicle and a two-vehicle accident. For a one-vehicle accident, assume that the driver and one passenger have the same probability of survival $P^* = P\{\text{survival}\} = .5$. The four possible events are illustrated below, and in this example, each event has the same probability of occurring of $0.5^2 = .25$.



Accidents in which both the driver and the passenger survive (shaded) are not included in the data set. Hence, the probability of either the driver or the passenger surviving in an accident with a fatality corresponds to the probability of one of three possible events with a probability of $P = P\{\text{survival} \mid \text{at least one fatality}\} = 0.25 / (1 - 0.25) = 0.33$. The observed probability of survival in the data set, P, is much lower than the unconditional probability, P^*. The observed probabilities of survival, P, are 0, 0.33, 0.43 and 0.47 for 1, 2, 3 and 4 occupants, respectively, and the values of P increase and get closer to P^* as the number of occupants increases.

In the one-vehicle accident with two occupants and $P^* = 0.5$, the expected number of fatalities is one (the modal type, corresponding to 91% of one-vehicle accidents in the data set). In a two-vehicle accident with two occupants in each vehicle, the same expected number of fatalities would occur if $P^* = 0.25$ (for multiple-vehicle accidents, 54% of vehicles have no fatalities, and 40% have one fatality). The probability of an accident having at least one fatality, and being in the data set, is $(1 - 0.75^4) = 0.68$. There are 16 possible permutations of survival / fatality for the four individuals and 15 of them are in the data set. For any selected individual, 7 of the 15 observed events correspond to surviving with a probability $P = 0.63$. While this is lower than the unconditional probability of survival $P^* = 0.75$, it is much larger than the corresponding probability for the one-vehicle accident $P = 0.33$. Setting the severity of the two types of accident at the same level (E [number of fatalities] = 1) makes the probability of a specific individual surviving in a fatal accident almost twice as large in the two-vehicle accident as in the one-vehicle accident. The reason is simple, for any unconditional probability of survival P^*, the expected number of fatalities is P^* × number of individuals in the accident. Since the data set includes all accidents in which at least one fatality occurs, a fatality is more likely to occur if more people are involved.

In reality, the unconditional probabilities of survival for individuals differ by individual characteristics such as age, whether or not a seat belt was used and the location of the seat in a vehicle. In addition, these probabilities differ by the type of vehicle, and for two-vehicle accidents by the relative size and type of the other vehicle. For an individual i riding in vehicle j, the unconditional probability of survival in a two-vehicle accident, for example, can be written:

$$P_{ij}^* = f(x_i, v_{i1}, v_{i2}) = f(z_{ij})$$

where x_i are the characteristics of individual i

v_{i1} are the characteristics of individual i's vehicle ($j = 1$)

v_{i2} are the characteristics of the other vehicle ($j = 2$)

z_{ij} is the vector of all explanatory variables

The probability of observing at least one fatality in the accident is

$$\left(1-\prod_{j=1}^{2}\prod_{i=1}^{n_j} P_{ij}^*\right)$$

where n_j is the number of individuals in vehicle j.

If $P_{ij}^* = f(z_{ij})$ is specified as a logistic function, then it can be written:

$$P_{ij}^* = \frac{e^{z'_{ij}\beta}}{1 + e^{z'_{ij}\beta}}$$

where β is a vector of unknown parameters that are the same for all individuals and vehicles. Using this form, it would be possible to recover the unconditional probabilities of survival using the available data on accidents with at least one fatality. In the simplest case with one individual in each vehicle, for example, the probability of observing two fatalities in the data set would be:

$$\frac{1}{1 + e^{z'_{11}\beta} + e^{z'_{12}\beta}}$$

and the unconditional probability of two fatalities would be:

$$\frac{1}{1 + e^{z'_{11}\beta} + e^{z'_{12}\beta} + e^{(z'_{11} + z'_{12})\beta}}$$

The unconditional probability of the individual in vehicle 1 surviving would be:

$$P_{11}^* = \frac{e^{z'_{11}\beta} + e^{(z'_{11} + z'_{12})\beta}}{1 + e^{z'_{11}\beta} + e^{z'_{12}\beta} + e^{(z'_{11} + z'_{12})\beta}} = \frac{e^{z'_{11}\beta}}{1 + e^{z'_{11}\beta}}$$

An equivalent expression for P^*_{12} can be derived in exactly the same way. Since β could be estimated from the available data on fatal accidents, the unconditional probabilities of survival could be calculated.

The parameters in β can be estimated by maximum likelihood. estimation. The likelihood function for the probability of survival in two-vehicle accidents, for example, can be specified as:

$$L = \prod_{k=1}^{K} \frac{\prod_{j=1}^{2} \prod_{i=1}^{n_{jk}} P_{ijk}^{*\,Y_{ijk}} (1 - P_{ijk}^{*})^{1-Y_{ijk}}}{(1 - \prod_{j=1}^{2} \prod_{i=1}^{n_{jk}} P_{ijk}^{*})},$$

where K = 1, ..., m, number of accidents;

n_{jk} is the number of individuals in vehicle j, accident k;

Y_{ijk} = 1 if individual i survived, else 0.

The basic structure of the model of the risk of having a fatality in an accident is to distinguish between one-vehicle, two-vehicle and multiple-vehicle accidents. The expectation is that the characteristics of drivers contribute more to the probability of having a one-vehicle accident than to a two- or multiple-vehicle accident. On the other hand, vehicle characteristics, particularly the weight relative to the weight of the other vehicle, will affect the survival rate in two-vehicle accidents but may be less important for one-vehicle accidents. In addition, the earlier discussion of why survival rates are likely to differ systematically between one-vehicle and two-vehicle accidents provides another reason for modeling one-vehicle and two-vehicle accidents separately. The justification for separating multiple-vehicle accidents from two-vehicle accidents is that it is impossible to identify the "other" vehicle from the data for multiple-vehicle accidents.

If r is the overall fatality rate, then the model's components can be written as follows:

$$r = [P\{V1\}(1 - P_1 *) + P\{V2\}(1 - P_2 *) + P\{Vm\}(1 - P_m *)]M,$$

where r is the annual fatality rate per occupant;

P{V1} is the probability of having a one-vehicle accident per 10,000 miles;

P{V2} is the probability of having a two-vehicle accident per 10,000 miles;

P{Vm} is the probability of having a multiple (three or more) vehicle accident per 10,000 miles;

P_1* is the probability of surviving in a one-vehicle accident;

P_2* is the probability of surviving in a two-vehicle accident;

P_3* is the probability of surviving in a multiple-vehicle (three or more) accident;

M is the average annual mileage traveled (13,989 miles from the NPTS).

The units for r, $P\{V1\}$, $P\{V2\}$ and $P\{Vm\}$ are all standardized to measure the probability of having a fatal accident per 1000 vehicles.

Conceptually, all six components of the observed values of r may be functions of the characteristics of the driver (and the passengers) and the vehicle driven (and the other vehicle for two-vehicle accidents). For computing a hedonic price index, the characteristics of an average driver and passenger are used to predict r for different types of vehicle (make, model and year), and each type of vehicle is assumed to have an accident with a typical other vehicle in a two-vehicle accident. Hence, the effects of drivers' characteristics are removed prior to estimating the hedonic price equation. The effect of standardizing the other vehicle in a two-vehicle accident is relatively small because the observed combinations of vehicles in two-vehicle accidents are approximately random. Standardizing drivers' characteristics, however, matters a lot for the probabilities of being in a fatal accident. It is the primary reason for the difference between our estimated value of a statistical life compared to a conventional model in which drivers' characteristics are added as additional regressors in the hedonic price equation.

The structure of the equations for the six components of r can be written as follows:

$$P\{V1\} = g_1(V_1, D_1)$$

$$P\{V2\} = g_2(V_1, D_1)$$

$$P\{Vm\} = g_m(V_1, D_1)$$

$$P_1^* = f_1(V_1, O_1)$$

$$P_2^* = f_2(V_1, V_2, O_1)$$

$$P_m^* = f_m(V_1, O_1)$$

where V_1 are the characteristics of a selected vehicle.

D_1 are the average driver's characteristics for the selected vehicle and include factors such as the use of seat belts and whether alcohol was a factor.

O_1 are the characteristics of the occupants of the selected vehicle, including the driver.

V_2 are the characteristics of the other vehicle, its weight relative to the weight of the selected vehicle being the most important.

Since all six dependent variables are probabilities, appropriate statistical models for limited dependent variables are used. P_1^*, P_2^* are specified as logistic functions and estimated by maximum likelihood in GAUSS. For P_m^*, we assume the unconditional probability P_m^* is the same as the observed probability P_m, and P_m is specified as a regular logit model and estimated in SAS. $P\{V1\}$, $P\{V2\}$ and $P\{Vm\}$ are determined by a censored regression model to allow for a probability mass at zero. Note that P_m^* is determined by the characteristics of the own-vehicle only because it is not possible to identify the "other" vehicle in a multiple-car accident.

The complete econometric analysis for determining the fatality rate, r, for a specified type of vehicle, consists of the following three steps:

Step 1. Augment the FARS data on observed fatal accidents with additional characteristics about the vehicles (e.g. weight and safety features), and use these data to estimate equations for the unconditional probabilities of survival in one-vehicle, two-vehicle and multiple-vehicle accidents (P_1^*, P_2^* and P_m^*). Derive the estimated numbers of serious accidents (including accidents with no fatalities) for one-vehicle, two-vehicle and multiple-vehicle accidents.

Step 2. Calculate the average drivers' characteristics in fatal accidents from the FARS data by make, model and year of the vehicle driven, and combine with survey data on the composition of the fleet of vehicles. Use these data to estimate equations for the probabilities of having one-vehicle, two-vehicle and multiple-vehicle accidents by the make, model and year of vehicle (P{V1}, P{V2} and P{Vm}).

Step 3. Use the average drivers' characteristics from the FARS data, and the average other vehicle in two-vehicle accidents, to standardize the unconditional probability of a driver and/or passenger being killed in a fatal accident by make, model and year of the vehicle.

Appendix B

The Estimated Models Used to Determine the Fatality Rates for Different Types of Vehicle

The inherent fatality rate for an individual in a vehicle can be decomposed as follows:

$$r = [P\{V1\}(1 - P_1 *) + P\{V2\}(1 - P_2 *) + P\{Vm\}(1 - P_m *)]M,$$

where r is the annual fatality rate per capita;

P{V1} is the probability of having a one-vehicle accident per 10000 miles;

P{V2} is the probability of having a two vehicle accident per 10000 miles;

P{Vm} is the probability of having a multiple (three or more) vehicle accident per 10000 miles;

P_1* is the probability of surviving in a one-vehicle accident;

P_2* is the probability of surviving in a two-vehicle accident;

P_m is the probability of surviving in a multiple-vehicle (three or more) accident;

M is the average annual mileage traveled (13989 miles from the NPTS).

The likelihood function for the probability of survival can be specified as:

One-car accidents:

$$L = \prod_{k=1}^{K} \frac{\prod_{i=1}^{n_k} P_{ik}^{*Y_{ik}} (1 - P_{ik}^{*})^{1-Y_{ik}}}{(1 - \prod_{i=1}^{n_k} P_{ik}^{*})}$$

Two-car accidents:

$$L = \prod_{k=1}^{K} \frac{\prod_{j=1}^{2} \prod_{i=1}^{n_{jk}} P_{ijk}^{*Y_{ijk}} (1 - P_{ijk}^{*})^{1-Y_{ijk}}}{(1 - \prod_{j=1}^{2} \prod_{i=1}^{n_j} P_{ijk}^{*})}$$

Multiple-car accidents:

$$L = \prod_{k=1}^{K} \prod_{j=1}^{m_k} \prod_{i=1}^{n_{jk}} P_{ijk}^{Y_{ijk}} (1 - P_{ijk})^{1-Y_{ijk}}$$

where i = 1, ..., n, individuals;

j = 1, ..., m, vehicle;

k = 1, ..., K, accidents;

Y_{ijk} = 1 if survived, else 0.

Survival rates P_1* , P_2* and P_m are specified as logit functions and estimated by maximum likelihood in GAUSS using data from the Fatality Analysis Reporting System (FARS) augmented with additional data about vehicle characteristics (step 1 in Appendix A). The explanatory variables are summarized in Table B1, and the estimated equations are shown in Tables B2 , B3 and B4, respectively. For the survival rate in a one-vehicle accident, the effect of using a restraint (seat belt or car seat) is very important and clearly positive, but the effect of an airbag was not significant. The number of occupants is significant, but without a clear explanation. The survival rate is relatively high in pickup trucks (Class 7). A very inexperienced driver, 16 years or younger, has a strong negative effect on the survival rate.

The equation for P_2* in Table B3 implies that the weight ratio is the most important explanatory variable. Being in a larger vehicle increases the chance of survival and visa-versa. Weight also has a positive effect on survival in multiple car accidents (see Table B4). The number of occupants is also important. The positive effect of using a restraint (seat belt or car seat) is substantially larger than the effect of airbags. In general, the effects of the class of vehicle are consistent with the effect of the weight ratio. Seating in a small vehicle (Class1) reduces the probability of survival, while hitting a small vehicle increases the probability of survival.

