B Davie

# Federal Tax Policy and Recycling of Solid Waste Materials

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## Executive Summary

This study, undertaken in response to a Congressional directive in Public Law 94-568, examines the impact of Federal tax policies that may impede or discourage recycling of solid waste materials, and evaluates potential tax policy changes to encourage recycling.

The study finds that existing tax subsidies to mining and timber growing, though substantial, do not significantly reduce the use of competing scrap metals and wastepaper in primary production. Therefore, these tax subsidies do not justify compensatory tax incentives for recycling. Additional arguments advanced to support subsidies for recycling are also faulty. However, if there is to be a subsidy for recycling, some methods are superior to others on administrative and economic grounds.

The solid waste stream and virgin materials are alternative sources of material inputs for primary production. Deriving useful inputs from either source involves refining or processing. Efficient production requires using that combination of virgin and recyclable materials that minimizes the cost of inputs to production. A decentralized market economy will automatically achieve this efficient combination, unless public subsidies or regulations bias the choice between sources of materials.

Tax subsidies to mining and timber growing are provisions of the Federal income tax specific to these industries that depart from normal methods of taxing income from investments. Such tax subsidies can be expressed as an equivalent cash grant that would provide the same incentive to production under normal methods of income tax accounting.

The tax subsidies to mining are percentage depletion; current expensing of some investments; and for some minerals, capital gains treatment of royalty income. These tax provisions are equivalent to cash grant subsidies of from 8 to 12 percent of the value of output for coal, copper, and iron ore mining.

The tax subsidies to timber growing are capital gains treatment of income from the sale of timber; mismatching of income and expense; and deductibility against income from other operations of those expenses incurred in generating the revenues taxed as capital gains. These three provisions are equivalent to cash grant subsidies of from 35 to 45 percent of the value of standing timber before harvest.

Available statistical evidence shows that these substantial subsidies to resources used in virgin materials can lead to increased domestic output from mining and timber growing, but they do <u>not</u> have a significant deterrent effect on the use of competing recyclable materials -- scrap steel, scrap copper, and wastepaper -- in primary production. Factors that dilute the impact of tax subsidies on recycling include:

- o The small share of total cost of virgin materials used as inputs in primary production accounted for by the subsidized input;

- o Rising unit costs of increasing output in mining and timber growing;

- o International trade in raw materials, which reduces the impact on prices of materials of subsidies to U.S. producers alone;

- o A small response of the supply of recyclables to changes in material prices, and

- o Low substitutability in primary production between virgin and recyclable materials.

The importance of these factors varies among materials.

The analysis of the tax subsidies to virgin materials implies that tax incentives for recycling are not needed to correct existing biases in th Federal income tax. Other arguments for subsidizing recyclables are that it would:

- o Reduce the burden of solid waste management to local governments,

- o Reduce environmental degradation, and

- o Promote conservation of finite resources and energy.

While these objectives are worthwhile, the benefits from additional recycling do not justify a Federal subsidy if the objective is to promote the best use of all scarce resources, including labor, capital, and the natural endowment.

Private markets force individuals to confront the full costs of using natural resources; and states and localities, the full costs of solid waste disposal. Therefore, altering market signals by Federal subsidies to promote recycling would cause more social costs to be incurred in additional recycling than the costs saved through reduced virgin materials consumption and reduced waste disposal. Market prices largely reflect the full costs of energy. To the extent that energy is underpriced because of controls, it is far better to correct this distortion directly than to encourage much more costly production methods that use only slightly less energy. Meeting current waste disposal standards will relieve environmental degradation from inappropriate solid waste disposal by localities much more cheaply than would subsidizing recycling.

Many economic activities are subsidized because policy makers believe their outputs should be greater than those resulting from the operation of private markets. Recycling is no exception. In the 1978 Revenue Act, Congress enacted an extra 10 percent investment credit for already qualified equipment used in recycling.

As noted, recycling subsidies encourage inefficient production methods. They also create inefficiencies in solid waste stream utilization by biasing resource recovery towards recycling and against conversion of solid waste into energy. However, if recycling is to be subsidized, some methods are preferable to others.

The only practical point at which to inject a recycling subsidy is at the level of the primary producer. Otherwise, multiple exchanges of the same recycled product could all qualify for subsidy. A subsidy at the primary producer level still presents administrative problems: It would be necessary to measure the recycled "content" of materials that may be physically indistinguishable, to license qualified recyclers, and to employ inspectors to validate claims.

The recycling subsidy could be in the form of an appropriated cash grant, or a tax reduction. The base of the subsidy could be value of materials recycled, or investment in recycling equipment. If cleared through the tax system, the subsidy could be in the form of special tax credits, extra tax deductions, or tax exemption of certain income.

In general, appropriated subsidies are preferable to tax subsidies, because:

- o Agencies with expertise in the field are likely to administer the subsidy more efficiently than the IRS.

- Costs are more controllable, because appropriated subsidies are accounted for in the budget of the responsible agency, and are subject to annual Congressional review, with the assistance of Congressional and agency staffs conversant with the subsidy program.

- Tax subsidies generally understate budgetary costs relative to appropriated subsidies providing the same incentives, because they are usually measured in after-tax, rather than before-tax, dollars.

- Tax subsidies usually enable taxpayers with above-average incomes to bear a lower share of the tax burden, while appropriated subsidies do not change the distribution of tax burdens.

Subsidies based on the value of recycled materials are better than subsidies to equipment used in recycling, because they serve more directly the objective of increased recycling, without biasing the choice between capital and labor in production. Subsidies in the form of tax credits, particularly credits included in taxable income, are preferable to subsidies in the form of extra deductions (either by percentage depletion or more rapid depreciation) or tax exemption. By understating taxable income, tax exemption confers relatively greater benefits on wealthy taxpayers, to whom tax exemption is more valuable, thus reducing the progressivity of the tax system. On the other hand, tax credits have the same economic effects as do cash grants if they are taxable and are not limited to tax liability.

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Chapter 1

# Solid Waste As a Source of Recyclable Material

## I. Legislative Mandate.

Section 4 of PL 94-568, enacted October 20, 1976, provides in part:

> "The Secretary of the Treasury, in cooperation with the Administrator of the Environmental Protection Agency, shall make a thorough and complete study and investigation of all provisions of the Internal Revenue Code of 1954 which currently impede or discourage the recycling of solid waste materials, and shall determine what actions Congress may take under the Internal Revenue laws to increase and encourage the recycling of solid waste materials."

On October 21, 1976, the Resource Conservation and Recovery Act of 1976 (P.L. 94-580) was enacted. Section 8002(j) of the Act established the Resource Conservation Committee composed of the Secretaries of Treasury, Labor, Commerce, and Interior, the Chairman of the Council on Environmental Quality, a representative of the Office of Management and Budget, and the Administrator of the Environmental Protection Agency, designated Chairman. Among other things, the Resource Conservation Committee was directed to

> "...conduct a full and complete investigation and study of all aspects of the economic, social and environmental consequences of resource conservation with respect to --
>
> ....
>
> the effect of existing public policies (including subsidies and economic incentives and disincentives, percentage depletion allowances, capital gains treatment and other tax incentives and disincentives) upon resource conservation, and the likely effect of the modification or elimination of such incentives and disincentives upon resource conservation...".

This report is formally a response to the directive of PL 94-568. By agreement with the Resource Conservation Committee, its preparation has been coordinated with the studies of the Committee.

## II. Introduction

The economic process is a web of interrelated activities by which individuals contribute labor services and savings to produce a flow of goods and services that constitutes their standard of living. In an economic system predicated on private decision making and private rights to property, individual judgments expressed in voluntary exchanges determine the outcome of the process. By their decisions to work--doing what and for how long--and to save rather than to consume, individuals determine the labor and capital which will be available to produce those goods and services they are willing to buy. It is the characteristic of such a voluntary system of exchange that the incomes of persons and the value of the system's output are simultaneously determined by a set of interdependent prices. These prices thus reflect the preferences of the participants in the system for goods and services, given the natural endowment and stock of knowledge and the willingness of individuals to work and to save.

If decisionmakers in the economic process confront prices which fully reflect costs of producing the goods and services they elect to purchase, the result of their decisions is commonly described as "efficient": no greater value of goods and services could be produced with the resources available. Such a result can also be called "conservation-perfect," for, if a maximum value product is produced, there can be no "waste" of resources, whether natural, personal, or capital.

It is frequently contended that the market prices of goods and services are distorted. Institutional failures may prevent market prices from reflecting certain significant social costs, such as environmental degradation, and public policies may subsidize particular economic activities, thereby reducing market prices of the favored products and services artificially. If, for either set of reasons, some market prices are too low or too high, the value of the output of the economic process is lower than it might be, and resources are wasted. Producers and consumers, not confronted directly with the true social cost of subsidized resources, produce and consume too much of the favored output, diverting resources from higher value uses and thereby lowering the total value of all output.

## III. Report objectives and summary of findings

### A. Identification of tax subsidies to virgin materials production.

The language of Section 2 of P.L. 94-568 suggests there are provisions in the Internal Revenue Code that favor the domestic production of minerals and timber. That such tax preferences prevail constitutes a priori evidence that resources are being wasted.

Chapter 2 reviews these tax preferences and provides estimates of the effects of these preferences on the availability of certain domestic virgin materials. The estimates show that the special tax preferences are equivalent to a direct cash subsidy of from 8 to 12 percent of the value of output of coal, iron ore and copper mining and of 35 to 43 percent of the value of standing timber.

### B. Quantifying the degree to which resource wastage due to tax subsidies is manifested in too little recycling of solid waste.

PL 94-568 refers to these tax provisions as "impediments" to recycling of solid waste, implying that the resource wastage due to the tax preferences for minerals and timber manifests itself in excessive and environmentally costly disposal of materials which could be recycled. In order that this be true, the effects of tax preferences would have to be to lower artificially the domestic prices of virgin materials and thereby make uneconomic the derivation of recyclable material from the solid waste stream. The pertinent issues involved in this recycling deterrence hypothesis are examined in Chapter 3. The analysis of this chapter concludes that the significant resource wastage due to tax preferences for virgin materials does not take the form of solid waste disposition rather than recycling. Tax preferences for production of virgin materials do not reduce the volume of recycled materials by more than one or two percent. Rather, the analysis concludes that resource wastage induced by tax preferences takes the form of excessive domestic production of virgin materials: too low a level of imports, or too large exports, of those materials traded in world markets, or simply excessive usage of certain materials locally produced and used for which recyclable materials are not readily substitutable.

C. Evaluation of alternative subsidies to recycling.

The final charge for this Report in PL 94-568 is a review of "actions Congress may take under the internal revenue laws to increase and encourage the recycling of solid waste materials." Chapters 2 and 3 generally set forth the basis for the conclusion that Federal tax laws do little to prejudice the choice between recycling materials from solid waste and production of virgin materials. World trade flows and the basic characteristics of markets for recyclables are such that, without tax preferences for virgin materials, there would be little change in the volume of recycling. On this ground, Chapter 4 concludes that there is no justification for considering a set of countervailing tax preferences for recycling activities. Chapter 4 also reviews additional justifications frequently set forth by proponents of tax subsidies for recycling: that recycling will "conserve" finite resources, save energy, and reduce the costs of disposal of municipal solid waste. The conclusion reached is that these justifications for recycling subsidies are either faulty or establish objectives which might be achieved more effectively by Federal programs less costly than recycling subsidies.

Finally, Chapter 4 evaluates the possible forms of tax subsidies to recycling in light of the market characteristics of recyclables and concludes that these would be economically inefficient and administratively difficult to implement. Included among those subsidies to recycling evaluated are the tax subsidies presently provided in the form of tax-exempt bond financing for solid waste disposal facilities and the recently enacted additional investment credit for recycling equipment.

The rest of this chapter sets out a framework for the subsequent analyses of the effects of tax preferences on the domestic production and/or prices of virgin materials. A glossary of terms used in the discussion of solid waste flows and recycling is included. This material is intended to guide the reader through the intricacies of an economic system that must be understood to analyze solid waste policy issues.

## IV. Locating the Solid Waste Stream and Recycling in the Economic Process

### A. The Economic Process

The 215 million persons comprising the population of the United States supply a labor force of 98 million workers and a capital stock valued at, perhaps, $9 trillion. Labor supply and consumption decisions are made by 70 million households; and economic activity is carried out in about 10 million enterprises in the private sector and in tens of thousands of decisionmaking units operated in the government sector. All these units make decisions that interact with each other. While it is unrealistic to attempt to describe such a highly decentralized system of tens of millions of decisionmaking units as a singular system of flows, the relationships pertinent to the issues addressed in this report can be usefully described in simplified terms. These relationships are illustrated in Figure 1.1.

This diagram portrays the end result of the economic process as consumption, the use of goods and services for personal purposes. The outcome of the economic process is a varied set of goods and services, the quantities and qualities of which constitute the society's standard of living. This is shown by the box labelled "consumption" at the right side of Figure 1.1. These goods and services flow principally from the box labelled "domestic fabrication," but are supplemented by imports of goods and services from other national economies paid for by exports of goods and services. The "fabrication" box is intended to represent all the private and governmental sector activities that produce and distribute the goods and services that are purchased (or paid for in taxes) by individuals as consumers. As noted in the diagram, some output from "fabrication" is exported.

The economic units labelled "primary product production" produce the basic materials, such as metals, textiles, plastics and paper, which feed the "fabrication" stage. Again, the domestic flow of primary products is supplemented by imports and is diminished by exports. Materials to feed primary production are diagrammed as coming from two sources, "mining and forestry, etc." and "recyclables," the domestic flows are again supplemented by imports and diminished by exports.

Finally, the recyclables are derived from "solid waste," a by-product of all stages of the economic process. The solid waste that is disposed of rather than recycled is indicated by boxes labeled "burn and landfill or sewage."

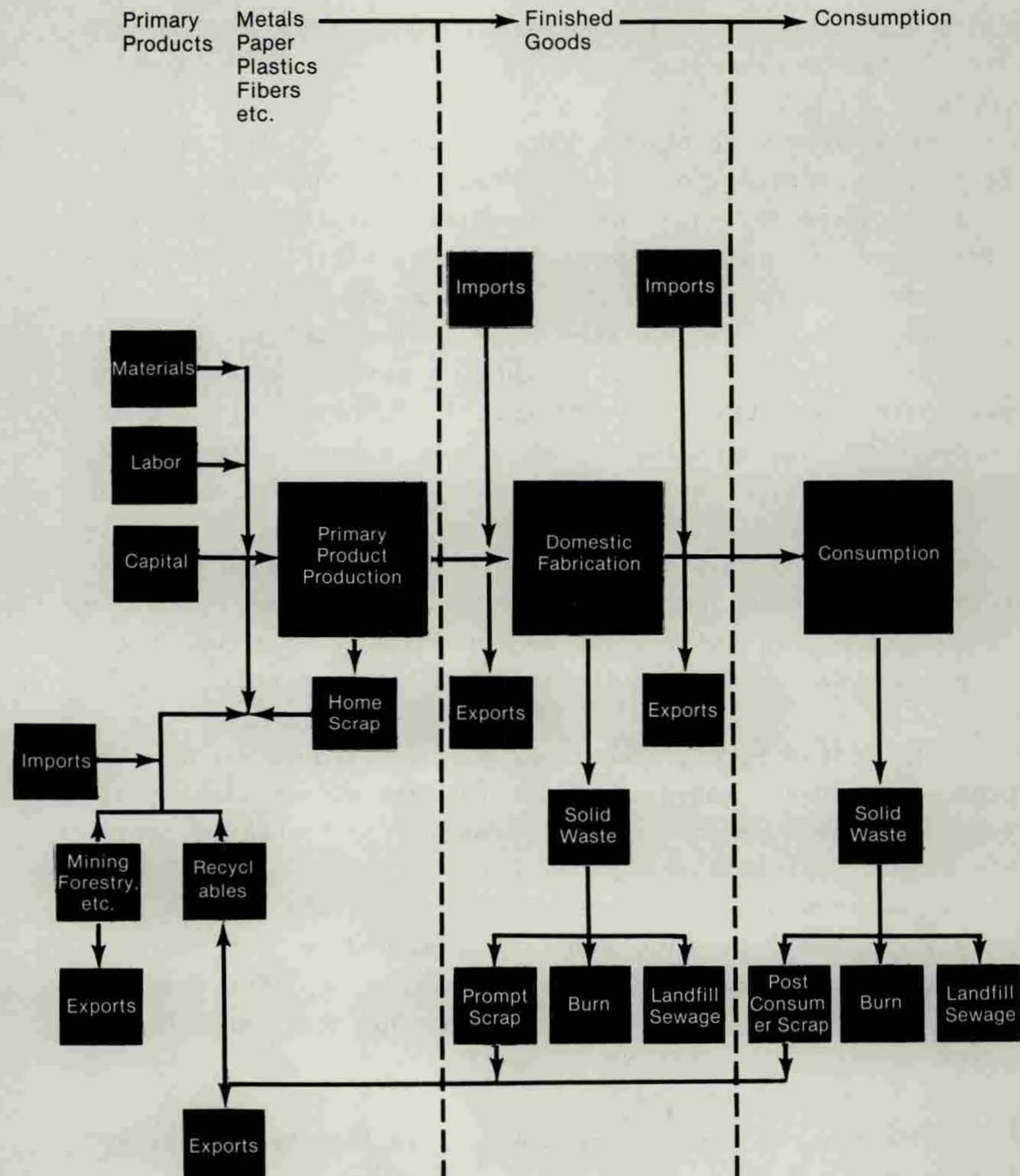


Figure 1.1 Resource and Product Flows

The diagrammed boxes are highly simplified groupings of economic activities, each of which is a combination of resources. The flow of services to productive activities is explicitly shown only for primary product production but similar productive service flows apply to fabrication, consumption, to the activities identified as mining and forestry, and to the several stages of solid waste collection, disposal, and recycling.

