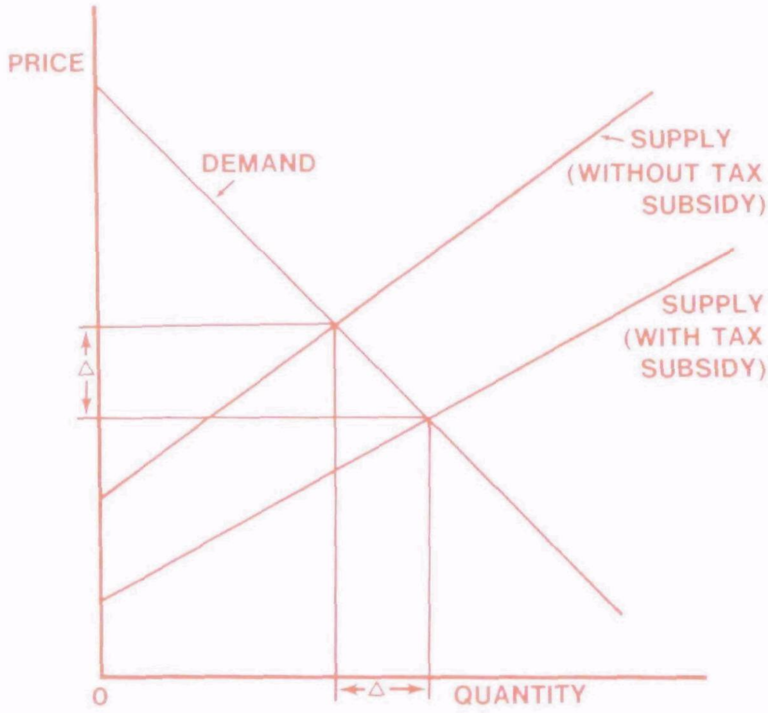
EPA-600/8-77-012 AUGUST 1977

IMPACT OF THE FEDERAL TAX CODE ON RESOURCE RECOVERY

A CONDENSATION



Municipal Environmental Research Laboratory
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IMPACT OF THE FEDERAL TAX CODE ON RESOURCE RECOVERY
A Condensation

by

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Grant No. R803362

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DISCLAIMER

FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

The extent to which federal tax subsidies to extractive industries restrict the recycling of secondary materials has been the subject of considerable controversy. This report analyzes the impacts of federal tax code on supply curves for the major extractive industries, using econometric techniques to obtain estimates of percentage changes in recycling which would result from elimination of the tax advantages.

Francis T. Mayo, Director
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ABSTRACT

This report assesses the extent to which a variety of federal tax subsidies to extractive industries affect the materials flow in competing secondary materials industries. The impacts of tax subsidies on virgin material supply curves for the steel, paper, lead, copper, and aluminum industries are analyzed in detail. The flows of virgin and secondary materials industries are characterized at points where the two materials substitute as inputs to production and consumption. Econometric models specified at these points of substitution are used to analyze the impacts of the tax subsidies on the quantities of secondary materials recycled. In the short run, within the limits of existing plant and equipment, it is estimated that elimination of tax subsidies to virgin material industries would increase the flow of scrap steel by 0.42 percent, wastepaper by 0.63 percent, lead by 0.75 percent, copper by 0.35 percent, and aluminum by 1.0 percent. These estimates make no allowance for the long run effects on investment which may arise from the elimination of subsidies to the virgin materials industries. When investment effects and other federal policies (for example, ICC regulation of freight rates, labeling requirements for scrap-based products, and the free access to minerals on federal lands) are also considered, the cumulative impact on recycling may be considerably greater than the relatively modest effects measured in this report.

The full report was submitted in fulfillment of Grant No. R803362 by the Environmental Law Institute under the sponsorship of the U.S. Environmental Protection Agency. This report, "Impact of the Federal Tax Code on Resource Recovery" by R. C. Anderson and R. D. Spiegelman, is available from the Department of Commerce, National Technical Information Service, Springfield, Virginia 22161, as NTIS PB-264 886/AS(EPA-600/2-77-009).

CONTENTS

FIGURES

Number | Page

TABLES

ACKNOWLEDGMENTS

The research reported in this publication was taken from a more extensive report Impact of the Federal Tax Code on Resource Recovery submitted by the Environmental Law Institute to the U.S. Environmental Protection Agency in fulfillment of Grant No. 803362.

The project director for that study was Robert Anderson and his associate Richard Spiegelman. Many other persons contributed to portions of the main report, including persons in private and public service. Oscar Albrecht of the Municipal Environmental Research Laboratory, Environmental Research Center, Cincinnati, Ohio served as the EPA's project officer for this condensation of the full report.

SECTION 1

SUMMARY AND CONCLUSIONS

While no specific legislation contains a comprehensive federal policy regarding the use of virgin versus recycled materials, a de facto policy can be discerned from a variety of sources. The present de facto federal policy, as found in various pieces of legislation, appears to favor the use of virgin materials rather than recycled materials. One of the most important components of this policy is the federal tax code, which impacts on relative prices and the use of virgin and secondary materials. Relevant components of the tax code which impact on materials prices include:

*Percentage depletion tax deductions

*Expensing of exploration and development costs

*Domestic International Sales Corporation allowances

*Foreign tax credits

*Western Hemisphere Trade Corporation allowances

Each of these components has the effect of reducing the costs of producing virgin materials, causing the supply curves for these materials to be lower than would prevail in the absence of favorable taxation. The lower supply curve leads to a lower market price for virgin materials and as a consequence to a relatively greater use of virgin goods. As these components of the tax code affecting the production of raw materials are available to producers of virgin materials and not to producers of recycled materials, the impact of the differentially favorable tax considerations appears to be an increase in the use of virgin materials at the expense of recycled materials.

The purpose of this report is positive rather than prescriptive. That is, no attempt is made to determine or design the essential features of future federal materials policies. The intent is to provide a comprehensive analysis of one element of the present de facto materials policy--the federal tax code--and its impact on virgin material use and recycling in selected key industries: paper, steel, copper, aluminum, and lead. The comprehensive analysis consists of two parts. First, a general theoretical approach towards determining the empirical effect of the federal tax code on virgin and recycled materials is developed. Second, on an industry by industry basis, econometric estimates are made of the parameters necessary to determine the empirical impact of the tax policy on resource use and recovery. Together, the two parts allow an estimate to be made of the quantitative impact of federal tax policies on materials use in each of the five industries.

The empirical estimates of the short run impact of preferential tax features for virgin material production on the volume of recycled material production attempt to be optimistic in that where assumptions must be made they err towards overestimating the increase in recycled materials production. However, it should be remembered that the short run estimates contain no allowance for long run impacts resulting from altered investment decisions which can reasonably be expected if tax equalization were effected.

Estimates of the increase in the supply curves for five virgin materials which could be expected to result from elimination of preferential tax provisions are displayed in Table 1. These figures can be interpreted as the price increase which would be necessary in order for virgin material output to be unchanged after removal of preferential tax treatment. The supply curve is shifted up for various reasons by the removal of each type of tax subsidy. Preferential taxation of capital gains probably should be viewed as a subsidy to capital used in production; elimination of this subsidy causes the supply curve to shift up in proportion to the capital intensity of the industry. For the depletion allowance, which can be regarded as a negative excise tax on capital input, supply is shifted up by the amount of the subsidy.

TABLE 1. IMPACTS OF TAX SUBSIDIES ON VIRGIN MATERIAL SUPPLY CURVES

Industry	Upward Shift in Supply Curves: Maximum Possible Impact (%)	Upward Shift in Supply Curves: "Most Likely" Impact (%)
Paper	4.2	1.0
Steel	3.0	2.0
Copper	6.0	5.0
Aluminum	2.2	---
Lead	3.0	---

As can be seen in Table 1, the copper industry is predicted to experience the greatest upward shift in the supply curve for virgin metal if preferential tax consideration of producers of virgin metal is eliminated. The supply curves for the five industries considered are expected to increase by amounts ranging from one to six percent from tax equalization.

To estimate the increase in recycled materials which would result from the increase in the supply curves of virgin materials presented in Table 1, econometric estimates of the supply and demand elasticities for virgin and recycled materials in each industry were necessary. These elasticities tended to bias the estimates because there are severe measurement errors associated with the reported virgin materials prices. In several markets, less than ten percent of recyled materials is actually sold and thus available data do not accurately reflect the market price. As an alternative to the use of direct price data, it was assumed that virgin and recycled materials are perfect substitutes for each other and that the quantity demanded of recycled goods is small enough relative to the quantity demanded of both virgin and secondary goods that the price elasticity of demand for recycled goods may be considered infinite. This assumption was used for the aluminum and the paper industries. Another alternative to the use of the direct price data is to assume that the elasticity of demand for recycled materials with respect to the price of virgin materials is infinite, implying that a single market exists for recycled and virgin materials and that the price of virgin materials equally reflects the price of recycled materials. This assumption is used for the lead and copper industries.

Table 2 contains a summary of the estimated impacts of virgin materials

TABLE 2. PERCENTAGE INCREASE IN RECYCLING OF SECONDARY MATERIALS EXPECTED FROM TAX EQUALIZATION

Secondary Material	Demand dependent on virgin and scrap prices (%)	Demand elastic with respect to all prices (%)	Demand dependent virgin price only (%)
Wastepaper	0.04	0.63	---
Scrap steel	0.42	---	---
Copper	---	---	0.35
Aluminum	---	1.00	---
Lead	---	---	0.75

tax subsidies on the quantity of secondary materials recycled. All figures are based on the maximum supply curve shifts which could possibly result from an equalization of the tax treatment for the virgin and secondary materials producers (as presented in Table 1), and are expressed as a percentage of the quantity of secondary materials currently recycled. Tax equalization is expected to result in an increase of approximately one percent in the quantity of aluminum recycled; smaller increases are expected for the other industries.