The equation for P{V1}, P{V2} and P{Vm} are specified as censored regression models to allow for a point mass at zero (18% and 27% of the vehicle types having no recorded fatalities for one-vehicle and two- vehicle accidents, respectively). This specification worked much better than a linear probability model. The data used corresponds to observations of make, model and year augmented by average driving characteristics from the FARS. Since the observed probabilities of having a fatal accident per 1000 vehicles are very small, it was unnecessary to impose an explicit upper limit of one on the dependent variable. The equations were estimated in SAS.

In order to be consistent with the unconditional probability of survival, each fatal accident is scaled by the inverse of the probability of observing the accident, i.e. at least one fatality occurred. The scaling is very easy for one-vehicle accidents. But for two-vehicle accidents, we need to know the characteristics, e.g. weight, of both vehicles. Among the 25126 two-vehicle accidents that occurred in 1995-1997 involving at least one of the vehicles we studied, there are 8282 accidents having complete information for both vehicles' characteristics. Thus, only one-third of the accidents have complete information about both vehicles' characteristics. There are two possible solutions: one is to find out the complete information of the other vehicle, the other is to scale the accidents with unknown characteristics of the other vehicle by the same scalar used to scale accidents with both vehicles' characteristics known. If the pattern of hitting the other vehicle is the same for each make/model/year vehicle whether the characteristics of the other vehicle is known or not, then the second way is a reasonable approximation.

A goodness-of-fit test is used to test whether the pattern of accidents is the same or not. The probability of having a two-vehicle accident is calculated by each make/model/year, but due to the limited number of observations, accidents for each make/model/year were aggregated to 23 types of vehicle. The overall χ^2 test is rejected, but when we only consider the first 21 types, the χ^2 test cannot be rejected. The remaining two types are small and large pick-up trucks. After comparing the distribution of the other vehicles hit by the 21 types, and by small and large pick-ups, pick-up trucks were found to hit a high proportion of old vehicles, whose characteristics are not included in this study. Since old and new vehicles are similar in weight, and the age of vehicle isn't a significant factor determining the probability of survival, all accidents by make/model/year were inflated by the scalar derived from the subset with complete vehicle characteristics.

The remaining part of the fatality rate model is to estimate the probabilities for multiple vehicle accidents P{Vm} and P_m. Unlike two-vehicle accidents, the pattern of collision is very hard to identify in multiple-vehicle accidents. Some of the vehicles may have no direct impact on each other. Therefore, the model for P_m is more like the model for a one-vehicle accident, i.e. no information of the other vehicles is included. In addition, we assume that all multiple-vehicle accidents are observed. Since the total number of vehicle occupants involved in a multiple-vehicle accident could be quite large (at least 3), this is a reasonable approximation. Also, the fatalities in multiple-vehicle accidents are only 8.5% of the total fatalities that occurred in 1995-1997. The equation for the survival rate P_m is specified as a regular logit model and estimated by maximum likelihood in SAS. The equation for P{Vm} is specified as a censored regression model to allow for a point mass at zero (24% of the vehicle type) and estimated by SAS.

Explanatory variables in the censored models for P_1, P_2, P_m that are not listed in Table B1 are described in Table B5. The basic differences are that additional subdivisions of the classes of vehicles are made, for example, to identify sports cars from non-sports cars for one-vehicle accidents. In addition, variables such as styling ((length plus width/height) are included to provide more information about the type of vehicle.

Before estimating the censored regression of P{V1}, P{V2}and P{Vm}, 12 of the total of 1261 vehicle types were dropped because they had sales less than 500 vehicles. With a very small number of vehicles on the road, even one fatal accident for that make/model/year will count as a big probability of having a fatal accident. The increase in the number of subclasses of vehicle for P{V1} was prompted by inspection of the raw data. The effects of variables such as alcohol and previous convictions are partly responsible for the high rates of accidents for some types of vehicles. For P{V1}, P{V2} and P{Vm}, shown in Tables B6, B7 and B8, the accident rate increases for young drivers, for older drivers and, surprisingly, for female drivers. Accidents are more likely to occur at highway speeds (Sp), and for all three types of accidents, powerful vehicles (Acceleration) are more likely to have accidents, especially for one-vehicle accidents. The use of alcohol and previous convictions increases P{V1}, P{V2} and P{Vm}. The overall conclusion is that driving behavior does matter and affects the probabilities of having a fatal accident for different types of vehicle.

Table B.1: Variable Definitions for Estimating the Probability of Survival

VARIABLE NAME	Definition
Restraint	**CODED AS 1 IF THE PASSENGER USED RESTRAINT, 0 OTHERWISE.**
Age0_5	Coded as 1 if the passenger age is ≤5, 0 otherwise.
Age15	Coded as 1 if the passenger age is ≥6 but ≤15, 0 otherwise.
Age21	Coded as 1 if the passenger age is ≥16 but ≤21, 0 otherwise.
Age24	Coded as 1 if the passenger age is ≥22 but ≤24, 0 otherwise.
Age_o	Coded as 1 if the passenger age is ≥65, 0 otherwise.
female	Coded as 1 if the passenger is female, 0 otherwise.
Occupants Number	logarithm of number of occupants.
ClassX	Discrete variables coded as 1 for the appropriate class. Class1 to class7 represent small, middle, large, luxury, SUV, van, and pick-up truck, respectively, class40, class41 represents luxury non-sports and luxury sports, respectively.
Weight	Weight of the vehicle (1000lb).
Weight Ratio	Weight ratio of the vehicle to the other vehicle in a two-vehicle accident.
Acceleration	Horsepower to weight ratio.
Vehicle Age	The age of the vehicle when the accident happened.
O_classX	The class code for the other vehicle.
Female Driver	Code as 1 if the driver is female.
Driver 16	Code as 1 if the driver is ≤ 16.
Young Driver	Coded as 1 if the driver is ≥16 but ≤24, 0 otherwise.
Older Driver	Coded as 1 if the driver is 65 or older.
Alcohol	Coded as 1 if the alcohol involvement is reported
Late Night	Code as 1 if the accident occurred between 12:00am to 5:59am.
No Previous Offenses	Code as 1 if the driver had no previous offenses.
Sp_limit	Speed limit (10 miles).
Seatfp	Coded as 1 for front seat non-driver passenger.
Seatb	Coded as 1 for back seat passenger.
airbag	Coded as 1 for airbag in that seat position.

Table B2: The Probability of Survival in a One-Vehicle Accident

Parameters	Estimates	t ratio	Prob.
Constant	1.485	5.067	0
Restraint	1.0943	25.028	0
Age0_5	0.2011	2.407	0.0161
Age15	0.6061	9.552	0
Age21	0.4501	8.547	0
Age24	0.3464	5.701	0
Age_o	-1.0999	-10.49	0
female	-0.2026	-5.948	0
Occupants Number	0.3961	5.999	0
Weight	-0.0737	-1.176	0.2395
Acceleration	-8.913	-2.539	0.0111
Vehicle Age	0.0025	0.154	0.8777
Class2	-0.0018	-0.022	0.9821
Class3	-0.0028	-0.016	0.9875
Class40	-0.1111	-0.739	0.4602
Class41	0.2465	0.924	0.3555
Class5	0.4951	3.601	0.0003
Class6	0.2715	1.992	0.0463
Class7	0.62	5.024	0
Sp_limit	-0.0627	-2.792	0.0052
airbag	-0.0054	-0.109	0.9132
Seatfp	-0.0612	-1.854	0.0637
Seatb	0.1249	2.535	0.0112
Driver 16	-0.4153	-4.046	0.0001
Young Driver	-0.2345	-3.42	0.0006
Older Driver	0.5054	3.625	0.0003
Female Driver	0.2059	3.248	0.0012
Alcohol	-0.0607	-0.965	0.3347
No Previous Offenses	-0.1916	-3.417	0.0006
Late Night	-0.1014	-1.672	0.0945

Table B3: The Probability of Survival in a Two-vehicle Accident

Parameters	Estimates	t ratio	Prob.
Constant	2.0436	6.544	0
Restraint	0.9234	18.053	0
Age0_5	0.0402	0.297	0.7663
Age15	0.4342	3.81	0.0001
Age21	0.4615	4.758	0
Age24	0.4571	4.14	0
Age_o	-1.5055	-13.25	0
female	-0.1744	-3.467	0.0005
Occupants Number	0.2572	4.65	0
Weight	0.1566	1.431	0.1523
Weight ratio	1.3538	6.626	0
Vehicle Age	-0.0018	-1.02	0.3077
Class2	0.0684	0.735	0.4624
Class3	0.0407	0.254	0.7993
Class40	-0.28	-1.773	0.0762
Class41	-0.4624	-1.136	0.2561
Class5	0.4542	2.837	0.0046
Class6	0.4554	3.184	0.0015
Class7	0.6685	5.06	0
O_class2	-0.1202	-1.167	0.2431
O_class3	-0.0789	-0.47	0.6387
O_class4	-0.289	-1.792	0.0732
O_class41	-1.7245	-5.119	0
O_class5	-0.3271	-2.064	0.039
O_class6	-0.3155	-2.067	0.0387
O_class7	-0.4214	-3.12	0.0018
Sp_limit	-0.447	12.714	0
airbag	0.1316	2.395	0.0166
Seatfp	-0.114	-1.306	0.1915
Seatb	0.2585	2.418	0.0156
Driver 16	-0.613	-4	0.0001
Young Driver	-0.0165	-0.177	0.8597
Older Driver	0.172	1.445	0.1484
Female Driver	-0.0423	-0.696	0.4862
Alcohol	-0.6062	-7.997	0
No Previous Offenses	-0.0599	-1.15	0.2501
Late Night	-0.6222	-6.02	0
Acceleration	-2.2826	-0.594	0.5523

Table B4: The Probability of Survival in a Multiple-vehicle Accident

Parameters	Estimates	Wald χ^2	Prob.
Constant	0.0075	0.001	0.9774
Restraint	0.9570	437.001	0.0001
Age0_5	-0.0337	0.066	0.7978
Age15	0.2592	5.312	0.0212
Age21	0.2673	6.274	0.0123
Age24	0.4072	10.560	0.0012
Age_o	-1.5429	177.689	0.0001
female	-0.1232	4.486	0.0342
Occupants Number	0.5399	100.273	0.0001
Weight	0.3223	35.925	0.0001
Acceleration	7.7231	4.251	0.0392
Vehicle Age	-0.0072	0.216	0.6424
Class2	0.2409	11.420	0.0007
Class3	0.4135	11.050	0.0009
Class40	0.2486	3.611	0.0574
Class41	-0.0749	0.042	0.8380
Class5	0.7535	33.524	0.0001
Class6	0.6679	36.716	0.0001
Class7	0.7384	52.197	0.0001
Sp_limit	-0.2297	116.802	0.0001
airbag	0.1788	8.380	0.0038
Seatfp	-0.0683	1.050	0.3055
Seatb	0.2892	8.380	0.0038
Driver 16	-0.3106	2.337	0.1264
Young Driver	-0.0581	0.354	0.5518
Older Driver	0.2642	4.784	0.0287
Female Driver	0.0268	0.199	0.6557
Alcohol	-0.8750	108.279	0.0001
No Previous Offenses	0.0627	1.844	0.1745
Late Night	0.0192	0.045	0.8316

Table B5: Variable Definitions for Estimating the Probability of Having an Accident

Variable Name	Definition
TypeXX	Coded as 1 for the appropriate type. Type1 to Type23 represent lower, upper small, small specialty, lower, upper middle, middle specialty, large, large specialty, lower, middle, upper luxury, luxury specialty, luxury sport, small, middle, large, luxury suv, small, middle, large, luxury van, small, large pickup, respectively.
Alcohol	Proportion of accidents in this make/model/year vehicle in which the alcohol involvement was reported.
No Previous Offenses	Proportion of accidents in this make/model/year vehicle in which the driver had no previous offense.
Late Night	Proportion of accidents in this make/model/year vehicle which occurred between 12:00am to 5:59am.
Driver 16	Proportion of accidents in this make/model/year vehicle in which the driver is 16 or younger.
Young Driver	Proportion of accidents in this make/model/year vehicle in which the driver is younger than 25 years, but older than 16..
Older Driver	Proportion of accidents in this make/model/year vehicle in which the driver is 65 or older.
Female Driver	Proportion of accidents in this make/model/year vehicle in which the driver was female.
Sp	Proportion of accidents at highway speed.
Acceleration	The horsepower-to-weight ratio.
Traditional Styling	Length plus width divided by height.
D_airbag	Coded as 1 for the driver-side airbag.
P_airbag	Coded as 1 for the passenger-side airbag.