This schematic diagram is drawn to portray directions of flow of goods and services, including the debris from the process called "solid waste." Corresponding to these flows, but opposite in direction, are money payments flows. Consumers of goods pay prices to fabricators, which enable the fabricators to pay their suppliers of materials, labor and capital. This enables the primary product producers to pay their raw materials and recyclables suppliers, as well as suppliers of labor and capital used in production. The total of all payments received by persons who have supplied labor and capital becomes the means by which the output of the economic process, consumption, is financed. The duality of product and payment flows applies as well to the solid waste stream: in order to effect the "removal" of solid waste -- an inherent accompaniment to maintenance of a standard of living -- and its disposition or reuse, labor, capital, and natural resources have to be employed, and payment for their services must be rendered.

The boxes that identify stages of the economic process also serve another purpose. The arrowheads signify exchanges and, hence, markets in which evaluations are made and prices correspondingly determined. If the relative flows of solid waste into recycling and disposition by burning, landfill, or sewage, are to be optimal, then the prices at all stages should fully reflect the value of resources consumed in carrying out the activities. If, in the right-hand bottom corner of the diagram, the full resource costs of burning and preparing landfills are not reflected in the prices, including taxes, paid for disposing of solid waste, too little solid waste will enter the recyclables stream, because disposition, rather than recycling, will appear to be "cheaper" to the pertinent decisionmakers. Similarly in the left-hand bottom corner of the diagram, if, in the market feeding inputs to the primary product stage, prices of virgin materials do not fully reflect the cost of resources used in mining and forestry, too little recyclable material will be utilized than is optimal, and too much will be disposed. Chapter 4 will consider the degree to which "prices" of solid waste disposition are fully reflective of all resource costs; and the remainder of this chapter will examine the same question with respect to the industrial input side of the economic process.

B. The economic process from the point of view of recycling.

Before considering the issues concerning the status of recyclables as industrial inputs, it is necessary to gain some perspective on the significance of price distortions for the physical size of recyclable flows. As noted, getting recyclable material out of the solid waste stream is not a costless activity. Recyclables contained in the solid waste streams must be separated and, frequently, decontaminated if they are to be reused. As used here, "decontamination" is the removal of foreign matter from already separated, or physically classified, objects in the solid waste stream.

Recycling may be viewed as a form of mining. Separation is analogous to beneficiation or concentration of ores in a mining process; and decontamination is analogous to smelting, or refining of ores. Solid waste available for recycling originates where production and consumption occur. Thus, if recyclable material is to be extracted from the solid waste stream and be available for reuse, transport costs must be incurred. The "market" for recyclables is functionally the same as the "market" for virgin materials, and the marketplace is, conceptually at least, the loading dock of enterprises engaged in the production of primary products. This is where the choice of materials to use in producing primary products must be made.

If we figuratively take these numerous individual markets for recyclable materials collectively subsumed in the "primary product production" box as the point from which to consider the terms on which tonnages of recyclable materials will be available to producers of primary products, reference to the diagram suggests three broad sources of recyclable materials should be distinguished.

(1) Home scrap.

Some amount of "scrap" material will be generated by the primary product producer himself. Defective batches of iron and steel, for example, are inevitable by-products of steel production, and these are immediately available for reprocessing. This class of solid waste is commonly called "home scrap." An obvious characteristic of home scrap as a source of recyclable material is that it is available to would-be users--the very same enterprises which generate it--at little additional cost. It is already on the premises and is almost always directly reusable in the original production process without costly preparation, or decontamination.

(2) Prompt scrap.

Fabrication activities provide another source of recyclables. This class of solid waste is the cuttings and shavings of metals, paper, textiles, and other primary products generated by the fabrication process; it also includes discards of defective, unsalable products. This class of solid waste is called "prompt scrap." As compared with home scrap, prompt scrap is available to would-be users in the primary production stages at the cost of collection, occasional decontamination, and transportation from a relatively few fabrication sites.

(3) Obsolete, or post-consumer, scrap.

Finally, recyclable materials can be derived from the solid waste stream emanating from final consumption. This class of solid waste includes the discard of fabricated products, and their packaging, when the perceived usefulness of the objects has come to an end. For this reason, this class of materials is commonly referred to as "obsolete scrap," or "post-consumer scrap." Obsolete scrap differs from home and prompt scrap in that its sources are more numerous and dispersed, and its content is more heterogeneous, or contaminated. If obsolete, or post-consumer scrap is to become available as recyclable material to primary product producers, more resources need to be devoted to collecting it, sorting it and otherwise decontaminating the desired materials, and shipping it longer distances.

These observations on the terms on which recyclable materials are available to primary product producers, the prices they must pay to obtain them, are summarized in panels A, B, and C of Figure 1.2. Panel A shows that, at a cost--purchase price--of virtually zero, any amount up to $Q_{hs}$ tons of recyclable home scrap would be available to primary product producers. As a concomitant of production, the maximum quantity, $Q_{hs}$, is simply determined by the output of primary products. Amounts up to $Q_h$s are available for reuse at virtually no cost because the only resources used in making it available, or recyclable, are space for holding the home scrap and for handling it.

Panel B, shows that some tonnage of recyclables from prompt scrap would be available at prices only slightly higher than those of home scrap but that higher prices are required to bring additional tonnage to market. These higher prices are required to cover the higher resource cost of collecting and shipping prompt scrap from fabricating plants that are increasingly distant from the primary product producers, as well as the costs of decontaminating the prompt scrap that is unfit for direct reuse. Additionally, the curve tracing out the quantities of prompt scrap that would be available at higher prices rises sharply and becomes vertical at a tonnage of $Q_{ps}$, the maximum prompt scrap available, given the level of fabricating activity.

Panel C depicts the availability of recyclable materials from post-consumer scrap. Reflecting the higher cost of bringing recyclable post-consumer scrap to market, the curve tracing available quantities of recyclable material from this

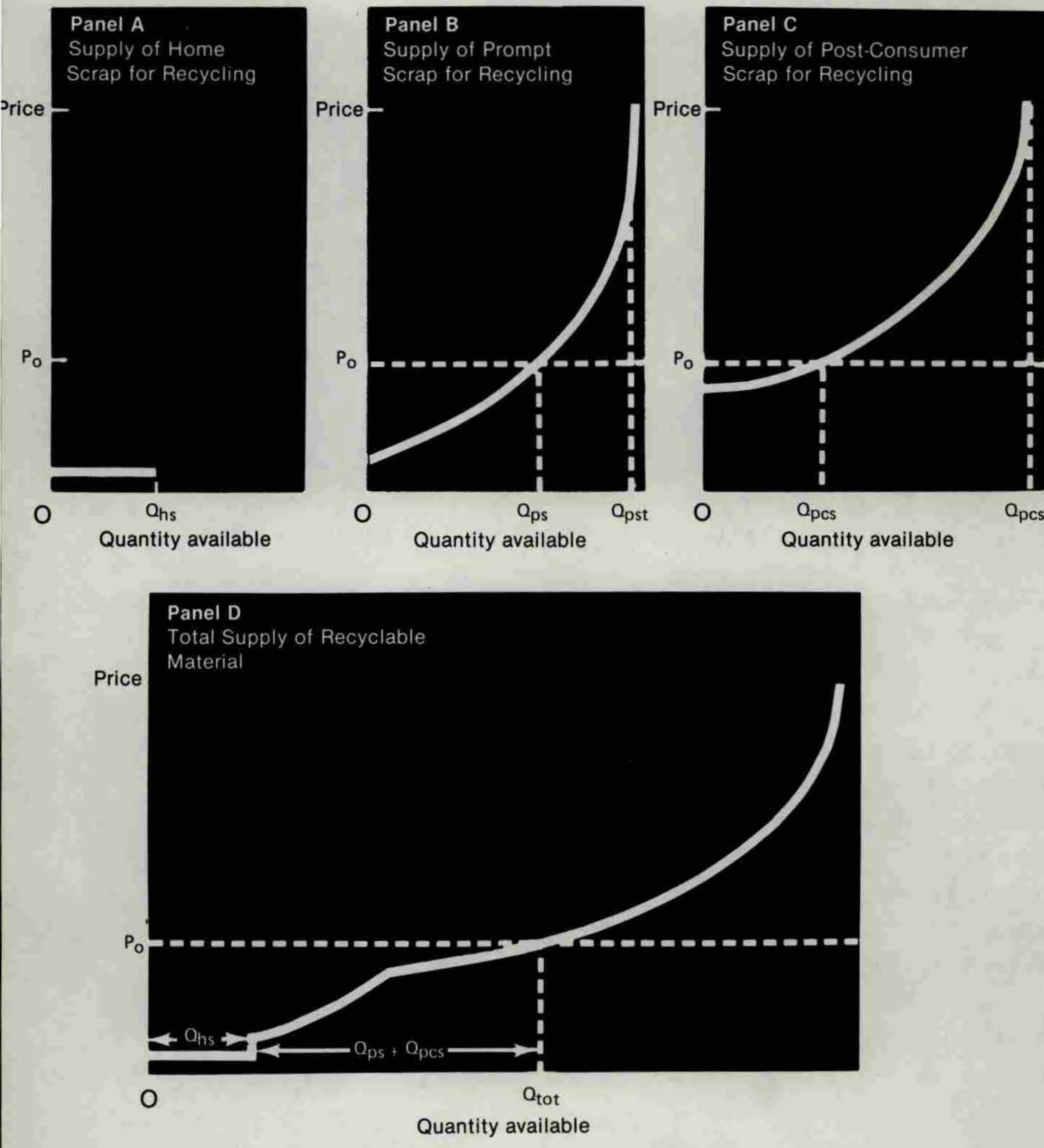


Figure 1.2 Relation of Quantity Available to the Price of Recyclable Materials

source is located higher on the price scale than the corresponding curves for home and prompt scrap. Like the curve for prompt scrap, the curve for post-consumer scrap shows that increases in available recyclable tonnage require higher prices to cover higher costs: for lengthier transportation and more intensive collection, separation, and decontamination efforts. Again, like the prompt scrap curve, the post-consumer scrap curve reaches a maximum availability, $Q_{pcs}$ reflecting the level of consumption which generates solid waste.

It should also be noted that the positions of the curves in Panels E and C describing the availability of recyclable materials at different prices offered for them is dependent on the cost of solid waste disposal. If the cost of disposal underlying the curves in Panels B and C rises, for example, because sites become scarcer, the amount of recyclables available from either prompt or post-consumer scrap sources would be greater at any price offered for them. This is because the higher cost of disposal can be avoided by recycling more of the solid waste. In this case the curves pictured in Panels B and C would shift downward and to the right. Conversely, when costs of disposal are lowered, because nearby sites become more numerous and have no alternative uses, or because disposal subsidies are provided, the availability of recyclable materials at each price offered for it would be decreased. In Panels B and C, the pictured curves would shift upward and to the left.

Of course, recyclables from all of these sources are ultimately interchangeable for each other since we are including decontamination as part of the process of making recyclable material available; that is to say the combined flows of recyclables constitute a single "market." Therefore, in Panel D the availabilities of recyclables from all sources are added together. Since all four panels are drawn with the same price and quantity scales it is easy to see that, if the price primary product producers are willing to pay is $P_o$, the total quantity of recyclables that would be made available and reused would be $Q_{tot}$, and this is equal to the sum of $Q_{hs}$ (home scrap), $Q_{ps}$ (quantity of prompt scrap), and $Q_{pcs}$ (quantity of post-consumer scrap) available at that price ($P_o$). At the pictured price of $P_o$, all home scrap, nearly two-thirds of prompt scrap, and only one-third of post-consumer scrap is recycled; the remainders of prompt and post-consumer scrap must be disposed of by landfill or incineration.

$P_o$, the price of recyclables primary producers are willing to pay for the quantity $Q_{tot}$, is the price of virgin materials which could otherwise be used to produce primary products. If $P_o$ is not artificially depressed, disposition of the unrecycled solid waste by incineration or sanitary landfill is a socially efficient procedure. To recycle more than two-thirds of prompt scrap or one-third of post-consumer scrap would use more resources than would be required to dispose of the solid waste. That is, the curve in Panel D is drawn to reflect the availability of recyclable materials, and this already takes into account the alternative of disposition. For example, if it had cost more than $P_o$ to dispose of solid waste, those who are presently burying or burning solid waste at higher cost would cease doing so and would, in fact, sort, decontaminate and ship the recyclable materials to primary product producers, or pay someone to do this. In this event, more than $Q_{tot}$ would be available for recycling at a price of Po. Thus, under real world conditions when the quantity of recyclable materials available for reuse entails costs that tend to increase with quantities available, it will <u>always</u> be the case that at all finite prices for virgin materials (different values of P) at least some solid waste will be disposed of and not recycled, for to do otherwise would waste resources.

The relation between the quantity of recyclable material available for reuse and the price users would pay for recyclable materials in the market is technically referred to as "market supply." The market supply of recyclable materials, as we have noted in detail above, has the characteristic shape of most supply curves. In order to elicit larger supplies, higher prices must be offered. This is implicitly the reason why proponents of additional recycling recommend that subsidies be provided. In Figure 1.3, which reproduces Panel D of Figure 1.2, but with the scales adjusted appropriately, if, in addition to the price $P_o$ paid by purchasers, a subsidy of s is provided enterprises which supply recyclable materials then a tonnage of more than $Q_{tot}$ will be forthcoming. In Figure 1.3, the subsidy of s per ton (on top of $P_o$) will bring forth a supply of $Q_{tot} + q$. From the point of view of purchasers of recyclables, who continue to pay $P_o$ per ton, it will appear as if the supply available had been increased by q tons. Alternatively, if the subsidy is paid to purchasers of recyclable materials, from the point of view of recyclables suppliers it will appear that demand has increased; they find they can sell $Q_{tot} + q$ tons of recyclables at a price of $P_o$ and would therefore be willing to supply that amount.

The responsiveness of recyclables tonnage available to a subsidy of s per ton may be quantitatively described as the percentage change in quantity, $q/Q_{tot}$ in this instance, relative to the percentage change in price received by suppliers of recyclable materials, $s/P_o$ in this instance. This ratio of percentage change in quantity to percentage change in price is technically referred to as "price elasticity of supply".[1/] Thus defined, the interpretation of elasticity is

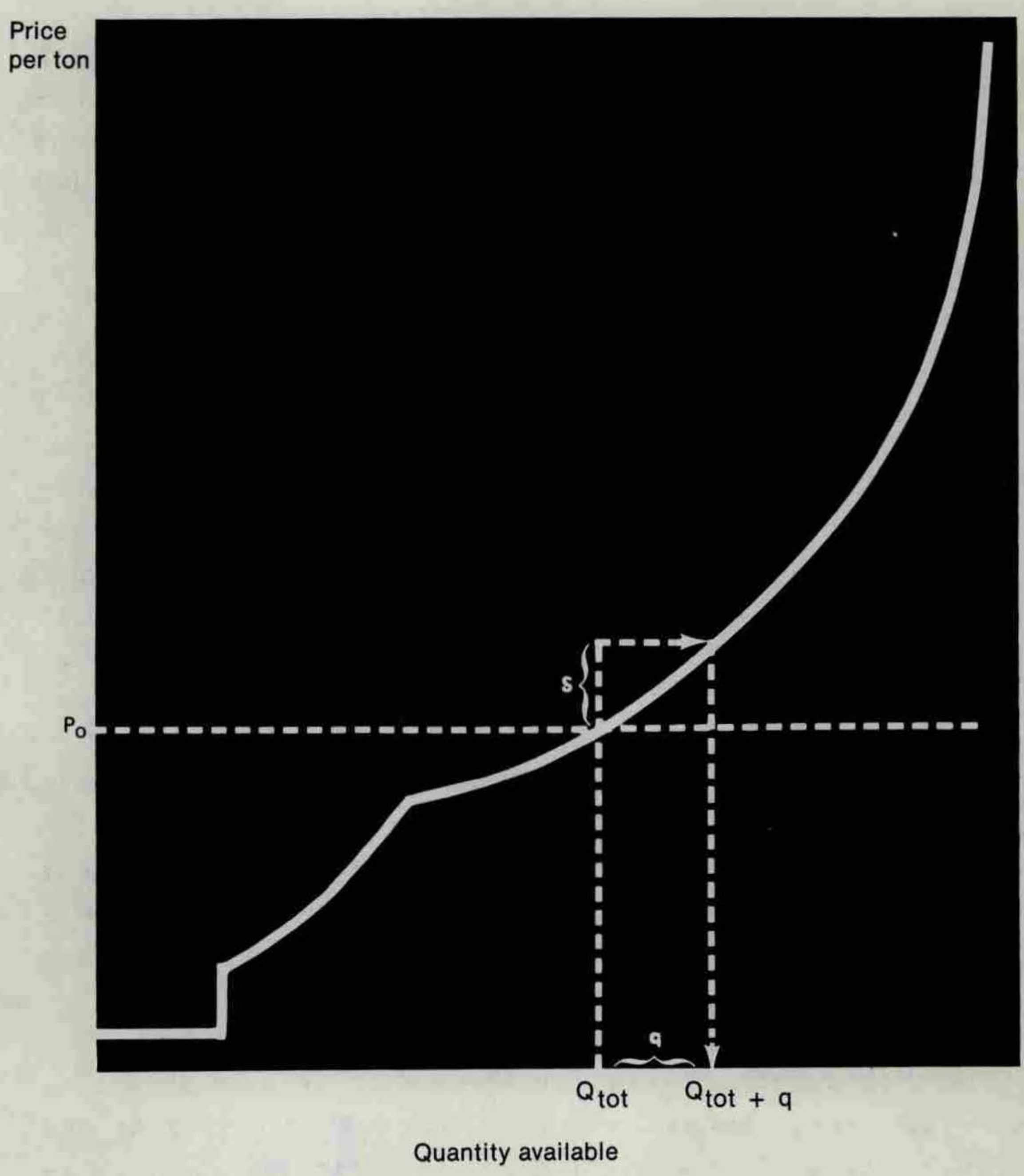


Figure 1.3 Quantity of Recyclable Materials Utilized

straightforward: If recyclable material elasticity of supply is 1, a one-percent price subsidy will be accompanied by a 1 percent increase in quantity of recyclables supplied. If conditions of supply are such that the elasticity equals 0.5, a one-percent price subsidy will bring about a change in quantity supplied of only 0.5 percent.