Tax subsidies to virgin material production are only one aspect of existing federal policies which adversely affect the flow of recycled materials. Other policies which allegedly may affect recycling include freight rate discrimination (which requires producers of a secondary material in competition with a virgin material to pay higher rates for shipment than the producer of the virgin material), labeling requirements for scrap based products (which may make marketing difficult if consumers believe that the virgin material is superior to the recycled material), mining laws (which give away valuable mining rights), failure to price residential solid waste collection and disposal, and in other ways pricing materials at less than their full social cost. Although the percentage impact on secondary material production estimated to result from equalization of tax provisions is relatively small (assuming existing technologies), the cumulative long run impact of all federal policies which affect virgin material use may significantly reduce the flow of recycled materials.

SECTION 2

THEORETICAL ANALYSIS

TAX SUBSIDIES AND THE PRICE OF VIRGIN PRODUCTS

The theoretical basis for determining the relationship between price of a virgin material and specific tax subsidies is considered below. Three types of tax provisions are considered:

1. Taxation of net income

2. Taxation of gross income

3. Deduction of expenses from income.

The first type of tax affects the paper industry, which is allowed to treat as a capital gain the increase in value of timber ready for harvest over its initial cost, thereby incurring a lower tax liability on portions of net income. The second type of tax provision reflects the impact of percentage depletion allowances on the mining industries--iron ore, copper, bauxite, and lead. This kind of tax subsidy acts to exempt a portion of gross income from taxation. Finally, expensing of exploration and development costs in many ways acts as an accelerated depreciation allowance and in effect shifts the time profile of tax liability. This provision is also available to the mining industries.

Taxation of Net Income

Economics defines profits as returns minus total costs, where costs are defined to include a "normal" rate of return on capital used in the production process. A tax on economic profits does not alter a producer's profit maximizing output level or price. For two reasons, the corporate profit tax, a tax on net corporate income, is not identical to a tax on economic profit. First, the corporate profits taxed by the United States governments include both economic profit and normal returns for the use of capital goods. The corporate profit tax is therefore a tax on an input to the production process as well as a tax on profits. Second, as the corporate profit tax is levied on accounting profits, the impact of the tax depends in part on how capital is obtained: where capital is borrowed, interest is deductible and the tax liability for the return on this capital is reduced by the amount of the interest paid.

Economists generally believe that since the corporate profit tax applies

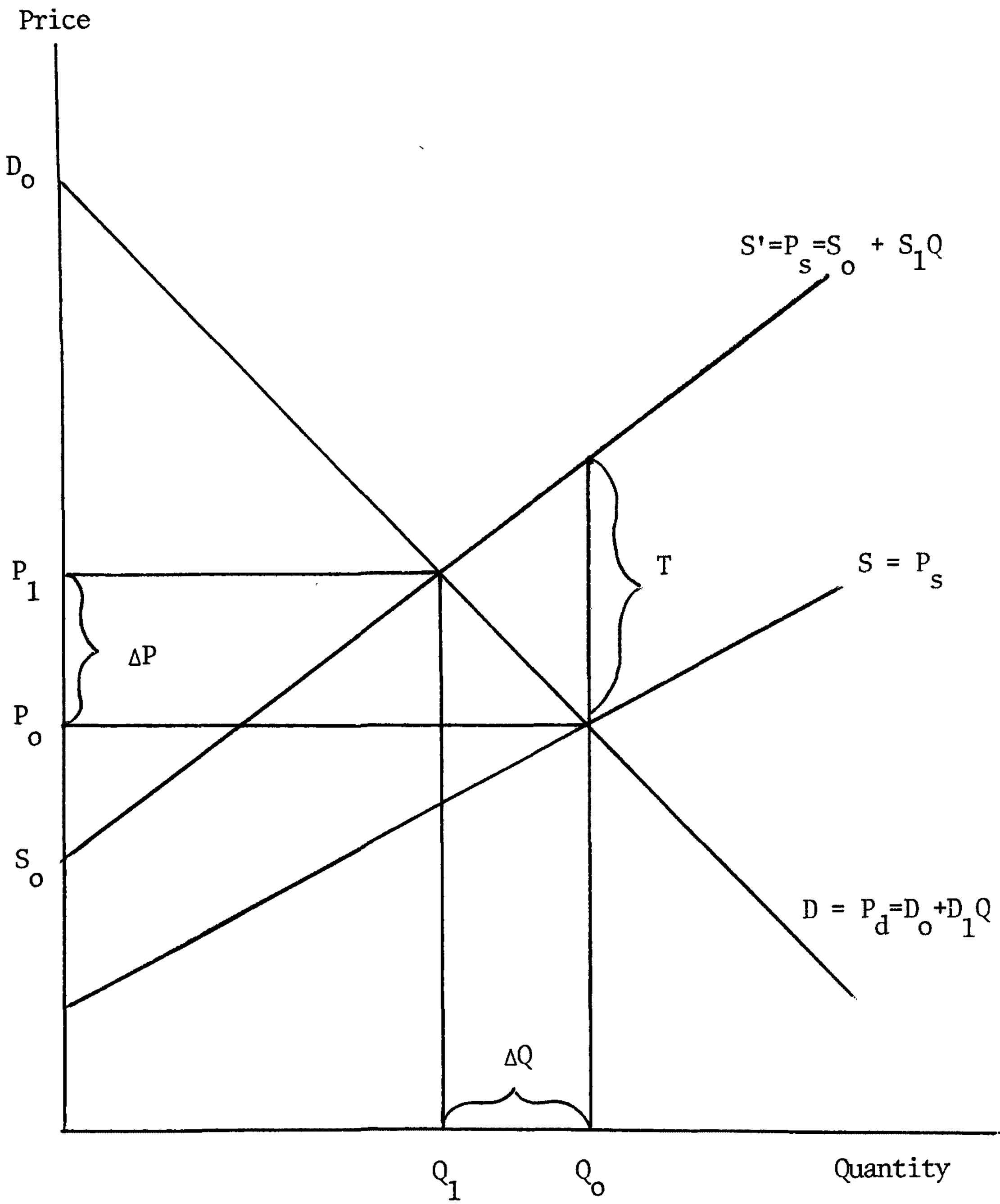

Figure 1. The impact of an excise tax on output and price.

not only to economic profits but also to the normal return to capital, it can be considered, at least in part, as a tax on that factor of production. The capital gains provision allowed the timber industry has the impact of reducing the profit tax paid by timber companies, or, to the extent that the subsidy falls on the capital good timber, of reducing its relative price in the production of paper. A subsidy to one factor of production should cause a substitution of that factor for other factors (such as labor). The size of the substitution of capital for labor as a result of the capital gains tax subsidy to timber would depend on the elasticity of substitution in the paper industry.

Precise estimates of the elasticity of substitution are difficult to obtain. One method is to calculate impacts based on an extreme case; for example, elasticity of substitution of zero, implying fixed factor proportions. With fixed factor proportions, the impact of the tax subsidy on the price of paper is greatest; however, using this assumption tends to overestimate the impact of removal of the subsidy on paper prices.

Taxation of Gross Income

Percentage depletion and severance taxes are similar in that both impact on the taxes which must be paid on gross revenues but their effects are in opposite directions. The severance tax is a direct tax on gross revenues. The percentage depletion tax, by exempting a given percentage of gross revenues from taxes (up to a maximum of 50% of net income for any one firm) results in a tax subsidy equal to the taxes which would have been paid on those exempted gross revenues. Producers who are constrained by the 50% rule would be less inclined to produce at a high level of output than would producers not constrained by the 50% rule.

The impact on production of removal of the percent depletion allowance can be analyzed as the imposition of an excise tax. Figure 1 shows the reaction of a competitive industry to imposition of an excise tax. Before the tax, the industry is at equilibrium at the intersection of its supply curve (S) and its demand curve (D) producing Q_o units of output for sale at a per unit price of P_o. Imposition of a tax of t percent of the price shifts the industry supply curve upward to S', causing a new equilibrium at a lower output, Q_1, and a higher price, P_1. The change in the price of the good, ΔP, depends on the slopes of the demand and supply curves facing the industry.

Algebraically, one can develop a general expression for the percentage change in the price of a virgin material which would be expected to result from a revocation of the percentage depletion allowance. This expression will be used later in the individual estimates for each mining industry.

Let the industry demand function be $D = D_o - D_1 Q$ where D_1 is equal to the slope of the demand function and D_o is its intercept. Let industry supply (after imposition of the tax--or after elimination of the percentage depletion allowance) equal $S' = S_o + S_1 Q$ where S_1 is the slope of the supply function and where S_o is its intercept. Referring to Figure 1, it is clear that the amount of the excise tax, T, may be defined according to equation (1):

$$(1)\ T = D_1 \Delta Q + S_1 \Delta Q$$

where ΔQ is the total change in industry output resulting from the imposition of the excise tax (i.e., the removal of the percentage depletion allowance). Also, it is clear that the change in the market price, ΔP, resulting from the imposition of the tax depends upon the slope of the demand function and the reduction in output resulting from the tax increase.

$$(2)\ \Delta P = D_1 \Delta Q$$

Using (1), equation (2) can be rewritten as:

$$(3)\quad \Delta P = \left(\frac{T}{D_1 \Delta Q + S_1 \Delta Q}\right)(D_1 \Delta Q) = TD_1/(D_1 + S_1).$$

Recalling that the elasticity of demand, E_D, is defined as $(\Delta Q/Q)/(\Delta P/P)$ or equivalently as $(P/Q)/D_1$, and that the elasticity of supply, E_S, can similarly be expressed as $(P/Q)/S_1$, we can express the slopes of the supply and demand curves in terms of elasticities of supply and demand:

$$(4)\quad S_1 = (P/Q)/E_S$$

$$D_1 = (P/Q)/E_D.$$

Substituting (4) into (3), dividing both sides of the equation by the market price before imposition of the tax (removal of the subsidy), and simplifying yields the following general expression for the percentage increase in the price of a virgin product expected to result from removal of the percentage depletion allowance:

$$(5)\quad \frac{\Delta P}{P_o} = \frac{(T/P_o)E_S}{E_D + E_S}.$$

Thus, to calculate the percentage increase in the price of the virgin material which would result from eliminating the depletion subsidy one needs to know the elasticity of supply, the elasticity of demand, the amount of the subsidy, and the current market price of the good. (This analysis is only approximately correct for several reasons. First, the elasticity of supply may vary along the supply curve. Second, imposition of an excise tax causes the slope of the supply function to shift; T is only approximately equal to $D_1\ Q + S_1^*\ Q$ where S_1^* is the slope of the supply curve prior to imposition of the tax. The formula works accurately enough, however, where the value of T is calculated from other data and the resulting figure merely substituted into (5) to estimate an increase in market price.)

