Automobile Industry Retail Price Equivalent and Indirect Cost Multipliers

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Assessment and Standards Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Prepared for EPA by
RTI International

and

Transportation Research Institute
University of Michigan

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Report

Prepared for

Gloria Helfand
U.S. Environmental Protection Agency
Office of Transportation and Air Quality
2000 Traverwood Drive
Ann Arbor, MI 48105

Prepared by

Alex Rogozhin

Michael Gallaher
RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

Walter McManus
Transportation Research Institute
University of Michigan
2901 Baxter Road
Ann Arbor, MI 48109

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Walter McManus
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EXECUTIVE SUMMARY

When developing environmental regulations, government agencies typically must estimate and consider the cost of the regulation to society. The cost of new regulations to producers, such as vehicle manufacturers, typically shows up in two broad categories: direct manufacturing costs and indirect costs. Direct manufacturing costs include manufacturing labor and direct material costs, which can be estimated via reverse engineering or other approaches. Indirect costs include research and development, corporate operations, dealer support, and marketing and are difficult to estimate because many indirect costs are difficult to allocate to specific production activities or are not affected by levels of production.

Because of the difficulties of estimating indirect costs associated with new technologies, the automotive industry has often applied scaling factors to changes in estimated direct costs to capture changes in indirect costs and, hence, predict the full impact vehicle modifications will have on the final selling price. A commonly used scaling factor is the retail price equivalent (RPE) multiplier, which is historically based and compares direct manufacturing costs with all other factors that influence the final price of a vehicle. Regulatory agencies, including the U.S. Environmental Protection Agency (EPA), have used RPE multipliers to scale the direct manufacturing costs associated with a regulation when estimating the total social cost of the regulation. However, a problem in using RPE multipliers in regulatory analysis is that some of the indirect cost components of the RPE multiplier, such as fixed depreciation costs, health care costs for retired workers, or pensions, may not be affected by all vehicle modifications resulting from regulation.

This report develops a modified multiplier, referred to as an indirect cost (IC) multiplier, which specifically evaluates the components of indirect costs that are likely to be affected by vehicle modifications associated with environmental regulation. A range of IC multipliers are developed that 1) account for differences in the technical complexity of required vehicle modifications and 2) adjust over time as new technologies become assimilated into the automotive production process.

We started our analysis by developing an industry average RPE multiplier for the passenger car industry. Using the methodology described by Vyas, Santini, and Cuenca (2000) as a guideline, we identified contributing factors to an automobile manufacturer's RPE multiplier. We used the data from annual reports of DaimlerChrysler, Ford, General Motors, Honda, Hyundai, Nissan, Toyota, and Volkswagen to calculate RPE multipliers for passenger car

manufacturers. Individual manufacturers' RPE multipliers are presented in Table ES-1 and range from 1.42 to 1.49. Weighting by 2007 worldwide sales provides an industry average RPE multiplier of 1.46.

Table ES-1. Industry Average and Individual Company RPE Multipliers: 2007

Company	Annual Production (number of vehicles) (2007)	RPE Multiplier
DaimlerChrysler[a]	4,635,601	1.47
Ford	6,247,506	1.45
GM	9,349,818	1.45
Honda	3,911,814	1.47
Hyundai	2,617,725	1.42
Nissan	3,431,398	1.49
Toyota	8,534,690	1.48
VW	6,267,891	1.43
Weighted Average		1.46

[a] Only 2006 sales were available. Thus, 2006 sales and a 2006 RPE multiplier for DaimlerChrysler were used in calculating the industry average.

Source: 2007 Company Annual Reports.

We then assert that not all components of the RPE will be affected by future EPA environmental regulations and conclude that a series of adjusted IC multipliers should be developed and be available for a range of possible regulatory alternatives. We show that environmental regulatory actions would have different impacts on cost contributors depending on the complexity of the technology associated with compliance. We introduce three levels of technology complexity: low, medium, and high. We argue that low-complexity technologies would have a smaller impact on manufacturers' operations than high-complexity technologies. We also argue that the magnitude of impacts would decline over time. Based on these findings, we constructed a series of IC multipliers, presented in Table ES-2, that more accurately reflect the change in manufacturers' indirect costs associated with the change in direct manufacturing costs under different scenarios. We believe using these IC multipliers is a more appropriate method for EPA to estimate indirect costs associated with future regulatory actions compared to using a single RPE multiplier.

Table ES-2. IC Multipliers by Technology Complexity and Time Frame

Time Frame	Technology Complexity		
	Low	Medium	High
Short-term effects	1.05	1.20	1.45
Long-term effects	1.02	1.05	1.26

This approach to estimating the indirect costs of new technologies can be used in two ways. First, the values in Table ES-2 can be used directly once the level of complexity of a new technology is determined. Second, if there is more detailed information about the indirect costs associated with a new technology, the methodology developed in this study can be used to develop a unique IC multiplier specific to that technology.

SECTION 1
INTRODUCTION

In addition to the direct manufacturing costs incurred during the vehicle production process, a manufacturer incurs certain indirect costs. These costs may be related to production, such as research and development (R&D); corporate operations, such as salaries, pensions, and health care costs for corporate staff; or selling, such as transportation, dealer support, and marketing. Indirect costs are generally recovered by allocating a share of the costs to each unit of goods sold (Vyas, Santini, and Cuenca, 2000). Because indirect costs affect the retail price of a vehicle, markup factors that relate indirect costs to the changes in direct manufacturing costs have been developed and are often referred to as retail price equivalent (RPE) multipliers. Cost analysts have frequently used these multipliers to predict the impact vehicle modifications will have on the final selling price. Using these multipliers implicitly assumes that incremental changes in direct manufacturing costs have a common (percentage) change on all indirect cost components as well as profits.

Conceptually, RPE multipliers provide, at an aggregate level, the relative shares of direct manufacturing costs and all other items that affect the business of auto manufacturing. The numerator of this ratio comprises indirect costs and profits.

RPE =   (Revenues)/(direct manufacturing costs),

or, equivalently,

RPE =   (direct + indirect costs + profits)/(direct manufacturing costs)

Regulatory agencies, including the U.S. Environmental Protection Agency (EPA), have used RPE multipliers to scale the incremental direct manufacturing costs associated with a regulation to estimate the total cost of the regulation. However, a problem in using RPE multipliers in regulatory analysis is that some of the indirect cost component of the RPE multiplier, such as fixed depreciation costs, retirees' health care costs, or pensions, may not be affected by vehicle modifications resulting from regulation. In addition, RPEs assume that market prices will increase by the full cost plus constant profit of the new technology; in fact, other factors that influence price (especially consumer demand and preferences) will affect how much of those costs will be passed along into market price.

This study develops a modified multiplier, referred to as an indirect cost (IC) multiplier, which specifically evaluates the components of indirect costs that are likely to be affected by vehicle modifications associated with environmental regulation.

IC Multiplier = (Incremental direct + indirect costs)/(incremental direct manufacturing costs)

A range of IC multipliers are developed that 1) account for differences in the technical complexity of required vehicle modifications and 2) adjust over time as modifications become assimilated into the automotive supply chain.

To calculate the IC multiplier, we began with the relative shares (%) for individual indirect cost categories developed through past RPE studies and updated them based on company-specific information obtained from recent annual reports. We then adjusted these indirect cost category shares to reflect differences in the technical complexity of automotive modifications that could result from different environmental regulations and to reflect how indirect cost impacts will change over time as new technologies are assimilated into the industry supply chain.

The remainder of this section describes how indirect multipliers have been developed in the past and focuses on the applicability of individual indirect cost components when considering vehicle technology changes due to environmental regulations. This discussion is followed by an overview of the methodology we used to calculate the IC multiplier we recommend to be used to assess potential environmental regulations.

1.1   Previous Indirect Cost Studies

In past mobile source regulatory actions, EPA has sometimes used a multiplier of 1.26 to account for the indirect costs associated with the direct manufacturing cost impacts of a regulation. This factor was originally derived for light-duty highway or passenger vehicles in the late 1970s and then updated (including other vehicle types) in 1985 by Jack Faucett Associates under contract to EPA (Jack Faucett Associates, 1985).

In 2000, researchers at the Argonne National Laboratory published a technical memorandum comparing three different estimates of RPE multipliers (Vyas, Santini, and Cuenca, 2000). In their study, Vyas et al. compared their own estimates (developed for passenger vehicles with an emphasis on electric vehicles) with those from Chrysler and Energy and Environmental Analysis and found that the three estimates, when put on a comparable basis,

were very similar. Vyas et al.'s analysis estimated RPE factors of 1.5 for outsourced components and 2.0 for products developed and manufactured internally at an automotive manufacturer.

A more recent analysis commissioned by the automobile manufacturing industry and conducted by Sierra Research, Inc. (2007) suggested that the 1985 Faucett report contains "basic methodological errors that make it unreliable for use in a regulatory analysis." The Sierra Research analysis concluded that an RPE factor for components manufactured internally at an automotive manufacturer should be about 2.0 to accurately account for indirect costs.

1.2   Indirect Cost (IC) Multiplier Developed as Part of This Study

Building on the analysis developed by Vyas et al., we developed a methodology to evaluate which indirect cost components will be affected by different potential regulatory actions. We distinguished between regulations requiring different levels of technical complexity. The underlying concept is that regulations requiring major changes in materials or manufacturing processes, or significant invention of new technology, will likely have a significant impact on indirect costs. In contrast, regulations requiring simple technology modifications may have negligible impacts on indirect costs. For this reason, implementing a single multiplier including all indirect costs across all technologies is not appropriate.

Our analysis is presented in four sections. In Section 2, we discuss the relationship of multiplicative adjustment factors to a market model based on a supply and demand modeling approach. We also explain why we believe the IC multiplier approach is more appropriate than the RPE multiplier approach when calculating a change in indirect costs associated with a regulation.

In Section 3, we present an overview of how we used Vyas et al.'s methodology to calculate RPE multipliers for individual manufacturers. We then calculated an average RPE multiplier for the automobile manufacturing industry using data from the annual reports of DaimlerChrysler, Ford, General Motors (GM), Honda, Hyundai, Nissan, Toyota, and Volkswagen[1].

In Section 4, we present the methodology we used to calculate IC multipliers customized for different types of regulations and present the application of the methodology for three potential technology categories. We then developed adjustment factors for each component of that multiplier for different complexities of technologies because not all components of the RPE will be affected by the introduction of new technologies. We also made adjustments for short-run

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[1] Calculations were based on the financial statements of manufacturers that covered worldwide automobile production (including passenger cars and light trucks). Manufacturers did not breakout financial results by production of passenger car vs. light truck vehicles, or worldwide vs. United States production.

(approximately the first 4 to 5 years of application of the new technology) and long-run (after 5 years of use) effects to account for technology assimilation over time. The multipliers that result from this adjustment process are called indirect cost multipliers, or IC multipliers. We estimated that the value of the IC multipliers varies from 1.02 to 1.45 for technologies with different levels of technical complexity in the short and long runs.

Section 5 summarizes our conclusions and provides a discussion of how IC multipliers might be affected by industry restructuring. Finally, in Appendix A we provide a detailed description of calculations and data sources of RPE multipliers for individual manufacturers.

SECTION 2
COMPARING RPE MULTIPLIER AND INDIRECT COST MULTIPLIER APPROACHES

Executive Order 12866, "Regulatory Planning and Review," issued in 1993, requires federal agencies to estimate the benefits and costs of significant regulatory actions. Circular A-4 of the Office of Management and Budget and the EPA's *Guidelines for Preparing Economic Analyses* stipulate use of a microeconomic framework to analyze the benefits and costs. This section discusses the relationship between the multipliers developed in this report and the microeconomic framework in which they will be used.

In this section, we compare two approaches for estimating the total cost of a regulation. One approach is to use an RPE multiplier to account for indirect costs and estimate the price change. The second is to use an IC multiplier to estimate the shift in the supply curve and then use a market model to estimate the change in price and quantity (which will influence the total cost of a regulation).

The RPE multiplier approach has been used as a method to estimate the change in indirect costs that are included in the total cost of a regulation. This approach has typically included using all indirect cost categories and profits to develop a multiplier that is then applied to the estimated direct manufacturing costs. The projected change in the retail price times the quantity affected is then used in the estimate of the full cost of the regulation.

We believe the RPE multiplier approach has problems in two areas. First, as we discuss in the following sections of this report, regulations will most likely not affect all categories of indirect costs. The indirect costs affected will vary by the complexity of the technology and will change over time (short run versus long run). In Section 4, we develop a series of IC multipliers to capture these factors.

Second, applying the RPE alone does not yield an accurate estimate of the change in price. Direct manufacturing costs and indirect costs resulting from a regulation reflect shifts in the total cost of production. In a market framework, this is represented by a shift in the supply function. Consider the following scenario presented in Figure 2-1. Initially the market is in equilibrium. Manufacturers produce quantity Q_1 and buyers purchase that quantity at the price of P_1 per vehicle (point A). Then a regulation is passed requiring manufacturers to implement a new technology. The added cost shifts the supply curve upward. The shift equals the per-unit cost of regulation, which includes both direct and indirect costs.