The supply curve portrayed in Figure 1.3 illustrates the variability of elasticity at different points along the supply curve. At the very lowest recyclables price levels, when only home scrap is available, elasticity of supply is infinite: at any price equal to (or above) the nominal holding cost of home scrap, any amount up to the total of home scrap generated by the level of output of primary product producers is available. At higher prices, which bring in supplies from prompt and obsolete scrap, supply elasticity drops as increasing costs for collection, sorting, decontamination and transportation are incurred to bring additional recyclable materials to market.

For any particular recyclable material, the elasticity of supply, the gain in recyclable material availability and use corresponding to an increase in the price for the material, is a highly complex empirical issue. For example, the elasticity of supply for any particular recyclable material depends not only on the facts surrounding the character of the solid waste streams from which it is to be derived--its physical location and degree of contamination and the technology for converting objects in the solid waste stream into recyclable materials--but also on the prices primary product producers are willing to pay. This last factor determines the segment of the particular recyclable material's supply curve on which enterprises engaged in using and supplying the material will be operating. The price which recyclable material users will pay, in turn, depends on the price at which virgin material is available; and this depends on the quality of the natural endowment and technology for extracting the materials (producing renewable material resources, such as timber and fiber), given the demand for final products.

Notwithstanding the large number of determinants of recyclable materials supply elasticities, and hence the imprecision of empirical elasticities that may be derived, the weight of the evidence is that they are generally low. This appears to be the case because, at the margin, the principal source of additional recyclable materials is the post-consumer solid waste stream.

Technical note:

The entire discussion of this section has hinged on the supply of recyclable materials available for use in primary product production. This implicitly has assumed that all "offensive" impurities have been removed so that the recyclable material is perfectly substitutable for virgin materials. Technically, this has enabled us to assume the demand for recyclables is infinite: at any slight reduction in price of recyclable materials, as much as is offered by recyclables suppliers will be used, displacing virgin materials.

Readers with knowledge of actual markets will recognize this as a highly artificial construction. They are aware, for example, that primary production activities are not homogeneous. For example, not all paper products are produced from the same set of raw materials, i.e., paperboard inputs could not, without extensive preprocessing, produce writing papers. Similarly, the charge to an electric steel furnace to produce concrete reinforcing bars could not, without extensive modification, be used to produce high-grade steel.

It thus turns out that "recyclable" materials in the form of scrap paper, for example, which may readily be used as a substitute for woodpulp in the production of paperboard, is unlikely to be used in the production of writing papers; and that, in fact, there are many grades of scrap paper corresponding to their "purity" which fetch different prices. Similarly, there are many grades of scrap iron also reflecting their mineral content which are marketed at different prices and used for different production processes.

Thus, for any general category of solid waste, such as "paper," "ferrous" or "nonferrous" metals, etc., there are many sub-markets corresponding to the grades of solid waste. These grades of solid waste materials roughly correspond to the degree of contamination present, and are suitable for particular industrial processes, as already noted. If we aggregate classes of solid waste for purposes of describing a real world "supply function", we should also specify the demand sides of these specialized markets. In this event, the "demands" for specific classes of scrap could not be reasonably described by assuming infinite price elasticity: to induce more scrap paper to be used in displacement of virgin materials, the price of the recyclable paper relative to other materials must be _reduced_ to offset the higher primary product production costs.

Put another way, if "decontamination" costs of solid waste can be avoided by using the "contaminated" material in production of certain primary products, _but not all_, then recyclables will be marketed in less than "pure" states, and the demand for this material will not exhibit the characteristic of "infinite elasticity." To penetrate markets for materials to be used in producing primary products, the "demand price" of the recyclable (price payable by a potential user) must be lower to overcome the higher cost of using the "contaminated" material, _i.e._, to compensate the recyclables user for his accomplishing the "decontamination."

To have introduced demand functions, along with supply functions, would have complicated the presentation without adding anything essential to understanding the economics of recycling. In order to get more paper, or any similar class, from the solid waste stream recycled, higher costs have to be incurred--to decontaminate--whether by the primary product producer or by the wastepaper supplier. If the cost is to be borne by the primary product producer, this determines the shape of his demand function; if the cost is to be borne by the recyclables supplier, this determines the shape of his supply function. By "homogenizing" recyclables as ready for reuse, all the costs are assigned to supply, and demand elasticity becomes infinite at the price of interchangeable virgin materials. Since it makes no difference in the final outcome whether injecting more solid waste into the recycling stream is viewed as overcoming higher primary product producer costs, given a quality of solid waste materiáls made available in existing markets, or higher recyclable materials supply costs, given a structure of prices for virgin materials for which the recyclable materials are perfect substitutes, we have opted for the latter presentation in this general discussion. In Chapter 3, however, where recourse is made to empirical market data, this simplification needs to be abandoned.

Indeed, there is a positive gain in understanding if the solid waste stream is treated in the same way as the natural endowment as a potential source of materials input. In both cases the sources are characterized by heterogeneity: cellulose for paper manufacture can come from numerous "natural" and solid waste stream sources; iron for steel manufacture can similarly come from numerous "natural" and solid waste sources. Whether the source is "natural", or solid waste, the cellulose or the iron is mixed with extraneous matter the existence of which must be dealt with in the production process. As a consequence, the "purer" the source of the material the higher will be the price it will fetch, and whether the process of enhancing "purity" is regarded as part of "mining" or solid waste "recycling," the cost of deriving the "pure" material rises as the distance to the source and/or its "impurity" increases.

Nor has it seemed necessary to introduce the notion of elasticity in derived demand for materials, virgin or recyclables. In principle, the demand for materials to produce primary products is derived from demands for metals, paper, textiles, etc., to be used in producing final goods and services. In turn, the quantities of final products are determined in their respective markets. Thus, prices at which materials may be supplied to primary products producers determine the costs, and hence the prices, at which these inputs to final product manufacture will be available and, therefore, the costs, and hence the prices at which these products will be available. Through this chain of relationships, variation in materials prices exert some influence on the price, and hence quantity, of final goods purchased, "determining" the quantity of materials which will be demanded at particular materials prices.

It has seemed unnecessary to deal with the characteristics of derived demand for materials in this context for two reasons. First, as has been noted above, most of the recyclable materials of interest are materials which are world-traded and, as will be developed in Chapter 3, this greatly reduces the amplitude of likely variations in U.S. materials prices associated with the conditions of domestic production. Secondly, given the likely range of variation in materials prices, the principal derivative effects on demand for recyclables will be in substitution for virgin materials, not changes in overall materials demand.

Footnotes to Chapter 1

1/ Since the P's and Q's are discrete, the relative changes implied by s and q are better measured by $s \div (P_o+P_o+s)/2$ and $q \div (Q_{tot}+Q_{tot}+q)/2$ , respectively. The reader is also cautioned that the supply elasticity described here is a special case. See Technical Note to this chapter, below.

# Chapter 2

## Federal Tax Subsidies to Virgin Materials

### I. Introduction

Federal tax subsidies to mining and timber-producing reduce the private net costs of using virgin materials in production processes. This reduction discourages the use of substitutable recyclable materials, though the analysis in Chapter 3 indicates that the quantitative effect on recycling is small. However, tax subsidies do reduce significantly the cost of producing a given amount of virgin materials. We estimate that the tax subsidies to mineral industries shift the supply curves for coal, iron ore, and copper down by between 8 and 12 percent, and shift the relevant supply curve of timber used to make pulp and paper down by between 35 and 43 percent.

This chapter presents detailed quantitative estimates of the effects of special provisions of the Federal tax code on the supply curves for coal, iron ore (taconite), copper, and timber. Coal and iron ore account for a significant fraction of the cost of producing pig iron, which can be substituted for scrap steel as an input in steel furnaces. Virgin and scrap copper are regarded as almost perfect substitutes in most uses. Wastepaper is a substitute for virgin pulp in manufacturing paper. Virgin pulp can be produced at a lower private cost because of tax subsidies to timber growers.

The estimated supply curve shifts show the maximum effect of the special tax provisions on mineral and timber prices. They show the percentage reduction in production cost that would occur for a typical mine or timber stand if output remained fixed. The percentage reduction in the production cost would be reflected in an equal percentage reduction in price only if supply is perfectly elastic, meaning that output could expand indefinitely without any increase in unit production costs. When minerals are traded internationally, changes in U.S. production cost may have a minimal impact on the world price. Then, the major effect of the tax subsidies is to increase domestic output, with the price of the virgin mineral left virtually unchanged. Even in the case of virgin pulp, less affected by international trade than most minerals, tax subsidies may mostly raise rents to owners of timber land, rather than lowering prices and increasing output of wood products.

## II. Special Tax Provisions Affecting Mineral Industries and Timber

For the purpose of these estimates, a special tax subsidy is regarded as a provision of the Federal tax code specific either to mining or to timber growing. The investment tax credit and accelerated depreciation, which may sometimes be regarded as tax subsidies to capital, are not counted among the special tax preferences given mining and timber growing. Because these and other provisions are generally available to all industries and for recycling efforts, they do not create special incentives to develop mines or to plant trees.

The special tax provisions affecting mineral industries are: 1) percentage depletion, 2) expensing of exploration and development costs, and 3) taxation of royalty payments to landowners leasing land for mineral production at capital gains rates. The special tax provisions benefiting timber growers are: 1) taxation of income from the sale of timber at capital gains rates, 2) mismatching of income and expense, and 3) deduction of expenses against other ordinary income.

## Tax Subsidies to Mineral Industries

### 1. Percentage Depletion

To compute taxable income, mining firms are required to deduct the greater of cost or percentage depletion. Cost depletion in general is determined by dividing the adjusted basis of the property (from exploration and development expenses) by an estimate of the number of units that make up the deposit. The resulting quotient, equal to the cost depletion per unit, is then multiplied by the number of units extracted and sold during any year to determine the allowable cost depletion deduction. Cost depletion for mines is analogous to depreciation for machinery and equipment; it allows the firm to write off the cost of the investment over the entire life of the asset in determining taxable income. Timber companies are permitted only cost depletion.

Under percentage depletion, firms in mining operations may deduct a flat percentage of gross income from mining to compute their tax base. This deduction is not limited to the cost basis in mining assets. The percentage depletion allowance is 22 percent for lead and zinc ores, 15 percent for copper and iron ore, 14 percent for limestone, and 10 percent for coal. These percentages apply to domestically produced ores. Foreign produced ores are eligible for lesser or no percentage depletion. Percentage depletion may not exceed 50 percent of otherwise taxable income.

Although problems arise in developing appropriate estimates of the fraction of a mine "depleted" in any year, cost depletion deductions are necessary to provide a reasonable measure of the annual net income from a mine. The deductions taken for cost depletion roughly reflect the decline in value of the property due to reduction in the size of the deposit. Under current law, these deductions over the life of the mine may not exceed the total adjusted basis in the property.

As stated, firms take the greater of cost or percentage depletion. The percentage depletion subsidy operates by reducing the present value of taxable income. This reduction in the present value of taxable income equals the present value of the difference, over the life of the investment, between deductions actually taken (both cost and percentage depletion) and deductions taken using only cost depletion. Because the sum of percentage depletion deductions may exceed the cost basis of the investment, the difference between percentage and cost depletion can be and frequently is very large.

Percentage depletion accounts for at least half of the value of all specific tax subsidies for every mineral studied. In all cases except one (Eastern coal), allowable percentage depletion for the typical investment was limited by the requirement that it not exceed 50 percent of otherwise taxable income. This means that percentage depletion in these cases halves the tax rate applied to income from mining investments.

2. Expensing of Exploration and Development Costs

Domestic mining companies may take an immediate deduction for <u>exploration expenses</u> provided that the amount so deducted is recaptured as taxable income once the mine reaches production stage, or is sold. In addition, development expenses may also be deducted when made, though they must be subtracted later from allowable depletion. 1/

These tax subsidies also operate by reducing the present value of taxable income. For exploration, this reduction equals the present value of expensed exploration costs less the present value of their future recapture. For development, this reduction in the present value of taxable income equals the present value of expensed development less the present value of cost depletion of development.

In the data we examined, the favorable tax treatment of exploration and development expenses does not have a significant effect on the supply price of coal, iron ore, or copper.

3. Taxation of Royalty Payments at Capital Gains Rates

Certain transactions that might normally be regarded as giving rise to ordinary income can be treated as if they were sales or exchanges of capital assets. Royalty payments to landowners leasing land for production of coal and iron ore are eligible for this treatment. Thus, to the extent that net income from operating a domestic coal mine or iron ore mine accrues to such taxpayers as royalty payments, a portion of the net income of the mine is converted from ordinary income to capital gain for tax purposes. The resulting lower tax rate, usually half of the ordinary tax rate for individuals and 28% instead of 46% for corporations, is regarded as a special tax subsidy to coal and iron ore mining because that type of transaction would normally be defined as ordinary income. The effect of the capital gains treatment is to lower the supply price of capital to those mining industries covered by the provision. If these royalty payments were taxed as ordinary income, the developer of the mine would have to pay greater pre-tax royalty payments to the landowner to enable him to earn the same after-tax return on his property. 2/

4. Other Tax Subsidies

It is sometimes argued that other tax subsidies also affect the price of virgin materials relative to recyclables. Two frequently mentioned provisions alleged to lower the supply price of virgin minerals are the foreign tax credit and Domestic International Sales Corporations (DISC). Under the foreign tax credit, domestic taxpayers may credit foreign income taxes against domestic tax liability of foreign income, up to the U.S. corporate rate. Foreign tax credits assure capital export neutrality; the tax rate on foreign profits does not exceed the tax rate on domestic profits, unless foreign countries impose higher tax rates than the U.S. The foreign tax credit cannot properly be considered a subsidy to mining, because it does not reduce the combined rate of tax on mining income abroad below the rate of tax on mining income in the U.S.

U.S. corporations that derive 95 percent of gross income from exporting goods to foreign countries are allowed to form a Domestic International Sales Corporation (DISC). Income earned through a DISC is taxed at a lower effective rate than income earned through other domestic corporations. However, DISC is not considered a subsidy to virgin minerals which compete with recyclables in the U.S. market, because DISC is limited to firms that are primarily exporters. Further, if international markets determine the price of the virgin mineral and if U.S. mining supply curves are upward sloping, DISC may increase U.S. exports and the worldwide market share accounted for by domestic mines, but this would not significantly depress the world price, unless the U.S. accounts for a major share of world output.

Tax subsidies to municipal disposal are sometimes viewed as artificial impediments to recycling. These subsidies take two forms: 1) tax exemption of interest on state and local bonds, which reduces the cost to localities of capital investments in solid waste disposal, and 2) deductibility under the Federal income tax of state and local sales, income, and property taxes by individuals who itemize personal deductions. These special provisions subsidize all types of public programs by state and local governments, including resource recovery activities that complement as well as compete with recycling. Because these provisions are not specific to the materials sector, their potential impact on recycling is not included in the quantitative analyses in Chapters 2 and 3. However, Chapter 4 discusses their likely direction and magnitude.

## Tax Subsidies to Timber Growing [3/]

### 1. Capital Gains Treatment

Almost all income from investments in timber is eligible for capital gains treatment. Thus, the revenue from the sale of timber--revenue which would otherwise be taxed as ordinary income received by the manufacturer of a product--is taxed at the lower rates normally applied only to exchanges of appreciated capital assets.

The special capital gains rate has a major impact on the supply cost of timber. For corporations, for example, income from timber is taxed at only 28 percent rather than 46 percent (ignoring the impact of the minimum tax).[4/] Moreover, timber growing is a very capital-intensive industry; its most important input is waiting time. Most of the value added in timber can be defined as a form of capital input, since the opportunity cost is interest foregone on assets other than forests. Therefore, reducing the tax rate on capital income from the sale of timber has a major impact on the supply price. It is estimated below that the capital gains preference alone reduces the supply price of timber by about 20 percent.

2. Mismatching of Income and Expense

An equally significant component of the timber tax subsidy is the mismatching of income and expense. This occurs because the expenses of growing and carrying timber are deducted currently, while the income is recognized only when the timber is sold. Deferral of the recognition of income is not regarded here as a preference, for reasons discussed below. To be consistent with general tax practice, however, deferral of income requires a corresponding deferral of expenses incurred to produce that income.