Expensing of Exploration and Development

Expensing the exploration costs in the year in which they are incurred has a counterpart in manufacturing such as expensing of research and development costs. Expensing of development costs such as tunnels in mines, etc., however, has no counterpart in manufacturing. An equivalent would be a tax provision allowing manufacturing plants to depreciate new plant and equipment acquisitions in a single year.

The immediate expensing of outlays for exploration and development results in a postponement in tax liabilities for firms making such investments. To the extent that profitable mines are located and put into production, the expenditures are eventually taxed later in the form of taxes paid on profits from the mines. Although capitalization of expenses is allowed, if a firm wishes to utilize the favorable percentage depletion tax provision the expenditures on exploration and development must be expensed.

The expensing of expenditures on exploration and development does not result in a tax savings on a profitable mine. When a mine for which exploration outlays were previously expensed reaches the producing stage, the deductions are recaptured through reductions in depletion deductions that may be taken (or through addition to the adjusted basis if cost depletion is used). Thus, the expensing provision serves mainly to provide an incentive to develop new sources of supply by allowing for tax purposes the immediate recognition of costs of acquiring new properties. A similar deduction is not available to secondary materials producers who incur expenses developing and constructing new types of recycling plants, for example.

MODELS OF TAXATION AND RESOURCE USE

Materials Flows

A general model of the relationship between taxation of virgin materials and resource recovery to generate recycled materials must consider demand and supply relationships in three markets. In the product market, where the final good to which the virgin or scrap-recycled product is an input is traded, demand can most generally be considered to be a function of the price of the good, income, and other prices whereas supply can be modeled as dependent upon the price of the virgin material input, the price of the scrap material input, and the prices of all other inputs to the production process. In the new materials market where the virgin material input is bought and sold, demand depends upon the price of the virgin input, the price of the final good, and the price of the scrap input, whereas supply depends upon the availability of the virgin material and the costs of processing the material. In the intermediate market where the scrap input, a substitute for the virgin material input, is traded, demand is modeled as a function of the price of the final good, the price of the scrap input, and the price of the virgin input, while supply is functionally determined by the availability of scrap and its processing cost.

Using this general framework of analysis, the impact on scrap output of a change in taxes on the virgin input can be identified. An increase in taxes on the virgin input would be expected first to shift up its supply curve, leading to an increase in the market price for the virgin input. An increase in the price of the virgin input leads to an upward shift in the supply curve in the product market and a consequent increase in the price of the final product. In response to an increase in the price of the virgin material input, the demand for the scrap input would shift upwards. The extent to which scrap would be substituted for virgin material would depend upon the elasticity of demand for scrap with respect to the price of virgin input (the cross price elasticity of demand) and the supply elasticities for scrap and virgin materials.

As the supply curve for final products shifts upwards, a lower production of final products will occur and perhaps lower the demand for inputs. Thus, the impact on the virgin input prices normally will be less than that indicated in the first round of changes. Similarly, the demand for scrap should rise somewhat less than predicted by estimated cross price elasticities multiplied by first order effects on virgin input prices.

The general model indicates that six relationships must be estimated in order to determine the effect on the recycled material of a tax increase on its virgin substitute. Fewer relationships will suffice where the recycled and virgin input are extremely close substitutes for each other, allowing estimation of a single demand function for recycled and virgin inputs. A single demand curve is estimated for the lead and copper industries. For the paper and steel industries, the virgin material supply functions are assumed to be infinitely elastic.

Before discussing the particular industry estimates, a brief overview of the relationship between the primary and the secondary markets is appropriate. Basically, there are five potential points in the production cycle of a raw to a finished output where a secondary material might be substituted for a primary input. Before an econometric model can be estimated, the relevant point of substitution for a particular industry must be established so that data can be collected for the proper variables. It is the particular technology existing within each industry which determines the proper point in the production process at which to model the substitution of secondary for primary inputs.

Figure 2 shows diagramatically the five possible substitution points. The secondary input may substitute for the primary at the point just past extraction and prior to processing, directly at the point of processing, past processing and prior to manufacture, directly at the manufacturing point, or directly at the point of consumption in the final product market. As will be discussed in greater detail for each industry below, the point of greatest substitutability between the primary and the secondary sectors differs from industry to industry. For each industry, however, demand and supply equations are estimated at that point of potential substitution in the production cycle where the possibilities for substitution are in actuality the greatest, given the technological constraints on production in that particular industry.

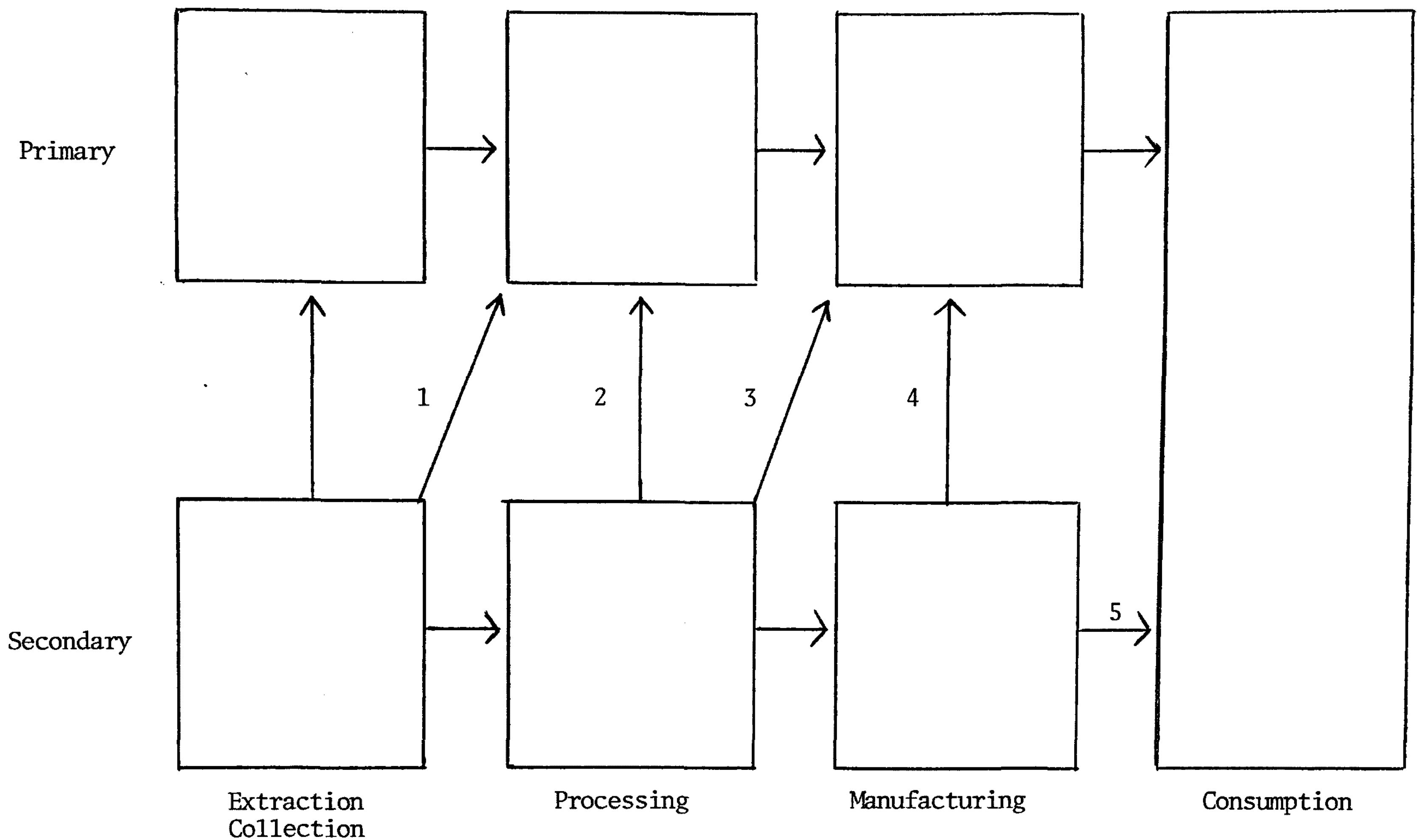

Figure 2. Materials flows and points of substitution.

Estimation Procedures

As both supply and demand functions are specified, though both may not be estimated for each of the five industries considered below, two stage least squares estimation techniques are used in all cases unless otherwise noted. This procedure yields consistent estimates of the coefficients in the equation. Where autocorrelation was evident, generalized least squares procedures were paired with the two stage least squares estimation technique.