The RPE multiplier approach assumes that the multiplier captures the full market impact of the new cost. Sales continue at Q_1, and the price will rise to P_2 (point B). The RPE multiplier approach implies that demand is perfectly inelastic and there is a full pass-through of costs to consumers.
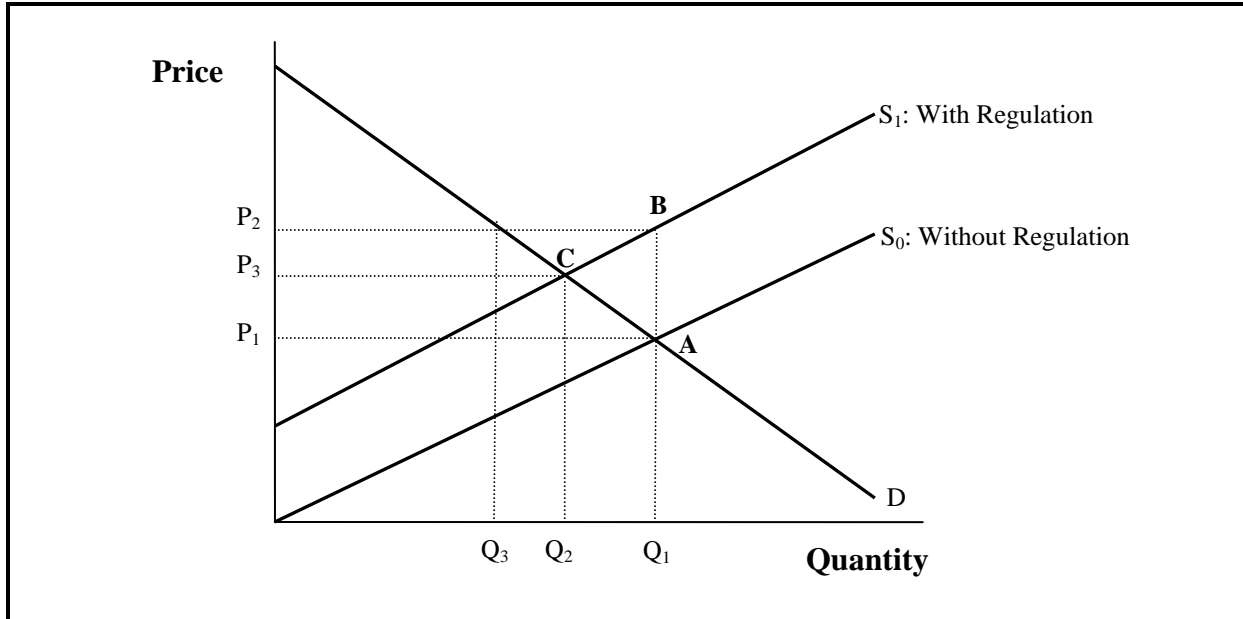
Figure 2-1. RPE Multiplier vs. IC Multiplier Approach

However, if the demand curve is less than perfectly inelastic (as shown in Figure 2-1), consumers will demand fewer vehicles as the price increases. A new equilibrium will be determined at the intersection of the supply and demand curves (point C). The new price will be P_3 and the new output will be Q_2. As a result, the final cost of the regulation (social cost) will be slightly less than the original cost estimate because of the decrease in quantity being produced. The original cost estimate, based on operation at point B, would be the area between lines S_0 and S_1, the price axis, and quantity Q_1. The actual social cost is the area between lines S_0 and S_1, the price axis, and points A and C; it is smaller than the original cost estimate by triangle ABC.

The market analysis represented in Figure 2-1 also highlights that profits should not be included in the IC multiplier. The RPE approach implicitly assumes disequilibrium in the market. Producer profits are calculated by assuming production at point B, even though consumers are not willing to pay P_2 and buy Q_1 vehicles. In reality, both price and quantity will change in response to the shift in costs. The impact on producer profits is determined by the slopes (elasticities) of the supply and demand curves. Producers and consumers typically share the burden of the compliance costs. Indeed, if profits were fully included in costs, then

producers would not be affected by regulations: their profits would be the same before and after the change. It is common, however, for a rule to affect profits; indeed, manufacturers often object to rules on this basis.

In a long run model of a perfectly competitive industry, microeconomic theory predicts that full costs are passed along to consumers. The perfect competition model assumes that firms make zero economic profits (that is, profits including all opportunity costs) before the regulation; the increased costs associated with the regulation will make profits negative if they are not able to pass them along. This is similar to assuming that the supply curve is horizontal in the long run. As a result, firms will exit the industry, until quantity supplied equals quantity demanded at price P_2, quantity Q_3. In an imperfectly competitive industry, firms are predicted to have profits greater than zero. When imperfectly competitive firms face increased costs, they seek to mitigate losses in production by not passing along the full costs; the quantity will not fall as much as Q_3, and the price will not rise as much as P_2. Economists often, but not always, argue that the automotive industry is imperfectly competitive.

Another factor that is difficult to predict in this setting is the effects of new technologies on consumer demand. Some changes may be invisible to consumers and will not affect their demand. Others, such as technologies that increase fuel economy with little other observable effect to the consumer, may increase demand. Finally, some technological changes may reduce demand, although automakers and regulators are not likely to pursue undesirable changes as long as more attractive alternatives exist. Any shifts in the demand curve due to new technologies should be included in regulatory impact analyses of new requirements. They should not, however, affect the estimate of indirect costs used to shift the supply curve. The RPE approach omits demand shifts as well as market adjustments due to the shifting supply curve.

In conclusion, we believe that the RPE approach has problems because it

- typically includes all categories of indirect costs, thus overstating the impact;

- typically includes profits in the multiplier and thus cannot be used as a supply shift in a market analysis;

- does not accurately project the change in market price or quantity or the total cost of the regulation, as a result of the first two bullets; and

- does not provide a framework in which demand shifts can be analyzed.

The IC multiplier is preferred because it models the appropriate shift in the supply curve (including direct manufacturing costs and relevant indirect costs) that then can be used in a

market analysis to determine a new equilibrium price and quantity, and hence the total cost of the regulation. A market analysis, pivoting on the new equilibrium generated from the IC multiplier approach, determines the distribution of regulatory burden between producers and consumers consistent with economic theory.

SECTION 3
RPE MULTIPLIER ESTIMATION

In this section, we identify and quantify the indirect cost components that constitute RPE multipliers for the automobile manufacturing industry. We present an overview of how Vyas et al.'s methodology was used to calculate RPE multipliers for individual manufacturers. We then calculate an average RPE multiplier for the automobile manufacturing industry using data from the annual reports of DaimlerChrysler, Ford, GM, Honda, Hyundai, Nissan, Toyota, and Volkswagen.

3.1   Components of Indirect Costs

We start our analysis by identifying components of indirect costs that EPA regulations could potentially affect. Table 3-1 presents the categories developed in Vyas et al.'s (2000) analysis[2]. The major categories among these are manufacturing costs,[3] production overhead costs,[4] corporate overhead costs,[5] selling costs,[6] and profit.[7] Added together these categories contributed to an estimated RPE multiplier of 2.0 for internally sourced components. That value was estimated to be 1.5 for externally sourced components (Vyas, Santini, and Cuenca, 2000). Since Ford spun off parts supplier Visteon in 1997, and GM spun off parts supplier Delphi in 1999, and since other manufacturers have independent parts suppliers (Denso for Toyota, Keihin for Honda, Bosch for Volkswagen, and Visteon for DaimlerChrysler, Nissan and Hyundai), we might expect the RPE multipliers for eight automobile manufacturers we estimate in this report to be close to 1.5 as a preliminary estimate.

Using Vyas et al.'s methodology as a guideline, we partitioned the indirect cost components as shown in Table 3-2. The corporate overhead costs component was broken into general administrative, retirement, and health care. The selling costs component was broken into transportation and marketing. We also accounted for dealer costs of selling new vehicles, and

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[2] Vyas et al.'s report also presents the results of two studies performed by Chrysler and EEA, Inc. However, our study specifically utilized the methodology developed by Vyas et al.

[3] *Manufacturing costs* refer to the total cost of making vehicles, consisting of direct production labor costs, direct materials costs, and other direct expenses.

[4] *Production overhead* is defined as indirect costs that arise from manufacturing and producing vehicles (such as the warranty, R&D, and depreciation and amortization).

[5] *Corporate overhead* costs refer to the costs of running a corporation, which include salaries of nonproduction workers, pensions, and health care expenses.

[6] *Selling costs* include salaries of marketing staff, advertising cost, dealer advertising etc.

[7] *Profit* (net profit) is defined as the difference between the total of all the manufacturers' revenue and the total of all the manufacturers' expenditures.

Table 3-1. RPE Multiplier Contributors in Vyas et al.'s Methodology

Cost Category	Cost Contributor	Relative to Cost of Manufacturing	Share of MSRP (%)
Manufacturing	Cost of manufacture	1.00	50.0
Production overhead	Warranty	0.10	5.0
	R&D/engineering	0.13	6.5
	Depreciation and amortization	0.11	5.5
Corporate overhead	Corporate overhead, retirement and health care	0.14	7.0
Selling	Transportation, marketing, dealer support, and dealer discount	0.47	23.5
Sum of costs		1.95	97.5
Profit	Profit	0.05	2.5
Total contribution to MSRP		2.00	100.0

Source: Vyas, A., D. Santini, and R. Cuenca. April 2000. "Comparison of Indirect Cost Multipliers for Manufacturing." Center for Transportation Research, Energy Systems Division, Argonne National Laboratory.

Table 3-2. RPE Multiplier Contributors in RTI's Methodology

Contributor
Manufacturing
Manufacturing cost
Production Overhead
Warranty
R&D (product development)
Depreciation and amortization
Maintenance, repair, operations cost
Corporate Overhead
General and administrative (G&A)
Retirement
Health care
Selling
Transportation
Marketing
Dealer
Dealer new vehicle net profit
Dealer new vehicle selling expense
Profit

dealer gross profits.[8] The increased level of disaggregation allowed for more flexibility when estimating the IC multipliers presented in Section 4.

3.2   Company-Level Indirect Cost Components and RPE Multipliers

Using automobile manufacturers' annual reports, we developed values for each of the indirect cost categories for individual automobile manufacturers. The majority of the information was obtained from income statement tables in manufacturers' annual reports. Appendix A presents detailed calculations of indirect cost components and RPE multipliers for individual manufacturers. Below we describe the limitations, assumptions, and adjustments for the data used in our analysis.

3.2.1   Data Origin and Limitations

The data for company-level RPE (and IC) multiplier analyses were gathered from publicly available annual reports. As a peer reviewer on this study, Glen Mercer, argues, although public availability is an advantage, these reports are accounting statements and may not relate directly to actual engineering costs. For example, depreciation is an accounting measure that might not correspond to actual wear and tear on the equipment. Additionally, annual reports might be biased toward corporate strategy rather than actual engineering realities. For example, a manufacturer might not raise the price of a vehicle by the full cost of a technology for marketing reasons. An alternative solution would be to request internal accounting information for various technology samples from each of the manufacturers, which would be slow, costly, and difficult. An argument can be made that some of these issues would wash out by averaging results across multiple manufacturers (Mercer, 2009).

3.2.2   Data Assumptions and Adjustments

In some instances, assumptions and adjustments were needed to make the cost data comparable across companies. Most of the manufacturers did not report direct manufacturing costs (cost of materials and labor used in manufacturing process). However, all manufacturers reported "cost of sales." Investopedia, Forbes's financial definitions Web site, defines cost of sales, which is often referred to as cost of goods sold (COGS), as "direct costs attributable to the production of the goods sold by a company, which includes the cost of the materials used in creating the good along with the direct labor costs used to produce the good." Manufacturing cost excludes indirect expenses such as costs and sales force costs. However, Investopedia (2008) warns that the exact costs included in cost-of-sales calculations may differ from one

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[8] Another item we reported was "other expenses,," which included interest expense, legacy costs and other miscellaneous expenses listed in annual reports as "other expenses." This expense is NOT included in RPE multipliers, and was reported for completeness of the snapshot of manufacturers' expenses.

business to another. Nevertheless, cost of sales was the best estimate of direct manufacturing costs reported by all companies.

"Health care" and "retirement" costs provided in domestic manufacturers' annual reports included expenditures for both manufacturing and corporate labor. The share of these costs related to manufacturing labor is a part of manufacturing expenses and, therefore, was added to the cost of manufacturing (i.e., to direct costs). The share related to corporate workers is a part of indirect costs and was added to the RPE multiplier. To determine how to attribute these shares, we looked at Ford's and GM's shares of manufacturing to production workers.[9] This showed that approximately 70% of workers were involved in manufacturing, while 30% were corporate workers. Since the share of manufacturing to production workers was not evident from other manufacturers' annual reports, a 70% to 30% share was used for all manufacturers.

Health care and retirement costs could be attributed to "legacy" or "current" costs. Legacy costs apply to workers who have already retired. A change in direct manufacturing costs due to a new vehicle technology applied to comply with an environmental regulation would have no effect on these costs. In contrast, current costs cover existing employees. These costs might change if the number of corporate employees were to change as a result of regulation (note that any increase in manufacturing labor would result in higher health care and retirement costs for those workers but, for this analysis, those costs would be captured under direct manufacturing costs). Based on domestic manufacturers' annual reports, we concluded that retirement costs included only current costs; therefore, all of these costs were included in the RPE multiplier. However, the reported health care costs appear to include both legacy and current costs. For example, for Ford Motor Company, the split was 45% legacy to 55% current. We used this share as a proxy for all domestic manufacturers and included only 55% of health care costs in the RPE multiplier calculations (as noted earlier, a regulatory change would have no effect on legacy costs). Since only a few foreign manufacturers reported actual health care costs, we applied a proxy of 0.03 of the cost of sales (30% of which were applicable as the corporate labor share) reported in the Sierra Research report (Sierra Research, 2007). It is worth noting that legacy costs are changing rapidly. For example, GM is gradually phasing out legacy costs. This and other forward-looking issues are discussed in Section 5.