Of course, it is not always easy to determine when an expenditure should be expensed and when it should be capitalized for tax purposes. In general, current deductions are not permitted for expenses that produce income over a long period of time. For example, investment in plant and equipment is generally depreciated according to defined rules over the productive life of the assets. Because income from timber growing is only recognized when the timber is actually sold, consistency with general tax practice requires that annual expenses of maintaining a forest be capitalized and be deductible only as sales occur. This should be accomplished by adding such capitalized expenditures to the basis to which cost depletion is applied when a portion of the timber is cut.

The tax treatment of interest incurred during construction reflects this principle. Such interest is capitalized rather than deducted, because it is regarded as a contribution to an asset from which income will be realized in the future. Then, as the asset is depreciated, the interest costs are properly reflected in the determination of net income. Analogously, timber should also be regarded as a "self-constructed" asset, with annual expenses deducted only when resultant income is realized.

Sunley cites several examples where expenses of timber growing that should be capitalized may be deducted immediately by taxpayers: 5/

1. Timber stand improvements such as brush control, thinning, pruning and shaping of trees are considered by timber owners as customary annual expenses. The Internal Revenue Service has held that such expenses should be capitalized since they add to the value of the trees. The Courts have held that such expenses do not increase the value of the trees and thus may be deducted.

2. Costs incurred in controlling outbreaks of forest insects or disease may have a useful life of more than one year. Should the useful life be determined by the time period after which trees so protected will be merchantable or by the time period after which the forest protection costs must again be incurred?

3. Property taxes and interest paid on a mortgage may be considered as costs necessary to carry timber to merchantibility, and thus they should be capitalized and added to the cost basis of the stand of timber. The tax law, however, holds that these costs may be said to be used up in the current period. That is, property taxes discharge an annual obligation to the State or local government, and the annual interest

cost is a cost for the use of the borrowed funds for one year. These costs are thus written off currently.

In the calculations below, the tax subsidy from this source is computed as the difference between the present value of all deductions allowed for a timber stand under current law and the present value of deductions that would be allowed under an appropriate timing pattern. An "appropriate" timing pattern is one in which all expenses except sales expenses attributable to commercial thinning are capitalized and written off at the time of the final harvest. Sales expenses attributable to commercial thinning are immediately deductible in the years in which they occur. Because thinning the forest is regarded as an investment in producing the final harvest, only sales expenses directly attributable to commercial thinning merit a deduction at the time of the thinning.

It can be argued that even this method of accounting for expenses and sales is too generous to the timber industry. Under a full comprehensive income tax, an asset such as standing timber, which grows every year, would be taxed annually on its appreciation in value. (Some expenses could then be deducted immediately, because income would be realized every year.) According to this view, taxing the net revenue from timber at the time of sale rather than as accrued represents a tax preference. While taxation of annual accrual is consistent with a comprehensive income base, the Federal Income Tax Code in general taxes income when realized, rather than when accrued. Thus, the deferral of tax liability on timber until the time of sale is not regarded in the calculations below as a special preference to timber growing.

The calculations in the next section indicate that the mismatching of income and expense provides as large a subsidy to timber growing as does the preferential capital gains rate. The long time period between planting and harvest (15-30 years in the profile used) makes current deductibility of expenses properly attributable to the final harvest very valuable.

3. Deduction of Expenses Against Other Ordinary Income

Normally, it is appropriate to deduct current operating costs against revenue in determining taxable income. As noted, some deductions allowed immediately as current operating costs for timber should be capitalized and written off only when the timber is sold. These deductions provide an additional subsidy because they can be written off against ordinary income from other operations, even though the revenue resulting from these deductible expenditures is taxed as capital gains. This means that the tax liability from growing timber, over the entire life of the asset, can be negative even if total revenue exceeds total costs.

Suppose, for example, that a corporation is engaged both in timber growing and in logging or manufacturing. An expense of $100 in the timber growing operation can be deducted against revenue from logging or manufacturing in computing net taxable income. If the $100 expense eventually produces $100 revenue from the sale of timber, the corporation's taxable capital gain increases by $100. Because corporate income is taxed at a 46 percent marginal rate, while corporate capital gain is taxed at a 28 percent rate (or slightly higher, if the minimum tax applies), the expense, which produced a net income of zero, has created a tax savings of $18. In effect, the deduction converts ordinary income in logging or manufacturing to capital gain in timber growing.

It is estimated that this last tax preference reduces the supply price of timber by about 9 percent, with the other two tax preferences in effect.

## III. Derivation of Supply Shift for Minerals

### Methodology

To estimate the supply shift from the mineral industry tax preferences described above, we use investment profiles for "typical" mines supplied to the Treasury Department by the U.S. Bureau of Mines. These profiles identify the amount and timing of different categories of expenses, and the amount and time pattern of revenue. The data on expense and on the timing of revenue flows are combined with information about how the tax rules would apply to revenue and to different categories of expenses to compute the present value of revenue required to yield a normal return on investment. The computations are made for two cases: 1) applying the tax rules under present law, and 2) applying the tax rules that would prevail in the absence of the special tax preferences affecting mineral industries. In both cases, required present value of revenue is defined as the present value of revenue that yields an after-tax return of 10 percent on capital for marginal investments of a corporation paying a marginal tax rate of 46 percent.

The required present value of revenue is computed by calculating the sum of the present value of all costs from the investment profiles supplied by the U.S. Bureau of Mines. These costs include current outlays, investment expenditures, royalty payments, severance taxes, and corporate income taxes. Because taxes paid depend on the amount of revenue, algebraic manipulation is needed to express required revenue as a function of the pattern of costs and the applicable tax rules. The Appendix to this chapter shows the derivation of the formulas used to compute required revenue, both under current law, and in the absence of special tax preferences.

Under current law, percentage depletion, unless constrained by the net income limitation, reduces the present value of taxable income by the product of the percentage depletion rate and the present value of gross revenue received by the owner of the mine. However, that portion of income received by landowners as royalty payments is not eligible for percentage depletion if taxed as capital gain. The present values of current outlays, expensed investments, depreciation, and severance taxes are deducted to compute the present value of the corporate tax base. The present value of recapture of expensed investments is added to the tax base, and is smaller than the present value of the expensed investments subject to recapture, because of deferral. The investment tax credit is treated as a direct reduction in tax liability.

Limits on the investment tax credit and percentage depletion can make computing the required revenues under current tax law very complex for a firm with one investment, because net income and taxes, and thus the allowable depletion deduction and investment credit, vary from year to year. However, most firms in the mining business are likely to be operating a number of similar mines of different vintage. Excess credits or deductions from one mine can be used to offset current taxable income from another one. In the calculations below, we adjust for excess credits or deductions only when the present value of the entire stream of otherwise allowable credits or deductions exceeds the present value of their limit.

For four of the mining profiles studied, the present value of statutory percentage depletion exceeds one-half the present value of otherwise taxable income. In those four cases, the percentage depletion allowance enables the firm to deduct one half of taxable income as percentage depletion, thereby reducing the marginal tax rate on corporate taxable income from 46 percent to 23 percent.

Under the formula used to calculate required revenue in the absence of special preferences, the mining firm would not be permitted to use percentage depletion or to expense investment in exploration and development. Cost depletion is deducted instead of percentage depletion for investments in exploration and development. Royalty payments enter the formula in the same way as in the current law case. However, the royalty payments reported in the profile are grossed-up so that landowners receive the same after-tax income under ordinary income taxation as they receive at the favorable capital gains rate prevailing under current law.

Because severance taxes are not imposed by the Federal Government, they are not counted among the special tax provisions affecting mining.

The investment tax credit for purchases of machinery and equipment is retained in the formula, and we use the same assumed formulas for depreciation in the no preference case as under current law. While the investment tax credit, and possibly current depreciation allowances represent tax subsidies under current law, they are not specific to mining, and would also apply to investment in machinery and equipment necessary to collect and transport recyclable materials.

The percentage downward shift in the cost of mineral production is determined after computing the required revenue under current law and absent special provisions affecting mineral industries.

### Quantitative Findings

Table 2.1 summarizes calculations from mining profiles. The profiles themselves are described in the Appendix to this chapter.

The data in Table 2.1 suggest that preferences to mining industries reduce the supply curve by around 10 percent for the typical mine. The estimates for the three coal mines vary from 8.4 percent for Eastern coal to 12.3 percent for Western coal (Powder River Basin). The supply curve for copper is estimated to shift downward by 10.0 per-cent and the supply curve for iron ore (taconite) by 8.3 percent.

## IV. Derivation of Supply Shift for Timber

### Methodology

The methodology used to compute the shift in the supply curve for timber is similar to the one used for mining. Profiles identifying the time pattern of expenses and receipts for model Southern Loblolly Pine stands were supplied to the Treasury by the U.S. Forest Service. From these profiles, gross revenues required to realize a 10 percent after-tax rate of return on investment were computed for two cases: (1) current law, and (2) current law absent special tax preferences for timber growing.

Table 2.1

Summary Calculations: Mining Profiles

| | Present value of gross revenue current law (thousands of $) | Present value of gross revenue neutral tax (thousands of $) | Percentage shift in supply curve |
|---|---|---|---|
| Eastern Underground Mine and Coal Preparation Plant | 113,338 | 123,769 | 8.4% |
| Surface Mine in Illinois Basin and Coal Preparation Plant | 136,582 | 155,452 | 12.1 |
| Surface Mine, Powder River Basin (Coal) | 172,763 | 196,897 | 12.3 |
| Copper Mine and Concentrator | 885,737 | 984,074 | 10.0 |
| Taconite Mine and Processing Plant | 844,549 | 921,242 | 8.3 |

discount rate = 10 percent

The economics of growing timber to produce paper are somewhat more complicated than the economics of mineral production. Virgin pulp used in paper production comes from two sources: (1) from trees grown specifically for pulp, and (2) as a by-product of trees grown for saw timber. In the latter case, pulp comes from both pre-commercial thinning of timber stands and from wood by-products, such as chips and sawdust.

Because saw timber and pulp are a joint product, there is some ambiguity in identifying the effect of a subsidy to growing timber on the supply curve for pulp. The rotation period is generally longer for timber stands that mainly produce saw timber than for those that mainly produce pulp, while the pulp from pre-commercial thinning is obtained earlier in the cycle than the saw timber ultimately produced. Because mismatching of income and expense is a significant part of the tax subsidy to timber growing, the effective rate of subsidy increases with the length of the rotation period of the timber stand. Thus, the tax subsidy for growing trees for saw timber is typically larger than the subsidy for growing trees for pulp only.

This computation measures the marginal incentive provided by the tax system to suppliers of virgin pulp. Because much of pulp is obtained as a by-product of growing saw timber, at a relatively small extra marginal cost, it is reasonable to assume that timber stands grown solely for pulp production represent the marginal supply. Thus, incentives to produce more virgin pulp would, to the extent that they increase output, largely encourage growers to increase the amount of timber grown only for pulp production. For this reason, the profiles used here provide data on the pattern of costs for timber stands used only to produce pulpwood.

The profiles supplied by the U.S. Forest Service indicate that the rotation period for the model Southern Loblolly pine stands may vary from 15 to 30 years. The calculations below show the increase in gross revenue required to yield a 10 percent after-tax rate of return for each of four possible rotation periods. If there were rising unit costs in increasing timber output, causing the after-tax return from timber growing to be reduced by removing tax preferences, the optimal rotation period would be shorter. The effect of such a change on timber output and prices is discussed briefly in Chapter 3, where behavioral responses are considered.

The Southern profiles are used because the South is the major region in the United States for growing trees for pulp production.

In timber growing, some expenditures can be capitalized, others expensed. In the timber profile supplied, clearing of site, site preparation, and planting, which occur in the first year of the rotation, and spraying (in the second year) are all capitalized. Annual costs for overhead, land rental, and property taxes, and periodic costs of prescribed burning for fire protection are expensed. All revenue to timber growers is obtained in the last year of the rotation period, when the right to cut the timber is sold. (This sale may be an internal transfer for an integrated company, which must estimate the value of the uncut timber to provide a measure of the capital gain.)

The present value of revenue realized at the time of sale must cover the present value of all costs and taxes. For a large, integrated paper company, the tax rate is 28 percent on capital gains (ignoring the minimum tax); however, a dollar of deductible expense reduces tax liability by 46 cents, because it can be written off against income from logging and manufacturing. All costs that have been capitalized rather than expensed enter the depletable basis and are subtracted from revenue to compute capital gain when the right to cut is sold.

To compute the present value of revenue when the special tax provisions are removed, all expenses are treated as if they were capitalized. They enter the depletable basis, which is then deducted from revenue realized when the timber is sold. This taxable income is assumed to bear a 46 percent tax rate. The after-tax proceeds are then discounted to the beginning of the holding period.

The Appendix to this chapter shows the formulas used to compute the present value of required revenue under current law and absent tax preferences to timber growing.

Quantitative Findings

Table 2.2 shows the effect of the tax subsidies to timber growing on the costs for a representative Southern Loblolly Pine Stand used for growing pulp, for different rotation periods. Column 2 of the table shows the present value of revenue per acre necessary to yield a 10 percent return on investment under current law, while Column 3 shows the comparable figure absent special tax provisions. The last column reports that the percentage shift in the supply curve ranges from 35.7 percent for a 15-year rotation to 43.4 percent for a 30-year rotation.

If the timber company has a sufficiently high capital gain in any year, it could be subject to the minimum tax on its capital gains. The minimum tax can raise the tax rate on marginal capital gains on the sale of timber by corporations to 29.8 percent at most. Under this rate, the percentage reduction in supply is only slightly less than under the 30 percent rate: 34.3 percent for a 15- year rotation, 37.9 percent for a 20-year rotation, 40.3 percent for a 25-year rotation, and 42.0 percent for a 30-year rotation.

Table 2.2

Summary Calculations: Profiles for Southern Loblolly Pine Stand Used for Pulp Production

| Rotation Period | Present Value of Gross Revenue: Current Law (dollars per acre) | Present Value of Gross Revenue: Neutral Tax (dollars per acre) | Percentage Shift in Supply Curve |
|---|---|---|---|
| 15 years | $330.81 | $514.53 | 35.7 |
| 20 years | $354.24 | $583.83 | 39.3 |
| 25 years | $368.77 | $633.03 | 41.8 |
| 30 years | $377.80 | $667.44 | 43.4 |

Table 2.3 summarizes the effect of tax preferences on the supply curve for Southern Loblolly Pine, for a twenty year rotation. The last row of the table shows that all the preferences combined reduce the gross revenue required for a 10 percent after-tax rate of return on investment by 39.3 percent. The first and second rows show the effects of two of the preferences, capital gains and mismatching of income and expense, taken by themselves. It can be seen that the two preferences are of almost equal magnitude. For longer rotation periods, mismatching of income and expense is a relatively greater preference; for shorter rotation periods the

capital gains preference is greater. Moving from the third to the fourth row shows the marginal effect of the third tax preference for timber, the deduction of expenses against other ordinary income.

Table 2.3
Effects of Individual Preference Items:
Timber Profile With 20 Year Rotation

| | Present Value of Gross Revenue; With Preferences(s) ($/acre) | Present Value of Gross Revenue; Neutral Tax ($/acre) | Percentage Shift in Supply Curve |
|---|---|---|---|
| Capital Gains Preference Only | 462.78 | 583.83 | 20.7 |
| Mismatching of Income and Expense Only | 464.34 | 583.83 | 20.5 |
| Capital Gains and Mismatching of Income and Expense | 408.23 | 583.83 | 30.1 |
| All Preferences | 354.24 | 583.83 | 39.3 |

The sum of the supply curve shifts from the first two preferences taken individually is greater than the total supply curve shift from the two combined, because each preference has a smaller marginal effect in the presence of the other one. For example, taxing income only at the capital gains rate decreases the tax saving from reducing the present value of the tax base through early write-off of investments.

The final preference, deduction of expenses against other ordinary income, is magnified by the other two. It would not be a preference without the capital gains preference, and it is magnified by the mismatching of income and expense. Allowing deduction of expenses against other ordinary income, rather than treating expenses as negative capital gains, reduces the supply price of timber by about 9 percent.

## V. Conclusions

A number of Federal tax subsidies reduce the costs of mining virgin materials and growing timber. These subsidies include percentage depletion; expensing of exploration and development costs; and capital gains treatment for royalty income for mining; and capital gains treatment of the sale of timber; mismatching of income and expense; and conversion of ordinary income into capital gain for timber growing. The combined effect of the subsidies is to shift the supply curve for virgin coal, copper, and iron ore down by 8 to 12 percent, and to shift the supply curve for timber down by 35 to 43 percent. Unless supply is highly elastic or demand highly inelastic, the effect of the tax subsidies on market price is likely to be considerably smaller.

The following chapter examines the likely effect of these subsidies on the amount of recycling of scrap steel, scrap copper, and wastepaper.

## Footnotes to Chapter 2

1/ For a fuller discussion of the comparison between these rules and what might be normal accounting procedure, see Gerard M. Brannon, Tax Provisions for Non-Energy Minerals and Timber, unpublished paper prepared for Resource Conservation Committee, 1977.

2/ This analysis assumes that, at the margin, the rental price of land in mineral production is determined by its value in alternative uses. Eliminating capital gains treatment of royalty payments means that pre-tax royalties would have to rise to induce the landowner to continue to supply mineral rights to the mining company. If, however, the landowner is earning economic rent, then he might absorb the higher cost that would accompany an end of "capital gains" treatment of royalty income and merely receive a somewhat lower economic rent. In this event, required gross payments by the mining company would not rise. This analysis provides an estimate of the maximum effect of capital gains treatment of royalty payments on the supply price of minerals, because it assumes that pre-tax royalities would have to increase.