The parameters and statistical tests for determining the significance of estimated coefficients are less well known for the two stage least squares technique than for the ordinary least squares technique. The method developed by Fisher (15), who suggests using a cutoff of 2.00 on the value of the ratio of a regression coefficient to its estimated standard error, was followed as a test of the statistical significance of individual regression coefficients. These t ratios are reported beneath coefficients in parentheses.

SECTION 3

THE IRON AND STEEL INDUSTRY

USE OF SECONDARY MATERIALS IN STEEL PRODUCTION

Steel can be produced from various combinations of virgin material and scrap iron inputs. From the virgin inputs material consisting of an intermediate product, "hot metal" or pig iron, is produced. Hot metal and scrap steel are the two basic charges for steel production. In terms of Figure 2, substitution occurs either at point 1 just after collection of scrap or, where collected scrap requires more preliminary processing (which would normally be required in the case of obsolete scrap such as automobiles) at point 2.

Depending upon the type of furnace process, scrap steel may be considered a perfect or a close substitute for pig iron as it is processed into steel. The open hearth furnace can accept any proportion of scrap steel and pig iron as a charge, allowing perfect substitution of scrap for pig iron. The basic oxygen furnace, however, can accept a maximum of about 40% of its charge in the form of scrap steel, and the maximum can be utilized only if the scrap is preheated. Thus, scrap and pig iron are only imperfect substitutes for each other where the basic oxygen furnace is used.

In practice, the open hearth furnace operates with an average of 40-45 percent of its charge in the form of scrap steel, the basic oxygen furnace with about 30 percent of its charge in the form of scrap steel, and the electric furnace, primarily designed to process scrap, with a charge of close to 100 percent scrap steel (5). Over half of total steel output is currently produced in the basic oxygen furnace, and this trend is continuing. It is predicted that by 1985 only 7 percent of all domestic steel will be produced in the open hearth furnace (as compared to about 25% today). The share of output attributable to the electric furnace is expected not to rise (26). This trend in technological process which is less suitable for recycling is due to the greater efficiency of the basic oxygen furnace as compared to the open hearth furnace. Production of a batch of steel requires ten hours in an open hearth furnace, while only forty-five minutes are required in the basic oxygen furnace. In sum, both currently and in the near future, scrap steel and pig iron are imperfect substitutes for one another. In the long run,development of a new technology might allow greater substitution between the alternative charges.

Of the three basic types of steel scrap, approximately 100 percent of the home scrap and 90 percent of the prompt scrap is automatically recycled

(26). Obsolete scrap is collected and processed by approximately 1,500 firms with 2,000 facilities located throughout the United States. These dealers engage in collection as well as upgrading processes such as burning to remove organic contaminants and breaking or cutting up of large irregularly shaped pieces into smaller more regularly shaped pieces. The major purpose of the model described below is to determine the effect on recycling of the obsolete scrap resulting from removal of tax subsidies to producers of virgin material.

THE MODEL: USE OF SCRAP STEEL IN THE STEEL INDUSTRY

Although the general model described above specified six separate functions which would ideally be estimated for each industry, only two specific functions are estimated for the steel industry. To obtain a quantitative estimate of the impact of removal of income tax subsidies to producers of iron ore, limestone, and coal, the following approach is used. Informed judgments are used to determine the increase in the price of a virgin substitute for scrap steel (i.e. pig iron) which could be expected if tax subsidies were eliminated. The demand and supply for scrap steel are then modeled econometrically and coefficients of these functions, together with the estimated price increase in pig iron resulting from eliminating tax subsidies are used to determine the increase in recycling of scrap steel which could be expected.

Supply and Demand in the Scrap Steel Market

Most generally, the model described here estimates how the quantity of scrap steel supplied responds to changes in its own price and how the quantity of scrap steel demanded responds to the changes in the price of obtaining pig iron and the price of scrap steel.

Equations and Data

The supply and demand functions are stated fully below.

$$Q_s = Q_s(P_{scrap}, Av_1, Av_2, Ex, T_{scrap})$$

$$Q_d = Q_d(P_{scrap}, P_{pig}, Q_{steel})$$

where: Q_s = the quantity of scrap steel supplied, in total dollar receipts for obsolete and prompt scrap.

P_{scrap} = the price of scrap, measured by the Bureau of Labor Statistics price indices for iron and steel, deflated by the wholesale price index.

Av_1 = availability of raw scrap (obsolete and low quality prompt) proxied by an Almon lagged scrap price variable, under the assumption that scrap availability is negatively associated with previous prices (and hence with collections).

Av_2 = availability measure for automatically recovered scrap (high quality prompt) measured as a lagged function of the Federal Reserve Board's index of automobile production, measured in thousands of short tons.

Ex = quantity of scrap exports, which is assumed to shift the domestic supply curve by an amount equal to the dollar value of exports.

T_{scrap} = the state of technology in the scrap industry, proxied by a time trend variable designed to reflect important recent labor saving innovations such as the automobile shredder.

Q_d = the quantity of scrap demanded, in total dollar receipts for obsolete and prompt scrap.

P_{pig} = the list price of pig iron ($/ton) which was used despite the fact that most pig iron is not traded on the marketplace and thus the list price need not accurately reflect the true equilibrium price, deflated by the Bureau of Labor Statistics wholesale price index.

Q_{steel} = the activity in the scrap consuming sectors, measured by the American Iron and Steel Institute's series on raw steel (4) production in thousands of short tons (treated as an Almon lag of five to eight months) produced in basic oxygen furnaces, a proxy for the ability of the steel producing industry to demand scrap steel.

In both equations, scrap demanded (or supplied) is measured as total dollar receipts for obsolete and prompt scrap. To the extent that 90 percent of prompt scrap is automatically recycled irrespective of the price elasticity of supply of scrap, use of this series leads to underestimation of the price elasticity of supply of scrap steel from obsolete sources.*

Estimated Equations

The linear supply and demand equations, as estimated using two stage least squares with an autoregressive correction are shown below:

$$(6) \quad Q_s = \underset{(9.9)}{-763} + \underset{(9.9)}{52.9}\, P_{scrap} - \underset{(1.58)}{10.2}\, Av_1 + \underset{(4.9)}{2.6}\, Av_2$$

$$- \underset{(6.9)}{.94}\, Ex + \underset{(5.6)}{5.0}\, T_{scrap}$$

---

* As, by using this series, Q in the elasticity formula $E_S = (\Delta Q/\Delta P)(P/Q)$ is approximately twice as large as would be desired.

$$(7)\quad Q_d = 601.7 - \underset{(3.7)}{23.5}\, P_{scrap} + \underset{(1.69)}{9.66}\, P_{pig} + \underset{(11.0)}{.30}\, Q_{steel}$$

The estimates used monthly data from 1962 through 1974. All signs of the coefficients were as expected, the magnitudes seemed reasonable, and most had a t ratio of two or more.

From equation (6), supply elasticities may be calculated. At the mean, the price elasticity of supply is 1.4. This takes into account both P_{scrap} and Av_1, the lagged price of scrap. As discussed above, however, the data series used for scrap supply biases the estimate of price elasticity downwards. Adjusting the estimated elasticity to reflect only those scrap receipts attributable to obsolete and other "not automatically recycled" scrap, one obtains a price elasticity of supply of 2.32.

Other variables in equation (6) tended to confirm expectations. High prices for scrap in the recent past indicating low current availability of scrap (Av1), are negatively associated with the quantity of scrap supplied. The availability of prompt scrap (Av2) is positively associated with scrap supply, as expected. However, the percent increase in supply resulting from a one percent increase in availability of prompt scrap, calculated as .2, seems a bit low. If prompt scrap is truly "automatically" recovered, and truly represents approximately 50 percent of total recycled prompt and obsolete scrap, an elasticity of approximately .5 would have to be expected. The low estimate may be attributable to the fact that automobile production fails to account for production of all prompt scrap. A one ton increase in exports leads to a decrease in scrap supplied domestically or approximately one ton (.94), as expected. The time trend, reflecting technological change in the scrap industry, indicates that, all other things equal, the quantity of scrap supplied increases by about one percent per year.

The estimated demand function indicates a price elasticity of demand of .63 and the usual downward sloping demand curve shape. A one percent increase in the price of pig iron is associated with a .28 percent increase in the demand for scrap steel. The coefficient on which this cross price elasticity estimate is based, however, is not estimated with great precision (t ratio computed as 1.69).

The Supply Price of Pig Iron and Tax Subsidies

Having estimated the cross price and own price elasticities of supply and demand in the scrap steel industry, one additional data item is needed to determine the effect on scrap steel output of elimination of tax subsidies to producers of pig iron. This is the increase in the price of pig iron which would arise were these subsidies no longer available to pig iron producers.

Two tax subsidies for virgin inputs to pig iron are available: percentage depletion allowances of fifteen percent on iron ore, ten percent on coal and fourteen percent on limestone and capital gains taxation of royalties in the production of coal and iron ore. The analysis of price impacts will be confined to the depletion allowances. Using the input proportions of coal (.77 tons), limestone (.20 tons), and iron ore (1.5 tons) cited by Vaughan (29), assuming that the full depletion allowance is taken and that the relevant corporate tax rate is .48, and taking the prices per ton for inputs to pig iron production as of May 1974 ($30 for coal, $2 for limestone, and $11 for iron ore), the maximum upward shift in the supply curve of pig iron attributable to increased taxes resulting from elimination of depletion allowances is calculated as the product of input tons x price/ton x depletion allowance x corporate tax rate for each of the three virgin inputs to pig iron. The maximum price increase, per ton of pig iron, is $2.33, of which $1.11 is attributable to the loss of the depletion allowance on iron ore, $.03 to the loss of the depletion allowance on limestone, and $1.19 to the loss of the depletion allowance on coal. This price increase represents about 3% of the May 1974 price per ton of pig iron of $70. Thus, the maximum effect of elimination of depletion allowances is a three percent increase in the price of pig iron.