Table B6: Censored Regression for the Probability of Having a One-Vehicle Accident

PARAMETER	Estimate	std. Error	ChiSquare
constant	-0.2231	0.097	5.25
Alcohol	0.0925	0.019	22.69
No Previous Offenses	-0.1255	0.017	51.53
Late Night	-0.0056	0.022	0.07
Driver 16	0.1232	0.048	6.69
Young Driver	0.1814	0.022	69.42
Older Driver	0.1038	0.028	13.44
Female Driver	0.1018	0.019	28.28
Sp	0.1247	0.017	53.40
Acceleration	3.9825	0.654	37.08
Traditional Styling	0.0280	0.025	1.24
Weight	-0.0059	0.018	0.11
D_airbag	-0.0360	0.012	8.74
P_airbag	-0.0159	0.013	1.42
Type2	-0.0702	0.023	9.11
Type3	-0.0604	0.029	4.21
Type4	-0.0965	0.027	12.94
Type5	-0.0805	0.028	8.17
Type6	-0.0632	0.031	4.23
Type7	-0.0969	0.038	6.44
Type8	-0.0996	0.054	3.40
Type9	-0.0985	0.034	8.45
Type10	-0.1095	0.033	10.70
Type11	-0.1558	0.041	14.47
Type12	-0.0797	0.043	3.40
Type13	0.0725	0.038	3.64
Type14	0.1634	0.044	13.98
Type15	0.1194	0.045	7.07
Type16	0.0569	0.060	0.91
Type17	0.1454	0.057	6.58
Type18	-0.0232	0.040	0.33
Type19	-0.0491	0.054	0.82
Type20	0.0110	0.062	0.03
Type21	-0.0366	0.065	0.31
Type22	0.1359	0.032	18.32
Type23	0.0932	0.052	3.23
Sigma	0.1526	0.003	

Table B7: Censored Regression for the Probability of Having a Two Vehicle Accident

parameter	Estimate	std. Error	ChiSquare
constant	0.0197	0.061	0.11
Alcohol	0.0063	0.023	0.08
No Previous Offenses	-0.1561	0.015	109.11
Late Night	0.0448	0.024	3.54
Driver 16	0.1449	0.051	7.94
Young Driver	0.0980	0.018	30.26
Older Driver	0.1098	0.019	32.47
Female Driver	0.1102	0.014	61.16
Sp	0.1067	0.014	58.72
Acceleration	0.0858	0.428	0.04
Traditional Styling	0.0074	0.015	0.23
Weight	0.0261	0.010	6.22
D_airbag	-0.0119	0.007	2.88
P_airbag	-0.0062	0.008	0.61
Type2	-0.0258	0.013	3.84
Type3	-0.0377	0.017	4.75
Type4	-0.0630	0.015	16.87
Type5	-0.0476	0.016	8.36
Type6	-0.0549	0.019	8.73
Type7	-0.0577	0.022	6.68
Type8	-0.0887	0.031	8.28
Type9	-0.1069	0.020	28.49
Type10	-0.0972	0.021	22.06
Type11	-0.1146	0.026	19.86
Type12	-0.0909	0.027	11.46
Type13	-0.0939	0.026	13.39
Type14	-0.0438	0.026	2.75
Type15	-0.0274	0.026	1.09
Type16	-0.0196	0.035	0.31
Type17	-0.0679	0.034	3.98
Type18	-0.0469	0.023	4.03
Type19	-0.0627	0.031	3.98
Type20	-0.0193	0.036	0.29
Type21	-0.0590	0.036	2.64
Type22	0.0338	0.018	3.35
Type23	0.0218	0.030	0.52
Sigma	0.0851	0.002	

Table B8: Censored Regression for the Probability of Having a Multiple (three or more) Vehicle Accident

parameter	Estimate	std. Error	ChiSquare
constant	-0.0067	0.013	0.25
Alcohol	0.0051	0.005	1.10
No Previous Offenses	-0.0192	0.002	68.94
Late Night	0.0118	0.005	6.58
Driver 16	0.0291	0.008	11.76
Young Driver	0.0130	0.003	17.97
Older Driver	0.0180	0.004	26.31
Female Driver	0.0213	0.002	93.38
Sp	0.0214	0.002	103.77
Acceleration	0.1539	0.092	2.79
Traditional Styling	0.0012	0.003	0.13
Weight	0.0038	0.002	2.58
D_airbag	0.0006	0.002	0.12
P_airbag	0.0004	0.002	0.06
Type2	-0.0100	0.003	10.86
Type3	-0.0133	0.004	11.30
Type4	-0.0128	0.004	13.05
Type5	-0.0078	0.004	4.30
Type6	-0.0124	0.004	9.00
Type7	-0.0099	0.005	3.80
Type8	-0.0139	0.007	3.77
Type9	-0.0164	0.005	12.73
Type10	-0.0163	0.004	13.13
Type11	-0.0203	0.006	12.85
Type12	-0.0020	0.006	0.12
Type13	-0.0173	0.005	10.03
Type14	-0.0005	0.006	0.01
Type15	-0.0006	0.006	0.01
Type16	-0.0035	0.008	0.20
Type17	-0.0136	0.008	3.13
Type18	-0.0086	0.005	2.65
Type19	-0.0049	0.007	0.49
Type20	-0.0036	0.008	0.20
Type21	-0.0031	0.008	0.16
Type22	0.0030	0.004	0.50
Type23	-0.0018	0.007	0.07
Sigma	0.0200	0.000	

Appendix C

The Hedonic Price and Fuel Efficiency Models

The econometric model used for the hedonic price of a vehicle is based on the work of Rosen (1974), Atkinson and Halvorsen (1990), and Dreyfus and Viscusi (1995) on hedonic pricing. Atkinson and Halvorsen (1990) use the data for 112 models of new 1978 automobiles to obtain estimates of the VSL. Since the available fatality data is a function of both the inherent risk of the vehicle and the driver's characteristics, the drivers' characteristics are included in the regression as control variables. Their estimated VSL for the sample as a whole, based on willingness to pay, is $3.357 million 1986 dollars.

The data used in Dreyfus and Viscusi (1995) differ from those used in earlier studies in that they reflect actual consumer automobile holdings. Dreyfus and Viscusi (1995) use the 1988 Residential Transportation Energy Consumption Survey together with data from industry sources. They generalize the standard hedonic models to recognize the role of discounting on fuel efficiency and safety. The estimates of the implicit value of life range from $2.6 to $3.7 million and the estimates of the discount rate range from 11 to 17 percent.

The hedonic price equation for automobiles can be written, following Atkinson and Halvorsen (1990), as follows:

$P_{auto} = f(R, A)$,

where P_{auto} is the price of an automobile, R is the inherent risk of mortality (a similar measure for injury could also be included) associated with the automobile, and A is a vector of other characteristics. The available mortality rate, F, is a function of both R and a vector of the involved driver's characteristics D. Assuming that F is monotonic in R, the above equation can also be written as:

$P_{auto} = g(F, A, D)$,

The standard functional form used for the estimation of a hedonic price equation is:

$$\log(P_{auto}) = \beta_0 + \sum_i \gamma_i D_i + \sum_k \beta_k \log(X_k) + e$$

where X_k is a representative measured regressor (e.g. horsepower to weight ratio), D_i is a dummy variable for vehicle type, γ_k, β_k are the corresponding parameters and e is an unobserved residual.

A different approach was used in this research, and it involves predicting the inherent mortality rate using standardized driver's characteristics. In other words, the unobserved values of R are predicted directly. Since the specified number of occupants of a vehicle is two, the observed mortality rate F is twice the size of the average mortality rate per occupant. The corresponding value of R should also reflect the fact that there are two occupants on average. Consequently, the predicted value $\hat{R} = \hat{r}_1 + \hat{r}_2$ (i = 1 is the driver and i = 2 is the passenger), where $\hat{r}_i$ is the predicted probability of a fatality for an individual, defined in the previous section. The standardized inherent mortality rates for two male occupants for year 1995 automobiles are summarized by type of vehicle in Figure C1. The minimum, average and maximum risks of mortality for each type of vehicle are illustrated. Figure C2 provides the corresponding scales for the raw (unadjusted) mortality data based on 1996-1997 FARS data. Comparing the two figures, the relative ranking among different types of vehicle are quite

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consistent, but the standardizing procedure significantly reduces the ranges of the risk of mortality.

One might be surprised by the implication from Figures C1 and C2 that large sports utility vehicles (SUVs) are not safer than small sedans and wagons. From Table C1, the average standardized and risks of mortality show that large SUVs are safer in two-vehicle and multiple-vehicle accidents (1.6+0.7=2.3 compared to 4.4+1.4=5.8 for small sedans). However, they are much less safe in one-vehicle accidents (7.1 compared to 3.4 for small sedans) because the probability of having an accident is higher. This point can be further illustrated by the information in Table C3. For two-vehicle accidents, large SUVs have the lowest observed mortality rate per occupant (0.186) among all types of vehicle, which is about a third of the rate for small sedans (0.512). However, the observed accident rates for large SUVs and small sedans are the same (0.193). The impression that large SUVs are safer than other vehicles comes from observing that occupants in a large SUV are more likely to survive in a fatal accident with another vehicle than the occupants of other types of vehicle.

Another cost associated with reducing the risk of mortality and injury is buying more fuel because heavier vehicles are safer but have lower fuel efficiencies. Consequently, a hedonic model of fuel efficiency augments the standard hedonic model of the purchase price in our model. In this model, the cost of additional safety has a capital component and an operating component. In the latter case, the cost penalty corresponds to the reduced fuel efficiency when a heavier vehicle is purchased. The hedonic model of fuel efficiency has the same form as the hedonic model of the purchase price, and it can be written:

$$\log(fe\_city) = \alpha_0 + \sum_i \delta_i D_i + \sum_k \alpha_k \log(X_k) + e$$

where fe_city is the rated miles per gallon for city driving, X_k is a representative measured regressor, D_i is a dummy variable for vehicle type, δ_i , and α_k are the corresponding parameters and e is an unobserved residual.

The primary source of the data for estimating the hedonic price and fuel efficiency models was the 1995 National Personal Transportation Survey (NPTS). This data was used to obtain information on each household's choice of automobiles. The 1995 NPTS was conducted by the Research Triangle Institute (RTI) under the sponsorship of the U.S. Department of Transportation (DOT). The survey covers 42,033 sampled households. A sub-data set of 4036 one-car households holding a 1990-1995 model year vehicle were merged with vehicle attribute data collected from industry and other sources for the same years. The vehicle price data were gathered from *NADA Official Used Car Guide*, and other attribute data were collected from *NADA Official Used Car Guide*, *Ward's Automotive Yearbook*, and *Consumer Reports*. The mortality rate is measured by the number of fatalities occurring in each make/model/year vehicle per 1000 vehicles sold. The number of fatalities is based on the models described in Appendix B. Since the observed mortality rate is jointly determined by the inherent risk associated with the type of automobile and the driver's characteristics and behavior, driver's characteristics were also collected from the data on fatal accidents for each make, model and year to provide control variables.

In addition to the risk of mortality, a second safety measure, injury rate, is introduced. The injury rate by make and model of vehicle is published annually by the Highway Loss Data Institute. It is measured by the frequency of insurance claims filed under Personal Injury Protection coverages. The raw injury rates are adjusted by the same factors used to standardize raw mortality rates. The implicit assumption is that the "bad" driving characteristics that contribute to fatal accidents also affect injuries.

The variables used in the hedonic price equation are summarized in Table C4, and Table C5 shows the descriptive statistics of selected vehicle attributes. The selection of vehicle attributes and driver's characteristics is similar to Dreyfus and Viscusi (1995) and Atkinson and Halvorsen (1990). It should be noted that the observed mean mortality rate is higher than the standardized mean and the observed standard deviation is also higher. The reason is that the standardized mortality is based on one average male driver and one average male passenger. Even though average values of the other regressors are used, the elimination of young drivers, for example, results in lower average mortality rates. The effect of standardizing drivers' characteristics to predict the inherent mortality rate has the effect, as expected, of reducing the variability of mortality among vehicles.

The Estimated Hedonic Models

Least square estimates of the hedonic price model and the fuel efficiency model are presented in Table C6. Model A is the hedonic equation of fuel efficiency, using the standardized mortality rate. Model B is the hedonic equation of capital cost, using the standardized mortality rate. In Model A and B, variables with small t ratios and perverse signs have been dropped.

The most important parameter for computing the VSL is the coefficient for the mortality rate, and the values in Model A and B have the right signs and are both significant. In other hedonic price models, fuel efficiency is included as a regressor in Model B, but it often has a large t ratio and a perverse negative sign (fuel efficiency is a positive attribute). Hence, some explanation is needed to explain why fuel efficiency is omitted in Model B. The implication of Model A is that fuel efficiency is a dependent variable, like the price, and is a function of the vehicle's characteristics. The model corresponds to a simplified reduced form for a system of two equations. If the predicted fuel efficiency from Model A is used as a regressor in Model B, the coefficient has a logical positive sign. The overall effect on the estimated VSL is small, however, if the direct effects of mortality on price and fuel efficiency are combined with the indirect effect on the price through fuel efficiency. This is not really surprising because the model presented in Table C6 is equivalent to a solved reduced form for a structural model which has fuel efficiency as a regressor in the hedonic price equation (the equation for fuel efficiency remains the same).