3/ For a fuller discussion of these issues, see Emil M. Sunley, "The Federal Tax Subsidy of the Timber Industry," in Joint Economic Committee, The Economics of Federal Subsidy Programs, July 15, 1972. This discussion borrows from Sunley's analysis.

4/ The minimum tax can raise the total tax rate on corporate income from the sale of timber to 29.8 percent at most.

5/ Taken directly from Emil M. Sunley, op. cit., p. 320.

# Chapter 3

## Impact of Federal Tax Subsidies to Virgin Materials on the Amount of Recycling

### I. Introduction

This chapter combines the data in Chapter 2 with estimates of production relationships and demand and supply equations to compute the impact of Federal tax subsidies to virgin materials on recycling of scrap steel, scrap copper, and wastepaper. In all cases, removing the Federal tax subsidy would increase recycling by no more than 5 percent under the most extreme assumptions and by only one percent or less using more plausible estimates.

The effect of the supply curve shifts on recycling is calculated in several steps, each corresponding to a different market where material inputs are exchanged. Available statistical estimates of demand and supply elasticities applied in each step were derived from data generated while the tax subsidies were in effect. All computations are based on changes compared to current levels; thus, the numbers at each step, when combined, show the _increase_ in recycling that would result from _removing_ existing subsidies. These estimates are then transposed to determine the _reduction_ in recycling caused by the existing tax subsidies.

The next section of this chapter outlines the framework of analysis used to estimate changes in recycling that would result from a shift in the supply curve for virgin materials. This general framework is then used to estimate potential increases in recycling of scrap steel, copper, and wastepaper resulting from removal of the tax subsidies.

## II. Framework of Analysis

### Overview

Subsidies to virgin materials affect recycling to the extent that they lower the price of virgin materials. Lower materials prices weaken incentives for recycling, particularly at the post-consumer stage, by making disposal an economically more attractive alternative to firms and households.

The tax subsidies affect only one stage of material production (i.e., growth of timber stands used in wood products, and mining of coal, iron ore, and limestone used to produce pig iron.) Consequently, the percentage shift in the supply price of the virgin material used in primary production is considerably smaller than the percentage shift in the supply curves reported in Chapter 2. (Hereafter, the terms "subsidized resource" and "virgin material" will distinguish that portion of the virgin input receiving the tax subsidy measured in Chapter 2 -- the subsidized resource -- from the total virgin input used in primary production -- the virgin material.)

Measuring the impact on recycling of a given shift in the supply curve for each subsidized resource requires:

- Estimating the impact of the shift in the supply curve for each subsidized resource on the price of that subsidized resource.

- Estimating the impact of the change in the price of the subsidized resource(s) on the price of the virgin input.

. Estimating the impact of the change in the price of the virgin input on the amount of recycling of secondary materials.

The general considerations that affect the sizes of each of these three impacts are discussed below.

Effects of Tax Subsidies on Price of Subsidized Resources

The tax subsidy to each of the subsidized resources lowers the private costs of production at any level of output by the percentage reported in Chapter 2. The resulting decline in the resource price depends on the elasticities of supply and demand for the resource. At one extreme, if supply of the resource is totally elastic and if U.S. producers can significantly affect the world supply, or if trade barriers insulate the U.S. market (either of which means U.S. producers would face a downward sloping demand curve), the percentage change in price would equal the percentage reduction in production cost from Chapter 2.

At the other extreme, if supply is totally inelastic or if price is determined on the world market and is unaffected by changes in U.S. output (i.e., U.S. producers face a totally elastic demand at the world price), the tax subsidy will not affect the resource price. When supply is totally inelastic, the subsidy increases the value of land where the resource is found without affecting output or price. Where the price is unaffected by changes in U.S. output, the subsidy only increases that share of world output produced in the United States.

The Appendix to this chapter illustrates the effect of the tax subsidies on the price of the subsidized resources for different supply and demand elasticities. It also presents an algebraic derivation of the price change as a function of the shift in the supply curve and the elasticities of supply and demand for the resource.

International trade is an especially important factor that limits changes in the prices of minerals that would otherwise result from percentage depletion, expensing of exploration and development costs, and treatment of royalty income as capital gain.

In an open economy where subsidized virgin materials are traded internationally, tax preferences will primarily affect domestic output, rather than price because the prices for traded goods are determined by worldwide rather than domestic supply and demand conditions. U.S. tax preferences will affect prices only to the extent they significantly change either world supply or world demand.

This output effect is itself a manifestation of resource waste caused by the tax subsidies. By encouraging U.S. companies to export minerals that cost more to produce than the price received or, alternatively, to encourage buyers to substitute domestic minerals for less expensive imports, the tax subsidies lower U.S. living standards. However, as explained below, the efficiency loss caused by the subsidy is not manifested in reduced recycling.

Suppose, for example, that the U.S. subsidizes a commodity which it normally exports, such as coal. Coal is exported because its world price is higher than its domestic market price would be in the absence of trade. The subsidy would encourage domestic coal production and thus increase U.S.

coal exports. But the price of coal would not fall unless the U.S. were a large supplier of coal on the world market, so that the increased exports could be sold only at a reduced world price. If the U.S. were a small supplier of coal on the world market, the increased exports could probably be sold at an unchanged world price.

Increased coal exports would tend to increase the foreign exchange value of the dollar. Since other currencies would be worth less in terms of the dollar, the world price of coal, measured in dollars, would fall. Any price decrease would be small, however, because any exchange rate adjustment would be spread over all U.S. exports and all U.S. imports.

Therefore, the tax subsidy would have little impact on coal prices if increased U.S. coal exports:

(1) can be sold at the going world price, and

(2) have a minor effect on the foreign exchange value of the dollar.

Under these conditions, the tax subsidy would increase output but would not lower relative prices of virgin materials. The main effect of the subsidy would be to increase U.S. coal exports.

The analysis is symmetrical for an imported product, such as bauxite, which is imported because its world price is below the price that would prevail in the U.S. market in the absence of trade. A bauxite subsidy would encourage domestic production and thus reduce bauxite imports. The world price of bauxite would not fall unless the U.S., as a large importer of bauxite, were an important factor in the world market. The appreciation in the exchange rate due to the reduced imports would, for reasons explained, be small.

Therefore, the subsidy would have little impact on bauxite prices if reduced U.S. bauxite imports:

(1) have little, if any effect on world prices, and

(2) have a minor effect on the foreign exchange value of the dollar

Under these conditions, the tax subsidy again would increase domestic output but would not lower relative prices of virgin materials. The main effect of the subsidy would be to reduce U.S. bauxite imports. These arguments are developed graphically in the Appendix to this chapter.

As shown in Table 3.1 below, the U.S. is a relatively large producer of aluminum, coal, copper, iron ore, limestone, newsprint, steel, and woodpulp. Through their impact on output, tax subsidies for these commodities may lower world prices slightly. However, the demand curve facing domestic producers is much more elastic than it would be in the absence of international trade. Thus, international trade causes increased U.S. output to depress the price much less than it would in a closed economy, reducing the impact of the tax subsidy on the price of virgin materials.

None of the commodities in Table 3.1, except for steel, accounts for more than 2.0 percent of the total value of U.S. trade; therefore, the impact of any of the subsidies on the foreign exchange rate can be ignored.

Table 3.1

U.S. Production as a Percent of World Production
Selected Commodities

| Commodity or Product | Percent of World Production 1/ |
|---|---|
| Steel | 20.0 |
| Coal | 25.0 |
| Iron Ore | 11.0 |
| Limestone | 27.0 |
| Copper Ore | 22.0 |
| Aluminum | 34.0 |
| Bauxite | 3.4 |
| Newsprint | 14.0 |
| Woodpulp | 37.6 |

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1/ All figures except limestone are for 1973 and are from United Nations, Department of Economic and Social Affairs, Statistical Yearbook, 1974 New York, 1975. Limestone figures are for 1975 and are from unpublished U.S. Commerce Department data.

Effect of Change in Subsidized Resource Price on Price of Virgin Material Input to Primary Product Production

The tax subsidies to mineral products are all at the mining stage; for timber, at the growing stage. Virgin material inputs to primary production require transportation and processing. These activities do not receive depletion allowances or special capital gains treatment. The price effect of the tax subsidy is diluted because the subsidized activities represent only one stage in the production of the virgin material that competes with recyclables.

For pig iron, which competes with scrap steel as an input in steel furnaces, one must consider tax subsidies to coal, iron ore, and limestone. The three together account for only a fraction of the value of pig iron used in blast furnaces. Similarly, timber accounts for only a small fraction of the value of virgin inputs which compete with wastepaper in production of paper products.

It is possible to approximate the price change of a virgin material product resulting from the price change of each of its subsidized resources by multiplying the percentage change in the price of the subsidized resource by its share in the total cost of the virgin material. For pig iron, with several subsidized mineral inputs, the percentage change in price can be computed as a weighted average of the effects of tax subsidies on the prices of coal, iron ore, and limestone. This method assumes fixed coefficients in production, meaning that the physical mix of inputs used will not change when relative input prices change.

The assumption of fixed coefficients understates the effect of a tax subsidy on price by disregarding the possibility that producers may use a greater fraction of the subsidized resources. Conversely, the same assumption overstates the effect of removing a tax subsidy by disregarding the possibility that manufacturers may use a smaller fraction of the more costly resources.

<u>Effect of Virgin Material Price Change on Amount of Recycling</u>

As noted in Chapter 1, it is technically possible to decontaminate materials recovered from the solid waste stream so that they are perfectly substitutable for virgin materials in production of primary products. The relative prices of virgin and recyclable materials will determine which is used as additional input to increase output of primary products. The supply curve of recyclables from Chapter 1 shows how lower materials prices reduce the amount of recycling. In general, the more elastic the supply of recyclable materials, the greater the effect on recycling of the tax subsidies to virgin material production.

Some recyclable materials, such as copper, are comparable in quality to virgin materials in quality and thus are interchangeable with them in production. However, scrap steel and wastepaper usually are not processed to the point where they are equivalent to virgin materials, because the costs of increasing quality to a higher grade normally exceed the increase in the value of the product. It is therefore difficult to estimate supply curves for those recyclable materials that are not perfect substitutes for virgin materials.

Because natural resources and the solid waste stream both supply various grades and types of materials for different uses, a full statistical analysis of all virgin and recyclable materials exchanged is too unwieldy to be practical. Available econometric studies usually use typical recyclable and virgin materials purchased by primary producers as observations, abstracting from the full complexity of all relevant markets. If the average recycled material differs from the average virgin material used in production, then they would not be perfect substitutes. For this reason, econometric studies of steel and paper treat virgin and recyclable materials as distinct goods, each with a separate demand curve. The supply of recyclable materials depends on their price and other variables, while the demand for recyclable materials depends on both their price and the price of virgin materials.

To compute the effect of changes in the price of virgin materials on recycling, it is necessary to know: 1) the elasticity of supply of recyclable materials, 2) the elasticity of demand for recyclable materials, and 3) the cross-elasticity of demand for recyclable materials with respect to virgin materials prices. (The cross-elasticity of demand is equal to the percentage change in desired consumption of recyclable materials per unit percentage change in the price of virgin materials and thus measures the degree of substitutability in use between virgin and recyclable materials.) These elasticities are estimated in the literature surveyed in this chapter.

1) If the elasticity of supply of recyclables is small, a reduction in the demand for recyclables would not reduce the amount recycled significantly. (Similarly, an increase in demand would not increase the amount of recycling significantly.) This could happen if most home and prompt scrap were already recycled, and post-consumer scrap were so expensive to collect that scrap prices would have to increase sharply to generate any supply. In general, the smaller the elasticity of supply of recyclables, the smaller the reduction in recycling from a decrease in the price of the substitute virgin material.

2) If the elasticity of demand for recyclable materials is great, a downward shift in the demand curve will have little effect on the amount of recycling, all other things the same. This might happen if goods other than virgin materials were readily substitutable for the recyclable material. Then, a reduction in the virgin materials price might cause a shift away from other inputs, but <u>not</u> a major decrease in recycling of the <u>same</u> input.

3) If virgin and recyclable materials are poor substitutes in most uses, the cross-elasticity of demand for recyclables will be small. In that case, the reduction in recycling will be small relative to any price reduction of virgin materials. In general, the smaller the cross-elasticity of demand for the recyclable input, the smaller the reduction in recycling that corresponds to any reduction in the price of virgin materials.

In the following three sections, this framework of analysis is used to estimate the effects of tax subsidies to virgin material production on recycling of scrap steel, scrap copper, and wastepaper. In making these computations, we rely on econometric results from previous independent studies. The available data are sketchy, and cannot be viewed as precise measures of the important behavioral responses. Nonetheless, all available evidence supports the same conclusion--<u>that existing tax subsidies do not significantly reduce the amount of recycling, nor would their absence markedly increase that amount</u>. [1/]

## III. Scrap Steel Recycling

### The Price of Pig Iron

Pig iron competes with scrap steel as an input in the basic oxygen furnace that makes finished steel. Pig iron is made from three virgin materials: iron ore, coal, and limestone. The estimated increase in the price of pig iron from removing the tax subsidies depends on: 1) the price increases of coal, iron ore, and limestone, 2) the percentage of the cost of producing a ton of pig iron accounted for by coal, iron ore, and limestone, and 3) the potential of substituting other inputs in pig iron production as the prices of coal, iron ore, and limestone change.

#### 1. The Price of Coal

In Chapter 2, we estimated that the supply curve for coal was lowered by from 8.4 to 12.3 percent by the tax preferences. Thus, removal of the preferences would shift the domestic supply curve upward by from 9.2 to 14.0 percent.[2/]

If the supply curve for coal were horizontal, the price of coal would increase by from 9.2 percent to 14.0 percent. However, the supply curve for coal is likely to be upward sloping, even in the long run, because additional annual outputs require developing new mines with higher extraction costs and mining existing properties more intensively, thereby increasing cost per unit of output. If the supply curve were not perfectly elastic, the price change would depend on the elasticities of supply and demand for coal. (For the exact formula, see the Appendix to this chapter.)

Suppose elasticities of supply and demand for coal are +5 and -1, respectively.[3/] Applying the formula shown in the Appendix to this chapter, a 1 percent shift in the supply curve would then reduce U.S. output by 4.2 percent and increase the world price by 0.8 percent, if the U.S. accounted for the entire world supply. Because the U.S. supplies only about 25 percent of world coal output, the percentage reduction in the world output would be considerably less than the percentage reduction in U.S. output, and the world price decline would be correspondingly smaller. The Appendix of this chapter provides estimates of the effects of international markets on the price change due to a shift in the domestic supply. These data and assumptions imply that removing the tax subsidy might increase the world price by about five ninths of the shift in the U.S. supply curve, or 5.1 to 7.8 percent.

In the calculations that follow, we use the midpoint of these estimates, 6.5 percent.

2. The Price of Iron Ore (Taconite)

The estimate from Chapter 2 implies that the supply curve of taconite would shift by up to 9.1 percent if the tax subsidy were removed. Again, the price change would equal the supply curve shift only if the supply curve were horizontal.

The depletion of some of the best U.S. iron ore reserves, and the consequent exploitation of higher cost sources suggests that the supply elasticity of iron ore may be lower than that of coal. Again, however, no econometric estimate is available.

If supply and demand elasticities were +1 and -1, and world markets determined the U.S. iron ore price, the increase in price would be much smaller than if supply were perfectly elastic. The U.S. accounts for about 11 percent of the world's iron ore production. Under the same method used for coal, the estimated price increase for iron ore is about one-tenth of the supply shift, or about 0.9 percent.

3. The Price of Limestone

We were not able to obtain an investment profile with which to estimate the impact of Federal tax subsidies on the supply of limestone. However, limestone also receives percentage depletion likely to be constrained by the net income limitation. It is therefore reasonable to assume that the shift in the limestone supply curve is comparable to the shift in the coal and iron ore supply curves. The estimated price change for limestone need not be precise, because limestone accounts for only a small fraction of the cost of producing pig iron.

If the limestone supply shift were within the range of the coal and iron ore supply shifts and the supply curve were perfectly elastic, removing the tax subsidies would increase the price of limestone from 8 to 12 percent. Alternatively, using supply and demand elasticities of +1 and -1, and noting that U.S. produced limestone accounts for 27 percent of world output, the central range of estimates for the limestone price increase is between 1.7 percent and 2.6 percent.

4. Determination of Pig Iron Price from Mineral Input Prices

Proportions of mineral inputs used in the production of pig iron are reported in two studies of the effects of the tax system on recycling--one by Booz-Allen and Hamilton (hereafter BAH), and the other by the Environmental Law Institute (hereafter ELI). 4/ ELI reports that manufacture of a ton of pig iron requires 1.5 tons of iron ore, .77 tons of coal, and .2 tons of limestone; BAH reports inputs of 1.20 tons of iron, .60 tons of coal, and .18 tons of limestone. ELI reports input prices of $11 per ton, $30 per ton, and $2 per ton for iron ore, coal, and limestone, respectively; BAH reports corresponding prices of $11.30 per ton, $13.76 per ton and $1.70 per ton. 5/

Table 3.2 summarizes the production cost data from the ELI and BAH studies. The last column of the Table shows the cost per ton of pig iron for each mineral input, as determined by multiplying mineral input per ton of pig iron by price per ton of mineral input.