FEDERAL TAX IMPACTS ON THE RECYCLING OF SCRAP STEEL

The calculated elasticities of demand will be used to estimate the percentage increase in the recycling of scrap steel which would result from elimination of percentage depletion allowances to producers of virgin materials. This supply increase, it should be emphasized, is an upper bound estimate of the short run impact of tax equalization.

Short run impacts on scrap steel production can be calculated from the previously discussed upward shift in the supply curve of pig iron (3%), the cross price elasticity of demand for scrap steel (.28), and the price elasticities of demand (.63) and supply for scrap steel (2.32). The three percent price increase in pig iron predicted from elimination of the percentage depletion tax provision times the cross price elasticity of demand for scrap steel (.28) leads to an upward shift of .84% in the demand for scrap function. Using an analysis comparable to that developed in Figure 1 and equations (1) through (5), the percent change in the market price resulting from this .84% upward shift in the demand function can be calculated as $.84E_D/(E_D + E_S)$ which is equal to .18%, where E_D and E_S refer to the elasticities of demand and supply, respectively. The quantity of obsolete scrap steel recycled would increase by the change in price multiplied by the supply elasticity, or .18 x 2.32 = .42%.

An estimate of the increase in the quantity of obsolete scrap steel which would be recycled in the long run can be obtained solely from the estimated supply curve for scrap steel. To make this estimate, it must be assumed that there is long run perfect substitutability between virgin and scrap inputs and that the long run supply of virgin inputs to steel production is highly responsive to price changes. With these assumptions, an upper estimate on the increased quantities of obsolete scrap which would be recycled should the tax subsidization of the inputs to pig iron be eliminated can be obtained by multiplying the supply elasticity of scrap steel by the change in the price of virgin based pig iron, to obtain a figure of 2.32% x 3% = 6.4%. This figure is biased upwards in large part due to the assumption of perfect substitutability between virgin and scrap inputs. Given current technology, this assumption is clearly an over simplification of the iron and steel industry.

SECTION 4

THE PAPER INDUSTRY

USE OF SECONDARY MATERIALS IN PAPER PRODUCTION

The percentage of paper products recycled has declined over the last twenty-five years. In 1950, about 28% of paper products were recycled, but by 1973 the figure had dropped to 17%. (14)

As in the iron and steel industries, except in periods of exceptionally weak demand, home and prompt paper scrap is generally recycled. In order of importance for recycling, obsolete paper scrap originates in commercial, industrial, and residential establishments.

Most recycled paper is sold as paperstock, a source of cellulose fibers in direct competition with other fiber sources, principally virgin wood. Paperstock and virgin wood may be used as substitutes in the production of paperboard (boxboard, corrugating medium and linerboard, for example), tissue, and newsprint. Substitution occurs, then, at flow point 2 in Figure 2, as is the case in the iron and steel industry. Paperboard production accounts for over three fourths of the consumption of paperstock. In modeling the demand for paperstock, then, it must be considered as a demand derived largely from the demand for paperboard.

THE MODEL: USE OF WASTE PAPERS IN THE PAPER INDUSTRY

Supply and Demand in the Wastepaper Industry

As for the iron and steel industry, only two of the six general equations in the model are specified and estimated. These are the equations of the demand for and supply of wastepaper products, or, more specifically, the demand for and supply of prompt and obsolete paperstock.

Equations and Data

In general, the demand for paperstock is hypothesized to depend on its price, the price of virgin woodpulp, and activity in the paperboard industry. The supply of paperstock is hypothesized to depend on its price and the availability of wastepaper.

The estimated equations are presented below:

$$Q_d = Q_d(P_{ps}, P_{wp}, Q_{pb1}, Q_{pb2})$$

$$Q_s = Q_s(P_{ps}, A_{v1}, A_{v2})$$

where:

Q_d = the quantity of paperstock demanded, measured as the raw tonnage (in thousands of tons) of all grades of paperstock consumed at user mills, Department of Commerce Series M26A in the Current Industrial Reports.

P_{ps} = the price of paperstock, a Bureau of Labor Statistics index divided by the Bureau of Labor Statistics wholesale price index (times 1,000).

P_{wp} = the price of woodpulp, measured by the Bureau of Labor Statistics composite of prices for a number of woodpulp grades divided by the Bureau of Labor Statistics wholesale price index (times 1,000).

Q_{pb1} = a measure of activity in the paperboard industry, proxied by the Department of Commerce Series M26A Current Industrial Reports figures for output of construction paper and board, in thousands of tons.

Q_{pb2} = a measure of activity in the paperboard industry, proxied as production of combined paperboard in thousands of tons. Together, construction and combined paperboard account for the use of 85% of paperstock.

Q_s = the quantity of paperstock supplied, measured as Q_d.

A_{v1} = availability of inputs to the production of paperstock, proxied as the Federal Reserve Board index of production of converted paper products and paperboard carton production (times 10).

A_{v2} = availability of wastepaper products for recycling, proxied by lagged prices of paperstock, under the assumption that recent high prices cause greater collection and recycling and a consequent current scarcity of recyclable materials.

Estimated Equations

The linear supply and demand functions, estimated using two stage least squares on monthly data from January, 1961 to December, 1972 are presented below. The t ratios are in parentheses beneath the coefficients.

$$(8)\quad Q_d = 49.1 - .13\,P_{ps} + .11\,P_{wp} + .51\,Q_{pb1} + 1.11\,Q_{pb2}$$

$$\qquad\qquad (2.37) \qquad (1.94) \qquad (6.20) \qquad (13.30)$$

$$(9)\quad Q_s = 457.1 + .46\,P_{ps} + .31\,A_{v1} - .40\,A_{v2}$$

$$\qquad\qquad (3.67) \qquad (10.62) \qquad (3.03)$$

All coefficients in the demand function have the expected signs and most have large t ratios. In addition, the magnitudes of the coefficients seem reasonable. For example, McClenahan shows that approximately twelve percent of paperstock consumed is used in construction paper, where it accounts for two thirds of production (23). Since the measure used for Q_{pb1} included output which used no paper stock, its coefficient should be less than two thirds; in fact, the coefficient of Q_{pb1} is .51.

The price elasticity of demand for paperstock is calculated as .16. The cross price elasticity of demand for paperstock, the percent change in paperstock demand resulting from a one percent change in the price of wood pulp is .13.

All estimated coefficients in the supply function have the expected signs and most have t ratios greater than 2.0. The elasticity of supply with respect to the current price of paperstock is 0.40. The elasticity with respect to both current and lagged prices can be thought of as representing a longer range price elasticity; its value is .15.

The Supply Price of Wood Pulp and Tax Subsidies

Since 1944, timber manufacturers have been allowed to treat the increase in value of timber from planting to harvest as a capital gain. The major effect of eliminating this tax provision would be to cause marginal lands planted with timber (called stumpage) to be removed from timber production, causing an upward shift in the long run supply curve for timber (stumpage) and wood pulp.

If an elastic supply of stumpage is assumed, with a unit of land currently earning \$1.00 before taxes and \$.70 after taxes, removal of the capital gain tax privilege implies that the same land must earn \$1.346 to yield the same \$.70 as before. Thus, the maximum long run impact of capital gains taxation on the price of stumpage would be 34.6%. As stumpage prices have historically averaged between 6 and 12 percent of market pulp prices, the maximum long run impact from elimination of capital gains taxation on market pulp prices would be 12 x 34.6 = 4.2% (16, p. 149).

FEDERAL TAX IMPACTS ON THE RECYCLING OF WASTEPAPER

Calculation of the increase in the quantity of wastepaper recycled as a result of eliminating the tax provisions favoring use of virgin paper follows the same procedures as used for the scrap steel industry. In the short run, a 4.2% rise in the price of woodpulp causes a .55% rise in the demand for paperstock function (the cross price elasticity of demand for paperstock, 0.13, times the percent increase in the price of woodpulp, 4.2%), which in turn results in an increase in the market price for paperstock. This can be calculated as .55 x $E_D/(E_D + E_S)$ where E_D and E_S refer to the elasticities of demand and supply, respectively, for paperstock. The percentage increase in paperstock price, .28, when multiplied by the price elasticity of supply of paperstock, .15, gives the percentage increase in recycled paperstock, .04%, which would result from equalizing tax treatment of primary and secondary producers of inputs to paper manufacture.

If in the long run perfect substitutability between wood pulp and paperstock prevails, then the impact of tax equalization on paperstock production can be calculated as the price increase in woodpulp from equalization (4.2%) times the price elasticity of supply for paperstock (0.15) which gives 0.63 percent.

SECTION 5

THE ALUMINUM INDUSTRY

USE OF SECONDARY MATERIALS IN THE ALUMINUM INDUSTRY

Aluminum is manufactured by processing alumina (aluminum oxide) bearing ores (for example, bauxite), to obtain alumina and then electrolytically reducing alumina in a molten bath of cryolite into aluminum ingot. The substitution of virgin and secondary aluminum supplies occurs primarily in the casting industry, where aluminum scrap competes directly with primary aluminum ingot. In Figure 2, this would occur at flow number 3.

The aluminum industry, which in 1968 produced 418 thousand short tons from virgin products and 817 thousand short tons from secondary metal, is second only to steel in domestic metal output (3). In contrast to other industries such as lead and copper, recycled obsolete scrap accounts for only one fifth of recovered aluminum. In part this fact is due to the newness of the aluminum industry and to the consequent lack of a large stock of metal available for recycling. However, in large part the fact is also due to a technological constraint in the production of aluminum, whereby it is not possible to produce as pure a product from recycled metal as it is from bauxite ore. Most recycled metal, then, comes from hone or prompt sources. What obsolete scrap is recycled comes largely from the airframe and automobile industries (9).