Table C1: The Standardized Risk of Mortality by Vehicle and Type of Accident

Vehicle Type	Total Risk	One-Car Accidents	Two-Car Accidents	Multiple-Car Accidents
small sedans & wagons	9.2	3.4	4.4	1.4
middle sedans & wagons	6.9	3.3	2.5	1.0
large sedans & wagons	6.5	3.5	2.1	0.8
luxury sedans & wagons	7.2	4.7	1.7	0.8
small & mid. specialties	9.5	5.6	3.0	1.0
luxury sports	25.3	21.8	2.6	0.9
small suv	17.1	12.0	3.6	1.6
large suv	9.4	7.1	1.6	0.7
van (minivan)	5.0	2.7	1.5	0.8
small pickup	12.4	7.7	3.5	1.2
large pickup	8.6	5.8	2.0	0.8

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Table C2: The Observed Risk of Mortality by Vehicle and Type of Accident (Year 1996-1997 Average)

Vehicle Type	Total Risk	One-Car Accidents	Two-Car Accidents	Multiple-Car Accidents
small sedans & wagons	30.8	12.2	14.1	4.6
middle sedans & wagons	22.5	12.1	8.8	1.6
large sedans & wagons	17.7	5.4	11.2	1.2
luxury sedans & wagons	9.3	4.9	3.2	1.2
small & mid. specialties	33.8	20.5	10.3	3.0
luxury sports	26.2	23.6	2.6	0.0
small suv	53.4	26.6	25.6	1.2
large suv	21.1	16.2	3.5	1.4
van (minivan)	24.6	12.8	8.8	3.0
small pickup	26.1	17.6	7.2	1.4
large pickup	17.6	11.6	4.8	1.2

Table C3: The Observed Mortality Rates Per Occupant and Accident Rates per 1000 Vehicles for Fatal Two-vehicle Accidents (Average 1996-1997)

Vehicle Type	Mortality Rate	Accident Rate
small sedan & wagons	0.512	0.193
middle sedan & wagons	0.435	0.169
large sedan & wagons	0.370	0.159
luxury sedan & wagons	0.369	0.113
small & mid. specialties	0.429	0.171
luxury sports	0.329	0.109
small suv	0.430	0.189
large suv	0.186	0.193
van (minivan)	0.218	0.221
small pickup	0.368	0.188
large pickup	0.201	0.244

Table C4: Variable Definitions

Variable Name	Definition
Price	Vehicle price as of end-of-year 1995.
Value Retained	Original sales value retained, as of end-of-year 1995.
Mortality Rate, Observed	Number of fatalities occurring in that make/model/year vehicle per 1000 of that vehicle sold.
Mortality Rate, Standardized	Predicted number of fatalities in that make/model/year vehicle per 1000 of that vehicle sold with average 2 occupants.
Injury Rate	An Index based on the frequency of insurance claims. The lower, the safer.
CityFuel efficiency	Miles per gallon in city area.
CityFuel efficiency Predicted	Predicted Miles per gallon in city area.
Reliability Rating	A discrete variable coded from 1 to 5, 5 is the highest while 1 is the lowest.
Acceleration	The horsepower-to-weight ratio.
Traditional Styling	Length plus width divided by height.
ClassX	Discrete variables coded as 1 for the appropriate class. Class1 to class7 represent small, middle, large, luxury, SUV, van, and pick-up truck, respectively.
YearXX	Discrete variables coded as 1 for the vehicle model year.
Young Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was younger than 25 years.
Older Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was 65 or older.
Alcohol	Proportion of fatalities in this make/model/year vehicle in which the alcohol involvement was reported.
Gender of Driver	Proportion of fatalities in this make/model/year vehicle in which the driver was male.
Seat Belt	Proportion of fatalities in this make/model/year vehicle in which the driver was wearing a seat belt.
Previous Offenses	Proportion of fatalities in this make/model/year vehicle in which the driver had no previous offense.
Late Night	Proportion of fatalities in this make/model/year vehicle which occurred between 12:00am to 5:59am.
One-car Accident	Proportion of fatalities in this make/model/year vehicle in which only one vehicle was involved.
Ford, GM, Chrysler, Germany, Japan	Discrete variables coded as 1 for the manufacturer and 0 otherwise.
MB	Dummy variable coded as 1 for Mercedes Benz, 0 otherwise.

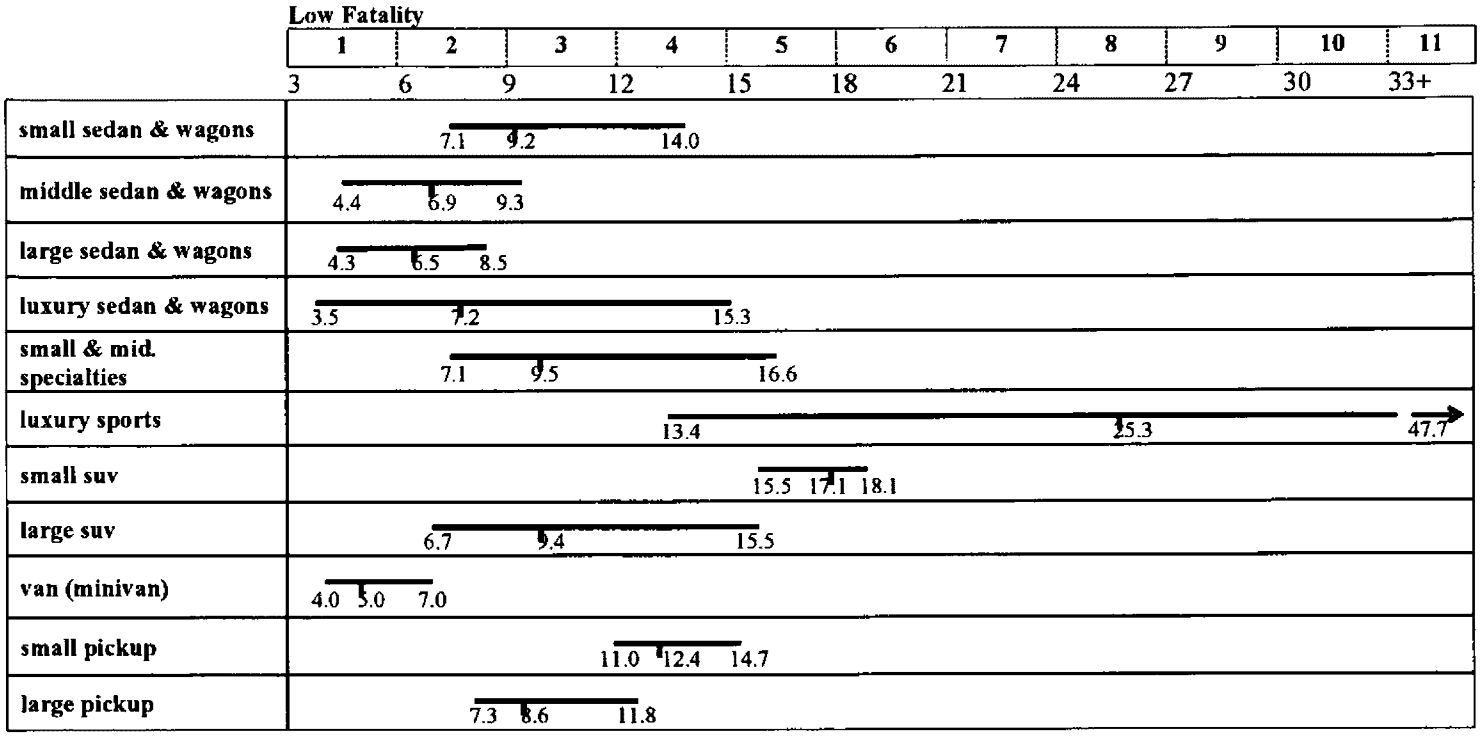
Table C5: Summary Statistics of Selected Variables

Variable	Mean	Standard Deviation
Price	15703.53	9371.57
Value Retained	0.7720	0.1753
Mortality Rate, Observed	0.1345	0.0994
Mortality Rate, Standardized	0.0939	0.0401
Injury Rate	73.72	42.12
City Fuel-efficiency	20.26	4.82
Reliability Rating	3.019	1.321
Acceleration	0.0475	0.0102
Traditional Styling	4.451	0.519

Table C6: Parameter Estimates for the Hedonic Equations

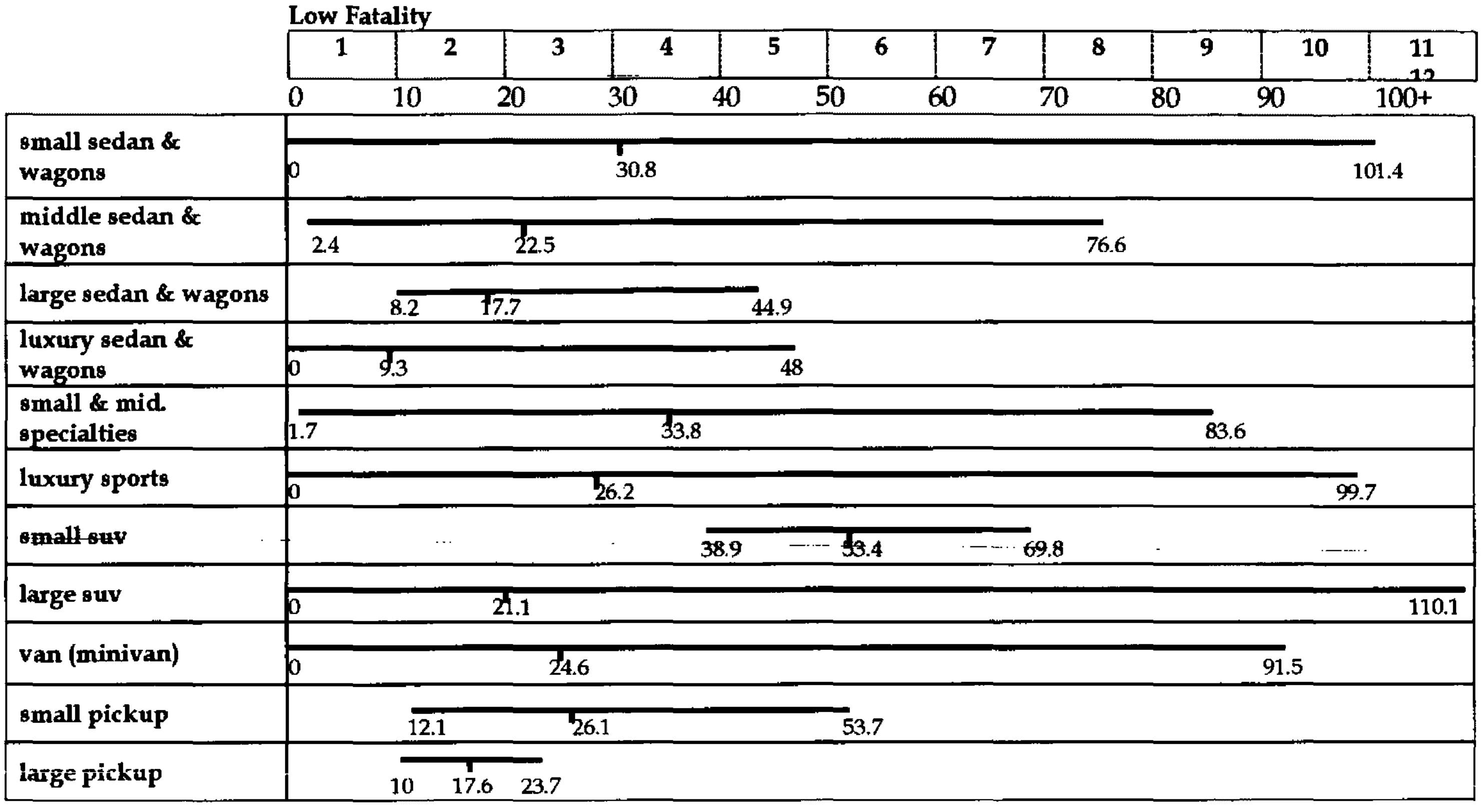
Variable	Model A Estimated Coefficient	t ratio	Model B Estimated Coefficient	t ratio
Dependent	**Fe_city**		**P_{auto}**	
Constant	2.5689	14.13	7.7174	25.45
Value Retained	0.0549	3.35	0.4594	11.10
Mortality Rate	0.0258	1.99	-0.0690	-3.53
Injury Rate	0.0330	4.01	-0.0161	-1.31
Reliability Rating	0.0170	5.05	0.0617	5.23
Acceleration	-0.2290	-8.04	0.6014	13.99
Traditional Styling	-0.2786	-5.21	0.6035	7.56
Class2	-0.1873	-16.56	0.2426	14.34
Class3	-0.2751	-14.69	0.3734	13.28
Class4	-0.2852	-19.29	0.6752	29.76
Class5	-0.6397	-37.47	0.8127	31.94
Class6	-0.4846	-24.84	0.6558	22.67
Class7	-0.4352	-27.49	0.3398	14.31
Year91			0.1137	6.31
Year92			0.2100	10.53
Year93			0.2977	13.16
Year94			0.3880	15.30
Year95			0.4474	16.14
Ford	0.0347	1.90	-0.0972	-3.58
GM	0.0334	1.94	-0.0879	-3.44
Chrysler	0.0196	1.12	-0.1148	-4.43
Germany	-0.0562	-2.84	0.1489	5.05
Japan	0.0470	2.73	-0.0430	-1.71
MB	-0.0078	-0.33	0.5237	14.89
R^2	0.7626		0.8996	

Figure C1: Standardized Scales for the Risk of Mortality



Note: The scale is based on predicted total fatalities per 100,000 vehicles (1995 model year) per 10,000 miles driven with 2 occupants.