Manufacturers did not report maintenance, repair, and operations (MRO) costs. The 2003 report from McKinsey was one source we identified for estimates of MRO costs (detailed

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[9] Ford Motor Company reported 64,000 hourly (73%) and 23,700 salaried workers (27%) (Ford, 2007, p. 12). General Motors reported expenditures for manufacturing labor of $27.9 billion (66%) and selling, general, administrative and other expenses of $14.4 billion (36%).

calculations of indirect cost contributors estimated using data from the McKinsey report are presented in Appendix B). However, McKinsey's estimate of MRO (0.14) was not documented and likely included direct manufacturing costs (such as purchase of equipment, technician labor costs, etc.) that are covered in depreciation, amortization, and cost of sales in our methodology.

The Sierra Research (2007) report estimated the historic value of MRO to the cost-of-sales ratio for Chrysler Company, which equaled 0.03. This value was used to reallocate costs to this category when a manufacturer did not provide estimates. In these cases, the value was subtracted from the cost of sales to redistribute existing costs instead of creating additional costs. Similarly, some manufacturers did not report health care costs. Since the McKinsey report did not provide an estimate of health care costs, we used the 0.03 estimate from the Sierra Research report to reallocate costs to health care. A detailed list of assumptions and sources for each manufacturer's indirect cost contributors is presented in Appendix A.

The only costs that were added (rather than redistributed from one of the indirect cost components) were dealer new vehicle net profit and dealer new vehicle selling expenses. These components are part of the final price of a vehicle but are not reported by automobile manufacturers. As discussed in Appendix Section A.2, we used the data from National Automotive Dealer Association (NADA) and estimated dealer new vehicle net profit to be 0.004, and new vehicle selling expenses to be 0.06.

3.2.3   Indirect Cost Components and RPE Multiplier Values

Table 3-3 presents the values of indirect cost components and RPE multipliers for individual manufacturers in 2007. Production overhead (and its subcomponents) were the largest contributor to the RPE multiplier and stayed relatively consistent across all manufacturers, ranging from 13% to 22% of cost of sales. Selling and dealer contributing factors were the second largest contributors to the RPE multiplier, with values ranging from 0.12 to 0.18. Corporate overhead (primarily general and administrative cost) were a smaller contributor to indirect costs and had greater variance, ranging from 4% to 14% of cost of sales. Other expenses, which are not part of indirect costs but are reflected in RPE multipliers, also varied significantly across companies.

Some corporations (e.g., Nissan and DaimlerChrysler) had lower corporate overhead costs but higher selling or production costs. The variance between companies can be explained by the differences in accounting definitions and practices. However, the sum of corporate overhead and selling costs tends to be comparable across the companies. Indirect production overhead costs tend to be inversely related to the sum of corporate and selling overhead. This

indicates that, although individual companies track and report indirect costs differently, aggregate indirect costs are similar.

Toyota, Hyundai, and Ford had the lowest totals of indirect cost components, equaling 38, 39 and 39 percent of cost of sales. Hyundai also had the lowest RPE multiplier at 1.42. Even though Toyota's share of indirect costs with respect to cost of sales was lower than Hyundai's, Toyota's profit (0.09) surpassed Hyundai's (0.03). Volkswagen had the second lowest RPE multiplier of 1.43. Among the American manufacturers, DaimlerChrysler had the highest RPE multiplier of 1.47, followed by GM and Ford with 1.45.

To ensure that 2007 was not an outlier year, we looked at a 5-year historical analysis of indirect cost contributors for individual manufacturers. For all but one manufacturer (DaimlerChrysler), the sum of three major indirect cost contributing factors (selling, administrative, and other expenses; operating and other expenses; and depreciation) deviated in the range of 10 percentage points in the past 5 years (see Appendix A for a historical RPE analysis for individual manufacturers). Keeping in mind that averaging manufacturers' costs would create an unbiased estimate, we concluded that 2007 RPE multipliers are unlikely to be underestimated.

Table 3-3. Individual Manufacturer and Industry Average RPE Multipliers: 2007

RPE Multiplier Contributor	Industry Average	Daimler Chrysler	Ford	GM	Honda	Hyundai	Nissan	Toyota	VW
Vehicle Manufacturing									
Cost of sales	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Production Overhead									
Warranty	0.03	0.04	0.03	0.03	0.01	0.02	0.03	0.04	0.02
R&D (product development)	0.05	0.04	0.02	0.06	0.07	0.04	0.06	0.05	0.06
Depreciation and amortization	0.07	0.11	0.05	0.06	0.05	0.06	0.09	0.08	0.09
Maintenance, repair, operations cost	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Total production overhead	0.18	0.22	0.13	0.17	0.16	0.15	0.21	0.19	0.20
Corporate Overhead									
General and administrative	0.07	0.05	0.12	0.07	0.11	0.08	0.03	0.06	0.03
Retirement	< 0.01	0.01	0.00	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Health	0.01	< 0.01	< 0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total corporate overhead	0.08	0.06	0.13	0.08	0.14	0.09	0.04	0.07	0.04
Selling									
Transportation	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.10
Marketing	0.04	0.02	0.04	0.05	0.03	0.05	0.08	0.03	0.02
Dealers									
Dealer new vehicle net profit	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dealer new vehicle selling cost	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Total selling and dealer contributors	0.14	0.12	0.14	0.14	0.13	0.15	0.18	0.12	0.17
Sum of Indirect Costs	0.40	0.40	0.39	0.40	0.44	0.39	0.43	0.38	0.41
Net income	0.06	0.07	0.05	0.05	0.04	0.03	0.06	0.09	0.02
Other costs (not included as contributors)	0.04	0.04	0.11	0.06	0.02	0.01	0.01	< 0.01	0.05
RPE Multiplier	1.46	1.47	1.45	1.45	1.47	1.42	1.49	1.48	1.43

The header "Relative to Cost of Sales" spans the columns Industry Average through VW.

3.3   Industry Average Indirect Costs and RPEs

To arrive at an RPE multiplier for the industry as a whole, we weighted each manufacturer's RPE multiplier by their 2007[10] worldwide production. Table 3-4 presents individual company production alongside the RPE multipliers. The weighted average RPE multiplier for the automobile manufacturing industry equaled 1.46 in 2007. The 2007 production figures presented in Table 3-4 were also used in Table 3-3 to generate industry-weighted average individual cost components.

Table 3-4.   Weighted RPE Multiplier: 2007

Company	Annual Production (number of vehicles) (2007)	RPE Multiplier
DaimlerChrysler	4,635,601	1.47
Ford	6,247,506	1.45
GM	9,349,818	1.45
Honda	3,911,814	1.47
Hyundai	2,617,725	1.42
Nissan	3,431,398	1.49
Toyota	8,534,690	1.48
VW	6,267,891	1.43
Weighted Average		1.46

Source: International Organization of Motor Vehicle Manufacturers (OICA). 2008. "World Motor Vehicle Production". http://oica.net/wp-content/uploads/world-ranking-2007.pdf.

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[10] DaimlerChrysler's RPE multiplier was calculated for 2006 (the last year the company released an annual report); therefore, their RPE multiplier was weighted by 2006 revenue.

SECTION 4
INDIRECT COST MULTIPLIER ESTIMATION

This section outlines calculations of IC multipliers that reflect differences in technology complexity and changes in indirect costs over time as modifications to production are assimilated. The motivation is to model the diversity of potential cost impacts that may influence the design and production of automobiles under a wide range of potential future environmental regulations.

In Section 3, we calculated an average RPE multiplier for the automobile manufacturing industry of approximately 1.46. This number includes markup for all indirect costs and profit. In this section, we focus solely on components of indirect costs that are likely to be impacted by future environmental regulations. We show that only a portion of the RPE multiplier should be used as a markup factor to account for the change in indirect costs from an environmental regulation. Because this factor reflects indirect costs only, it is referred to as an IC multiplier.

Regulations that require implementing different levels of technology complexity are likely to impact indirect cost contributors with different magnitudes. Rather than assuming that a single multiplier is appropriate for all technologies, we consider the possibility that regulations with low technology complexity (such as simply replacing an existing technology) would have a lower IC multiplier than a regulation involving high technology complexity (such as requiring significant new integration efforts). In addition, the magnitude of impacts of different technologies is also likely to change over time as new technologies are assimilated: for instance, although such expenses as research are likely to be high in the short run, in the long run, the new technology may no longer require special research efforts.

In this section, we describe the methodology used to calculate six automobile manufacturing industry IC multipliers, which capture technology differences associated with diverse EPA regulatory actions, as well as short- versus long-term impacts. Table 4-1 repeats the indirect cost contributors from Table 3-3, which are calculated as part of the industry average RPE multiplier. Table 4-1 excludes dealer and manufacturer profits for reasons discussed in Section 2. Our approach is to scale these values up or down depending on the complexity of the technology (which would be used by a manufacturer to meet new EPA regulations) and the time frame (short or long run).

Table 4-1. Weighted Average IC Multiplier Contributors to RPE: 2007

Cost Contributor	Light Car Industry Average
Production Overhead	
Warranty	0.03
R&D (product development)	0.05
Depreciation and amortization	0.07
Maintenance, repair, operations cost	0.03
Total production overhead	0.18
Corporate Overhead	
General and administrative	0.07
Retirement	0.00
Health care	0.01
Total corporate overhead	0.08
Selling	
Transportation	0.04
Marketing	0.04
Dealers	
Dealer new vehicle selling cost	0.06
Total selling and dealer costs	0.14
Sum of Indirect Costs	0.40

Technology complexity is defined in our methodology by the scope of the innovation in the automaker's products, product architectures, and processes induced by the technology. The more complex the technology associated with a regulation (low, medium, or high), the more indirect cost contributors that constitute the IC multiplier would be affected and to a greater degree.

4.1 Technology Complexity and Innovation Scope

Figure 4-1 provides a visual representation of the relationship between technology complexity and indirect costs. The flow of impacts from left to right in the figure starts with the technological complexity facing the automaker in meeting a new or revised EPA regulation. The broader the innovation scope, the greater the impact on the company's operations (e.g., manufacturing or purchasing of materials). The nature of the impact on operations determines which indirect costs will change and by what amount. In the following sections, we clarify and describe each of the categories.

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┌─────────────────────────────────────────────────────────────────────────┐
│  ┌──────────────┐      ┌──────────────┐    ┌──────────────┐   ┌──────────────┐  │
│  │  Technology  │ ──▷  │  Innovation  │──▷ │  Impact on   │──▷│  Impact on   │  │
│  │  Complexity  │      │    Scope     │    │  Operations  │   │ Indirect Cost│  │
│  │              │      │              │    │              │   │ Contributors │  │
│  └──────────────┘      └──────────────┘    └──────────────┘   └──────────────┘  │
└─────────────────────────────────────────────────────────────────────────┘
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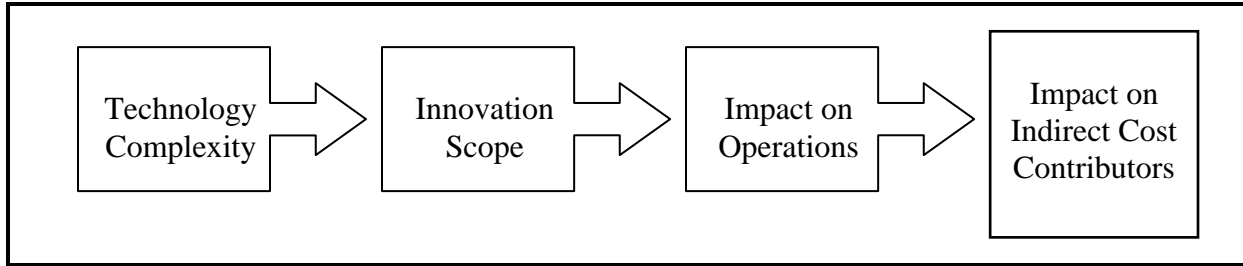
Figure 4-1. Impacts of Technology Complexity on IC Multiplier

As mentioned above, technology complexity is defined by the innovation in the automaker's products, product architectures, and processes induced by the technology. The framework to classify innovation was originally developed by Henderson and Clark (1990) and is based on the idea that successful product innovation requires two types of knowledge: knowledge about core design concepts of a product and knowledge about the architecture of the product or how components are integrated and linked together in a coherent whole. Following on Henderson and Clark, we identify four different innovation scopes, presented in Figure 4-2: incremental, modular, architectural, and differential.

```
                              Core Concepts
                    Reinforced              Overturned
                ┌──────────────────┬──────────────────┐
   U            │                  │                  │
   n            │                  │                  │
   c            │   Incremental    │     Modular      │
   h            │   Innovation     │   Innovation     │
   a            │                  │                  │
   n            │                  │                  │
   g            ├──────────────────┼──────────────────┤
   e            │                  │                  │
   d            │                  │                  │
                │   Architectural  │   Differential   │
   C            │   Innovation     │   Innovation     │
   h            │                  │                  │
   a            │                  │                  │
   n            │                  │                  │
   g            └──────────────────┴──────────────────┘
   e
   d
```

Linkages between Core Concepts and Components

Figure 4-2. Definition of Innovation Processes
Adapted from: Henderson, R.M., and K.B. Clark, 1990. "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms." *Administrative Science Quarterly* 35(1):12.

Incremental innovation introduces only minor changes to an existing product, using an established design. The underlying core design concepts and the links between them remain the same. A low-complexity technology would fall within this scope. An example of such technology in the automotive industry is low rolling resistance tires because they simply replace existing tires and require no vehicle redesign or part-integration effort by the automaker.

Modular innovation does not change the architecture of how the components interact with each other, but it changes the core concept of the technology. A medium-complexity technology would fall within this scope.

Architectural innovation changes the way in which the product's components are linked together without changing core design concepts. Again, a medium-complexity technology would fall within this scope. An example of such technology in the automotive industry is dual clutch transmission (DCT) because such transmissions simply replace an existing transmission but, unlike the case with low rolling resistance tires, would require some redesign and integration effort since the way that parts interact with each other would have to be changed.