THE MODEL: USE OF SECONDARY ALUMINUM IN THE ALUMINUM INDUSTRIES

Supply and Demand in the Scrap Aluminum Market

Due to the relative abundance of bauxite ores in the earth, it is expected that the price of aluminum is determined by production costs. Given this expectation, as Figure 3 shows, the demand elasticity is irrelevant for determining the impact of tax equalization on recycling of aluminum.

In Figure 3, the Secondary Supply curve is upward sloping, reflecting the fact that production costs of secondary aluminum rise as less desirable scrap is recycled and more effort is expended in collection. The primary supply curve is drawn as perfectly elastic. An equalization in taxes for the primary sector would result in an increase in the price of primary (and secondary) aluminum equal to the value of the foregone tax subsidy. (In Figure 3, P' as compared to P_0.) Under such assumptions, the percentage change in secondary production resulting from a price increase in the primary

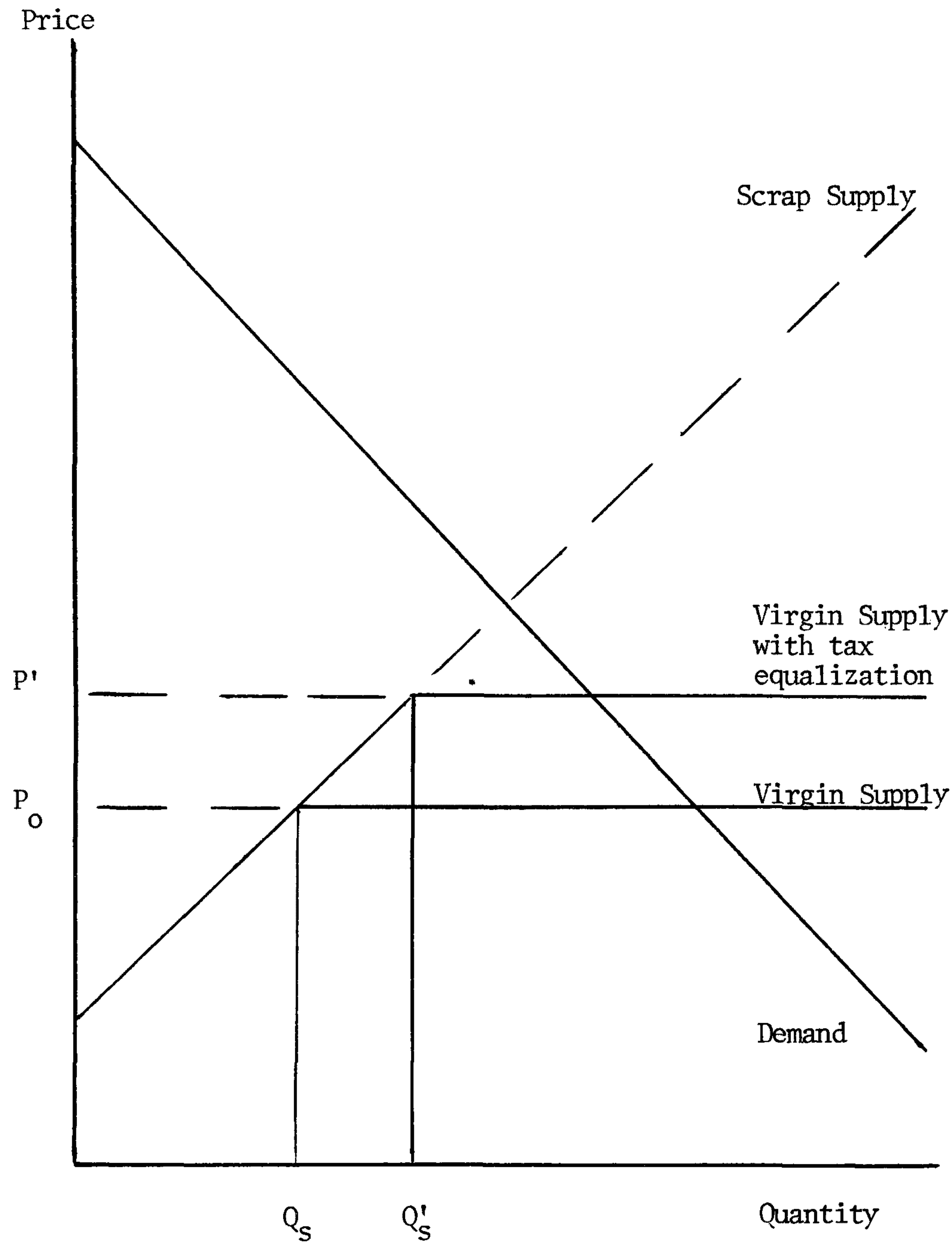

Figure 3. Primary and secondary supply and price determination in the aluminum industry

market $(Q_s' - Q_s)/Q_s$, can be calculated using the percentage price increase, $(P' - P_0)^s / P_0$, and the price elasticity of secondary supply.

Thus, an equation for secondary supply is estimated using two stage least squares on monthly data from 1962 through 1972.

$$(10) \quad Q_s = 5.8 + 1.44 P_a$$
$$(1.42)$$

where:

Q_s = the net metallic recovery from aluminum scrap and sweated pig consumed at secondary smelters.

P_a = the price of a #12 secondary alloy ingot.

The elasticity of supply is .86. This number must be interpreted with caution as the coefficient from which it is derived is not precisely estimated and is of only marginal significance.

The Supply Price of Aluminum Ores and Tax Subsidies

The major tax subsidy to the aluminum industry is the percentage depletion allowance on bauxite ore. In 1973, Alcoa obtained a percentage depletion allowance (as a percent of the value of ingot produced) of 1.4%; Kaiser Aluminum and Chemical, 1.9%; and Reynolds Aluminum, 2.3% (13 and 17). Since Reynolds Aluminum controls most of the domestic production of bauxite, and since the depletion rate for domestic production exceeds that for foreign output, it would be expected that the depletion allowance is more important to Reynolds Aluminum as a percentage of final product price than to the other producers.

The impact of the percentage depletion allowance in terms of lower prices for final outputs is, at most, equal to the tax savings, or 48% of the ratio of depletion to final product price. Percentage depletion would thus reduce market price by somewhere between .48 x 1.4 = .7 and .48 x 2.3 = 1.1 percent.

FEDERAL TAX IMPACTS ON THE RECYCLING OF SCRAP ALUMINUM

Elimination of the percentage depletion allowance for aluminum would result in a maximum price increase of 1.1 percent. Multiplying this figure by the price elasticity of supply for scrap aluminum gives the maximum increase in output of recycled aluminum to be expected from tax equalization. This figure is 1.1 x .86 = 1.0%.

SECTION 6

THE COPPER INDUSTRY

USE OF SECONDARY MATERIALS IN THE COPPER INDUSTRY

Copper ranks third in production by weight among metals in the United States. The secondary copper industry is the largest of the secondary nonferrous metal industries. In 1972, secondary copper production totaled 1,479 thousand tons, of which 40% was attributable to old or obsolete scrap and 60% to new or prompt scrap. Total output equaled about 42% of the domestic copper supply produced in 1972 (22).

The largest source of obsolete copper scrap is electric wire, followed by cartridge brass, automotive radiators, low grade scrap and residue, railway car boxes, and magnet wire. Copper scrap is sold in dispersed markets. There are approximately 80 secondary smelters and about one dozen primary producers (18). Copper scrap is consumed by each of these entities. Some substitutions of scrap for virgin copper occur at each stage of the flows diagrammed in Figure 2. Brass mills and primary producers each purchase about one third of copper scrap, foundries buy about 6% of copper scrap, and the remainder is bought by secondary smelters, ingot producers, and, to a lesser degree, chemical plants.

THE MODEL: USE OF SCRAP IN THE COPPER INDUSTRY

As prompt scrap is generally substituted for primary copper ingots in the brass industry, and as old or obsolete copper scrap substitutes for primary copper earlier in the production process, it is useful to disaggregate the copper scrap supply function into two parts: that supplying new scrap and that supplying old scrap. In addition to the two supply functions for copper scrap, the model below presents a supply function for new copper, a demand function for copper output, and an equation describing the net exports of copper from the rest of the world to the United States.

Supply and Demand in the Copper Industry

An annual model, developed by Fisher, et. al., is postulated below (15). Use of annual data means that estimated elasticities can be considered to provide relatively long run estimates of supply and demand. The five equations in the model are:

$$Q_{s1} = Q_{s1}(P_{c1}, Q_{av1})$$

$$Q_{s2} = Q_{s2}(P_{c2}, A_{v2})$$

$$Q_{s3} = Q_{s3}(C_t)$$

$$C_t = C_t(P_c, P_a, IP, ID, ID_{t-1}, Ct_{t-1})$$

$$X_t = X_t(PDIF, CDIF, D)$$

where:

Q_{s1} = the total United States mine production of primary copper, in thousands of metric tons.

P_{c1} = the price of copper, from the Engineering and Mining Journal, divided by the wholesale price index, expressed as \$/metric ton.

A_{v1} = a measure of copper availability, proxied by lagged values of domestic output of primary copper.

Q_{s2} = the supply of obsolete scrap, in thousands of metric tons.

P_{c2} = the price of copper scrap, obtained from the London Metal Exchange, deflated by the wholesale price index.

A_{v2} = the availability of scrap for recycling, proxied by a series generated by assuming a 1948 stock of scrap and adjusting this stock annually to account for production, net imports, and removals for recycling, measured as the lagged scrap recycled in the preceding year.