Figure C2: Unadjusted Scales for the Risk of Mortality



Note: The scale is based on the observed total fatalities in year 1996-1997 per 100,000 vehicles (1995 model year) on road per 10,000 miles driven (average annual miles driven is 13989 miles

Appendix D: Auto Safety Survey (Full scale)

NOTE:
1. Variable names are in bold type.
2. A code of system missing (•) means the question was not applicable (NA).
3. Questions were asked of all respondents unless indicated otherwise.
4. (A) after variable name indicates a string variable.
5. For cases where the answers were not clear, we entered that data as missing (e.g. a respondent circled both 2 and 5 on M2a so we entered -9).
   For cases where the answers were ranges, we entered the midpoint (e.g. a respondent wrote in $50-$80 on M3_1 so we entered $65).
   All cases with unclear answers or ranges are detailed along with their caseids in "DEissues.xls" file.

Sample Information

RESPOND Unique identification number for completed recruitment screeners

CASEID Unique case identification number for mailed surveys

DATE_C Date recruit completed

DATE_R Date mail survey returned

VERSION Version number of survey mailed
- 1 Version 1
- 2 Version 2

STATUS Level of mail survey completion
- 0 Refused to be recruited for mail survey
- 1 Agreed to mail, but did not return survey
- 5 Partial mail complete
- 10 Full recruit and mail complete

STATE (A) State where respondent resides

ZIP (A) Zip code where respondent resides

FIPSTATE Numeric FIPS state code

FIPCONTY Numeric FIPS county code

REMAIL Whether or not respondent received follow-up survey mailing

0 No reminder survey mailing (either because had returned completed survey or said during follow-up call that they would return the survey they had)
1 Sent follow-up survey mailing

Recruitment Survey

Hello, my name is *(FILL IN)* and I am calling on behalf of Cornell University. May I speak with an adult head of your household?

My name is *(FILL IN)* and I am calling from Discovery Research. We are conducting a study for Cornell University of people's use of automobiles and their opinions about automobile safety. I'd like to assure you that this is a research project and I am <u>not</u> trying to sell you anything.

(IF NEEDED): You are part of a small group of U.S. residents who have been scientifically selected for this study. Your opinions will represent other people like you. This should take about 15 minutes.

For this survey, when I say automobiles, I mean all types of passenger automobiles including station wagons, sport utility automobiles (SUVs), mini-vans, and light trucks that were purchased or leased by someone in your household and are used regularly by someone in your household. Do *not* include motorcycles, or automobiles, such as antique cars, that are rarely driven.

(VERIFY THAT RESPONDENT IS AN ADULT HEAD OF HOUSEHOLD.)

Q1 Including yourself, how many people live in your household? Please count yourself and any family members or partners who live with you. Do not include unrelated adult roommates who make their own automobile purchase decisions.

(INTERVIEWER NOTE: WE WANT HOUSEHOLDS THAT ARE JOINT DECISION MAKING UNITS, SO THIS SHOULD INCLUDE PARTNERS, BUT NOT UNRELATED ADULTS WHO ARE JUST ROOMMATES AND MAKE THEIR OWN SEPARATE CAR PURCHASE DECISIONS. IF THE LATTER, THEN SAY TO RESPONDENT: "For the remainder of this survey, I only want you to tell me about yourself and anyone else in this household who is part of your decision making for automobiles purchases."*)*

_____ People (including respondent)

(NOTE: IF Q1 GREATER THAN 5, THANK AND TERMINATE.)
57 Households with more than 5 people.

Q2 How many automobiles does your household currently own or lease?

(IF NEEDED): When I say automobile, I mean all types of passenger automobiles including station wagons, sport utility automobiles (SUVs), mini-vans, and light trucks that were purchased or leased by someone in your household. Do not include motorcycles, or automobiles that are not driven more than 500 miles per year.

_____ automobiles

(NOTE: IF Q2 EQUALS 0, OR Q2 GREATER THAN 3, THANK AND TERMINATE.)

235 Households with 0 autos.
181 Households with more than 3 autos.

Q3 Does anyone in your household regularly use an automobile that was purchased by his or her employer?

1 Yes *(NOTE: IF YES, THANK AND TERMINATE.)*
2 No *118 Households had an employer-purchased auto.*

Q4 Does anyone in your household regularly use an automobile that was given to them by someone outside your household?

1 Yes (NOTE: IF YES, THANK AND TERMINATE.)
2 No *74 Households had a gift auto.*

Q5 Do you drive any of your household's automobiles?

1 Yes
2 No *(ASK TO SPEAK WITH AN ADULT DRIVER)*

Q6 I'd like you to tell me about each of the automobiles that are owned or leased by members or your household. Starting with the automobile that is driven the most, . . .?

	Characteristics	Most Driven Automobile (in terms of miles/year)	2nd Most Driven Automobile	3rd Most Driven Automobile
a.	What make or brand is this automobile? (e.g., Chevrolet, Mercedes)	**Q6a1 (A)**	**Q6a2 (A)**	**Q6a3 (A)**
b.	What model is it? (e.g., Camaro, S-Class) (If don't know, please ask respondent to check.)	**Q6b1 (A)**	**Q6b2 (A)**	**Q6b3 (A)**
c.	Type of model? (e.g., LE, LX, SE) (If don't know, please ask respondent to check.)	**Q6c1 (A)**	**Q6c2 (A)**	**Q6c3 (A)**
d.	What model year is the automobile?	**Q6d1** -8 Don't Know	**Q6d2** -8 Don't Know	**Q6d3** -8 Don't Know
e.	What year did you purchase or lease the automobile?	**Q6e1** -8 Don't Know	**Q6e2** -8 Don't Know	**Q6e3** -8 Don't Know
f.	What was the approximate purchase price of this automobile/equivalent price that was used in calculating your lease payments?	**$ Q6f1** -8 Don't Know -9 Refused	**$ Q6f2** -8 Don't Know -9 Refused	**$ Q6f3** -8 Don't Know -9 Refused
g.	Have you had this automobile for less than 12 months?	**Q6g1** 1 Yes 2 No	**Q6g2** 1 Yes 2 No	**Q6g3** 1 Yes 2 No
h.	About how many miles (was this automobile <u>driven over the last 12 months</u>/*IF HAD FOR LESS THAN 12 MONTHS*: will this automobile be driven in a 12-month period?)	**Q6h1** -8 Don't Know *(If Don't Know, prompt with categories; see Q6h1f below.)* -9 Refused	**Q6h2** -8 Don't Know *(If Don't Know, prompt with categories; see Q6h1f below.)* -9 Refused	**Q6h3** -8 Don't Know *(If Don't Know, prompt with categories; see Q6h1f below.)* -9 Refused
	Range of miles *(if Q6h is DK)*	**Q6h1f** 1 Under 3,000 miles 2 3,000 to 5,999 3 6,000 to 8,999 4 9,000 to 11,999 5 12,000 to 14,999 6 15,000 to 17,999 7 18,000 to 20,999 8 21,000+ miles -8 Don't Know • NA	**Q6h2f** 1 Under 3,000 miles 2 3,000 to 5,999 3 6,000 to 8,999 4 9,000 to 11,999 5 12,000 to 14,999 6 15,000 to 17,999 7 18,000 to 20,999 8 21,000+ miles -8 Don't Know • NA	**Q6h3f** 1 Under 3,000 miles 2 3,000 to 5,999 3 6,000 to 8,999 4 9,000 to 11,999 5 12,000 to 14,999 6 15,000 to 17,999 7 18,000 to 20,999 8 21,000+ miles -8 Don't Know • NA

(PROGRAMMING NOTE: FROM NOW ON, FILL "MOST DRIVEN AUTOMOBILE," "2ND MOST DRIVEN VEHICLE", "3RD MOST DRIVE AUTOMOBILE" WITH ACTUAL MAKE AND MODEL AND MODEL YEAR OF AUTOMOBILE.")

(PROGRAMMING NOTE: FROM NOW ON, IF AN AUTOMOBILE HAS BEEN IN THE HOUSEHOLD LESS THAN 12 MONTHS, USE THE SECOND PHRASE IN THE PARENTHESIS WHICH REFERS TO THE AMOUNT THE VEHICLE WILL BE USED IN A 12-MONTH PERIOD.)

Q7 To understand auto safety, we need to know how your household uses your automobiles. I'd like to get the first name or initial, age and gender of all the people living in your household. We will be referring to these family members in the next set of questions, so it will be easier if we have a way to identify each individual. You can use nicknames if you prefer. First, what is your first name?

Person	First Name	Age	Gender	Relationship with Respondent
		__ -9 Refused • NA	1 Male 2 Female • NA	1 Spouse 2 Partner 3 Son 4 Daughter 5 Mother 6 Father 7 Other relative 8 Friend • NA
Person A (Yourself)	NA	**Q7aage**	**Q7amf**	NA
Person B	**Q7bname (A)**	**Q7bage**	**Q7bmf**	**Q7brelat**
Person C	**Q7cname (A)**	**Q7cage**	**Q7cmf**	**Q7crelat**
Person D	**Q7dname (A)**	**Q7dage**	**Q7dmf**	**Q7drelat**
Person E	**Q7ename (A)**	**Q7eage**	**Q7emf**	**Q7erelat**

(PROGRAMMING NOTE: FROM NOW ON, FILL "PERSON A" WITH "YOU," AND "PERSON B-E" WITH THE FIRST NAME).

Q8 In this next question, I would like to know how much each person in your household (was in each automobile during the past 12 months/*IF HAD FOR LESS THAN 12 MONTHS*: will be in this automobile in a 12-month period), either as a driver or a passenger. For the *[FILL WITH AUTOMOBILE MAKE AND MODEL]*, you mentioned it (was/will be) driven about *[FILL WITH ANNUAL MILEAGE]* miles in a 12-month period. What percentage of these miles (did/will) *[FILL WITH PERSON NAME]* drive or ride in this automobile? We know that this is a difficult question, and it is okay to give approximate answers. *(PROBE):* For example, did this person drive or ride in this automobile for all the miles (it was driven/it will be driven), for about 50% of the miles, for about 25% of the miles, or some other amount?

For Q8a_1 to Q8e_3: ____ %
-8 Don't Know
-9 Refused
• NA

Most Driven Auto:

Approximate percentage of annual miles each person rides in the Most Driven Car (either as driver or passenger)				
A - Yourself	Person B	Person C	Person D	Person E
Q8a_1	**Q8b_1**	**Q8c_1**	**Q8d_1**	**Q8e_1**

2nd Most Driven Auto:

Approximate percentage of annual miles each person rides in the 2nd Most Driven Car (either as driver or passenger)				
A - Yourself	Person B	Person C	Person D	Person E
Q8a_2	**Q8b_2**	**Q8c_2**	**Q8d_2**	**Q8e_2**

3rd Most Driven Auto:

Approximate percentage of annual miles each person rides in the 3rd Most Driven Car (either as driver or passenger)				
A - Yourself	Person B	Person C	Person D	Person E
Q8a_3	**Q8b_3**	**Q8c_3**	**Q8d_3**	**Q8e_3**

(ADDITIONAL CLARIFICATION): The following example may help you think through the question. Suppose that the "Most Driven Car" in your household is your car that you drive alone to work most days. Also, most household outings and longer vacation trips are in that car. Thus, you may estimate that of the total annual miles that the "Most Driven Car" is driven, about 70% you are driving alone, and about 30% are family trips when you are all in the car. Thus, you may estimate that you are in the "Most Driven Car" 100% (70% + 30%) of the miles it is driven and your spouse and each of your children are in the car 30% of the

miles it is driven. In this case you will fill in the box of the "Most Driven Car," under A-yourself, 100%, and under persons B (your spouse), C and D (your children) 30%.

Q9 You said that *[FILL WITH PERSON NAME]* (rode in or drove/will ride in or drive) *[FILL WITH AUTOMOBILE MAKE AND MODEL]* about *[FILL WITH PERCENT OF MILES]* of the miles it is driven in a 12-month period. What percent of this time (did they/will they) occupy the front seat and the back seat?

For Q9a_f1 to Q9e_b3: ____ %
-8 Don't Know
-9 Refused
• NA

(NOTE: THIS MUST TOTAL 100% IF THEY RODE AT ALL IN THE AUTOMOBILE.)