Differential innovation is based on different engineering and scientific principles; it establishes a new dominant design and, hence, a new set of core design concepts embodied in components that are linked together in a new architecture. A high-complexity technology falls within this scope. An example of such technology in the automotive industry is the hybrid electric vehicle because it represents an entirely new approach to propulsion relative to total reliance on an internal combustion engine.

We classified these different kinds of innovation into different degrees of complexity of new technologies. Incremental innovation involves low complexity for new systems. Medium complexity is associated with either architectural innovation or modular innovation. Finally, differential innovation involves high complexity. Low, medium, and high complexities are the major categories that are used in the remainder of this section.

4.2 Impacts of a New Technology on Automotive Manufacturers' Operations

Implementation of a new technology can affect company operations in several ways. An obvious impact would be on the direct costs of operation. Even something as simple as changing a bolt or screw would require a new part number in a parts database to ensure that the proper bolt is used in every appropriate instance. Such a change could also trigger requirement for validation and/or durability testing. For operations, we have considered three areas of indirect costs that are

likely to be affected by a change in a part or technology: R&D and retooling[11] (through the change in R&D costs and production overhead), indirect labor costs (through increases in health care and retirement of corporate staff, corporate overhead, training of dealer mechanics to service new technologies, and dealer sales force to market new technologies), and indirect costs linked to materials used (due to warranty costs).

Table 4-2 illustrates possible impacts on each of the three areas. A technology's complexity determines to what degree that technology will impact company operations. The addition of a new low-complexity technology would likely require minimal investment in new tools and machinery (since existing tools can be used), and perhaps a minimal investment in R&D in order to validate the safety, compatibility and durability of the new component. No additional labor would be required, because current labor can be shifted easily to accommodate

Table 4-2.   Impact on Operations

Technology Complexity	Innovation Scope	One-Time R&D and Retooling	Corporate and Dealer Labor	Materials
Low	Incremental innovation	Minimal	No additional corporate labor needed No labor training needed. No impact on corporate labor health care, retirement, corporate overhead	Purchase of new materials is required
Medium	Modular innovation	Some R&D efforts are required	Minimal additional corporate labor needed	Purchase of new materials and parts is required
	Architectural innovation	Some investment in new tools is required	Labor training is required. Minimal impact on corporate health care, retirement, corporate overhead.	
High	Differential innovation	Extensive R&D efforts are required	Additional corporate labor needed	Purchase of new materials, parts, and systems is required
		Extensive investment in new tools is required	Extensive labor training is required. Substantial impact on corporate health care, retirement, corporate overhead	

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[11] Among the indirect cost contributors, retooling is captured in depreciation and amortization cost.

the implementation of such technology. The majority of the costs would be incurred to purchase new materials.

In contrast, the addition of a new medium-complexity technology would likely require some R&D effort to redesign a core component or a product's architecture such as replacing a larger 6-cylinder engine with a smaller turbo charged 4-cylinder engine. New machines and tools might need to be purchased to accommodate the production or assembly of redesigned parts. Minimal additional labor might be required, and some labor training may be necessary. Companies may need to purchase new materials and tooling to manufacture new designs.

Finally, the addition of a new highly complex technology would likely require extensive R&D efforts and substantial investment in tools and machinery to design and build new core concepts and architecture. Additional labor would likely be needed, and extensive labor training would likely be required. Companies might need to purchase new materials, parts, tooling, and whole systems to support implementation of high-complexity technologies.

4.3   Evaluating Indirect Cost Contributors

As the above discussion argues, the indirect costs associated with new technologies are expected to differ based on the degree of complexity of the technology and the time frame involved. EPA's National Vehicle and Fuel Emissions Laboratory assembled a team of engineers with experience working for auto manufacturers to provide adjustment factors for the contributions of indirect cost categories to the costs of new technologies. The team had among them 11 bachelor's degrees in engineering and physics; 10 master's degrees in engineering, atmospheric chemistry, and business; one Ph.D. in mechanical engineering; approximately 100 years of experience working for auto and engine manufacturers and service companies; and expertise in a wide range of auto technologies, including (among others) engines, powertrains, onboard diagnostics, fuel economy, and emissions controls. The team met five times over a period of 3 weeks to discuss each indirect cost component and reach a consensus on the potential impact resulting from different regulatory scenarios.

For low-, medium-, and high-complexity technologies, for both the short run and long run, the team of engineers reviewed the indirect costs required for new technologies. The baseline was the IC multiplier reported in Table 4-1. To provide context for the analysis, the team focused on three example technologies that are described in more detail in Sections 4.3.1, 4.3.2, and 4.3.3:

- Low complexity: low rolling resistance tires

- Medium complexity: dual clutch transmission

- High complexity: hybrid electric vehicle

For the low- and medium-complexity technologies, the team assumed that the development and manufacturing of these components is primarily purchased from suppliers. In contrast, the high-complexity example assumes in-house development and manufacturing. Using these technologies, the team identified adjustment factors that capture the extent to which each indirect cost contributor would be affected by the new technology, both in the short run (approximately the first 4 to 5 years from putting the technology into use) and in the long run (after 5 years of use). The adjustment factors are presented Tables 4-3 (short run) and 4-4 (long run), along with the rationale for their magnitude. A value of 0 indicates that current expenditures on the component will not change as a result of the new technology. A value greater than 0 indicates that the new technology will add costs to that component. The additional costs of that component then are calculated as the additional cost of the technology multiplied by the indirect cost contributor for the given category multiplied by the adjustment factor. An adjustment factor of 1 indicates that the indirect cost contributor scales directly with the cost of the new technology.

4.3.1 *Low Complexity: Low Rolling Resistance Tires*

Low rolling resistance tires are designed to reduce the energy wasted as heat from the flexing of the tire during driving and by reducing the tires' rolling resistance. The advances slightly change handling and braking but do not compromise the overall comfort of driving a vehicle (NRC, 2002). The Department of Energy recently estimated that, on average, this technology can reduce CO_2 emissions by 3% for light-duty vehicles (DOE, 2008).

Implementing this technology will require automobile manufacturers to purchase low rolling resistance tires. Implementing this technology does not require a change in core structure or redesign of architecture. The low rolling resistance tire is installed in place of a stock tire with a low degree of additional testing and development required. The development work may include some tuning and validation of stability control, ride and handling, and anti-lock brake systems; new vehicle coastdown tests; and recertification of fuel economy labels. This example assumes that there will not be significant modifications required in the chassis or suspension components. This technology is an example of a low-complexity technology.

4.3.2 Medium Complexity: Dual Clutch Transmissions

DCTs were recently introduced into mass production (primarily by the Volkswagen-Audi group in Europe). This technology combines the high mechanical efficiency of a manual transmission with the shift control of an automatic transmission. The benefits of this technology are lower CO_2 emissions and better fuel economy. Mechanically, DCT represents two transmission paths in parallel, each containing its own clutch. A change in gear is achieved by disengaging one clutch, while simultaneously engaging the other (Ricardo Inc., 2007).

Table 4-3.   Short-Term Effects on Indirect Cost Contributors

Indirect Cost/Technology Complexity	Low	Medium	High
Production Overhead			
Warranty	1.2	1.6	2.0
Warranty costs reflect the risk of failure and the cost of failure. In the short run, the expectation is that warranty costs will be higher for any new part or configuration, because of the manufacturers' lack of market exposure of the item. Warranty, especially risk, is expected to be higher for higher levels of complexity. The low and medium complexity warranty costs are assumed to include some sharing of the costs between the manufacturer of the component and the vehicle manufacturer.			
R&D	0.2	1.1	2
R&D is expected to increase with the complexity of the activity. For a low-complexity activity, the additional R&D associated with the incremental cost of the activity is expected to be less than the average R&D. For a medium-complexity activity, the additional R&D is expected to be slightly more than the average level. For high-complexity, much more R&D is necessary.			
Depreciation and amortization	0	0	1
For low- and medium-complexity activities, no new technology is considered necessary at the vehicle manufacturer level; therefore, there is no increment for depreciation of new equipment. For high-complexity activities, the average level of new equipment is expected.			
Maintenance, repair, operations cost	0	0	1
For low- and medium-complexity activities, there is no expected change in maintenance or other plant requirements because the new component or system replaces an existing one. For high-complexity activities, the average level of plant maintenance, repair, and operations is expected.			
Corporate Overhead			
G&A	0	0	0.5
For low- and medium-complexity activities, there is no expected change in personnel in corporate offices. For high-complexity activities, a small increase in personnel, less than proportional to the increase in direct manufacturing cost, is expected.			
Retirement	0	0	0.5
These values are expected to correspond to the values for G&A.			

Table 4-3.   Short-Term Effects on Indirect Cost Contributors (continued)

Indirect Cost/Technology Complexity	Low	Medium	High
Corporate Overhead (continued)			
Health care	0	0	0.5
These values are expected to correspond to the values for G&A.			
Selling			
Transportation	0	0	0.3
This value represents the cost of transporting the new vehicle to the dealer. For low- and medium-complexity activities, there is not expected to be any increase in cost. For high-complexity activities, it is possible that additional costs may be associated with transporting the vehicle because of special requirements and increased value of the vehicle.			
Marketing	0	1	1.5
The key factor that affects marketing is whether consumers notice the difference. For low-complexity activities, consumers are not expected to notice any change. For medium- and high-complexity activities, consumers are expected to need additional information, with a greater marketing effort for high-complexity activities than for medium.			
Dealer new vehicle selling cost	0.1	1	1.5
Dealer new vehicle selling costs in part depend on the cost of the vehicle and in part depend on the amount of training for servicing the vehicles. These costs are expected to increase with the complexity of the vehicle. Low-complexity activities are expected to have very small additional costs, medium-complexity activities are expected to have an average weight for additional costs, and high-complexity activities will have a weight greater than average.			

Table 4-4.   Long-Term Effects on Indirect Cost Contributors

Indirect Cost/Technology Complexity	Low	Medium	High
Production Overhead			
Warranty	0.6	0.8	1
Warranty costs reflect the risk of failure and the cost of failure. In the long run, the expectation is that warranty costs will be directly proportional to direct costs of a product for high-complexity technologies, as manufacturers work to reduce the failure rate for all products. For low- and medium-complexity technologies, the risk and cost of failure are expected to fall more than those of high-complexity technologies.			

Table 4-4.   Long-Term Effects on Indirect Cost Contributors

Indirect Cost/Technology Complexity	Low	Medium	High
Production Overhead			
R&D	0	0	0.3
	Almost all R&D is expected to be done (by definition) in the short run. Any remaining R&D, except for high-complexity activities, is expected to be no different than the R&D that would have taken place in the absence of the regulatory action. In the case of a high-complexity activity, some additional R&D is expected even in the long run.		
Depreciation and amortization	0	0	1
	For low- and medium-complexity activities, no new technology is considered necessary; therefore, there is no increment for depreciation of new equipment. For high-complexity activities, the average level of new equipment is expected.		
Maintenance, repair, operations cost	0	0	1
	For low- and medium-complexity activities, there is no expected change in maintenance or other plant requirements. For high-complexity activities, the average level of plant maintenance, repair, and operations is expected.		
Corporate Overhead			
G&A	0	0	0.5
	For low- and medium-complexity activities, there is no expected change in personnel in corporate offices. For high-complexity activities, a small increase in personnel is expected.		
Retirement	0	0	0.5
	These values are expected to correspond to the values for G&A.		
Health care	0	0	0.5
	These values are expected to correspond to the values for G&A.		
Selling			
Transportation	0	0	0.3
	This value represents the cost of transporting the new vehicle to the dealer. For low- and medium-complexity activities, there is not expected to be any increase in cost. For high-complexity activities, it is possible that additional costs may be associated with transporting the vehicle because of special requirements and increased value of the vehicle.		
Marketing	0	0	0
	In the long run, consumers are expected to have adapted to any changes, and no additional incremental increase in marketing is expected.		
Dealer new vehicle selling cost	0	0.3	1
	Dealer new vehicle selling cost in part depend on the cost of the vehicle and in part depend on the amount of training for servicing the vehicles. These costs are expected to increase with the complexity of the vehicle. In the long run, low-complexity activities are expected to have no additional costs, medium-complexity activities are expected to have small additional costs, and high-complexity activities will have an average value for dealer support.		

This example assumes that implementation of this technology in mass production requires the vehicle manufacturer to integrate the purchased transmission with the other vehicle systems, such as the engine. However, the core task of the transmission—to provide stepped gear ratios to maximize vehicle performance and efficiency—remains. This work is completed by the supplier, with the associated costs included in the direct cost. This technology is an example of a medium-complexity technology.

4.3.3 High Complexity: Hybrid Electric Vehicle

Hybrid electric vehicles are in various stages of development by almost all major light-duty car manufacturers. Among the popular hybrid cars being developed are "mild hybrids," with regenerative breaking, integrated starter generator (ISG), launch assist, and minimal battery storage. There are two basic types of driveline structure found in hybrid vehicles. The most common, parallel hybrid, is where the engine drives the powertrain and a generator helps recharge the battery. A second type, a series hybrid, is where the engine does not drive the powertrain but always drives the motor/generator to move the vehicle and recharge the battery. Reductions in carbon dioxide emissions vary between 15% and 30% (Ricardo Inc., 2007).

Production of a hybrid vehicle would require automobile manufacturers not only to redesign the car's physical and electronic architecture to accommodate the additional electric drive components, but also redesign the core structure of the main driveline components, including the transmission, engine, and other elements of the propulsion system. This technology is an example of a high-complexity technology.