Q_{s3} = the supply of new scrap, in thousands of metric tons.

C_t = the total consumption of copper, in thousands of metric tons. New scrap is assumed to be generated as copper is used for other purposes.

P_a = the price of the substitute for copper, aluminum, lagged one year.

IP = the Federal Reserve Board's index of industrial production.

ID = the change in inventories of consumer durable goods.

ID_{t-1} = the change in inventories of consumer durable goods lagged one year.

Ct_{t-1} = the consumption of copper, lagged one year.

X_t = exports of copper, <u>from</u> the rest of the world to the

United States.

PDIF = the spread between the United States and the London Metal Exchange price of copper.

CDIF = the difference between domestic consumption and primary domestic output ($C_t - Q_{s1}$).

D = a dummy variable taking the value of 1 if export controls exist for copper and zero otherwise.

These equations were estimated, using two stage least squares and a correction for autocorrelation, on annual data from 1950 to 1968, and are reported below. The t ratios are in parentheses beneath the coefficients.

$$(11) \quad Q_{s1} = -160.04 + \underset{(2.99)}{14.27}\, P_{c1} + \underset{(3.55)}{.726}\, A_{v1}$$

$$(12) \quad Q_{s2} = -9.878 + \underset{(3.99)}{.422}\, P_c - \underset{(2.96)}{.373}\, A_{v2} \qquad \text{(log-log form)}$$

$$(13) \quad Q_{s3} = -275.2 + \underset{(7.56)}{.3961}\, C_t$$

$$(14) \quad C_t = -14.75 - \underset{(7.06)}{12.37}\, P_c + \underset{(1.79)}{8.29}\, P_a + \underset{(5.56)}{5.08}\, IP + \underset{(9.43)}{60.69}\, ID$$

$$- \underset{(6.25)}{44.40}\, ID_{t-1} + \underset{(7.02)}{.79}\, Ct_{t-1}$$

$$(15) \quad X_t = 795.5 + \underset{(2.21)}{1.397}\, PDIF + \underset{(2.20)}{.934}\, CDIF + \underset{(2.64)}{145.8}\, D$$

With the exception of the coefficient of the price of aluminum (the substitute for copper), all coefficients have t ratios over two. Moreover, all coefficients are of the expected signs. Fisher reports the elasticities, calculated at the means (with the exception of those obtained from equation (12), which was estimated in a log-log specification and whose coefficients can, then, be directly interpreted as elasticities) for the various sections of the model. The price elasticity of supply of primary copper is 1.67 (from equation (11)), that of obsolete scrap is .42 (based on current prices, from equation (12)), and .32 when prices are lagged, allowing short run adjustments to be elininated from the estimate. From equation (14), Fisher calculates that the short run price elasticity of demand is .173 and the long run price elasticity is .876. No elasticities are reported for the exports to the United States in Fisher's model.

The Supply Price of Copper and Tax Subsidies

Copper producers have available to them many income tax subsidies: percentage depletion allowances, expensing of exploration and development, foreign tax credits, and investment tax credits. As the impact of expensing provisions are difficult to quantify, and as the investment tax credit is available jointly to primary and secondary producers of copper, and as foreign tax credits (since the nationalization of the copper industry in Chile) have a minimal impact on the copper industry, quantification of tax impacts on the supply curve of primary copper producers is limited to an estimate of the effect of the percentage depletion allowance on copper prices.

Copper producers may take a 15% depletion allowance on revenues from copper concentrates. Copper concentrates, in general, are not traded; however, the revenues attributable to them are obtained by allocating costs to other operations involved in transforming copper concentrates to copper (primarily smelting and refining), and treating the residual as the value of copper concentrates. While determination of the tax impact at this level is difficult, one can estimate that, given that 5/6 of the price of blister copper is not attributable to refining and smelting of concentrates (and is, then, allocated to concentrates), the depletion rate is 15%, and the tax rate is .48, that the price of blister copper is reduced by the tax savings attributable to percentage depletion by an amount equal to (5/6) x .15 x .48 = 6%. Actually, 5% seems to be a better estimate of the tax impact of depletion on blister copper prices as a Treasury Depletion Survey (25, p.309) showed that rates of less than 15% are common for the industry.

FEDERAL TAX IMPACTS ON THE RECYCLING OF SCRAP COPPER

The following estimated effect of tax equalization on the recycling of scrap copper assumes that elimination of tax subsidies to primary copper producers will cause their supply curve to shift up by the full amount of the tax subsidy foregone. As the Fisher model does not provide an elasticity for foreign suppliers of copper with respect to our domestic price, the estimate will be biased upwards to the extent that increased imports of copper resulting from an increase in our domestic price are ignored.

Assuming that tax equalization will cause a 5% increase in the price of blister copper, the supply curve for final copper products will shift upward by a weighted average of the price elasticity of supply of the primary and secondary producers. Weighting the primary elasticity (1.67) by its share of the market (.45) and the scrap sector's elasticity (.32) by its share of the market (.185), (the remaining supply coming from new scrap or imports), the industry supply curve for final copper products is predicted to increase by 4.05% as a result of tax equalization. The supply curve for final output is assumed to shift upward by 5% times the share of primary copper (0.45) in the total domestic industry supply, or 2.25%. From equation (5), the percentage increase in the equilibrium price of copper can then be calculated as: (2.25% x .81)/(.876 + .81) = 1.08%, where .81 is the (weighted) price elasticity of supply and .876 is the price elasticity of demand. Based on the price elasticity previously calculated, a 1.08% increase in the price of copper will result in a .35% increase in the supply of obsolete copper recycled.

SECTION 7

THE LEAD INDUSTRY

USE OF SECONDARY MATERIALS IN THE LEAD INDUSTRY

The major source of primary lead is galena, a lead sulfide, which contains desirable antimony as well as sulfur. Smelting of galena burns off the sulfur and reduces lead ores to metallic lead. Although antimony is present in lead ores, most such ores are refined into soft lead products such as gasoline additives, cable sheathing, lead oxides, pigments, and a variety of lead alloys.

Secondary lead supplied the major portion of domestically consumed lead in 1973: 42% used came from secondary sources, 39.5% from primary output and 18.5% from imports. Unlike the steel industry, virgin and scrap lead are processed by separate firms, and the majority of scrap lead is obsolete. Only two percent of scrap lead is home scrap and from fifteen to eighteen percent is prompt scrap; the remainder is obsolete scrap. Automobile and other lead-based batteries provide about sixty percent of the obsolete scrap lead.

Scrap lead substitutes for primary lead at point flows three and four in Figure 2. Battery lead is processed in either a blast or a reverberating furnace, with some antimony added, to produce antimonial lead which is used directly in the manufacture of grids for new battery plates. Other scrap lead is processed in furnaces to yield a less refined product which must then proceed through flows two and three before being offered for final consumption.

THE MODEL: USE OF SCRAP LEAD IN THE LEAD INDUSTRY

Supply and Demand in the Lead Industry

The model assumes, as shown in Figure 4, that the primary and secondary lead products constitute perfect substitutes for one another, implying that the separate supply curves for each may be added horizontally to form a single supply function for the industry as a whole. Equalizing of tax subsidies to the primary and the secondary producers of lead results in an upward shift of the primary lead supply function to Sp', leading to a consequent decrease in the quantity of primary lead demanded ($-\Delta Qp$), an upward shift in the industry supply function for lead (to Si'), and an increase in both the market price for lead (to Pi') and the quantity of scrap