The effect of the mineral industry tax subsidies on the price of pig iron is shown in Table 3.3. The first column of Table 3.3 reports the contribution of each mineral to the cost of one ton of pig iron. Columns 2 and 3 report central and high estimates of the additional cost of each mineral used to produce a ton of pig iron under neutral taxation of mineral industries. Columns 2 and 3 estimate the tax subsidy by multiplying the percentage price increase from removing the tax subsidy by the cost per ton under present law. The central estimates use both the central estimate of the supply shift and the central estimate of the effect of the supply shift on price. The high estimates assume that the percentage price increase equals the high estimate of the supply shift.

Table 3.3 reveals that removing the tax subsidies would increase the price of pig iron a maximum of 6.2 percent using the ELI weights, and 3.3 percent using the BAH weights. The central estimates are 2.2 percent using the ELI weights, and 0.9 percent using the BAH weights.

Table 3.2

Virgin Mineral Inputs in Production of Pig Iron Input

| Mineral | Input per ton of pig iron | Price per ton | Cost per ton of pig iron |
|---|---|---|---|
| Iron ore | | | |
| ELI | 1.50 | $11.00 | $16.50 |
| BAH | 1.20 | $11.30 | $13.56 |
| Coal | | | |
| ELI | .77 | $30.00 | $23.10 |
| BAH | .60 | $13.76 | $ 8.26 |
| Limestone | | | |
| ELI | .20 | $ 2.00 | $ 0.40 |
| BAH | .18 | $ 1.70 | $ 0.31 |

Price of Pig Iron:
ELI: $77.00
BAH: $74.07

Table 3.3

Effect of Mineral Industry Subsidies on Price of Pig Iron

| Mineral | Cost per ton of pig iron Present law | Tax subsidy per ton of pig iron Central estimates | High estimates |
|---|---|---|---|
| Iron ore | | | |
| ELI | $16.50 | $0.15 | $1.50 |
| BAH | $13.56 | $0.12 | $1.23 |
| Coal | | | |
| ELI | $23.10 | $1.50 | $3.23 |
| BAH | $ 8.26 | $0.54 | $1.16 |
| Limestone | | | |
| ELI | $ 0.40 | $0.01 | $0.05 |
| BAH | $ 0.31 | $0.01 | $0.04 |
| Sum | | | |
| ELI | | $1.66 | $4.78 |
| BAH | | $0.67 | $2.43 |
| Sum as percentage of pig iron price | | | |
| ELI | | 2.2% | 6.2% |
| BAH | | 0.9% | 3.3% |

The method used here overstates the increase in the pig iron price, because it assumes that physical ratios of minerals and other inputs used to produce pig iron are insensitive to price changes. If these ratios respond to price changes, producers will shift to relatively lower cost inputs if the tax subsidies to minerals are ended. Thus, prices will rise by less than the weighted sum of the change in minerals prices using current law input proportions.

## Effect of Pig Iron Price on Steel Recycling

The impact of pig iron price changes on the amount of recycling of scrap steel can be estimated using Equation (3.6) derived in the Appendix to this chapter. The effect on scrap recycling of a pig iron price change is larger for higher values of the elasticity of supply of scrap and the cross-elasticity of demand for scrap, and for lower absolute values of the elasticity of demand for scrap.

ELI has estimated econometric models of supply and demand for scrap.[6/] The cross-elasticity of scrap demand was estimated to be 0.28. The supply elasticity was estimated to be 1.12. However, this estimate includes the supply of scrap from all sources. The supply of home and prompt scrap is very inelastic at the margin, because its low collection costs allow it to be recycled at almost any positive scrap price. Increases in recycling of post-consumer scrap account for most of the supply response to the price change. When considering the percentage change in post-consumer scrap alone, the elasticity is higher--2.32, in ELI's estimate. Finally, ELI estimates the demand elasticity for scrap steel to be -0.63.

Research Triangle Institute (RTI) has estimated supply elasticities for scrap steel ranging from 0.3 to 1.0 by a method called "process analysis," which uses engineering data.[7/]

For our upper bound estimate of the amount of recycling, we use values of 2.32, 1.0, and -0.63 for the supply elasticity, cross-elasticity of demand, and own-price elasticity of demand, respectively. For the central estimate, we use ELI's estimates for all scrap: 1.12, 0.28, and -0.63. ELI's supply elasticity estimate is close to the upper bound value reported by RTI. With these elasticities, we estimate a percentage increase in recycling of from 17.9 percent to 78.6 percent of the percentage increase in the pig iron price.

Combined Effect of Mineral Subsidies on Scrap Steel Recycling

We combine the upper bound and central estimates of the pig iron price change with the upper bound and central estimates of the effects of that price change on recycling, to estimate the effect of all virgin mineral tax subsidies on scrap steel recycling. The upper bound estimate is that scrap post-consumer steel recycling would increase by 4.9 percent if the tax subsidies were removed (the tax subsidies reduce post-consumer scrap steel recycling by 4.7 percent.) If the supply elasticity for all scrap steel is used (1.12 instead of 2.32), the upper bound estimate is 2.3 percent. The central estimate is less than 0.5 percent.

It is important to note that the upper bound estimates, while not large, are probably greatly exaggerated. The large difference between the upper bound and central estimates reflects considerable uncertainty about the elasticity parameters. For this reason, the central estimate cannot be considered precise. However, the upper bound estimate is based on the most extreme assumptions that might yield an estimate of a large effect.

In computing the upper bound estimate, it was assumed that: 1) supply curves for the relevant minerals are totally elastic, 2) the shift in the supply curves is at the upper range of our estimates, 3) there is no substitutability among input minerals used to produce pig iron, 4) the higher of the ELI and BAH estimates of the effect of mineral prices on the pig iron price is the correct one, and 5) the responsiveness of scrap demand to pig iron prices is about four times the elasticity estimated by ELI. Modifying any one of these assumptions would reduce the estimated impact considerably. For this reason, it is extremely unlikely that the tax subsidies could reduce the amount of recycling of scrap steel by more than one percent.

## IV. Scrap Copper Recycling

The output of a copper concentrator, including the stages of production of mining and concentration is eligible for percentage depletion. Scrap copper is a very close substitute for virgin blister copper. ELI estimates that blister copper is about 20 percent more expensive than copper concentrates; thus, percentage depletion applies to about 5/6 of the value of the virgin copper product that competes with recyclable copper. It is reasonable to assume that the virgin and scrap products are perfect substitutes.

### The Price of Copper

The tax preferences to mining of virgin copper provided by percentage depletion and expensing of exploration and development costs lower the supply curve of copper by about 10 percent. Thus, removing the tax subsidies would raise the supply curve for copper concentrates by about 11.1 percent.

Because copper concentrates represent about 5/6 of the value of blister copper, removing the subsidies would raise the supply curve for blister copper by 9.3 percent.

Supply and demand elasticities are available from an econometric study by Fisher, Cootner and Baily of the world copper industry. 8/ The study estimates long-run elasticities of 1.67 for supply of primary copper, -0.867 for demand for copper, and 0.32 for supply of scrap copper.

Using equation (3.3) from the Appendix to this chapter, and using the Fisher, Cootner, and Baily elasticity estimates, a 9.3 percent upward shift in the supply curve for blister copper implies a 6.1 percent increase in the price. This estimate is biased upwards, however, because the domestically produced virgin copper affected by the subsidies accounts for only a fraction of total supply; the U.S. accounts for about only 22 percent of world copper output. Scrap production also affects the price of copper, but it is not curtailed by removing the subsidy to virgin materials. Taken together, these factors imply that the price increase could be significantly less than the upper bound estimate of 6.1 percent. Application of the methodology in the Appendix to adjust only for the effect of international trade on the price change reduces the estimated increase in copper price to 2.8 percent.

Recycling of Scrap Copper

The increased recycling of scrap copper resulting from an increase in price is computed by multiplying the estimated percentage price change by the estimated supply elasticity of scrap (0.32). This formula yields an upper bound estimate of increased recycling of 2.0 percent and a central estimate of 0.9 percent.

Thus, the current Federal tax subsidies to copper mining appear to have little deterrent effect on the amount of recycling of scrap copper.

## V. Wastepaper Recycling

Wastepaper competes with virgin wood pulp as an input to a wide variety of paper industry products. By lowering the cost of woodpulp, the tax subsidies to the timber industry create a bias against the use of recycled paper; however, their effect on recycling is small.

Compared to tax subsidies to the minerals industry, the tax subsidies to the timber industry are very large. However, the subsidies are not a major impediment to recycling for two reasons: 1) the small share of timber in the cost of supplying woodpulp to primary product production, and 2) the relative insensitivity of wastepaper recycling to changes in relative prices.

### Effect on the Price of Woodpulp

Chapter 2 showed that the tax preferences lower the cost of growing timber by between 35.7 and 43.4 percent. Removing these subsidies would shift the supply curve for timber upward by from 55.5 percent to 76.7 percent.

The increase in the price of timber, however, may be considerably smaller than the supply curve shift from removing the subsidies. Timber land is generally inferior land, not suitable for most agricultural uses. Were the tax subsidies removed, growing timber might still be the best use for this land. In that event, removing the tax subsidies would lower the value of timber land, without affecting timber output and price. At the margin, there are undoubtedly some areas where timber growing does substitute for other uses, and where patterns of land use would change if the tax subsidies were removed. Therefore, in the long run, timber prices would increase to some degree if tax policy changes caused the private costs of growing timber to increase. [9/] However, it has not been possible to quantify the extent to which the tax changes would alter prices and output, and the extent to which they would only affect the value of timber land.

As noted in Chapter 2, reducing the tax preference to capital income from timber growing would shorten the optimal rotation period for timber stands. The immediate effect of this change could be an acceleration of timber cutting and an increase in the available supply of virgin woodpulp. However, the earlier harvest would mean a reduction in future supplies and a further reduction would occur if land were converted from timber growing to other uses.

The extremely long production period for timber products makes it very difficult to a infer long term relationship between changes in timber prices and changes in output from historical data. Absent available statistical studies that can be cited with even a minor degree of confidence, it is assumed that the reduction in the Federal subsidy to timber growing from removing the tax subsidies increases the price of standing timber by the full amount of the supply curve shift. This assumption provides a maximum estimate of the disincentives to recycling from timber tax subsidies. The reader should note that removing the tax subsidies may lower the price of virgin woodpulp in the short run, and may increase price in the long run by much less than is shown below.

Under this upper bound assumption, ending the tax subsidies would increase the price of timber by at most 76.7 percent. According to estimates supplied by ELI, timber accounts for between 6 and 12 percent of the price of virgin woodpulp. Thus, removing the tax subsidies could increase the price of woodpulp by as much as 9.2 percent, if there were no substitutability in production. Even if the price of timber rises by the full amount of the increase in growing cost, the increase in the price of woodpulp could still be as little as 3.3 percent (6 percent of a 55.5 percent increase in the timber price).

## Effect on Recycling

It is possible to process wastepaper so that it is equivalent to paper made from virgin woodpulp. It is usually more expensive to manufacture paper of any quality from recyclable sources; therefore, wastepaper is sold to users who do not require an exact duplication of the characteristics of paper made from virgin woodpulp. For this reason, existing econometric studies of the market for recycled paper have treated wastepaper and virgin paper as distinct, though related goods.

ELI has estimated the demand and supply for wastepaper. Their estimated elasticities are: 0.40 for elasticity of supply of wastepaper, 0.17 for cross-elasticity of demand for wastepaper (with respect to woodpulp price), and -0.16 for elasticity of demand for wastepaper (with respect to wastepaper price). RTI estimates the elasticity of supply to be between 0.4 and 1.7, using process analysis. Equation (3.6) in the Appendix and the ELI elasticities imply that recycling would increase by 12 percent of the increase in the price of woodpulp. Because, as noted, removing the tax subsidies would increase the price of woodpulp by at most 9.2 percent, this would yield an increase in recycling of at most 1.2 percent. If RTI's highest supply elasticity is combined with all the other upper bound estimates, removing the tax subsidies could increase recycling by 1.4 percent.

ELI's econometric equations show low elasticities of demand and supply for wastepaper. While these estimates are consistent with the casual observation of low substitutability between wastepaper and virgin pulp, they may be biased downwards because of poor data in the estimating equations. In particular, the price data, based on list price, might not adequately capture changes in real transactions prices. However, even elasticity values substantially higher than those estimated by ELI do not lead to a conclusion that removing the tax subsidies would dramatically increase recycling. For example, if the relevant parameters were assumed to be 0.8 for the cross-elasticity of demand, 0.5 for the supply elasticity, and -0.5 for the demand elasticity, the percentage increase in recycling might be 31 percent of the increase in the woodpulp price, or a maximum of 3 percent above current law levels.

## VI. Conclusions

The quantitative impact of tax subsidies to virgin materials on the amount of recycling is uncertain, because the probable responsiveness of suppliers and users to changes in prices of virgin and scrap materials has not been quantified precisely. Nonetheless, illustrative calculations using the best available evidence show that current Federal tax subsidies to virgin materials do not have a major negative effect on recycling of scrap steel, scrap copper, and wastepaper under the most extreme assumptions, and most probably have very little effect. Similar conclusions have been reported in research performed by independent contractors for EPA, some of whose methodology and data have been used in this chapter. [10/]

However, these conclusions do not mean that tax subsidies to virgin materials production are insignificant. The tax preferences reviewed in Chapter 2 entail important equity concerns, and may also have a considerable impact on domestic output of some virgin materials. These effects, however important, are not a concern of this report.

## Footnotes to Chapter 3

[1/] A similar type of computation has been made by the Environmental Law Institute (hereafter referred to as ELI) in a study performed under contract to the U.S. Environmental Protection Agency. ELI's estimates of the impact of tax subsidies on the supply price differ from those developed in Chapter 2. This chapter combines the supply price effects from Chapter 2 with ELI's and alternative econometric estimates of supply and demand elasticities. See Robert C. Anderson and Richard D. Spiegelman, The Impact of The Federal Tax Code on Resource Recovery, report prepared at Environmental Law Institute for Office of Research and Development, U.S. Environmental Protection Agency, 1976.

[2/] If the price of an input is lowered by "x" percent by a tax subsidy, then it has become (1-x) times the initial price. Removing the subsidy would then raise the price by "x/(1-x)" percent of the post-subsidy price.

[3/] A demand elasticity of -1 implies that the total value of coal consumption would be unchanged for small changes in the price because the percentage increase in the price per unit would be matched by an equal percentage reduction in the quantity consumed. Absent available econometric estimates of the long run demand for coal, this assumption is reasonable; it falls within the range of demand elasticities estimated for other minerals.

A much higher value is used for the supply elasticity because accessible coal reserves are abundant and, in the long run, more coal could probably be mined without a substantial increase in unit costs. However, no long run supply elasticities for coal are available in the literature surveyed. A recent study by Charles River Associates (CRA) provides estimates of short run elasticities ranging from 0.33 to 2.36. The value used here is twice the maximum short run elasticity estimated by CRA. See Charles River Associates, Coal Price Formation, final report prepared for Electric Power Research Institute, December 1977.

If the supply elasticity is lower than the value used in these calculations, then the tax subsidies have a smaller effect on the price of coal and, hence, a smaller negative impact on recycling of scrap steel.

4/ Booz-Allen and Hamilton, An Evaluation of the Impact of Discriminatory Taxation on the Use of Primary and Secondary Raw Material, final report submitted to Environmental Protection Agency, Washington, D.C., June 28, 1974, and Robert C. Anderson and Richard D. Spiegelman, op. cit.

5/ The two studies use price data from different years, and production estimates from different sources.

6/ See Robert C. Anderson and Richard D. Spiegelman, op. cit. See also Robert C. Anderson and Richard D. Spiegelman, "Tax Policy and Secondary Material Use," Journal of Environmental Economics, volume 4, Number 1, March 1977.

[7/] A.K. Miedema, An Empirical Evaluation of the Market and Net Welfare Effects of A Product Disposal Charge, Research Triangle Institute (RTI), December 1977. For a review of the RTI work and other studies estimating supply elasticities for recyclable inputs, see ICF Incorporated, Estimates of Substitution and Supply Elasticities for Post-Consumer Waste Materials, draft report submitted to U.S. Environmental Protection Agency, August 11, 1978.

[8/] F. Fisher, P. Cootner, and N. Baily, "An Econometric Model of the World Copper Industry," Bell Journal of Economics and Management Science, August 1972.

[9/] In technical terms, if the supply curve were totally inelastic (i.e., timber output were unchanged if timber prices changed), removing the tax subsidies would simply lower the value of timber land. If, on the other hand, the supply curve were totally elastic, the price would increase by the full amount of the estimated cost increase.

[10/] See Environmental Law Institute, op. cit and Booz-Allen, Hamilton, op. cit.

## Chapter 4

## Recycling Subsidy Options

### I. Justifications commonly cited for subsidizing recycling activities.

Solid waste management involves two distinctive activities. First, collecting the debris of production and consumption; second, physically disposing of it by landfill or incineration, or subjecting it to some form of resource recovery process and then disposing of the residual solid waste. Both sets of solid waste management activities are subject to competitive conditions. The technologies for collection and for processing solid waste are widely known, and entry into these activities is not barred by patents. The resources required, labor and capital, have no limiting specialized characteristics. While there may be economies of scale in both sets of waste management activities, in neither does the condition of natural monopoly prevail. 1/

If the activities of waste collection and processing fulfill the conditions of competitive markets, there is no *a priori* justification for public subsidies to any of these activities. However, proponents of resource recovery, including recycling, cite one or more of the following four justifications for subsidizing resource recovery from solid waste: it relieves communities of some solid waste management costs; it reduces environmental degradation; it offsets price-distorting effects of tax subsidies to virgin materials production; and it conserves finite resources and energy. We turn now to a critical review of these rationales for subsidizing resource recovery from solid waste.