4.4 Calculating IC Multipliers

The adjustment factors in Tables 4-3 and 4-4 are then multiplied by the industry weighted average indirect cost contributors to RPE presented in Table 4-1. The adjusted indirect cost contributors are then summed to calculate IC multipliers. These calculations are presented in Table 4-5. Adjustment factors are in effect scaling up or down the magnitude of the impact of specific indirect cost categories based on technology complexity. The time frame adds another dimension to our study. In the short run, indirect costs are likely to be higher, depending on the complexity of the technology, because of such factors as increased R&D, training of workers and dealers. However, R&D, investment in tools and machinery, and training represent one-time fixed costs. Thus, we expect to see higher indirect costs initially and lower impacts in the long run as companies assimilate the new technologies. Table 4-5 presents the final IC multipliers for the different levels of complexity and time frames.

4.5   Summary

IC multipliers are calculated to range from 1.05 to 1.45 in the short run and from 1.02 to 1.26 in the long run. The differences between the short- and long-run IC multipliers are primarily due to R&D and warranty costs, which are projected to decrease over time. R&D expenditures also vary greatly over the level of technology complexity, as does the need for dealer support.

To use the multipliers presented in Table 4-5, analysts can start by assessing the degree of complexity of the new technology under consideration. That identification process will lead to the short-run and long-run multipliers for the new technology. If an analyst has additional information about the role of indirect cost contributors for the new technology, that information can be used to develop different adjustment factors than those in Tables 4-3 and 4-4. This will then lead to the calculation of project-specific adjustment factors that can be substituted for those in Table 4-5.

Table 4-5. Short- and long-Term IC Multiplier Calculations

	RPE Multiplier Approach	IC Multiplier Approach											
		Short-Term Effects						Long-Term Effects					
	Weighted Average Industry Indirect Cost Contributors to RPE	Low Technology Complexity		Medium Technology Complexity		High Technology Complexity		Low Technology Complexity		Medium Technology Complexity		High Technology Complexity	
RPE and IC Multiplier Contributors		Adjust-ment Factor	IC Multip-lier	Adjust-ment Factor	IC Multip-lier	Adjust-ment Factor	IC Multip-lier	Adjust-ment Factor	IC Multip-lier	Adjust-ment Factor	IC Multip-lier	Adjust-ment Factor	IC Multip-lier
Manufacturing													
Cost of sales	1.00		1.00		1.00		1.00		1.00		1.00		1.00
Production overhead													
Warranty	0.03	1.20	0.04	1.60	0.05	2.00	0.06	0.60	0.02	0.80	0.02	1.00	0.03
R&D (product development)	0.05	0.20	0.01	1.10	0.06	2.00	0.10	0.00	0.00	0.00	0.00	0.30	0.02
Depreciation and amortization	0.07	0.00	0.00	0.00	0.00	1.00	0.07	0.00	0.00	0.00	0.00	1.00	0.07
Maintenance, repair, operations cost	0.03	0.00	0.00	0.00	0.00	1.00	0.03	0.00	0.00	0.00	0.00	1.00	0.03
Total production overhead	0.18		0.04		0.10		0.26		0.02		0.02		0.14
Corporate Overhead													
General and administrative	0.07	0.00	0.00	0.00	0.00	0.50	0.03	0.00	0.00	0.00	0.00	0.50	0.03
Retirement	0.00	0.00	0.00	0.00	0.00	0.50	<0.01	0.00	0.00	0.00	0.00	0.50	<0.01
Health	0.01	0.00	0.00	0.00	0.00	0.50	<0.01	0.00	0.00	1.00	0.01	0.50	<0.01
Total corporate overhead	0.08		0.00		0.00		0.04		0.00		0.01		0.04
Selling													
Transportation	0.04	0.00	0.00	0.00	0.00	0.30	0.01	0.00	0.00	0.00	0.00	0.30	0.01
Marketing	0.04	0.00	0.00	1.00	0.04	1.50	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Dealers													
Dealer net profit	<0.01												
Dealer new vehicle selling cost	0.06	0.10	0.01	1.00	0.06	1.50	0.08	0.00	0.00	0.30	0.02	1.00	0.06
Total selling and dealer contributors	0.14		0.01		0.09		0.15		0.00		0.02		0.07
Sum of Indirect Costs	0.40		0.05		0.20		0.45		0.02		0.05		0.26
Net income	0.06												
Other costs (not included in contributing costs)	0.04												
Total contribution to cost of sales	1.46		1.05		1.20		1.45		1.02		1.05		1.26

SECTION 5
CONCLUSION

The RPE multiplier approach has been used as a method to estimate the change in indirect costs which are included in the total cost of a regulation. This approach has typically included using all indirect cost categories and profits to develop a multiplier that is then applied to the estimated direct manufacturing costs. Regulatory agencies, including EPA, have used RPE multipliers to scale the direct manufacturing costs associated with a regulation when estimating the total social cost of the regulation. However, a key problem in using RPE multipliers in regulatory analysis is that some of the indirect cost components of the RPE multiplier, such as fixed depreciation costs, health care costs for retired workers, or pensions, may not be affected by all vehicle modifications resulting from regulation.

This report develops a modified multiplier, referred to as an IC multiplier, which specifically evaluates the components of indirect costs that are likely to be affected by vehicle modifications associated with environmental regulation. A range of IC multipliers are developed that 1) account for differences in the technical complexity of required vehicle modifications and 2) adjust over time as new technologies become assimilated into the automotive supply chain.

The IC multiplier is preferred because it models the appropriate shift in the supply curve (including direct manufacturing costs and relevant indirect costs) that then can be used in a market analysis to determine a new equilibrium price and quantity, and hence the total cost of the regulation. The new equilibrium generated from the IC multiplier approach and the market analysis determines the distribution of regulatory burden between producers and consumers consistent with economic theory.

5.1   Applicability of the RPE and IC Multipliers in Future Years

The results of this analysis suggest that each manufacturer's RPE multiplier has been fairly consistent from 2002 to 2007 (2002 to 2006 for DaimlerChrysler). Further, the adjustments to develop the IC multipliers were based on engineering judgment of the effects of new technologies. While the technologies to which they will be applied might be very different in the future, there is unlikely to be a structural reason over time for the adjustment factors to change. These factors suggest that the multipliers developed here will continue to be appropriate in the future.

On the other hand, the economic recession that began in 2008 had a strong effect on automobile sales and, especially for the United States automakers, the industry's access to the

capital it needs to operate. As a result, the domestic manufacturers have stated that they intend to undergo significant restructuring in coming years to increase their productivity. This restructuring could affect the ratio of indirect costs to direct manufacturing costs that forms the basis for the RPE and IC multipliers.

The domestic auto manufacturers have proposed plans to improve their financial viability. [12] All three companies are in the process of downsizing both their manufacturing and their white-collar workforce; they also are reducing their physical plants and changing their investment strategies. The magnitude of these changes may be sufficient to alter the RPE calculated here. Whether the multiplier for each manufacturer is likely to increase or decrease in response to the restructuring depends on the relative changes that will take place in the indirect and direct manufacturing cost categories.

Direct manufacturing costs consist of direct production labor costs, direct materials costs, and other direct expenses. Direct materials costs and other direct expenses are not discussed in the restructuring plans. A change in materials costs could result from a major change in vehicle design. They might increase if vehicles use more expensive inputs; they might decrease because of using less expensive inputs or the increased emphasis on smaller vehicles that the plans imply. Direct labor costs are on a trajectory to decrease because of the new 2007 contract that each company negotiated with the United Auto Workers. Thus, it is likely but not certain that direct manufacturing costs will decrease because of restructuring.

Indirect cost categories include production overhead (including warranty, R&D, depreciation and amortization, and MRO cost), corporate overhead (including general and administrative, retirement, and health care), and selling (including transportation, marketing, dealer support, discounts, and markup). The restructuring plans all imply major reductions in these categories. Each producer is closing plants and has reduced salaried labor costs. In addition, each plans to coordinate more across international divisions to achieve greater economies of scale in design and production. Warranty costs are expected to continue to decrease; health care and retirement costs are becoming more contained over time, and they are closing a number of dealerships. While the reports all discuss new technologies that the automakers plan to develop, it is not clear whether these R&D expenditures involve increases in that account. The plans all imply that the sum of these costs is likely to go down significantly.

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[12] Robert Nardelli, "Chrysler's Plan for Short-Term and Long-Term Viability," United States House Committee on Financial Services, December 2, 2008; "Ford Motor Company Business Plan Submitted to the House Financial Services Committee," December 2, 2008; General Motors Corporation, "Restructuring Plan for Long-Term Viability: Submitted to Senate Banking Committee & House of Representatives Financial Services Committee," December 2, 2008; all found at http://financialservices.house.gov/autostabilization.html.

How the multiplier is affected by industry restructuring depends on whether the indirect costs go down more quickly or less quickly than the direct manufacturing costs. Much of the restructuring implies large reductions in indirect costs, through plant and dealership closures, reductions in salaried employees and warranty costs, and greater coordination across international divisions. These changes will reduce the RPE multiplier. The revised UAW contract, on the other hand, will reduce direct manufacturing costs and thus increase the RPE multiplier. The net effect of these changes on the RPE multiplier is difficult to predict.

The foreign automakers do not appear to be under the same pressures to restructure that the U.S. automakers appear to face. Their RPE multipliers are not very different from the U.S. companies' RPE multipliers. As Table 3-3 shows, Nissan has the highest RPE multiplier in 2007, while Hyundai had the lowest, with RPE multipliers for U.S. producers between them. If the U.S. restructuring leads them to have cost structures similar to those of foreign automakers, their RPE multipliers may not change greatly from the current values.

For low- and medium-complexity changes, the adjustment factors are such that a change in the RPE multiplier is not likely to have very much effect on the relevant IC multiplier. A change in the RPE multiplier will have a larger effect on the IC multiplier for high-complexity technologies.

In sum, while the RPE multiplier is likely to change because of domestic auto industry restructuring, the direction of the change cannot be predicted at this time. The fact that foreign automakers have similar RPE multipliers and do not appear to face the same restructuring pressures suggests that the RPE multipliers may not in fact change greatly. The adjustment factors developed in Section 4.3 are unlikely to need modification in the future. For these reasons, using the IC multipliers in Table 4-5 is likely to be reasonable. It may nevertheless be worthwhile to re-evaluate the RPE multipliers periodically to examine the effect of changes in industry structure.

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APPENDIX A

CALCULATION OF RPE MULTIPLIERS FOR INDIVIDUAL MANUFACTURERS

This appendix describes calculations of RPE multipliers for the automobile manufacturing industry and for individual automobile manufacturers. The section is structured in the following manner:

- Appendix A.1: Automobile Industry (McKinsey)

- Appendix A.2: Dealer Cost and Profit Calculation

- Appendix A.3: General Motors

- Appendix A.4: DaimlerChrysler AG

- Appendix A.5: Ford Motor Company

- Appendix A.6: Honda Motor Company

- Appendix A.7: Hyundai Motor Company

- Appendix A.8: Nissan Motor Company

- Appendix A.9: Toyota Motor Company

- Appendix A.10: Volkswagen Group

A.1   Automobile Industry (McKinsey)

A white paper developed by McKinsey & Company (2003) described an analysis of costs (in dollars per vehicle) observed by original equipment manufacturers (OEMs) and their contribution to the manufacturer's suggested retail price (MSRP). The analysis was based on data provided by Roland Berger Consultants, Deutsche Bank, and McKinsey. These costs are presented in Table A-1.

Using cost categories and profit reported in the McKinsey study, we developed an RPE multiplier. In Table A-2, costs of materials (both raw and purchased parts) and manufacturing costs are combined to comprise the "cost of manufacturing" category (these costs are listed separately in Table A-1). G&A costs were counted as part of corporate overhead. Transportation costs and dealer discount were counted in selling costs. As Table A-2 indicates, the RPE multiplier was 1.70.

Table A-1. McKinsey's Automobile Industry Manufacturers' Cost Contributions to MSRP

Cost Contributor	Average Amount Per Vehicle ($)	Percent Share
Material cost (purchased parts)	10,030	41.6%
Material cost (raw materials)	1,770	7.3%
Manufacturing cost	2,400	10.0%
Maintenance, repair, operations cost	2,000	8.3%
Product development	1,600	6.6%
Transportation	500	2.1%
Sales & marketing	1,200	5.0%
Depreciation and Interest	1,150	4.8%
Warranty costs	600	2.5%
General & administrative	500	2.1%
Net profit	750	3.1%
Wholesale price to dealer	22,500	93.4%
Dealer gross	1,600	6.6%
MSRP	24,100	100.0%

Source: McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

Table A-2. Automobile Manufacturing Industry RPE Multiplier (based on McKinsey's Data)

RPE Multiplier Contributor	Relative to Cost of Manufacturing	Share of RPE Multiplier
Manufacturing		
Manufacturing cost	1.00	0.59
Production Overhead		
Warranty	0.04	0.03
R&D (product development)	0.11	0.07
Depreciation and amortization	0.08	0.05
Maintenance, repair, operations cost	0.14	0.08
Total production overhead	0.38	0.22
Corporate Overhead		
Corporate overhead, retirement and health	0.04	0.02
Selling		
Transportation, marketing, dealer support, dealer discount	0.23	0.14
Sum of Indirect Costs	0.64	0.38
Profit	0.05	0.03
RPE Multiplier	1.70	1.00

A.2 Dealer Cost and Profit Calculation

This section describes a calculation of dealer net profit and new vehicle selling cost as a share of manufacturers' cost of sales. Car dealerships in the United States primarily engage in three types activities: new vehicle sales, used vehicle sales, and service and parts sales. For automobile industry RPE and IC multipliers, we are only concerned with profit and cost of new vehicle sales, because only these profits and costs will affect new vehicle retail price. Sales of used cars are not directly related to manufacturers, and service and parts operations are covered under warranties and otherwise paid for by consumers and not by manufacturers.