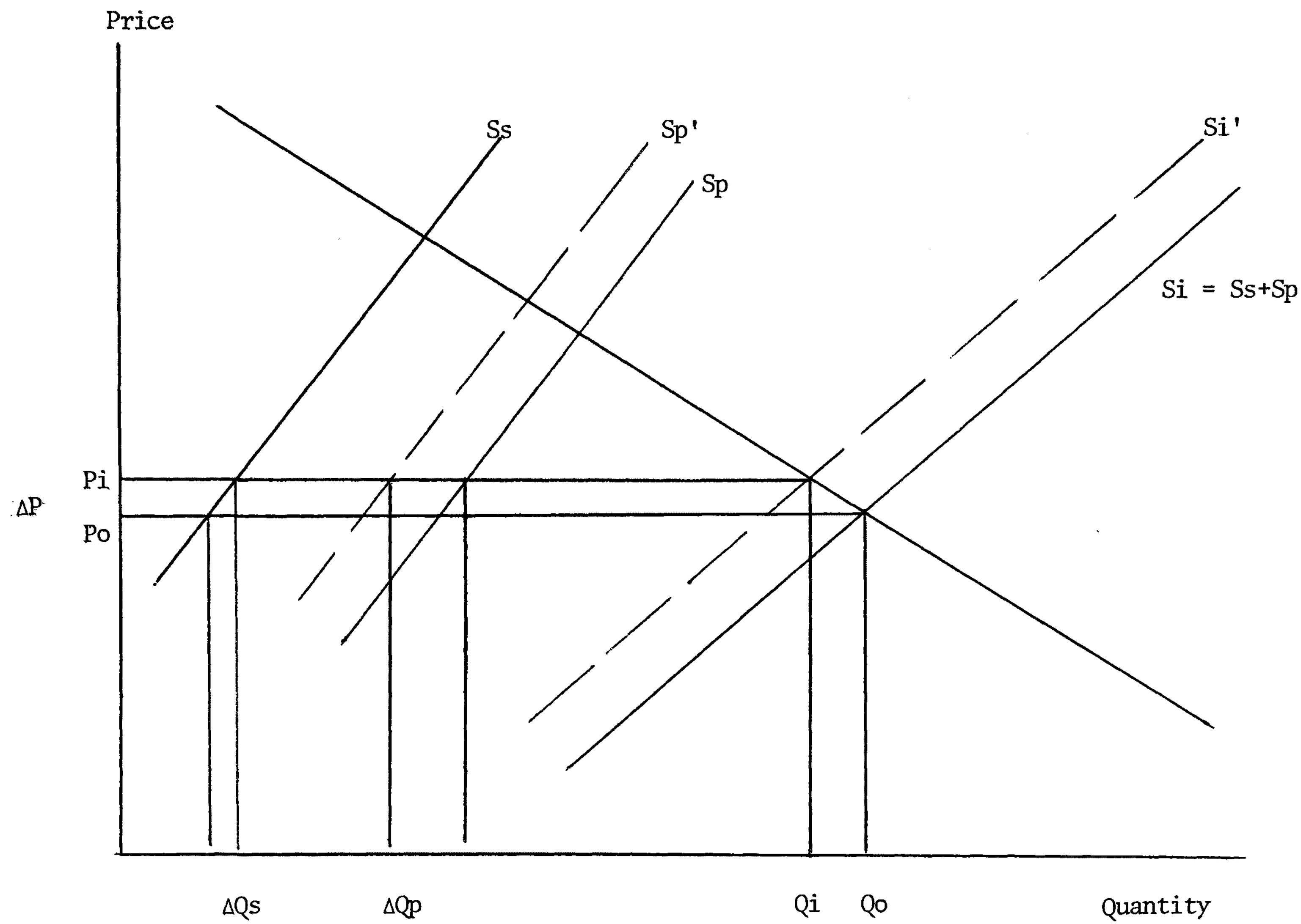

Figure 4. Primary and secondary supply and price determination in the lead industry.

scrap lead provided (ΔQs).

Equations and Data

The model contains equations for the supply of primary and secondary lead as well as for the demand for lead. The supply of primary lead is hypothesized to depend on the price of lead and on recent outputs of the lead production industry. The supply of scrap lead is hypothesized to depend on the price of lead and the availability of two year old batteries for recycling. Consumption of lead is modeled as dependent on the price of lead and the general level of industrial activity. The equations and data are described below.

$$Q_{11} = Q_{11}(P_1, A_{v1})$$

$$Q_{12} = Q_{12}(P_1, B)$$

$$C_1 = C_1(P_1, I_1)$$

where:

Q_{11} = output of primary lead in thousands of short tons, obtained from the Mineral Yearbook.

P_1 = the producer price of lead in cents/pound deflated by the Bureau of Labor Statistics wholesale price index.

A_{v1} = the availability of lead, measured as the one year lagged output of primary lead.

Q_{12} = the output of secondary lead, measured in thousands of short tons.

B = the Federal Reserve Index of replacement of storage battery production, a proxy for availability of scrap lead for recycling.

C_1 = domestic consumption of lead, measured in thousands of short tons.

I_1 = the index of industrial production, from the Bureau of Mines Mineral Yearbook.

Estimated Equations

Estimates of the preceding equations, based on annual data from 1949 to 1967 using two stage least squares with a correction for autocorrelation, are shown below:

$$(16)\quad Q_{11} = 4.19 + \underset{(4.21)}{11.58}\, P_1 + \underset{(3.70)}{.45}\, A_{v1}$$

$$(17) \quad Q_{12} = 27.29 + \underset{(7.49)}{18.23} P_1 + \underset{(18.10)}{2.98} B$$

$$(18) \quad C_1 = 711.3 - \underset{(2.62)}{17.31} P_1 + \underset{(4.94)}{10.23} I_1$$

All coefficients are of the expected signs and significant at the .05 level or higher. From equation (16) it is calculated that the short run price elasticity of primary lead supply (using information from the lagged variable) is about 1.00. The estimated price elasticity of supply of scrap lead is .48.

From equation (18) the price elasticity of demand was estimated as .21, indicating that consumption is largely unresponsive to changes in market price. This is to be expected for an input which is low in value relative to the final output price (as it is in pigments, gasoline additives, and bearings), or has few or no substitutes at present price levels (as in storage batteries).

The Supply Price of Primary Lead and Tax Subsidies

Primary lead producers may use a 22% percentage depletion allowance on domestically produced lead concentrates, a commodity which, like copper concentrates, is not traded on any organized market. In 1972, however, the proportion of lead concentrates in refined lead was estimated as 7.6/15 (28).

In calculating the effect of tax equalization on the supply curve for primary lead it is assumed that primary and secondary lead are perfect substitutes for one another. In this case, the subsidy attributable to the producers of primary lead at a maximum is equal to the product of the corporate tax rate (.48), the percentage depletion allowance (.22) and the proportion of the value of lead attributable to lead concentrate (7.6/15), or 5.3%. However, firms producing lead claim less than the allowed 22% in depletion (25). On average, they claim only about half the maximum rate, or 11%. Thus, the price of primary lead is decreased about 2.5 to 3% by the presence of the percentage depletion allowance.

FEDERAL TAX IMPACTS ON THE RECYCLING OF SCRAP LEAD

As the relationships estimated in the model described above did not yield any significant relationships between domestic prices and the import of lead, and as estimates of the reaction of imported lead suppliers to an increase in the domestic price of lead can consequently not be quantified, the following estimates of the impact of tax equalization on resource recovery in the lead industry will tend to overstate the probable increase in recycling of lead. Tax equalization would no doubt raise lead prices, causing an increase in lead imports and thus lessening the impact on lead recycling discussed below.

The price elasticity of total lead supply is equal to the weighted average of primary, secondary, and import elasticities of supply, or .6. The supply curve for final lead outputs is shifted by .4% for every one percent increase in the supply curve for primary lead. The maximum impact of percentage depletion is estimated at 5.3% of the value of lead concentrates; thus elimination of the depletion allowance would result in an increase in the lead industry supply curve of approximately 2.1%.

The equilibrium price of lead rises by a percentage equal to the product of the percent shift in final lead output (2.1%) and the estimated supply elasticity (0.6), divided by the sum of the supply and demand elasticities (0.6 and 0.21). Assuming that elimination of the percentage depletion allowances results in a shift in primary supply of 5.3%, as stated above, and the supply curve for final lead outputs shifts by 0.4% for every one percent shift in primary supply, the equilibrium price rise would amount to 1.6 percent. The estimated increase in scrap lead recycling is then 1.6 percent times the scrap supply elasticity (0.48) or 0.75 percent.

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GLOSSARY

ELASTICITY. In general, elasticity indicates the percentage change in one variable which results from a one percent change in the value of another variable. Many different types of elasticities occur so frequently in economics as to have their own names. Those used in the text are summarized below.

Price elasticity of demand: the percentage change in the quantity of a demanded resulting from a one percent increase in its price.

Cross price elasticity of demand: the percentage change in the quantity of a good demanded resulting from a one percent increase in the price of a substitute good.

Elasticity of substitution: the percentage change in the ratio of inputs (e.g. capital to labor) resulting from a one percent change in the ratio of their relative prices (price of capital to wages).

SCRAP DEFINITIONS.

Home scrap: the name given to secondary materials generated in the production processes and then reused at the same location or within the plants of the same company, ususally in the same production process.

Prompt scrap: the category of materials which originate as the by products of one production process and then shipped off to other plants to be used as inputs to other production processes.

Obsolete scrap: the category of materials consisting of discarded industrial equipment and consumer goods which are no longer in use. It is also referred to as old scrap (as distinguished from new scrap which also includes home and prompt).

TAX PROVISIONS.

Percentage depletion allowance: a provision available to the mineral industries which allows exemption of a certain percentage of gross revenues from income taxes.

Severance taxes: those levied by states on mining industries, usually as a percentage of the value of output or quantity of output.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/8-77-012	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Impact Of The Federal Tax Code On Resource Recovery: A Condensation		5. REPORT DATE August 1977 (Issuing Date)
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Barbara J. Stevens		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Columbia University, Graduate School of Business, New York, N.Y. 10027		10. PROGRAM ELEMENT NO. 1D1312
		11. CONTRACT/GRANT NO. Grant No. R803362
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin.,OH; Office of Research and Development; U.S. Environmental Protection Agency; Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Condensation of full report
		14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES Full report "Impact of the Federal Tax Code on Resource Recovery" by R. C. Anderson and R. D. Spiegelman is available from the Department of Commerce, National Technical Information Service as NTIS PB-264 886/AS(EPA-600/2-77-009).

16. ABSTRACT

The report assesses the extent to which a variety of federal tax subsidies to extractive industries affect the flow of materials from competing secondary materials industries. The impacts of tax subsidies on virgin material supply curves and prices for the steel, paper, lead, copper, and aluminum industries are analyzed. Flows of virgin and secondary materials are characterized at points where these substitute as inputs to production and consumption processes. The econometric models specified at the points of substitution are used to analyze the impacts of the tax subsidies on the quantities of secondary materials recycled. In the short run, and within the limits of existing plant and equipment, it is estimated that elimination of the specific tax subsidies to virgin materials industries would increase the flow of scrap steel by 0.42 percent, wastepaper by 0.63 percent, lead by 0.75 percent, copper by 0.35 percent, and aluminum by 1.00 percent. These estimates make no allowance for the long run effects on investment which may arise from the elimination of the subsidies. When investment effects and other federal policies (for example, ICC regulation of freight rates, labeling requirements for scrap-based products, and the free access to minerals on federal lands) are also considered, the cumulative impact on recycling may be considerably greater than the effects indicated by this study.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Supply (economics)	Incentive taxes	5B
Demand (economics)	Recycling	5C
Taxes	Federal taxes	
Prices	Extractive industries	
Economic analysis	Solid waste	
Regulations	Municipal solid waste	

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 47
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977— 757-056/6495