Most Driven Auto:

A - Yourself		Person B		Person C		Person D		Person E	
Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles
Front	**Q9a_f1**	Front	**Q9b_f1**	Front	**Q9c_f1**	Front	**Q9d_f1**	Front	**Q9e_f1**
Back	**Q9a_b1**	Back	**Q9b_b 1**	Back	**Q9c_b1**	Back	**Q9d_b 1**	Back	**Q9e_b1**
Total	100%	Total	100%	Total	100%	Total	100%	Total	100%

2nd Most Driven Auto:

A - Yourself		Person B		Person C		Person D		Person E	
Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles
Front	**Q9a_f2**	Front	**Q9b_f2**	Front	**Q9c_f2**	Front	**Q9d_f2**	Front	**Q9e_f2**
Back	**Q9a_b2**	Back	**Q9b_b 2**	Back	**Q9c_b2**	Back	**Q9d_b 2**	Back	**Q9e_b2**
Total	100%	Total	100%	Total	100%	Total	100%	Total	100%

3rd Most Driven Auto:

A - Yourself		Person B		Person C		Person D		Person E	
Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles	Seat	% of miles
Front	**Q9a_f3**	Front	**Q9b_f3**	Front	**Q9c_f3**	Front	**Q9d_f3**	Front	**Q9e_f3**
Back	**Q9a_b3**	Back	**Q9b_b 3**	Back	**Q9c_b3**	Back	**Q9d_b 3**	Back	**Q9e_b3**
Total	100%	Total	100%	Total	100%	Total	100%	Total	100%

(ADDITIONAL CLARIFICATION): The following example may help you think through the question. Suppose that of the total miles that you ride in the "Most Driven Car," 90% of these miles you drive and 10% you occupy a back seat while another family member drives. In this case you will fill in the box of the "Most Driven Car," under A-yourself, 90% Front and 10% Back.

Recruit: Reasons For Using Your Automobiles

Q10 In the next set of questions, I am interested in learning the main reasons why you and other members of the household use your automobiles, either as a passenger or a driver. *(Not asked if person was younger than 14. If younger than 14, Q10a=No.)*

Use of Automobiles for Work	Person A - Yourself	Person B	Person C	Person D	Person E
a. Do/Does *[FILL WITH NAME]* work outside the home?	**Q10a_a** 1 Yes 2 No (SKIP TO Q10a_f)	**Q10b_a** 1 Yes 2 No (SKIP TO Q10b_f) • NA	**Q10c_a** 1 Yes 2 No (SKIP TO Q10c_f) • NA	**Q10d_a** 1 Yes 2 No (SKIP TO Q10d_f) • NA	**Q10e_a** 1 Yes 2 No (SKIP TO Q10e_f) • NA
b. Do/Does *[FILL WITH NAME]* travel to work in one of your household's automobiles?	**Q10a_b** 1 Yes 2 No (SKIP TO Q10a_f) • NA	**Q10b_b** 1 Yes 2 No (SKIP TO Q10b_f) • NA	**Q10c_b** 1 Yes 2 No (SKIP TO Q10c_f) • NA	**Q10d_b** 1 Yes 2 No (SKIP TO Q10d_f) • NA	**Q10e_b** 1 Yes 2 No (SKIP TO Q10e_f) • NA
c. What automobile do you/they use most often to get to work?	**Q10a_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10b_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10c_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10d_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10e_c** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA
d. How many miles is it (one-way) from your house to the workplace? *(INTERVIEWER NOTE: THE PRIMARY WORKPLACE IF MORE THAN ONE.)*	**Q10a_d** -8 Don't Know -9 Refused • NA	**Q10b_d** -8 Don't Know -9 Refused • NA	**Q10c_d** -8 Don't Know -9 Refused • NA	**Q10d_d** -8 Don't Know -9 Refused • NA	**Q10e_d** -8 Don't Know -9 Refused • NA
e. Who usually drives you/*[FILL WITH NAME]* to work?	**Q10a_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10b_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10c_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10d_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10e_e** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA

Use of Automobiles for School/Day Care	Person A - Yourself	Person B	Person C	Person D	Person E
a. Do/Does *[FILL WITH NAME]* go to school or day care?	**Q10a_f** 1 Yes 2 No (GO TO Q10b_a) • NA	**Q10b_f** 1 Yes 2 No (GO TO Q10c_a) • NA	**Q10c_f** 1 Yes 2 No (GO TO Q10d_a) • NA	**Q10d_f** 1 Yes 2 No (GO TO Q10e_a) • NA	**Q10e_f** 1 Yes 2 No (GO TO Q11) • NA
b. Do/Does *[FILL WITH NAME]* travel to day care or school in one of your household's automobiles?	**Q10a_g** 1 Yes 2 No (GO TO Q10b_a) • NA	**Q10b_g** 1 Yes 2 No (GO TO Q10c_a) • NA	**Q10c_g** 1 Yes 2 No (GO TO Q10d_a) • NA	**Q10d_g** 1 Yes 2 No (GO TO Q10e_a) • NA	**Q10e_g** 1 Yes 2 No (GO TO Q11) • NA
c. Which automobile is used most often to get to school or day care?	**Q10a_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10b_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10c_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10d_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA	**Q10e_h** 1 Most Driven Auto 2 2nd most driven 3 3rd most driven • NA
d. How many miles is it (one-way) from your house to school or day care?	**Q10a_I** -8 Don't Know -9 Refused • NA	**Q10b_I** -8 Don't Know -9 Refused • NA	**Q10c_I** -8 Don't Know -9 Refused • NA	**Q10d_I** -8 Don't Know -9 Refused • NA	**Q10e_I** -8 Don't Know -9 Refused • NA
e. Who usually drives you/*[FILL WITH NAME]* to school or day care?	**Q10a_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10b_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10c_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10d_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA	**Q10e_j** 1 Yourself 2 Person B 3 Person C 4 Person D 5 Person E 6 Other person • NA

Q11 What is the approximate distance, one way in miles, from your house to the grocery store where you most often do your grocery shopping?

___ miles *(NOTE: less than 1 mile = 1)*
-8 Don't know
-9 Refused

Q11a Does your household use your automobile(s) for grocery shopping?

1 Yes
2 No (SKIP TO Q12)

(IF ONLY 1 AUTOMOBILE, SKIP TO Q12. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q11b.)

Q11b Which of your automobiles is used most often for grocery shopping?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
• NA

Q11c Which of your automobiles is used second most often for grocery shopping?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No second car is ever used (SKIP TO Q12)
• NA

(IF NO THIRD AUTOMOBILE, SKIP TO Q12)

Q11d Which of your automobiles is used third most often for grocery shopping?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No second car is ever used
• NA

Q12 What is the approximate distance, one way in miles, from your house to the shopping centers, malls or stores where you go most often to do your other shopping?

____ miles *(NOTE: less than 1 mile = 1)*
-8 Don't know
-9 Refused

Q12a What is the approximate distance, one way in miles, from your house to the shopping centers, malls or stores where you go second most often to do your other shopping?

____ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q13)
-8 Don't know
-9 Refused

Q12b What is the approximate distance, one way in miles, from your house to the shopping centers, malls or stores where you go third most often to do your other shopping?

____ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q13)
-8 Don't know
-9 Refused
• NA

Q13 Does your household use your automobile(s) for getting to the shopping centers, malls, or stores?

1 Yes
2 No (SKIP TO Q14)

(IF ONLY 1 AUTOMOBILE, SKIP TO Q14. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q13a.)

Q13a Which of your automobiles is used most often for going to shopping centers, malls or stores?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
-7 Not asked
• NA

Q13b Which of your automobiles is used second most often for going to shopping centers, malls or stores?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile

4 No second car is ever used (SKIP TO Q14)
-7 Not asked
• NA

(IF NO THIRD AUTOMOBILE, SKIP TO Q14)

Q13c Which of your automobiles is used third most often for going to shopping centers, malls or stores?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No second car is ever used (SKIP TO Q14)
-7 Not asked
• NA

Q14 What is the approximate distance, one way in miles, from your house to the theater where your household most often watches movies?

____ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q15)
-8 Don't know
-9 Refused

Q14a Does your household use your automobile(s) to get to the theater?

1 Yes
2 No (SKIP TO Q15)
• NA

(IF ONLY 1 AUTOMOBILE, SKIP TO Q15. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q14b.)

Q14b Which of your automobiles is used most often for going to the theater?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
-7 Not asked
• NA

Q14c Which of your automobiles is used second most often for going to the theater?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No second car is ever used (SKIP TO Q15)
-7 Not asked
• NA

(IF NO THIRD AUTOMOBILE, SKIP TO Q15)

Q14d Which of your automobiles is used third most often for going to the theater?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
4 No third car is ever used (SKIP TO Q15)
-7 Not asked
• NA

Q15 Does anyone in your household use one of your automobiles on the job for more than just commuting to and from work?

1 Yes (IF YES, GO TO Q15_R)
2 No (SKIP TO Q16)
• NA

For Q15_R to Q15_C:
0 Not mentioned
1 Mentioned
• NA

Q15_R = Respondent uses auto on the job (Ask Q15a1 and Q15b1)
Q15_B = Person B uses auto on the job (Ask Q15a2 and Q15b2)

Q15_C = Person C uses auto on the job (Ask Q15a3 and Q15b3)

Q15a1 Which of your automobiles is used by *(Respondent)* on the job?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
-7 Not asked
• NA

Q15b1 About how many miles did *(Respondent)* travel in this automobile in the last 12 months for the job?

____ miles
-8 Don't know
• NA

Q15a2 Which of your automobiles is used by *(Person B)* on the job?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
• NA

Q15b2 About how many miles did *(Person B)* travel in this automobile in the last 12 months for the job?

____ miles
-8 Don't know
• NA

Q15a3 Which of your automobiles is used by *(Person C)* on the job?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
• NA

Q15b3 About how many miles did *(Person C)* travel in this automobile in the last 12 months for the job?

____ miles
-8 Don't know
• NA

Q16 Some households have certain places that they often drive to on weekends such as a lake, a park, or relative's home. In this question, I would like to learn about your household's travel as a group on weekend trips. Please think about how far it is (one way) from your home to the three <u>farthest</u> places you went on weekends over a typical year, and how many times you visited.

(NOTE: RESPONDENTS OFTEN DID NOT ANSWER THIS QUESTION IN THE ORDER INTENDED. MANY WERE LIKELY TO ANSWER IN THE ORDER OF HOW OFTEN THEY MADE THESE TRIPS.)

Q16a What is the approximate distance, one way in miles, from your house to the <u>farthest</u> place you go on weekends over a typical year?

___ miles *(NOTE: less than 1 mile = 1)*
-7 Don't go on weekend trips (SKIP TO Q17)
-8 Don't know
-9 Refused

Q16aa About how many times do you go to this place each year?

___ miles *(NOTE: less than 1 mile = 1)*
-8 Don't know
• NA

Q16b What is the approximate distance, one way in miles, from your house to the second <u>farthest</u> place you go on weekends over a typical year?

___ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q17)
-8 Don't know
-9 Refused
• NA

Q16bb About how many times do you go to this place each year?

___ times
-8 Don't know
• NA

Q16c What is the approximate distance, one way in miles, from your house to the third <u>farthest</u> place you go on weekends over a typical year?

____ miles *(NOTE: less than 1 mile = 1)*
-7 No other place (SKIP TO Q17)
-8 Don't know
-9 Refused
• NA

Q16cc About how many times do you go to this place each year?

____ times
-8 Don't know
• NA

Q17 Does your household use your automobile(s) on these weekend trips?

1 Yes
2 No (SKIP TO Q18)
• NA

(IF ONLY 1 AUTOMOBILE, SKIP TO Q18. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTO WAS RECORDED DURING DATA CLEANING INTO Q17a.)

Q17a Which of your automobiles is used or will be used most often for these weekend trips?

1 Most driven automobile
2 Second most driven automobile
3 Third most driven automobile
-7 Not asked
• NA

Q18 In a typical year, do you drive your automobile(s) on any longer vacations?

1 Yes
2 No (IF NO, SKIP TO Q19)

Q18a What is the approximate distance, one way in miles, from your house to the farthest place your household drove in a typical year on a longer vacation?

- ____ miles *(NOTE: less than 1 mile = 1)*
- -8 Don't know
- • NA

Q18aa About how many times do you drive to this place each year?

- ____ times *(.5 = every other year)*
- -8 Don't know
- • NA

(IF ONLY 1 AUTOMOBILE, SKIP TO Q19. NOTE: IF ONLY 1 AUTOMOBILE, THE INFORMATION FOR THAT AUTOMOBILE WAS RECORDED DURING DATA CLEANING INTO Q18b.)

Q18b Which of your automobiles is used or will be used most often for longer vacation trips?

- 1 Most driven automobile
- 2 Second most driven automobile
- 3 Third most driven automobile
- -7 Not asked
- • NA

Recruit: Recruitment

Q19 As I mentioned earlier, Cornell University is conducting a study to learn about people's opinions on automobile safety. You have just told me about your household's use of your automobiles. The opinion questions on auto safety are best presented on paper, since we have a couple figures or graphs that we want you to actually see. I would like to send you a brief survey containing these opinion questions. Can I get your name and address so I can send you the materials?

(IF RESPONDENT IS HESITANT): You have been scientifically selected to participate in this study. By helping us out with this mail survey you will be representing the opinions of other households in the U.S. like yours that were not chosen for this study. Since we cannot afford to call every household, your responses are very important. We can't afford to pay you for your time to

complete the survey, but we will include a token of our appreciation along with the survey. Would you be willing to help us out?