A. Reduction in the burden of solid waste management borne by local governments.

In its Fourth Report to Congress: Resource Recovery and Waste Reduction, the Environmental Protection Agency has estimated that 134.8 million tons of municipal solid waste was disposed of in the United States in 1974 at an estimated total cost of nearly $4 billion. A major but unquantified fraction of this cost is financed by municipally operated collection and disposal systems; and a significant fraction, again unestimated, of the municipally controlled waste management is financed by general taxes. 2/ Disposing of the waste in an environmentally acceptable manner would have cost an estimated $1.6 billion more. The volume of municipal solid waste has been growing at an estimated annual rate of 1.9 percent, and will reach 166 million tons by 1985.

Although these facts indicate that solid waste disposal absorbs large amounts of resources, by themselves, they provide no basis for subsidizing recycling activities:

--Some local governments, with the consent of their voters, undertake solid waste management tasks and finance them by local taxes; others undertake the tasks and finance them with fees; still others contract with private firms and finance the work by appropriations from the general fund, or by fee assessments. In all these cases, communities decide how they wish to have solid waste management services performed and financed. Federal government subsidies which would reduce the costs of solid waste management merely transfer that burden from those who generate the waste to Federal taxpayers. If communities elect to have their governments perform services on their behalf and to finance them by taxes and fees, the resultant burdensome taxation is not a valid claim to Federal subsidy that would relieve these burdens. 3/

--The evidence does not support a conclusion that municipal solid waste management is any more a financing problem for local governments than other categories of expenditure. Even if the estimated $4 billion cost of solid waste management in 1974 were borne entirely by local governments, which was not the case, and we add to this the estimated $1.6 billion of unmet environmental protection costs, the total would be only 4 percent of all local governmental expenditures that year. Moreover, while local government expenditures have increased at an annual rate of 11 percent during the last decade, the inflation-adjusted rate of increase in municipal solid waste costs is but 3.5 percent.

B. Reduction in environmental degradation.

The Environmental Protection Administration has estimated that 92 percent of municipal solid waste in the United States is disposed of by landfill and more than two-thirds of land disposal sites do not meet environmental standards. These estimates imply that, under present conditions, waste disposal imposes a sizable social cost in degradation of the environment. As noted, it would have cost annually $1.6 billion (in 1974 dollars) to conform disposal systems to environmental standards. If the volume of waste requiring disposal could be reduced to zero by resource recovery, not only would the $1.6 billion of unmet environmental losses suffered by society be saved, but also the actual disposal costs incurred that year, estimated to be

\$500 million. [4/] While subsidies to recycling cannot reduce disposal to zero, they can contribute to some reduction, and hence to a reduction in environmental damage.

The evasion of environmental laws in the disposal of solid waste by communities is deplorable, but does not warrant assumption by Federal taxpayers of the burden of maintaining local environmental quality through the funding of subsidies to recycling. Not only does a recycling subsidy violate the "polluter pays" principle, it does so in a costly manner. If the polluter pays principle is to be breached, the least costly way for the Federal government to assume some or all of the cost of environmental maintenance is directly, through grants or similar payments to local governments, per ton of waste collected; this payment might then be used by those governments <u>either</u> for disposal of solid waste in an environmentally acceptable manner, <u>or</u> for building and operating resource recovery facilities. To subsidize resource recovery generally, or recyclable materials only, is to bias unnecessarily the choice among disposal options. When environmentally acceptable disposal is cheaper, as it is in most places in the United States, to encourage resource recovery is a waste of scarce labor and capital resources.

Moreover, for reasons detailed in Chapters 1 and 3, the incremental cost per ton removed from the solid waste stream by a subsidy to recycling only is extremely high and rises rapidly as the volume to be removed from the waste stream increases. In 1974, the average disposal cost of municipal solid waste was estimated to be less than \$4 per ton, and if all disposal had conformed with environmental standards, that cost might have increased by an average of \$1.19. In contrast, the estimated <u>subsidy cost</u> of removing an additional ton of paper from the municipal solid waste stream is \$395; a ton of ferrous scrap, \$120 to \$185; and a ton of copper scrap, \$4,720. [5/] These estimates pertain only to removal of additional tonnages in the range of one or two percent of the quantities currently recycled and, hence, to even smaller fractions of municipal solid waste. Removing more would rapidly escalate these costs per ton.

In sum, avoidance of environmental degradation costs affords no basis for Federal subsidy to recycling. Nonetheless, if a Federal subsidy to local communities is to be provided to help them meet their obligations to maintain environmental quality while disposing of their solid waste in violation of the polluter pays principle, it should be provided at the point where collected municipal solid waste is available for disposal, whether by landfill, incineration, or resource recovery processing. Such a direct subsidy to local communities conditional on their avoidance of environmental damage in the disposal of solid waste will cost less than 0.1 to 1.0 percent of a subsidy to recycling for the same purpose.

C. Offset to price-distorting effects of tax subsidies.

Chapter 2 reviewed the Internal Revenue Code provisions that create a preference, or subsidy, for the production of virgin materials. Although many observers conclude that these subsidies justify compensatory subsidies to recyclable materials, Chapter 3 notes that the claim for compensatory subsidy assumes that subsidies to the domestic production of virgin materials results in lower prices of those materials and, thus, reduces demand for recyclable materials. But the degree to which domestic prices of virgin materials are reduced by production subsidies depends upon the character of world markets for these materials and the relative importance of U.S. consumption and production in those markets. Moreover, the induced reduction in demand for recyclable materials associated with any depression of virgin materials prices attributable to U.S. subsidies is greatly attenuated by the far less than perfect degree of substitutability of recyclable for virgin materials in production of the full spectrum of primary products derivable from these materials.

In sum, leaving aside the question, not dealt with in this report, whether subsidies for the domestic production of virgin materials is a justifiable governmental intervention in the allocation of scarce labor and capital resources, the evidence available does not support an inference that these subsidies, by their effect on domestic virgin material prices, deter resource recovery from solid waste to a degree that warrants a countervailing subsidy. For the three significant recyclable materials examined--ferrous scrap, copper and paper--the probable deterrence to recycling attributable to virgin material subsidies is in the range of 0.5 to 1.0 percent of the volume recycled. This is not a magnitude sufficient to warrant installing a countervailing subsidy program which is likely to have serious administrative problems, as discussed below. (See Section II, A, below).

D. Conservation of "finite" resources and energy.

1. Finite resource conservation.

It is a truism that the earth's resources are finite, and it follows from this that if present generations "use-up" high-grade ores and other nonrenewable resources constituting the earth's crust, succeeding generations will have less. This being so, the argument continues, we should recover resources from solid waste for the benefit of future generations. Since much of the solid waste stream is presently disposed of, not processed as a source of material and energy, a strong case is therefore alleged to exist for subsidizing resource recovery. The extra resources invested in recycling by the present generation is to preserve for future generations their claim to the earth's resources.

There are three weak links in this chain of reasoning to justify a subsidy to resource recovery activities. First, although the earth's crust is "finite" it is vast. So little of it has been thoroughly surveyed geologically, no one can with reasonable confidence estimate its useful resource content. Unmeasured "finiteness" is not a satisfactory reason to constrain current rates of economic utilization of the natural endowment.

Second, living standards are determined by the stock of human and physical capital that embody the store of knowledge, as well as by the natural endowment. Growth in the stock of physical capital, and in its productivity, as well as accretion of knowledge--enhanced productivity of human capital--together substitute for depleting natural resources. The available evidence suggests that not only has the real cost of extracting minerals in the United States declined, but that the decline in cost of extraction is greater than the decline in real costs of other production. [6/] All this has occurred over the last century notwithstanding the fact that the grades of most ores exploited have declined. [7/]

Finally, it is not correct to assert that claims of future generations are unaccounted for in decisions made today. Individuals consume and save today according to their judgment of future needs. Each generation comprises persons of all ages; thus, each "generation" makes decisions that span an average of two or more decades, linking generations to each other in infinite sequence. Moreover, enterprises that make production decisions for a full spectrum of economic activities ranging from mining and forestry to retailing of consumer goods organize as corporations in order that they may operate with extremely long planning horizons. Well organized markets exist through which households and enterprises may execute their decisions spanning decades; these are called "capital markets" in which present claims are exchanged for future claims.

If, say, copper-trading enterprises believed that the world were in danger of running out of low cost ores, they would restrict current sales, preferring to hold inventories in the ground and in warehouses rather than to sell at current prices. If the cost of acquiring funds in capital markets is 10 percent, anyone who supposes the future growth in price of materials will be greater than 10 percent, compounded, will withhold current available supplies, <u>raising</u> current prices of the materials to "reflect the claims" of future consumers. Additionally, enterprises in the copper business will invest (acquire present claims to resources in capital markets in exchange for promises to make future payments) in finding new ore deposits and in reducing the cost of extracting and processing ores from existing deposits. While some contend that the market rate of discount which functionally links present and future generations is too high, <u>i.e.</u>, discounts future claims too much, this does not mean that the claims of future generations are disregarded.

In sum, the apparent finiteness of natural resources provides no compelling argument for expending society's scarce resources in a subsidized level of resource recovery. We don't know the magnitude of resources in the earth's crust; we continue to increase the rate at which we learn to extract useful minerals from rock; and we already have a reasonably useful mechanism for adapting current use of natural resources to likely future demands.

2. Energy conservation.

The energy conservation rationale for subsidizing resource recovery is based on the observation that the number of Btu's, or barrels of oil-equivalent energy, required to produce a unit of primary product--metal, paper, glass--from virgin materials exceeds the energy required to produce the same unit from recyclable materials. If we subsidize resource recovery, we save Btu's of energy.

There is some validity in this argument, but it rests on an inference that the effect of our oil, gas, and electric energy price controls is to cause the market prices of energy to be understated. If that inference is correct, then reducing usage of energy by one Btu saves more resources than is implied by the "saving" measured at the present market prices of energy. That is, the relative attractiveness of using recyclable materials, which embody less energy, is understated by the underpricing of energy.

On the other hand, there are reasons to believe that the inefficiencies of price regulation make energy prices higher than they would be in the absence of regulation: "rate of return" regulation of utility prices induces too capital intensive modes of electric energy generation and distribution; oil and gas price regulation has increased the costs of finding, processing, and distributing this form of energy so that what has been gained by suppressing prices at the well-head may be largely offset by increased costs elsewhere in the system. It is doubtful that mispricing of energy measurably biases choices against resource recovery; therefore, saving a Btu of energy through recycling does not result in a resource saving not already accounted for in the choice to recycle, rather than dispose of solid waste.

Energy is not some special resource external to the economic system, but simply an embodiment of capital, labor and the natural endowment in a particularly useful form. Economic policy should aim to minimize the total cost of production to improve our standard of living. We gain nothing by substituting an extra dollar's worth of resources in recycling material in order to save less than a dollar's worth of costs, whether those costs are for society's labor and capital in the form of energy, or other inputs. If it pays to recycle, one of the reasons it pays is that, among other things, recycling uses less energy. If, despite its lesser energy use, recycling does not pay, the energy saving due to recycling is irrelevant.

Summary.

If a subsidy corrects a failure of markets to allocate resources efficiently, it yields society a net gain. That is, should social valuation of the output of the economic system fail to be reflected in market prices, or should the costs of resources consumed in production fail to be accounted for by enterprises engaged in production, or should there be a barrier to utilization of least costly technology, government intervention to correct these failures results in a net benefit--increased standard of living. In such instances, the apparent cost of a subsidy financed by taxes is offset, in part or in whole, by a larger value of goods and services.

There are no glaring market failures which might be offset effectively by subsidies to recycling, or resource recovery.

--Solid waste management, recycling, and resource recovery are activities not characterized as natural monopolies. Technologies are widely known, and there are no market economies of scale or institutional barriers that limit entry. Recycling and resource recovery will take place whenever value of product justifies incurring production costs.

--Although municipalities frequently fail to price solid waste collection services to equate costs and benefits at the points where solid waste collection occurs, this is an exercise of constitutional rights reserved to states, not a manifestation of market failure.

--Although there are numerous instances in which solid wastes are disposed of in an environmentally unacceptable manner, these are failures to comply with Federal, state, and local environmental standards, not market failures.

--Although there are tax subsidies to virgin material production which reduce imports of certain materials and increase exports of others, recycling and resource recovery are not appreciably deterred. Additional subsidy to recycling therefore would not avoid resource wastage due to existing tax subsidies.

--There is no persuasive argument that markets for natural resources, including those convertible into energy, do not account for present and expected future scarcity.

In sum, subsidies to recycling and resource recovery do not ensure a more efficient allocation of resources. Instead they are likely to reduce total social welfare by devoting too many resources to recycling compared with the benefits received and too few resources to more economical means of waste disposal.

II. Considerations in the formulation of a subsidy to recycling.

Notwithstanding the absence of a justification for subsidizing recycling on the ground of improved overall allocation of society's resources of labor and capital, noneconomic considerations compel many to support institution of a system of recycling subsidies. Personal belief in a "conservation ethic" is a sufficient reason for some to urge public support for more recycling of solid waste than is justified on pure cost-benefit grounds. Others, engaged in the recycling process, have a pardonable pride in their activities, and they seek public recognition and support to expand their sphere of interest.

The remainder of this chapter reviews the issues in formulating a subsidy program to increase the recycling of solid waste: definition of the activity to be subsidized; the form of the subsidy; and how resolution of these questions interacts with the structure of activities engaged in recycling to determine the ultimate cost of achieving the declared objective.

A. Definition of recycling activities.

"Recycling" describes a process in which material things which have become worthless and therefore disposable are converted into materials usable in the production of things which do have value. Recycling is often thought to be restoration of the contents of trashbins and garbage pails to flows of raw materials, and this is the view taken in this report. But, for the purpose of evaluating a subsidy program, this is an over-simplified view of the way raw materials that have been fashioned into products move through the economic system.

Consider the variety of choice-paths that exist at each stage of the economic process. At the primary production stage referred to in Chapter 1, defective batches may become home scrap and reprocessed, or they may be salable, at lower prices, for use in less demanding product fabrication. At the fabrication stage, the same choice prevails for defective products: they may be salable as "seconds," they may be reworked, or they may be thrown in the trash pile. Similarly, when the first purchaser of a product finishes with his principal use of it, he may put it to secondary use--relegate his older car to utility use, add books and periodicals he has completed reading to his library shelves--or he may sell it to a dealer, or he may throw it into a trash heap, paying someone to collect it. Second-hand dealers may recondition articles for resale, discarding more or less of the original material in the process, or they may hold them in inventory for future resale. Finally, once the collectors of trashbins and garbage pails have acquired the contents, the choices available include processing the solid waste into recyclable materials, useful energy, and, possibly, other products, or disposing of the original volume. Even the resource recovery activity will generate solid waste, and this may be held in a kind of slag heap awaiting further processing, or it may be disposed of.

This diversity of paths traced by ultimately recyclable materials through the economic system raises two issues. First, in addition to the direct costs of a subsidy to increase recycling, a considerable additional indirect cost will be incurred that is in conflict with the conservation ethic; and second, the pragmatic difficulty of identifying both the agents to whom the subsidy will be paid, and the base on which the amount of subsidy will be computed.

1. Additional indirect costs of a recycling subsidy.

If, at all stages from primary production through consumption, there are choices between some continued use of a semi-finished product or finished good, or discarding it, subsidization of recycling will discourage continued use. When "seconds" and reconditioned products are made more valuable as grist for the recycling process, they will more readily be entered into solid waste streams. The "useful life" of products will be shortened by the introduction of a recycling subsidy. Thus given, a standard of living, one of the results of a recycling subsidy will be a tendency to increase the volume of solid waste generated. Part of the recycling subsidy therefore will be absorbed in more primary product production to sustain a given standard of living than would occur without the subsidy. The increased primary product production will induce an increase in virgin material usage that will offset some of the conservation achieved by recycling. Subsidizing recycling per se also discourages general resource recovery, including conversion of waste into useful energy. Thus, a subsidy policy narrowly aimed toward encouraging recycling of materials to replace virgin materials causes an induced waste of resources. The wasted resources include natural resources as well as capital and labor.

2. Identifying the agents and base for a recycling subsidy.

But, more importantly, the large numbers of transactors involved in the process affected by a recycling subsidy, and the variety of interrelated decisions that would be affected, implies a severity of operational administrative problems seldom given attention by recycling subsidy proponents. Given the objective of a recycling subsidy, the least ambiguous set of activities engaged in the process, and also one comprising the fewest economic units, is that in which recyclable material is incorporated into a primary product. To simply recount the numbers of trash collectors, dealers and brokers in "scrap," and reconditioners and salvagers of articles, and to consider the numbers of transactions which may be consummated between the discard of solid waste and its ultimate conversion into reusable material should be sufficient to disqualify any of these preliminary stages of the recycling process from consideration as feasible points at which to interject a subsidy.