We find that the industry average dealer net profit margin on new vehicle sales as a share of manufacturers' cost of sales was 0.004, and the industry average new vehicle selling costs as a share of manufacturers' cost of sales was 0.06. We will describe calculation steps below.

Table A-3 lists dealer gross profit margin on new vehicle sales, which were obtained from J.D. Power and Associates.

Table A-3. Dealer Gross Profit Margin on New-Vehicle Sales

Year	Dealer Gross Profit Margin
2003	0.044
2004	0.041
2005	0.039
2006	0.038
2007	0.034
Average	0.039

Source: Estimates of annual U.S. dealer gross profit margins on new vehicle sales based on Walter McManus' direct communication with J.D. Power and Associates

The National Automotive Dealer Association (NADA) books provide detailed information on sales and profits, including new vehicle sales, and new vehicle net profits (NADA, 2008). Using new vehicle sales (NADA, 2008) and dealer gross profit margin on new vehicle sales (from J.D. Power and Associates) we calculated gross profit (the difference between total sales and vehicle costs) on new vehicle sales (row C in Table A-4). We then obtained new vehicle selling costs (row E in Table A-4) by subtracting net profits on new vehicle sales (NADA, 2008) from gross profit on new vehicle sales. Finally, we calculated ratios of net profit and selling expenditures on new vehicle sales to new vehicle sales. To

normalize these ratios we performed this calculation by first averaging new vehicle sales, net profits, and selling expenses and calculating the ratios then. The values of these ratios were:

$$\frac{\text{Dealer new vehicle net profit}}{\text{New vehicle sales}} = 0.003$$

$$\frac{\text{Dealer new vehicle selling cost}}{\text{New vehicle sales}} = 0.04$$

The low ratio of net profits on new vehicle sales to new vehicle sales makes sense. The surge in dealers' net profits from new vehicles in 2001-2005 is largely the result of the rapid deflation of new vehicle prices (through cash and interest rate incentives) by automakers. The automakers doubled consumer incentives each year from 2002 through 2004 (and a smaller increase in 2005).

Table A-4. Average U.S. Dealership Net Profit and Selling Expenses on New Vehicle Sales, 2003–2007

Row		Average Dealership Financials ($ Thousand)					
		2003	**2004**	**2005**	**2006**	**2007**	**Source / Calculation**
A	New vehicle sales	19,359	20,116	19,469	18,795	19,545	NADA
B	New vehicle gross profit margin	0.044	0.041	0.039	0.038	0.034	J.D. Power
C	New vehicle gross profit	848	818	768	714	672	A * B
D	New vehicle net profit	147	141	44	-25	-41	NADA
E	New vehicle selling cost	701	677	724	739	713	C - D

Source: NADA, 2008.

We then calculate a share of dealer net profit and selling cost on new vehicle sales as a share of the automobile manufacturers' cost of sales (this will allow us to include these costs as cost contributors to the RPE and IC multiplier calculations). We started with individual manufacturers' annual sales (row B in Table A-5) and calculated new vehicle sales (row D in Table A-5) by adding average[13] dealer gross profit (row C in Table A-5) from Table A-3. This new vehicle sales value is comparable to dealer new vehicle sales value from Table A-4. We then calculate the ratios of new vehicle sales to manufacturers' cost of sales (row E in Table A-5).

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[13] 5-year arithmetic average was used to normalize the value of dealer gross profit margin

We then multiplied the ratios in row E in Table A-5 by the ratios in rows F and G in Table A-4 to arrive at dealer's net profit and selling expense on new vehicles:

$$\frac{\text{Dealer new vehicle net profit}}{\text{New vehicle sales}} \; x \; \frac{\text{New vehicle sales}}{\text{Manufacturer's cost of sales}} = \frac{\text{Dealer new vehicle net profit}}{\text{Manufacturer's cost of sales}}$$

$$\frac{\text{Dealer new vehicle selling cost}}{\text{New vehicle sales}} \; x \; \frac{\text{New vehicle sales}}{\text{Manufacturer's cost of sales}} = \frac{\text{Dealer new vehicle selling cost}}{\text{Manufacturer's cost of sales}}$$

Finally, we weighted these values by individual manufacturers' annual production (row H in Table A-5) to arrive at industry averages. As Table A-5 shows, dealer new vehicle net profit as a share of cost of sales equaled 0.004, and new vehicle selling cost as a share of cost of sales equaled 0.06. Thus, the value of these cost contributors would be 0.004 and 0.06 respectively.

Table A-5. Dealer Net Profit and Selling Expenses on New Vehicle Sales as a Share of Manufacturers' Cost of Sales

Row	Calculation of Dealer Profit and Dealer Expense	Daimler Chrysler[1]	Ford	GM	Honda	Hyundai	Nissan	Toyota	VW	Source/ Calculation
A	Cost of sales 2007 ($ Billion)	$124.7	$130.4	$143.0	$65.4	$53.5	$67.0	$150.2	$67.0	Annual Reports
B	Annual sales 2007 ($ Billion)	$190.3	$154.0	$178.2	$93.9	$74.2	$88.7	$262.4	$149.2	Annual Reports
C	Dealer new vehicle gross margin	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	J.D. Power (Table A-3)
D	New vehicle sales ($ Billion)	$197.7	$160.0	$185.1	$97.6	$77.1	$92.2	$272.6	$155.0	B x (1 + C)
E	New vehicle sales / Cost of sales	1.59	1.23	1.29	1.49	1.44	1.38	1.82	2.31	D / A
	Line items for RPE multiplier									**Weighted Average**
F	Dealer new vehicle net profit	0.004	0.003	0.003	0.004	0.004	0.004	0.005	0.006	0.004
G	Dealer new vehicle selling cost	0.06	0.04	0.05	0.05	0.05	0.05	0.07	0.08	0.06
H	Annual production 2007	4,635,601	6,247,506	9,349,818	3,911,814	2,617,725	3,431,398	8,534,690	6,267,891	

[1] 2006 Sales and production data was used for Daimler Chrysler.

A.3   General Motors Corporation

Cost information presented in GM's annual report did not always match cost contributors useful to our analysis. We performed several calculations to adjust costs presented in GM's annual report so they can be applied to our methodology. GM's annual report did not clearly state manufacturing labor costs and material costs. However, it did provide "material cost, freight and policy, warranty" and "manufacturing labor, pensions and postretirement benefits, engineering expense and marketing related costs" categories. Thus, manufacturing costs were calculated as follows:

Manufacturing labor cost = Manufacturing labor, pensions and postretirement benefits, engineering expense and marketing related costs – Pensions – Postretirement Employee Benefits – Advertising – Dealer Advertising – R&D

Material cost = Material cost, freight, warranty and policy – Warranty and policy – Freight (was not readily available, so we used 2.07% McKinsey Industry Average)

Calculated Manufacturing Costs = Manufacturing labor costs + Material cost

Since no information on the MRO cost category could be deduced from GM's annual reports, we used 0.03 (see Table A-6) from the Sierra Research study as a proxy for reallocating MRO costs. Also, since GM experienced a loss of $4.4 billion in 2007, we used 0.05, the McKinsey study estimate, to account for long-term profit. The share of retirement and health care costs applicable to the RPE multiplier (see the discussion in Section 3.2.2) was calculated as a ratio of selling, G&A, and other expenses to the sum of selling, administrative, and other expenses and manufacturing labor cost. The remaining contributors to the RPE multiplier are shown in Table A-6, which shows the result as 1.45 in 2007.

Table A-7 provides historical indirect cost contributors for GM. Here and in the remainder of this appendix, historical indirect cost contributors were based on high-level cost categories: selling, administrative, and other expenses; operating and other expenses; and depreciation. Profit was also included as part of the calculation. Manufacturing costs are presented in the companies' respective currency, and high-level cost contributors are presented as a share of the cost of sales. The cost of sales numbers are not adjusted as in Table A-6, but cited as they were stated in annual reports.

Table A-6. General Motors RPE Multiplier Calculations: 2007

RPE Multiplier Contributor	Expense ($ Billions)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	143.0	1.00	Calculated Manufacturing Cost + 70% x (Retirement + 55% x Health Care) − Maintenance, Repair, Operations Cost
Production Overhead			
Warranty	4.7	0.03	[p. 72, General Motors, 2007]
R&D (product development)	8.1	0.06	[p. 86, General Motors, 2007]
Depreciation and amortization	8.3	0.06	[p. 67, General Motors, 2007]
Maintenance, repair, operations cost	4.0	0.03	[p. 9, Sierra, 2007]
Total production overhead	25.0	0.17	
Corporate Overhead			
General and administrative	9.4	0.07	[p. 49, General Motors, 2007]
Retirement	0.9	0.01	30% x (Pension Expense (1.799) [p. 84, General Motors, 2007] + Pension Contributions (0.937) [p. 84, General Motors, 2007])
Health	0.7	0.01	30% x (Payroll and Benefits (2.148) [p. 92, General Motors, 2007])
Total corporate overhead	11.0	0.08	
Selling			
Transportation	5.0	0.04	Based on McKinsey study
Marketing	6.5	0.05	Advertising [p. 86, General Motors, 2007] + Dealer Advertising [p. 52, General Motors, 2007]
Dealers			
Dealer new vehicle net profit	8.2	<0.00	RTI calculation
Dealer new vehicle selling cost	7.9	0.06	RTI calculation
Total selling and dealer contributors	27.6	0.14	
Sum of Indirect Costs		0.40	
Net income	7.6	0.05	Based on McKinsey study
Other costs (not included as contributors)	8.8	0.06	Legacy Costs[a] + Automotive Interest and Other Income (0.961) [p. 50, General Motors, 2007]
RPE Multiplier		1.45	

[a] Legacy Costs = OPEB Expense (2.362) + VEBA Withdrawals (1.694) + OPEB Payments (3.751) [all p. 84, General Motors, 2007]

Source: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems.".

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Table A-7. General Motors Main Indirect Cost Contributors (as a share of Cost of Sales)

Indirect Cost Contributor	2007	2006	2005	2004	2003	2002
Selling, administrative, and other expenses	0.09	0.08	0.08	0.08	0.08	0.08
Operating and other expenses	0.05	0.05	0.06	0.06	0.06	0.06
Depreciation	0.05	0.05	0.06	0.04	0.04	0.04
Profit	−0.23	−0.01	−0.07	0.02	0.03	0.01
Other expenses (not included as contributor)	0.07	0.07	0.08	0.08	0.07	0.05
Sum of main indirect cost contributors (including profit)	0.96	1.17	1.13	1.19	1.21	1.20

Source: General Motors Corporation: Annual Report 2007, Annual Report 2005.

Table A-7 illustrates that sum of the main indirect cost contributors had little variation between 2002 and 2004. It is worth noting that GM's sum of main indirect cost contributors was 0.96 in 2007 (see Table A-7). This value is much smaller than the RPE multiplier value of 1.45, which was calculated using our methodology (Table A-6). The discrepancy was caused by the use of some averages from other studies for missing values; these are cost contributors subtracted from the cost of sales in our methodology, but kept in the cost of sales in the sum of the main indirect cost contributors. Missing costs and overstated cost of sales (where missing costs are lumped together with our definition of cost of sales) force the sum of the main indirect cost contributors to be lower.

We believe that our methodology is an improved method to account for costs. For example, in our methodology (Table A-6) we used a proxy of 0.05 for profit, while the same category in the historic calculation was -0.23.

A.2   DaimlerChrysler AG

In our analysis, we included DaimlerChrysler's RPE multiplier, even though DaimlerChrysler AG was dissolved and Chrysler was sold to a private equity firm, Cerberus Capital Management, in 2007. This allows us to consider the cost structure from what was one of the world's largest automotive firms based on publicly available information. The RPE multiplier calculations cover the entire DaimlerChrysler Corporation for 2006. Relevant RPE contributing factors gathered from DaimlerChrysler's annual report are presented in Table A-8.

Table A-8. DaimlerChrysler RPE Multiplier Calculations: 2006

RPE Multiplier Contributor	Expense (€Million)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	124,668.1	1.00	125,673 [p. 50, DaimlerChrysler, 2006] + 70% x (Retirement + 55% x Health Care) − Maintenance, Repair, Operations Costs
Production Overhead			
Warranty	5,267.7	0.04	Based on McKinsey study
R&D (product development)	5,331.0	0.04	[p. 214, DaimlerChrysler, 2006]
Depreciation and amortization	13,614.0	0.11	[p. 205, DaimlerChrysler, 2006]
Maintenance, repair, operations cost	3,490.7	0.03	[p. 9, Sierra, 2007]
Total production overhead	-	0.22	
Corporate Overhead			
General and administrative	6,292.6	0.05	18,513 [p. 50, DaimlerChrysler, 2006] − Marketing − Transportation − Warranty
Retirement	922.8	0.01	30% x Retirement (2247 + 829) [both p. 184, DaimlerChrysler, 2006]
Health	185.6	Less than 0.01	30% x 55% x Health Care (832 + 293) [both p. 188, DaimlerChrysler, 2006]
Total corporate overhead	7,401.0	0.06	
Selling			
Transportation	4,389.7	0.04	Based on McKinsey study
Marketing	2,563.0	0.02	[p. 162, DaimlerChrysler, 2006]
Dealers			
Dealer new vehicle net profit	7,158.2	<0.01	RTI calculation
Dealer new vehicle selling cost	6,873.9	0.06	RTI calculation
Total selling and dealer contributors	20,984.8	0.12	
Sum of Indirect Costs		0.40	
Net income	3,227.0	0.07	[p. 214, DaimlerChrysler, 2006]
Other costs (not included as contributors)	4,699.3	0.04	Interest Paid (4,193) [p. 214, DaimlerChrysler, 2006] + 45% x Health Care
RPE Multiplier		1.47	

Source: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems."

McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

As Table A-8 shows, DaimlerChrysler did not provide warranty or MRO expenditures. Values were added for these factors from the McKinsey and Sierra studies. Marketing,

transportation, and warranty costs were included in G&A expenditures and, thus, were subtracted. The estimated RPE multiplier for DaimlerChrysler was 1.47 in 2006.

DaimlerChrysler's sum of the main indirect cost contributors increased between 2002 and 2003. This was mostly due to increasing selling, administrative, and other expenses, which increased from 0.05 to about 0.20 between those years. Other factors changed much less during this period. The sum of the main indirect cost contributors varied between 1.24 and 1.38 in the 2002–2006 time period (Table A-9).

Table A-9. DaimlerChrysler Main Indirect Cost Contributors (as a Share of Cost of Sales)

Indirect Cost Contributor	2006	2005	2004	2003	2002
Selling, administrative, and other expenses	0.19	0.20	0.21	0.21	0.05
Operating and other expenses	0.05	0.05	0.05	0.05	0.04
Depreciation	0.11	0.10	0.10	0.11	0.12
Profit	0.03	0.02	0.02	0.00	0.04
Other expenses (not included as contributor)	0.01	0.01	0.01	0.01	0.01
Sum of main indirect cost contributors (including profit)	1.38	1.38	1.37	1.37	1.24

Sources: DaimlerChrysler AG. 2007. DaimlerChrysler: Annual Report 2006. Available at: http://www.daimlerchrysler.com/Projects/c2c/channel/documents/1003905_DCX_2006_Annual_Report.pdf. Accessed on November 14, 2008.

DaimlerChrysler AG. 2005. DaimlerChrysler: Annual Report 2003. Available at: http://www.daimler.com/dccom/0-5-660593-1-169901-1-0-0-0-0-0-12591-7164-0-0-0-0-0-0-0.html. Accessed on November 14, 2008.

A.3   Ford Motor Company

Relevant RPE contributing factors gathered from Ford Motor Company's annual report are presented in Table A-10. Ford included "freight, engineering, and research and development (R&D)" costs in their cost of sales (Ford Motor Company, 2008). We subtracted this line item ($7.5 billion), together with the cost of employee separation (i.e., the recent buy-outs of employees, reported as $2.21 billion + $0.22 billion + $0.15 billion) and certain "electricity physical supply contracts" ($0.65 billion) and other factors (see Table A-10) from the cost of sales to arrive at an adjusted value for the cost of sales of $130.4 billion. Ford reported "selling, general, and other expenses" of $21.2 billion in their annual report. The report also indicated that marketing costs were included in "selling, general, and other expenses." Marketing costs included advertising expenses and variable marketing expenses in the United States and were

Table A-10. Ford Motor Company RPE Multiplier Calculations: 2007

RPE Multiplier Contributor	Expense ($ Billions)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	130.4	1.00	Cost of Sales [FS1, Ford, 2007b] − Cost of Employee Separation (1.036–0.817) [FS36, Ford, 2007b] − Other Employee Separation Actions (2.435–0.225) [FS36, Ford, 2007b] − Certain Electricity Physical Supplies Contracts (0.154) [90, Ford, 2007a] − Hedge Accounting Designations (0.65) [p.101, Ford, 2007a] − Maintenance, Repair, Operations Cost - Transportation
Production Overhead			
Warranty	3.3	0.03	[p. 117, Ford, 2007a]
R&D (product development)	2.9	0.02	[p. 63, Ford, 2007a] - Transportation
Depreciation and amortization	6.8	0.05	[p. 56, Ford, 2007b]
Maintenance, repair, operations cost	3.7	0.03	[p. 9, Sierra, 2007]
Total production overhead	16.6	0.13	
Corporate Overhead			
General and administrative	15.8	0.12	Selling, Administrative and Other Expenses (21.2) [FS2, Ford, 2007] − Advertising (5.4) [p. 64, Ford, 2007a] − Transportation
Retirement	0.5	0.00	30% x Pensions (1.128+0.885) [107, Ford, 2007a]
Health	0.4	0.00	30% x 55% x Health Care[a]
Total corporate overhead	16.7	0.13	
Selling			
Transportation	4.6	0.04	Based on McKinsey study
Marketing	5.4	0.04	Advertising (5.4) [p. 56, Ford, 2007b]
Dealers			
Dealer new vehicle net profit	7.5	<0.01	RTI calculation
Dealer new vehicle selling cost	7.2	0.06	RTI calculation
Total selling and dealer contributors	24.7	0.14	
Sum of Indirect Costs		0.39	
Net income	6.9	0.05	Based on McKinsey study
Other costs (not included as contributors)	14.3	0.11	Goodwill Impairment (2.4) [p.54, Ford, 2007a] + Interest Expense (10.92) [p.54, Ford, 2007a] + Provision for Credit (0.688) [p.54, Ford, 2007a]+ 30% x 45% x Health Care[a]
RPE Multiplier		1.45	

[a] Health care = Health care (2.2) [11, Ford, 2007a] + OPEB (0.414) [107, Ford, 2007a] + Benefits Paid (3,937)[108, Ford, 2007a]

Sources: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems."

McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

Ford Motor Company. 2007. Ford Company: 2007 Annual Report. Available at: http://www.ford.com/microsites/annual-reports. Accessed on September 20, 2008.

Ford Motor Company. 2007a. 10-K Annual Report 2007. Available via EDGAR database from: http://sec.gov/edgar. Accessed on September 20, 2008.

lumped in G&A costs. We subtracted marketing costs ($5.4 billion) from "selling, general, and other expenses" to arrive at an adjusted G&A of $15.8 billion. Ford did not report "maintenance, repair, and operations" costs; therefore, we used an industry average of 0.03 from the 2007 Sierra study as a proxy. Results of these calculations are outlined in Table A-10.

As mentioned in Section 3.2.2 of this report, health care and retirement costs include expenditures for manufacturing and corporate workers. Ford's annual report provided the number of hourly versus salaried workers it employed. In 2007, the number of hourly workers was 64,000, while the number of salaried workers was 23,700. We used these values as estimates for the number of manufacturing versus corporate workers. Thus, 73% of Ford's retirement and health care costs were included in manufacturing costs, and 27% were used in the RPE multiplier calculation.

Ford did not separate out transportation costs and dealer support or dealer discount costs, which were lumped into R&D and G&A costs, respectively. Lastly, Ford Motor Company reported a $2.7 billion loss in 2007, which is likely a result of the current economic conditions in the United States. In the long run, Ford's profits are expected to be closer to the industry average. Because of this, we substituted the McKinsey study estimate of 0.05 for the net income loss reported by Ford. As a result, the value of the RPE multiplier for Ford Motor Company was 1.45 in 2007.

Table A-11 presents Ford's sum of the main indirect cost contributors, which are much lower than the RPE value derived above for 2007.

A.5 Honda Motor Company

RPE calculations for Honda Motor Company are presented in Table A-12. Honda Motor Company's annual report provided financials in Japanese yen. In 2007, the cost of sales equaled ¥7,865 billion. Honda did not report MRO costs or health care cost; therefore, the Sierra study values of 0.03 and 0.03 (which was then multiplied by 30% to account for corporate labor only) were used as a proxy. As opposed to U.S. manufacturers, Honda's historical profits were relatively comparable to that available for the 2007 RPE multiplier calculated using our methodology. The RPE multiplier for Honda Motor Company equaled 1.47 in 2007.

Table A-13 presents Honda's sum of the main indirect cost contributors, which are again lower than the RPE value derived above for 2007.

Table A-11. Ford Motor Company Main Indirect Cost Contributors (as a Share of Cost of Sales)

Indirect Cost Contributor	2007	2006	2005	2004	2003	2002
Selling, administrative, and other expenses	0.10	0.09	0.08	0.08	0.08	0.08
Operating and other expenses	0.01	0.01	0.04	0.04	0.04	0.04
Depreciation	0.05	0.04	0.04	0.05	0.07	0.08
Profit	−0.02	−0.13	−0.03	0.03	0.00	−0.01
Other expenses (not included as contributor)	0.06	0.06	0.06	0.06	0.08	0.10
Sum of main indirect cost contributors (including profit)	1.13	1.01	1.13	1.20	1.19	1.19

Sources: Ford Motor Company. 2006. Ford Company: 2005 Annual Report. Available at: http://www.ford.com/microsites/annual-reports. Accessed on September 20, 2008.

Ford Motor Company. 2008. Ford Company: 2007 Annual Report. Available at: http://www.ford.com/microsites/annual-reports. Accessed on September 20, 2008.

A.6   Hyundai Motor Company

Table A-14 presents relevant RPE cost contributors and the RPE multiplier for Hyundai Motor Company in 2007. Hyundai Motor Company's financials were reported in Japanese yen. R&D expenses were included in the cost of sales, which we subtracted to arrive at an adjusted cost of sales of ¥53.27 billion. Hyundai did not report MRO cost, so we used the Sierra study value of 0.03 as a proxy. Health care cost was not reported, and because there was no industry estimate for this number, we used the Sierra study value of 0.03 as a proxy. Hyundai's RPE multiplier value was calculated to be 1.42 for 2007.

Hyundai's annual reports were available dating back to 2004. Similar to Honda, Hyundai's historical profits presented in Table A-15 were relatively comparable to that available for the 2007 RPE multiplier calculated using our methodology.

Table A-12. Honda Motor Company RPE Multiplier Calculations: 2007

RPE Multiplier Contributor	Expense (¥ Billion)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	7,609.8	1.00	Cost of Sales [p. 54, Honda, 2007] + 70% x Pensions and Postretirement Benefits − Maintenance, Repair, Operations Costs
Production Overhead			
Warranty	113.5	0.01	[p. 109, Honda, 2008]
R&D (product development)	551.8	0.07	[p. 2, Honda, 2008]
Depreciation and amortization	371.5	0.05	[p. 113, Honda, 2008]
Maintenance, repair, operations cost	213.1	0.03	[p. 9, Sierra, 2008]
Total production overhead	1,249.8	0.16	
Corporate Overhead			
General and administrative	883.7	0.12	Selling, General and Administrative (1818.2) [p. 72, Honda, 2008] − Transportation − Marketing [p. 78, Honda, 2008] – Dealer Support
Retirement	10.6	Less than 0.01	
Health	220.9	0.01	30% x Retiree Health Care [p. 9, Sierra, 2007]
Total corporate overhead	1,115.2	0.15	
Selling			
Transportation	267.9	0.04	Based on McKinsey study
Marketing	247.0	0.03	[p. 78, Honda, 2008]
Dealers			
Dealer new vehicle net profit	436.9	<0.01	RTI calculation
Dealer new vehicle selling cost	419.6	0.06	RTI calculation
Total selling and dealer contributors	1,371.5	0.13	
Sum of Indirect Costs		0.44	
Net income	268.6	0.04	Net Income [p. 72, Honda, 2008]
Other costs (not included as contributors)	114.6	0.02	Interest + Other Expenses [p. 72, Honda, 200]
RPE Multiplier		1.47	

Sources: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems."

McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

Honda Motor Company. 2008. Annual Report 2008. Available at: http://world.honda.com/investors/annualreport/2008/. Accessed on September 20, 2008.

Table A-13. Honda Motor Company Main Indirect Cost Contributors (as a Share of Cost of Sales)

Indirect Cost Contributor	2007	2006	2005	2004	2003	2002
Selling, administrative, and other expenses	0.23	0.24	0.25	0.27	0.27	0.26
Operating and other expenses	NA	NA	NA	NA	NA	NA
Depreciation	0.05	0.04	0.04	0.04	0.04	0.04
Profit	0.08	0.09	0.08	0.08	0.08	0.07
Other expenses (not included as contributor)	0.02	0.01	0.01	0.00	0.02	0.02
Sum of main indirect cost contributors (including profit)	1.35	1.36	1.37	1.39	1.41	1.40

NA = Not available

Sources: Honda Motor Company: Annual Report 2006.

> Honda Motor Company. 2008. Annual Report 2008. Available at: http://world.honda.com/investors/annualreport/2008/. Accessed on September 20, 2008.

A.7 Nissan Motor Company

Relevant RPE contributing factors gathered from Nissan's annual report are presented in Table A-16. Nissan Motor Company's annual report provided expenses in Japanese yen and did not provide an estimate of MRO cost; therefore, the Sierra study value of 0.03 was used as a proxy (see Table A-16). Selling expenses (transportation, marketing, dealer support, and dealer discount) were reported as part of G&A expenses, so G&A was adjusted by that cost. Nissan also did not provide an estimate of health care cost, and since no industry average was available, this item was not included in Nissan's RPE multiplier calculations. Nissan's RPE multiplier value was calculated to be 1.49 in 2007.

Nissan experienced little variation in its sum of main indirect cost contributors (see Table A-17). Between 2002 and 2007, the sum of main indirect cost contributors varied between 1.39 and 1.51.