1	Yes (IF YES, PLEASE SPECIFY):	name address city state zip
2	No	*(IF NO, GO TO Q20)*

Recruit: About Your Household And Your Cars

Q20 I just have a couple final questions that will help our researchers better understand automobile use by different types of households. What is your present marital status? Are you . . .? *(READ LIST)*

1	Single, never married	
2	Married	
3	Separated	
4	Divorced	
5	Widowed	
7	Other (PLEASE SPECIFY)	(SEE Q20oth BELOW)
-9	Refused	

Q20oth Other marital status (FROM Q20 ABOVE)

1	Domestic partner
2	Engaged
3	Living with someone
4	Widowed and divorced
•	NA

Q21 Are you presently . . .? *(READ LIST)*

1	Employed full-time	
2	Employed part-time	
3	A full-time homemaker	(SKIP TO Q23)
4	Unemployed	(SKIP TO Q23)
5	Retired	(SKIP TO Q23)
6	A student	(SKIP TO Q23)
7	Other (PLEASE SPECIFY)	(SEE Q21oth below)
-9	Refused	

Q21oth Other employment (FROM Q21 ABOVE)

1 Disabled
2 Self-employed
• NA

Q22 Which one of the following occupational categories most closely reflects the type of work you do in your job? (If you had more than one job in 2001, we only need to know about your main job.)

1 Service worker, such as retail sales or hair stylist
2 Transportation operator, such as taxi, bus, train, or limo driver
3 Equipment operator
4 Craft worker, such as plumber or electrician
5 Traveling salesperson
6 Farm worker
7 Clerical worker
8 Laborer
9 Manager or administrator
10 Professional or technical
11 Other (PLEASE SPECIFY) (SEE Q22oth below)
-9 Refused
• NA

Q22oth Other occupations (FROM Q22 ABOVE)

1 Actor
2 Child Care
3 Communications
4 Correctional Officer
5 Custodian
7 Disabled
9 Hotel
10 Mail Carrier
11 Manufacturing
12 Meat Department
13 Parent Liaison
15 Self-employed
16 Teacher Aid
17 Truck Driver
18 U.S. Military
19 Works with Handicapped
20 YMCA
• NA

Q23 What is the highest grade or year of school that you have completed?

1	No school
2	Grade school (1-8 years)
3	Some high school (9-11 years)
4	Completed high school (12 years)
5	Some college, but no degree (13-15 years)
6	Associate degree
7	Bachelor's degree
8	Post graduate
-9	Refused

Q24 What was your approximate gross household income from all sources (before taxes and other deductions) in 2000?

1	Under $10,000	10	$90,000 to $99,999
2	$10,000 to $19,999	11	$100,000 to $119,999
3	$20,000 to $29,999	12	$120,000 to $139,999
4	$30,000 to $39,999	13	$140,000 to $179,999
5	$40,000 to $49,999	14	$180,000 to $219,999
6	$50,000 to $59,999	15	$220,000 to $259,999
7	$60,000 to $69,999	16	$260,000 to $300,000
8	$70,000 to $79,999	17	More than $300,000
9	$80,000 to $89,999	-9	Choose Not To Answer

(IF NEEDED FOR Q25 - Q27): We are studying household choices and automobile safety so it is important for us to know if there is a parent outside the household who provides financial support for one or more of the children.

Q25 Does any of your household's income come from child support?

1	Yes	
2	No	(SKIP TO CLOSING)
-9	Refused	(SKIP TO CLOSING)

Q26 How many children receive support? ______

Q27 How regularly are the full support payments received? Would you say . . .? *(READ LIST)*

1	All of the time
2	Most of the time
3	Some of the time
4	None of the time
-9	Refused
•	NA

CLOSING:

(IF RECRUITED, READ): You will be receiving your opinion survey by priority mail within the next few days. I would appreciate it if you could return it as soon as possible. It is very important that we collect the opinion data in this mail survey so we can use it to better understand usage and opinions.

I'd like to thank you for taking the time to help me and Cornell University out with this important study.

Mail Survey

Mail: What Are Your Views on Auto Safety?

Important Information Before You Start

Thank you for agreeing to complete this important survey on automobile safety. When talking with you on the telephone we asked several questions about the automobiles that your household owns or leases.

Please look over the information below and fill in anything that is incomplete as best you can. Cross out any incorrect information and write in correct information as best you can. Please continue to answer the remaining questions about the automobiles you had at the time of the phone survey, even if there have been changes since then.

Characteristics	Most Driven Automobile	2nd Most Driven Automobile	3rd Most Driven Automobile
Make or brand	**make_f1 (A)* make_c1 (A)****	**make_f2 (A) make_c2 (A)**	**make_f3 (A) make_c3 (A)**
Model	**model_f1 (A) model_c1 (A)**	**model_f2 (A) model_c2 (A)**	**model_f3 (A) model_c3 (A)**
Type of model	**type_f1 (A) type_c1 (A)**	**type_f2 (A) type_c2 (A)**	**type_f3 (A) type_c3 (A)**
Model year	**year_f1 year_c1**	**year_f2 year_c2**	**year_f3 year_c3**
Year you purchased or leased the automobile	**purch_f1 purch_c1**	**purch_f2 purch_c2**	**purch_f3 purch_c3**
Approximate purchase price or equivalent price used in calculating lease payments	**price_f1 price_c1**	**price_f2 price_c2**	**price_f3 price_c3**
Miles this automobile driven over the last 12 months. (If you've had this auto for less than 12 months, please estimate the miles it will be driven in a 12-month period.)	**miles_f1 miles_c1**	**miles_f2 miles_c2**	**miles_f3 miles_c3**

* The _f# variables contain the information provided in the recruit screener (series Q6a1 to Q6h3f) that were used to customize the mail survey. Respondents could change or update this information if necessary.

** The _c# variables contain any new data that was added by the respondent. Sometimes this included the addition of another automobile.

Mail: Automobile Safety and Your Household

M1 The purpose of this survey is to find out how important automobile safety is to you. About how often have you seen, heard, or read about automobile safety from TV, radio, newspapers, or magazines in the past 6 months? (*Please circle one number.*)

1 Never
2 A few times (1 to 4)
3 Several times (5 to 10)
4 Many times (11 to 20)
5 Very many times (More than 20)
-9 Missing

M2 Below is a list of factors that might affect your decision when purchasing or leasing an automobile for use by yourself and your household. For each factor, please indicate how important that factor would be to you when selecting an automobile for purchase or lease. Circle the number that most closely corresponds to your answer, where 1 = not at all important, and 7 = extremely important. *(Please circle one number for each factor.)*

		Not at all Important						Extremely Important	Missing
M2a	Passenger capacity	1	2	3	4	5	6	7	-9
M2b	Cargo space	1	2	3	4	5	6	7	-9
M2c	Comfort	1	2	3	4	5	6	7	-9
M2d	Fuel economy	1	2	3	4	5	6	7	-9
M2e	Four wheel drive	1	2	3	4	5	6	7	-9
M2f	Engine power	1	2	3	4	5	6	7	-9
M2g	Price	1	2	3	4	5	6	7	-9
M2h	Safety	1	2	3	4	5	6	7	-9

M3 Please tell us the approximate monthly costs for gas for each of your automobiles. *(Please fill in the dollar amounts.)*

For M3_1 to M3_3: $___
-9 Missing
• NA

MONTHLY COST	Most Driven Auto	2nd Most Driven Auto	3rd Most Driven Auto
Gas	**M3_1**	**M3_2**	**M3_3**

M4 Please tell us the approximate annual (yearly) insurance and maintenance and repair costs for each of your automobiles. *(Please fill in the dollar amounts.)*

For M4a_1 to M4a_3 and M4b_1 to M4b_3: $___
-9 Missing
• NA

ANNUAL COST	Most Driven Auto	2nd Most Driven Auto	3rd Most Driven Auto	Totals
Insurance	**M4a_1**	**M4a_2**	**M4a_3**	**M4a_t**
Maintenance and repair	**M4b_1**	**M4b_2**	**M4b_3**	**M4b_t**

M5 Please tell us if your automobiles are equipped with the following features: *(For each automobile, please circle either "Yes" or "No" for your answer for each feature.)*

For M5a_1 to M5p_3:
1 Yes
2 No
-9 Missing
• NA

DO YOU HAVE THESE FEATURES ON YOUR AUTOMOBILES?	Most Driven Auto	2nd Most Driven Auto	3rd Most Driven Auto
Automatic Transmission	**M5a_1**	**M5a_2**	**M5a_3**
Sun roof/Moon roof	**M5b_1**	**M5b_2**	**M5b_3**
Air Conditioning	**M5c_1**	**M5c_2**	**M5c_3**
Compact Disc Player	**M5d_1**	**M5d_2**	**M5d_3**
Driver Side Air Bag	**M5e_1**	**M5e_2**	**M5e_3**
Passenger Side Air Bag	**M5f_1**	**M5f_2**	**M5f_3**
Side Door Air Bag	**M5g_1**	**M5g_2**	**M5g_3**
Anti-Lock Brakes	**M5h_1**	**M5h_2**	**M5h_3**
Two Doors (i.e., not 4 door)	**M5i_1**	**M5i_2**	**M5i_3**
Wagon	**M5j_1**	**M5j_2**	**M5j_3**
Convertible	**M5k_1**	**M5k_2**	**M5k_3**
Anti-theft/Recovery System	**M5l_1**	**M5l_2**	**M5l_3**
Cruise Control	**M5m_1**	**M5m_2**	**M5m_3**
Alloy Wheels	**M5n_1**	**M5n_2**	**M5n_3**
Leather Seats	**M5o_1**	**M5o_2**	**M5o_3**
Special Package (Sport, Limited, GTS, etc.)	**M5p_1**	**M5p_2**	**M5p_3**

M6 Has anyone in your household bought any roadside assistance packages such as AAA, in the last five years? *(Circle the number of your answer.)*

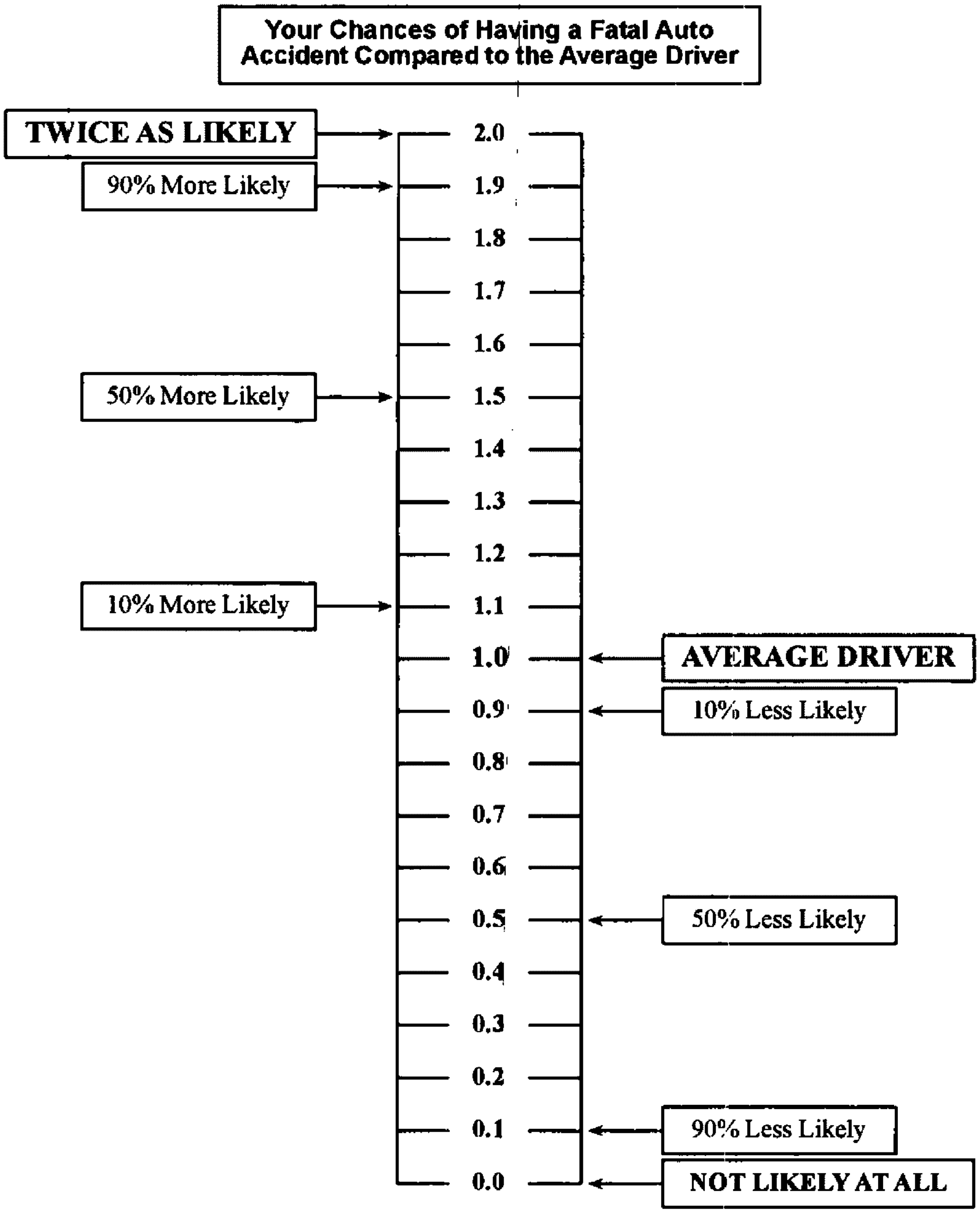
1 Yes (If Yes, ASK M6a)
2 No
-9 Missing
• NA

M6a Approximately how much did/do you pay per year?
I paid/pay $____ per year.
-8 Don't know

-9	Missing
•	NA

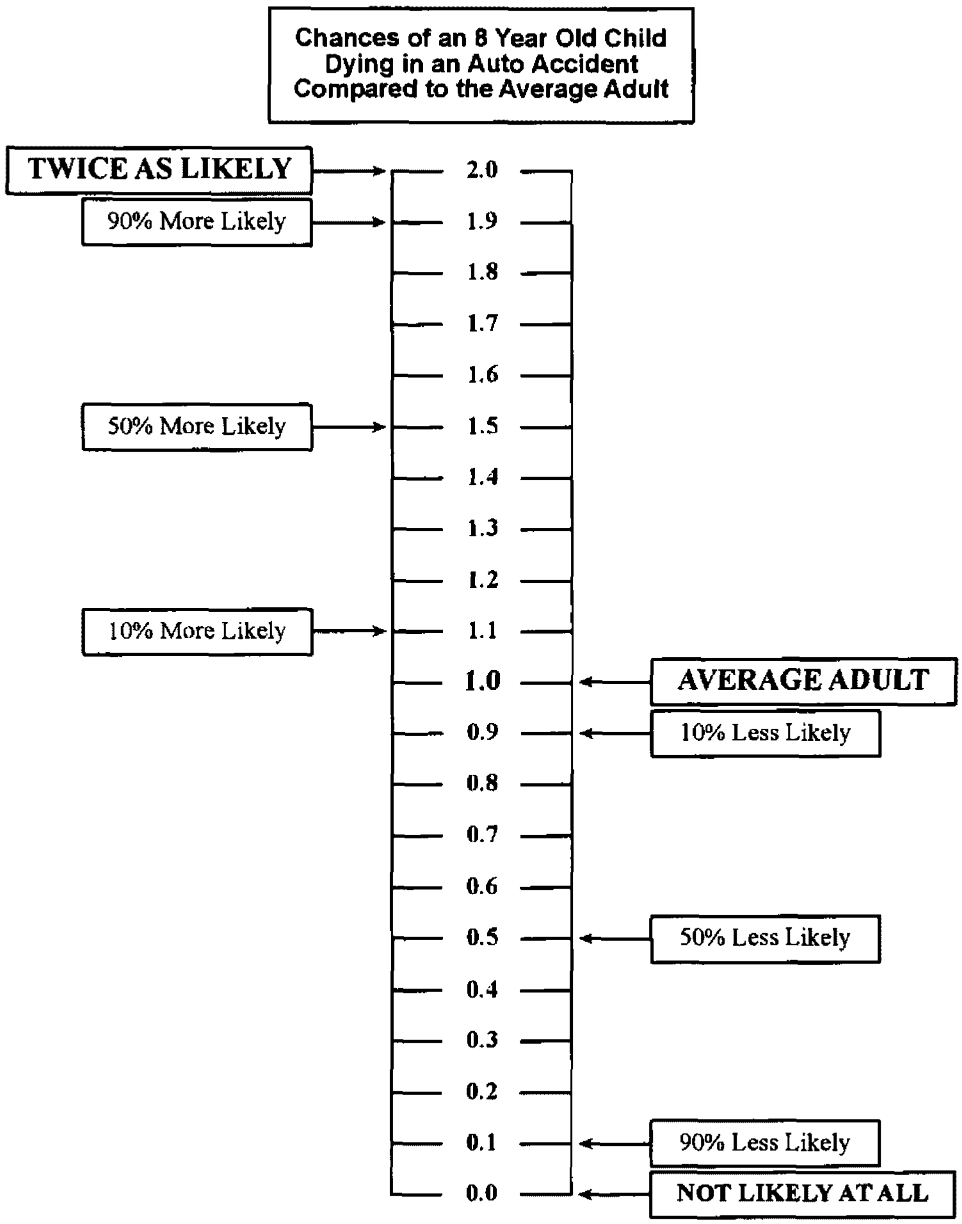
M7 We are interested in your perception of the likelihood of you having a fatal accident while driving, compared to the average driver in the same type of automobile. On the scale below, the likelihood that an average driver will have a fatal accident is equal to 1.0.

Please compare yourself with the average driver and tell us how likely you think it is that you will have a fatal accident compared to the average driver. *(Please circle the number in the middle of the ladder that best reflects your opinion. –8 indicates Don't Know and –9 indicates Missing data.)*



M8 In this question, we are interested in your perception of the likelihood of an 8-year-old child dying compared to an average adult when involved in a serious automobile accident. Assume they are both riding in the back seat of the same type of automobile.

Using the scale below, where the chance that an adult will die in a serious accident is equal to 1.0, tell us how likely you think it is that an 8-year-old child would die in an equally serious automobile accident compared to an average adult. *(Please circle the <u>number</u> in the middle of the ladder that best reflects your opinion. –8 indicates Don't Know and –9 indicates Missing data.)*



M9 Next, we are interested in your perception of the likelihood of a 70-year-old person dying compared to an average adult when involved in a serious accident.

Assume that they are riding as a passenger in the front seat of the same type of automobile.

Using the scale below, tell us how likely you think it is that a 70-year-old person would die in an equally serious automobile accident compared to an average adult. *(Please circle the <u>number</u> in the middle of the ladder that best reflects your opinion. –8 indicates Don't Know and –9 indicates Missing data.)*

Mail: How Safe Is Your Automobile?

In this section, we are interested in knowing about the safety of your automobiles.

Please look at the risk ladder on the facing page.

- The ladder shows the average annual fatality risk for different types of automobiles.
- The risks vary somewhat for individual makes and models. These are averages for the automobile categories.
- The ladder assumes that each type of automobile is driven an average of 14,000 miles per year by someone of average driving ability.
- Each step of the ladder is one fatality each year for every 100,000 automobiles per occupant. Thus, a single step represents 1 fatality each year for every 100,000 automobiles with 1 occupant, 2 fatalities each year for every 100,000 automobiles with 2 occupants, and so forth.

For example, based on 1997 automobile accidents in the United States, there was an average of about 5 fatalities for every 100,000 large sport utility vehicles (SUVs) with 1 occupant, and about 10 fatalities for every 100,000 large SUVs with 2 occupants.

M10 Please indicate the step number from the risk ladder that you think is closest to describing the annual fatality risk per occupant for each of your automobiles. *(Please mark an X on the line indicating the value for your automobile listed on the left side.)*

For M10_1 to M10_3: -8 Don't know
-9 Missing
• NA

	Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
M10_2	2nd Most Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
M10_3	3rd Most Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Mail: Your Value for Improved Automobile Safety

M11_v1 *(Version 1):*

Several promising safety features are being developed that would improve automobile safety. Experts estimate that these features can reduce average fatality risk per occupant by 1 or 2 steps on the risk ladder on the previous page for all types of automobiles.

If safety features were added to your household's most driven automobile that reduced the risk by 1 step, what would be the new fatality risk for that automobile? Please indicate the step number that is 1 step below your answer to Q10 for your household's most driven automobile. *(Please mark an X on the line indicating the new value for your most driven automobile.*

For M11_v1:
- -8 Don't know
- -9 Missing
- • NA

Most Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

M11_v2 *(Version 2):*

Several promising safety features are being developed that would improve automobile safety. Experts estimate that these features can reduce average fatality risk per occupant by 1 or 2 steps on the risk ladder on the previous page for all types of automobiles.

If safety features were added to your household's most driven automobile that reduced the risk by 2 steps, what would be the new fatality risk for that automobile? Please indicate the step number that is 2 steps below your answer to Q10 for your household's most driven automobile. ***(Please mark an X on the line indicating the new value for your most driven automobile.)***

For M11_v2: -8 Don't know
-9 Missing
• NA

Most Driven Auto	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

M12_v1 *(Version 1):*

How important to you would it be to have the fatality risk for your [MOST DRIVEN AUTOMOBILE] reduced by 1 step on the risk ladder? *(Circle the number of your answer.)*

Not at all Important						Extremely Important	Don't Know	Missing	NA
1	2	3	4	5	6	7	-8	-9	•

M12_v2 *(Version 2):*

How important to you would it be to have the fatality risk for your [MOST DRIVEN AUTOMOBILE] reduced by 2 steps on the risk ladder? *(Circle the number of your answer).*

Not at all Important						Extremely Important	Don't Know	Missing	NA
1	2	3	4	5	6	7	-8	-9	•

M13_v1 (*Version 1):*

Please imagine that when you purchased or leased your [MOST DRIVEN AUTOMOBILE] you could have selected an automobile with additional safety features but otherwise exactly the same. The annual fatality risk per occupant would be decreased by 1 or 2 steps on the risk ladder, depending on the safety features you selected.

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 1 step on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ _______ EXTRA FOR 1 STEP.

-8 Don't know
-9 Missing
• NA

M13a_v1 (A) Other comments on payment amount.

M13_v2 *(Version 2):*

Please imagine that when you purchased or leased your [MOST DRIVEN AUTOMOBILE] you could have selected an automobile with additional safety features but otherwise exactly the same. The annual fatality risk per occupant would be decreased by 1 or 2 steps on the risk ladder, depending on the safety features you selected.

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 2 steps on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ ______ EXTRA FOR 2 STEPS.

- -8 Don't know
- -9 Missing
- • NA

M13a_v2 (A) Other comments on payment amount.

M14_v1 (*Version 1):*

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 2 steps on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ ______ EXTRA FOR 2 STEPS.

- -8 Don't know
- -9 Missing
- • NA

M14a_v1 (A) Other comments on payment amount.

M14_v2 (*Version 2):*

What is the most extra you would have been willing to pay on the price of the automobile to have the safety features that reduce the fatality risk by 1 step on the ladder? *(Please do your best to give a dollar amount; approximate answers are fine. If you wouldn't be willing to pay anything extra, write $0.)*

I WOULD HAVE BEEN WILLING TO PAY $ ______ EXTRA FOR 1 STEP.

- -8 Don't know
- -9 Missing
- • NA

M14a_v2 (A) Other comments on payment amount.

M15 Below are some reasons why people choose the amounts they do when answering Questions 13 and 14. Please read each statement and indicate whether you agree or disagree. If you agree with the statement, please then indicate how much it influenced your answer of how much you would be willing to pay. *(Circle agree or disagree for each statement, and then, if you agree, circle the number of your answer.)*

NOTE: This section was data entered as it was answered. There were many respondents who filled in a rating but who did not indicated whether they agreed or disagreed. We made no assumptions about what their answers should have been because some respondents who circled Disagree also circled a rating. Therefore, we entered only what was circled.

M15a_a I could not afford to pay more for my automobile. . . .

1 Disagree (SKIP TO M15b_a)
2 Agree
• NA

M15a_b I could not afford to pay more for my automobile . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
• NA

M15b_a I believe it is important to increase automobile safety. . . .

1 Disagree (SKIP TO M15c_a)
2 Agree
• NA

M15b_b I believe it is important to increase automobile safety. . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
• NA

M15c_a I don't believe that the safety features would actually save lives . . . .

1 Disagree (SKIP TO M15d_a)
2 Agree
• NA

M15c_b I don't believe that the safety features would actually save lives . . . .

1 Did not influence my answer at all
2 Moderately influenced my answer
3 Greatly influenced my answer
• NA

M15d_a I don't believe it is my responsibility to pay for automobile safety improvements. . . .

1 Disagree (SKIP TO M15e_a)

2 Agree

• NA

M15d_b I don't believe it is my responsibility to pay for automobile safety improvements . . . .

1 Did not influence my answer at all

2 Moderately influenced my answer

3 Greatly influenced my answer

• NA

M15e_a I was thinking more about the cost of the safety features than about the reductions in fatality risk . . . .

1 Disagree (SKIP TO M15f_a)

2 Agree

• NA

M15e_b I was thinking more about the cost of the safety features than about the reductions in fatality risk . . . .

1 Did not influence my answer at all

2 Moderately influenced my answer

3 Greatly influenced my answer

• NA

M15f_a I need more information before committing any money . . . .

1 Disagree (SKIP TO M15g_a)

2 Agree

• NA

M15f_b I need more information before committing any money . . . .

1 Did not influence my answer at all

2 Moderately influenced my answer

3 Greatly influenced my answer

• NA

M15g_a Automobile safety is good enough now – improvements are not necessary . . . .

1 Disagree (SKIP TO M16)

2 Agree

• NA

M15g_b Automobile safety is good enough now – improvements are not necessary . . . .

1 Did not influence my answer at all

2 Moderately influenced my answer

3 Greatly influenced my answer

• NA

M16 Is there anything we have overlooked? Please use this space for additional comments you would like to make.

(Verbatim comments are located in a separate section of the User Guide.)

YOUR PARTICIPATION IS GREATLY APPRECIATED!

Please return your completed survey in the enclosed envelope or return to:

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