Table A-14. Hyundai Motor Company RPE Multiplier Calculations: 2007

RPE Multiplier Contributor	Expense (¥ Billion)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	51,926,743.9	1.00	Cost of Sales [p. 52, Hyundai, 2008] + 70% x Payments of Severance Benefits − Research and Development − Maintenance, Repair, Operations Costs
Production Overhead			
Warranty	975,825.0	0.02	[p. 109, Hyundai, 2008]
R&D (product development)	2,193,479.0	0.04	[p. 86, Hyundai, 2008]
Depreciation and amortization	3,293,479.0	0.06	Depreciation [p. 56, Hyundai, 2008] + Amortization of intangibles [p. 56, Hyundai, 2008]
Maintenance, repair, operations cost	2,786,433.0	0.03	[p. 9, Sierra, 2007]
Total production overhead	9,249,216.0	0.15	
Corporate Overhead			
General and administrative	4,038,378.0	0.08	Selling and Administrative Expenses [p. 109, Hyundai, 2008] − Export Related Expenses − Sales Promotion − Sales Commission − Sales Warranties − Freight and Warehousing − Rent − Travel − Research − Depreciation − Amortization
Retirement	241,712.4	Less than 0.01	30% x Payment of Severance Benefits [p. 57, Hyundai, 2008]
Health	389,450.6	0.01	30% x Retiree Health Care [p. 9, Sierra, 2008]
Total corporate overhead	4,669,541.0	0.09	
Selling			
Transportation	1,975,596.0	0.04	Export Related Expenses + Freight and Warehousing + Rent + Travel [all p. 109, Hyundai, 2008]
Marketing	2,392,644.0	0.05	Sales Promotion [p. 109, Hyundai, 2008]
Dealers			
Dealer new vehicle net profit	2,981,515.7	<0.01	RTI calculation
Dealer new vehicle selling cost	2,863,122.9	0.06	RTI calculation
Total selling and dealer contributors	10,212,878.6	0.15	
Sum of Indirect Costs		0.39	
Net income	1,600,480.0	0.03	[p. 69, Hyundai, 2008]
Other costs (not included as contributors)	430,631.0	0.01	Interest Expense [p. 52, Hyundai, 2008]
RPE Multiplier		1.42	

Sources: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems."

McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

Hyundai Motor Company. 2008. Annual Report 2007. Available at: http://csr.hyundai-motor.com/download/Annual_Report_2007.pdf. Accessed on October 10, 2008.

Table A-15. Hyundai Motor Company Main Indirect Cost Contributors (as a Share of Cost of Sales)

Indirect Cost Contributor	2007	2006	2005	2004
Selling, administrative, and other expenses	0.20	0.23	0.23	0.29
Operating and other expenses	NA	NA	NA	NA
Depreciation	0.05	0.06	0.05	0.04
Profit	0.03	0.03	0.05	0.04
Other expenses (not included as contributor)	NA	NA	NA	NA
Sum of main indirect cost contributors (including profit)	1.28	1.32	1.33	1.37

NA = Not available

Sources: Hyundai Motor Company. 2006. Annual Report 2005. Available at: http://csr.hyundai-motor.com/download/Annual_Report_2005.pdf. Accessed on October 10, 2008.

Hyundai Motor Company. 2008. Annual Report 2007. Available at: http://csr.hyundai-motor.com/download/Annual_Report_2007.pdf. Accessed on October 10, 2008.

A.8   Toyota Motor Company

The RPE multiplier calculations for Toyota Motor Company are presented in Table A-18. Toyota Motor Company's annual report provided expenses in Japanese yen. Toyota included their R&D expenses in cost of sales (which was called "cost of product sold" in its annual report) and G&A expenses. Because they did not report fractions that were charged to either of those costs, 50% of R&D costs were subtracted from the cost of sales and 50% from G&A expenses. Warranty costs included the actual costs paid throughout the year (¥336.5 billion) and the costs provisioned for warranties (¥290.0). Again, the Sierra study value of 0.03 was used as a proxy for MRO cost, since those costs were lumped into operations cost, which Toyota did not provide in its annual report. Research and development and advertising costs were reported as part of G&A expenses, and these costs were subtracted from G&A. Health care cost was not reported in Toyota's annual report, so the Sierra study value of 0.03 was used as a proxy. The RPE multiplier for Toyota Motor Company was calculated to be 1.48 in 2007.

Toyota experienced very little variation in the sum of the main indirect cost contributors: between 1.31 and 1.35 (see Table A-19). In this case, higher profits are associated with lower selling, administrative, and other expenses and higher manufacturing costs.

Table A-16. Nissan Motor Company RPE Multiplier Calculations: 2007

RPE Multiplier Contributor	Expense (¥ Million)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	7,789,660.3	1.00	Cost of Sales [p. 50, Hyundai, 2008] + 70% x Retirement Benefit Expenses
Production Overhead			
Warranty	222,390.0	0.03	Accrual for warranty costs (current) [p. 49, Nissan, 2008] + Accrual for warranty costs (long-term) [p. 49, Nissan, 2008]
R&D (product development)	464,839.0	0.06	[p. 63, Nissan, 2008]
Depreciation and amortization	705,380.0	0.09	[p. 58, Nissan, 2008]
Maintenance, repair, operations cost	218,110.5	0.03	[p. 9, Sierra, 2008]
Total production overhead	1,610,719.5	0.21	
Corporate Overhead			
General and administrative	267,054.0	0.03	Selling, General, and Administrative Costs [p. 50, Nissan, 2008] − Transportation − Marketing − Research and Development
Retirement	21,079.5	Less than 0.01	30% x Retirement Benefit Expenses
Health	1,635.8	0.01	30% x Retiree Health Care [p. 9, Sierra, 2007]
Total corporate overhead	289,769.4	0.04	
Selling			
Transportation	274,283.8	0.04	Based on McKinsey study
Marketing	658,281.2	0.08	Based on McKinsey study
Dealers			
Dealer new vehicle net profit	447,264.6	0.06	RTI calculation
Dealer new vehicle selling cost	429,504.2	0.06	RTI calculation
Total selling and dealer contributors	1,809,333.8	0.18	
Sum of Indirect Costs		0.43	
Net income	460,796.0	0.06	[p. 50, Nissan, 2008]
Other costs (not included as contributors)	93,343.0	0.01	Other, net [p. 50, Nissan, 2008]
RPE Multiplier		1.49	

Sources: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems."

McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

Nissan Motor Company. 2008. Annual Report 2006–2007. Available at: http://www.nissan-global.com/EN/IR/LIBRARY/AR/. Accessed on October 10, 2008.

Table A-17. Nissan Motor Company Main Indirect Cost Contributors (as a Share of Cost of Sales)

Indirect Cost Contributor	2007	2006	2005	2004	2003	2002
Selling, administrative, and other expenses	0.21	0.22	0.22	0.24	0.25	0.26
Operating and other expenses	0.08	0.06	0.01	0.09	0.08	0.01
Depreciation	0.10	0.09	0.08	0.09	0.08	0.08
Profit	0.06	0.07	0.08	0.10	0.10	0.08
Other expenses (not included as contributor)	0.02	0.02	0.02	0.02	0.01	0.03
Sum of main indirect cost contributors (including profit)	1.44	1.44	1.39	1.51	1.51	1.43

Sources: Nissan Motor Company. 2006. Annual Report 2004–2005. Available at: http://www.nissan-global.com/EN/IR/LIBRARY/AR/. Accessed on October 10, 2008.

Nissan Motor Company. 2008. Annual Report 2006–2007. Available at: http://www.nissan-global.com/EN/IR/LIBRARY/AR/. Accessed on October 10, 2008.

A.9 Volkswagen Group

Relevant RPE contributing factors gathered from Volkswagen's annual report are presented in Table A-20. The Volkswagen Group reported its financial results in Euros. As opposed to other manufacturers, Volkswagen health care cost was relatively minor compared to the cost of sales and thus was substituted with the Sierra study value 0.03. The RPE multiplier for the Volkswagen Group was estimated to be 1.43 in 2007.

Volkswagen experienced almost no variation in the sum of the main indirect cost contributors, which stayed around 1.28 (see Table A-21). Higher profits for the Volkswagen Group are associated with lower depreciation stated in their annual reports.

Table A-18. Toyota Motor Company RPE Multiplier Calculations: 2007

RPE Multiplier Contributor	Expense (¥ Million)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	17,463,582.6	1.00	Cost of Product Sold [p. 71, Toyota, 2007] − 50% x Research and Development + 70% x Pensions
Production Overhead			
Warranty	616,133.0	0.04	Warranties Paid Through the Year [p. 109, Toyota, 2007] + Provisions for Warranties [p. 109, Toyota, 2007]
R&D (product development)	890,700.0	0.05	[p. 79, Toyota, 2007]
Depreciation and amortization	1,382,594.0	0.08	Depreciation [p. 94, Toyota, 2007]
Maintenance, repair, operations cost	488,980.3	0.03	[p. 9, Sierra, 2007]
Total production overhead	3,378,407.3	0.19	
Corporate Overhead			
General and administrative	969,568.1	0.06	Selling, General, and Administrative − 50% x Research and Development − Advertising − Transportation
Retirement	83,765.7	Less than 0.01	30% x Pensions
Health	130,976.9	0.01	30% x Retiree Health Care [p. 9, Sierra, 2007]
Total corporate overhead	1,184,310.7	0.07	
Selling			
Transportation	614,914.9	0.04	Based on McKinsey study
Marketing	451,182.0	0.03	Advertising [p. 97, Toyota, 2007]
Dealers			
Dealer new vehicle net profit	1,002,719.3	0.06	RTI calculation
Dealer new vehicle selling cost	962,902.4	0.06	RTI calculation
Total selling and dealer contributors	3,031,718.5	0.12	
Sum of Indirect Costs		0.38	
Net income	1,644,032.0	0.09	[p. 96, Toyota, 2007]
Other costs (not included as contributors)	49,326.0	0.00	Interest Expense [p. 94, Toyota, 2007]
RPE Multiplier		1.48	

Sources: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems."

McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

Toyota Motor Company. 2008. Annual Report 2008. Available at: http://www.toyota.co.jp/en/ir/library/annual/index.html. Accessed on October 10, 2008.

Table A-19. Toyota Motor Company Main Indirect Cost Contributors (as a Share of Cost of Sales)

Indirect Cost Contributor	2007	2006	2005	2004	2003	2002
Selling, administrative, and other expenses	0.14	0.14	0.14	0.13	0.16	0.16
Operating and other expenses	0.05	0.04	0.03	0.03	0.04	0.04
Depreciation	0.08	0.07	0.07	0.07	0.07	0.07
Profit	0.09	0.08	0.08	0.09	0.06	0.05
Other expenses (not included as contributor)	0.00	0.00	0.00	0.00	0.00	NA
Sum of main indirect cost contributors (including profit)	1.35	1.33	1.31	1.32	1.33	1.33

NA = Not available

Sources: Toyota Motor Company. 2006. Annual Report 2006. Available at:
http://www.toyota.co.jp/en/ir/library/annual/index.html. Accessed on October 10, 2008.

Toyota Motor Company. 2008. Annual Report 2008. Available at:
http://www.toyota.co.jp/en/ir/library/annual/index.html. Accessed on October 10, 2008.

Table A-20. Volkswagen Group RPE Multiplier Calculations: 2007

RPE Multiplier Contributor	Expense (€Million)	Relative to Cost of Sales	Calculation and Source
Vehicle Manufacturing			
Cost of sales	82,595.6	1.00	Cost of Sales [p.135, VW, 2007] − Warranty −R&D − MRO + 70% x Pensions and Postretirement Benefits
Production Overhead			
Warranty	2,056.3	0.02	Based on McKinsey study
R&D (product development)	4,653.3	0.06	Based on McKinsey study
Depreciation and amortization	7,278.0	0.09	[p. 133, VW, 2007]
Maintenance, repair, operations cost	2,312.7	0.03	[p. 9, Sierra, 2007]
Total production overhead	16,300.3	0.20	
Corporate Overhead			
General and administrative	2,453.0	0.03	[p. 135, VW, 2007]
Retirement	386.4	Less than 0.01	30% x Old-Age Pensions [p. 143, VW, 2007]
Health	17.3	0.01	30% x Retiree Health Care [p. 9, Sierra, 2007]
Total corporate overhead	2,856.7	0.04	
Selling			
Transportation	7,864.0	0.10	Distribution Expenses − Marketing
Marketing	1,410.0	0.02	Selling, general and administrative expense − Administrative Expenses [p. 139, VW, 2007]
Dealers			
Dealer new vehicle net profit	4,742.5	<0.01	RTI calculation
Dealer new vehicle selling cost	4,554.1	0.06	RTI calculation
Total selling and dealer contributors	18,570.6	0.17	
Sum of Indirect Costs		0.41	
Net income	1,455.0	0.02	[p. 142, VW, 2007]
Other costs (not included as contributors)	3,799.0	0.05	Financial Result [p. 142, VW, 2007]
RPE Multiplier		1.43	

Sources: Sierra Research, Inc. November 21, 2007. "Study of Industry—Average Mark-Up Factors Used to Estimate Changes in Retail Price Equivalent (RPE) for Automotive Fuel Economy and Emissions Control Systems."

McKinsey & Company. 2003. *Preface to the Auto Sector Cases*.

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gb2007/content/en/annual_report_2007.html. Accessed on October 10, 2008.

Table A-21.   Volkswagen Historical Main Indirect Cost Contributors (as a share of Cost of Sales)

Indirect Cost Contributor	2007	2006	2005	2004	2003	2002
Selling, administrative, and other expenses	0.12	0.13	0.13	0.13	0.14	0.13
Operating and other expenses	0.05	0.06	0.04	0.04	0.04	0.05
Depreciation	0.08	0.09	0.09	0.10	0.09	0.08
Profit	0.05	0.02	0.01	0.01	0.01	0.04
Other expenses (not included as contributor)	NA	NA	NA	NA	NA	NA
Sum of main indirect cost contributors (including profit)	1.29	1.29	1.28	1.27	1.29	1.29

NA = Not available

Sources: Volkswagen Group AG. 2004. Annual Report 2003. Available at:
        http://www.vwfsag.de/fsag/ucus/vwfsag/en/investor_relations/annual_report/ archive_2003.htx. Accessed
        on October 10, 2008.

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    10, 2008.