For example, suppose the subsidy is \$5 per ton of paper. If the subsidy is paid to the collector, how may it be ascertained that the collection is only from the waste discarder, and not a second collection of the same paper already bearing a \$5 subsidy? The initial collector might sell the paper to a dealer who, after sorting and bailing it, has the paper collected a second time for delivery to a paper mill. Absent a subsidy, the functional identification of transactors is unnecessary: each party to a transaction is free to exchange. In the presence of a subsidy, a pre-identification procedure--some licensing scheme--becomes necessary; and to administer the subsidy, an elaborate licensee monitoring system is also necessary. Moreover, if the subsidy is injected at any point prior to actual use of the recyclable material in primary product production, there can be no assurance that the subsidy will go entirely to furthering of recycling rather than other disposal of the materials.

Although there are fewer primary product producers than there are entities that handle solid waste, thereby facilitating formal identification of points to which the subsidy will flow, the basis for awarding the subsidy remains difficult to define. Suppose that identification of a primary product producer is made. Ideally, the base for the subsidy would be the recyclable material content of his final product, for this is the only quantity of homogeneous material qualifying for the subsidy. Unfortunately, there is no way to determine from the physical and chemical characteristics of metals, paper, and glass which, if any, of the product's molecules were derived from virgin, and which from recycled materials.

The alternative is to measure inputs of recyclable materials to the primary production process. But this requires classifying of materials the physical identities of which are destroyed in the production process. Invoices and evidences of payment, which are sufficient to audit purchases and inventories of materials and supplies entering "cost of goods sold" in an income statement, or tax return, would not be adequate to distinguish between recyclable materials, which qualify for subsidy, and virgin materials, which do not. Physical identification of materials is possible only when they arrive on the premises of a qualified primary product producer; thus, administration of a recycling subsidy will require some mechanism, such as on-site inspectors, to examine materials, validate invoices, and ensure that a shipment of materials qualifying for subsidy is not resold or otherwise made eligible for resubsidization.

Now suppose that an appropriate mechanism for administering the subsidy is installed at the primary product producer level, the only practical point for injecting it. The next question is how to frame the subsidy. The subsidy might be some specific dollar amount per unit of recyclable material purchased, or it might be some percentage of the purchase price of the material. Recognizing that the purchase price of recyclable material depends on its degree of contamination and the distance it has been shipped, either of these two ways of providing the subsidy will have unintended distortionary consequences. If the subsidy is a fixed amount per unit, it will favor low-priced materials, those which are less pure and transported over shorter distances. If the subsidy is ad valorem, it will not affect the relative attractiveness of different grades of materials but it will encourage decontamination at sites other than the primary producers' premises. In either case, the subsidy causes changes in the location of activity that only increase the size and cost of the subsidy without increasing the amount of recycling.

In sum, specification of a subsidy program for recycling presents formidable problems. Injecting the subsidy at points where recyclable materials are converted into primary products minimizes these problems, but does not eliminate the need for some licensing procedure and the possible use of inspectors to monitor and to validate claims. However the subsidy is stated, whether as a specific or <u>ad valorem</u> bounty, it will induce a relocation of activity.

B. Subsidy mechanisms.

A subsidy is simply a payment by government which causes the price paid by the purchasers of a subsidized good or service to be <u>less</u> than the seller's net proceeds from the sale. As noted in Chapter 1, whether the subsidy payment goes to the seller or to the buyer, the result is the same. If the subsidy payment is to the buyer, his net outlay is less than the payment he makes to the seller. If he wishes to buy more of the now cheaper (to him) goods, he can afford to bid more to elicit additional supplies, if that is necessary, and still pay a (subsidized) price lower than he had previously. If the subsidy payment is to the seller, his profit per unit sold increases. To sell more of the now more profitable subsidized goods, he will have to exert more effort, incur some costs, or lower selling price. If a particular seller does not respond to the more profitable conditions created by the subsidy, his competitors will. Thus, whether the subsidy is handed over to the buyer or the seller, the result is an increased usage with the amount of the subsidy a "wedge" between the payment of the buyer and the net realization of the seller.

As noted in Chapter 3, the degree to which a subsidy increases usage depends upon the responsiveness of demand for, and supply of, the subsidized goods. The more responsive, or price elastic, are demand and supply, the greater the change in usage due to the subsidy. The underlying conditions in recyclables markets make these elasticities small. Most of any recycling subsidy therefore will be absorbed in higher selling cost: reduction of selling price, net of subsidy, to penetrate markets, and/or higher costs to gather and decontaminate recyclables for reuse. These conditions of demand and supply of recyclables explain why the costs noted above of recycling an additional ton of paper, or ferrous and nonferrous material, are so high. We now turn to a critical examination of proposed ways to pay recycling subsidies.

1. The two ways to effect subsidy payments.

Governments may make subsidy payments in either of two ways which are equivalent, in principle. A government may make the payment in cash: for each ton of recyclable material, the government offers to pay a transactor X dollars on submission of evidence that an exchange has occurred. Alternatively, since virtually all possible transactors are taxpayers, the government may offer to reduce a transactor's tax liabilities otherwise due by X dollars per ton of recyclable material, again on submission of evidence that an exchange has occurred. In either case, the subsidized transactor and subsidizing government end up in the same position: the transactor has X dollars more in pocket per ton (he has either received a Treasury check for X dollars, or he has reduced his tax payment by X dollars); the government has increased its deficit by X dollars (it has expended X dollars, or it has reduced Treasury receipts by X dollars).

It is important to note that, whether the subsidy is paid in cash or is cleared through a qualified transactor's tax account, the economic consequences are also the same. In effect, the government, through the agency of the qualified transactor, has "purchased" X dollars of the resources embodied in a ton of the subsidized recyclable material and given them to private persons for private use. For each ton of subsidized recyclable materials ultimately used to produce goods and services, private parties are relieved of X dollars in resource costs, which are paid for by taxpayers without regard to their consumption. The deficit of X dollars per ton subsidized will either be made-up in reduced government expenditures for other purposes, or by additional tax imposed to cover the deficit. If the subsidy is not compensated for, the net deficit will be a source of inflation, if it is monetized, or a reduction in the savings available to finance private capital formation if it is not monetized. There is no free lunch. 8/

2. Differences between tax and appropriated subsidies.

Given a definition of the activity to be subsidized and a formula for determining the amount of the subsidy, the economics of the subsidy are the same. Its effect on the volume of subsidized activity and its using-up of productive resources, will be the same whether the subsidy is financed by appropriated funds or by reductions in tax otherwise due. But there are political and administrative differences between the two methods of payment which must be considered when framing a subsidy program.

Couching the subsidy as an expenditure program involves those Congressional committees that authorize and appropriate funds for the substantive program purpose of the

If supply and demand elasticities were +1 and -1, and world markets determined the U.S. iron ore price, the increase in price would be much smaller than if supply were perfectly elastic. The U.S. accounts for about 11 percent of the world's iron ore production. Under the same method used for coal, the estimated price increase for iron ore is about one-tenth of the supply shift, or about 0.9 percent.

3. The Price of Limestone

We were not able to obtain an investment profile with which to estimate the impact of Federal tax subsidies on the supply of limestone. However, limestone also receives percentage depletion likely to be constrained by the net income limitation. It is therefore reasonable to assume that the shift in the limestone supply curve is comparable to the shift in the coal and iron ore supply curves. The estimated price change for limestone need not be precise, because limestone accounts for only a small fraction of the cost of producing pig iron.

If the limestone supply shift were within the range of the coal and iron ore supply shifts and the supply curve were perfectly elastic, removing the tax subsidies would increase the price of limestone from 8 to 12 percent. Alternatively, using supply and demand elasticities of +1 and -1, and noting that U.S. produced limestone accounts for 27 percent of world output, the central range of estimates for the limestone price increase is between 1.7 percent and 2.6 percent.

4. Determination of Pig Iron Price from Mineral Input Prices

Proportions of mineral inputs used in the production of pig iron are reported in two studies of the effects of the tax system on recycling--one by Booz-Allen and Hamilton (hereafter BAH), and the other by the Environmental Law Institute (hereafter ELI). 4/ ELI reports that manufacture of a ton of pig iron requires 1.5 tons of iron ore, .77 tons of coal, and .2 tons of limestone; BAH reports inputs of 1.20 tons of iron, .60 tons of coal, and .18 tons of limestone. ELI reports input prices of $11 per ton, $30 per ton, and $2 per ton for iron ore, coal, and limestone, respectively; BAH reports corresponding prices of $11.30 per ton, $13.76 per ton and $1.70 per ton. 5/

Table 3.2 summarizes the production cost data from the ELI and BAH studies. The last column of the Table shows the cost per ton of pig iron for each mineral input, as determined by multiplying mineral input per ton of pig iron by price per ton of mineral input.

The effect of the mineral industry tax subsidies on the price of pig iron is shown in Table 3.3. The first column of Table 3.3 reports the contribution of each mineral to the cost of one ton of pig iron. Columns 2 and 3 report central and high estimates of the additional cost of each mineral used to produce a ton of pig iron under neutral taxation of mineral industries. Columns 2 and 3 estimate the tax subsidy by multiplying the percentage price increase from removing the tax subsidy by the cost per ton under present law. The central estimates use both the central estimate of the supply shift and the central estimate of the effect of the supply shift on price. The high estimates assume that the percentage price increase equals the high estimate of the supply shift.

Table 3.3 reveals that removing the tax subsidies would increase the price of pig iron a maximum of 6.2 percent using the ELI weights, and 3.3 percent using the BAH weights. The central estimates are 2.2 percent using the ELI weights, and 0.9 percent using the BAH weights.

Table 3.2

Virgin Mineral Inputs in Production of Pig Iron Input

| Mineral | Input per ton of pig iron | Price per ton | Cost per ton of pig iron |
|---|---|---|---|
| Iron ore | | | |
| ELI | 1.50 | $11.00 | $16.50 |
| BAH | 1.20 | $11.30 | $13.56 |
| Coal | | | |
| ELI | .77 | $30.00 | $23.10 |
| BAH | .60 | $13.76 | $ 8.26 |
| Limestone | | | |
| ELI | .20 | $ 2.00 | $ 0.40 |
| BAH | .18 | $ 1.70 | $ 0.31 |

Price of Pig Iron:
ELI: $77.00
BAH: $74.07

Table 3.3

Effect of Mineral Industry Subsidies on Price of Pig Iron

| | Cost per ton | Tax subsidy per ton of pig iron | |
|---|---|---|---|
| | of pig iron | Central | High |
| Mineral | Present law | estimates | estimates |
| Iron ore | | | |
| ELI | \$16.50 | \$0.15 | \$1.50 |
| BAH | \$13.56 | \$0.12 | \$1.23 |
| Coal | | | |
| ELI | \$23.10 | \$1.50 | \$3.23 |
| BAH | \$ 8.26 | \$0.54 | \$1.16 |
| Limestone | | | |
| ELI | \$ 0.40 | \$0.01 | \$0.05 |
| BAH | \$ 0.31 | \$0.01 | \$0.04 |
| Sum | | | |
| ELI | | \$1.66 | \$4.78 |
| BAH | | \$0.67 | \$2.43 |
| Sum as percentage of pig iron price | | | |
| ELI | | 2.2% | 6.2% |
| BAH | | 0.9% | 3.3% |

The method used here overstates the increase in the pig iron price, because it assumes that physical ratios of minerals and other inputs used to produce pig iron are insensitive to price changes. If these ratios respond to price changes, producers will shift to relatively lower cost inputs if the tax subsidies to minerals are ended. Thus, prices will rise by less than the weighted sum of the change in minerals prices using current law input proportions.

<u>Effect of Pig Iron Price on Steel Recycling</u>

The impact of pig iron price changes on the amount of recycling of scrap steel can be estimated using Equation (3.6) derived in the Appendix to this chapter. The effect on scrap recycling of a pig iron price change is larger for higher values of the elasticity of supply of scrap and the cross-elasticity of demand for scrap, and for lower absolute values of the elasticity of demand for scrap.

ELI has estimated econometric models of supply and demand for scrap. [6/] The cross-elasticity of scrap demand was estimated to be 0.28. The supply elasticity was estimated to be 1.12. However, this estimate includes the supply of scrap from all sources. The supply of home and prompt scrap is very inelastic at the margin, because its low collection costs allow it to be recycled at almost any positive scrap price. Increases in recycling of post-consumer scrap account for most of the supply response to the price change. When considering the percentage change in post-consumer scrap alone, the elasticity is higher--2.32, in ELI's estimate. Finally, ELI estimates the demand elasticity for scrap steel to be -0.63.

Research Triangle Institute (RTI) has estimated supply elasticities for scrap steel ranging from 0.3 to 1.0 by a method called "process analysis," which uses engineering data. [7/]

For our upper bound estimate of the amount of recycling, we use values of 2.32, 1.0, and -0.63 for the supply elasticity, cross-elasticity of demand, and own-price elasticity of demand, respectively. For the central estimate, we use ELI's estimates for all scrap: 1.12, 0.28, and -0.63. ELI's supply elasticity estimate is close to the upper bound value reported by RTI. With these elasticities, we estimate a percentage increase in recycling of from 17.9 percent to 78.6 percent of the percentage increase in the pig iron price.

Combined Effect of Mineral Subsidies on Scrap Steel Recycling

We combine the upper bound and central estimates of the pig iron price change with the upper bound and central estimates of the effects of that price change on recycling, to estimate the effect of all virgin mineral tax subsidies on scrap steel recycling. The upper bound estimate is that scrap post-consumer steel recycling would increase by 4.9 percent if the tax subsidies were removed (the tax subsidies reduce post-consumer scrap steel recycling by 4.7 percent.) If the supply elasticity for all scrap steel is used (1.12 instead of 2.32), the upper bound estimate is 2.3 percent. The central estimate is less than 0.5 percent.

It is important to note that the upper bound estimates, while not large, are probably greatly exaggerated. The large difference between the upper bound and central estimates reflects considerable uncertainty about the elasticity parameters. For this reason, the central estimate cannot be considered precise. However, the upper bound estimate is based on the most extreme assumptions that might yield an estimate of a large effect.

In computing the upper bound estimate, it was assumed that: 1) supply curves for the relevant minerals are totally elastic, 2) the shift in the supply curves is at the upper range of our estimates, 3) there is no substitutability among input minerals used to produce pig iron, 4) the higher of the ELI and BAH estimates of the effect of mineral prices on the pig iron price is the correct one, and 5) the responsiveness of scrap demand to pig iron prices is about four times the elasticity estimated by ELI. Modifying any one of these assumptions would reduce the estimated impact considerably. For this reason, it is extremely unlikely that the tax subsidies could reduce the amount of recycling of scrap steel by more than one percent.

## IV. Scrap Copper Recycling

The output of a copper concentrator, including the stages of production of mining and concentration is eligible for percentage depletion. Scrap copper is a very close substitute for virgin blister copper. ELI estimates that blister copper is about 20 percent more expensive than copper concentrates; thus, percentage depletion applies to about 5/6 of the value of the virgin copper product that competes with recyclable copper. It is reasonable to assume that the virgin and scrap products are perfect substitutes.

### The Price of Copper

The tax preferences to mining of virgin copper provided by percentage depletion and expensing of exploration and development costs lower the supply curve of copper by about 10 percent. Thus, removing the tax subsidies would raise the supply curve for copper concentrates by about 11.1 percent.

Because copper concentrates represent about 5/6 of the value of blister copper, removing the subsidies would raise the supply curve for blister copper by 9.3 percent.

Supply and demand elasticities are available from an econometric study by Fisher, Cootner and Baily of the world copper industry. [8/] The study estimates long-run elasticities of 1.67 for supply of primary copper, -0.867 for demand for copper, and 0.32 for supply of scrap copper.

Using equation (3.3) from the Appendix to this chapter, and using the Fisher, Cootner, and Baily elasticity estimates, a 9.3 percent upward shift in the supply curve for blister copper implies a 6.1 percent increase in the price. This estimate is biased upwards, however, because the domestically produced virgin copper affected by the subsidies accounts for only a fraction of total supply; the U.S. accounts for about only 22 percent of world copper output. Scrap production also affects the price of copper, but it is not curtailed by removing the subsidy to virgin materials. Taken together, these factors imply that the price increase could be significantly less than the upper bound estimate of 6.1 percent. Application of the methodology in the Appendix to adjust only for the effect of international trade on the price change reduces the estimated increase in copper price to 2.8 percent.

Recycling of Scrap Copper

The increased recycling of scrap copper resulting from an increase in price is computed by multiplying the estimated percentage price change by the estimated supply elasticity of scrap (0.32). This formula yields an upper bound estimate of increased recycling of 2.0 percent and a central estimate of 0.9 percent.

Thus, the current Federal tax subsidies to copper mining appear to have little deterrent effect on the amount of recycling of scrap copper.

V. Wastepaper Recycling

Wastepaper competes with virgin wood pulp as an input to a wide variety of paper industry products. By lowering the cost of woodpulp, the tax subsidies to the timber industry create a bias against the use of recycled paper; however, their effect on recycling is small.

Compared to tax subsidies to the minerals industry, the tax subsidies to the timber industry are very large. However, the subsidies are not a major impediment to recycling for two reasons: 1) the small share of timber in the cost of supplying woodpulp to primary product production, and 2) the relative insensitivity of wastepaper recycling to changes in relative prices.

Effect on the Price of Woodpulp

Chapter 2 showed that the tax preferences lower the cost of growing timber by between 35.7 and 43.4 percent. Removing these subsidies would shift the supply curve for timber upward by from 55.5 percent to 76.7 percent.

The increase in the price of timber, however, may be considerably smaller than the supply curve shift from removing the subsidies. Timber land is generally inferior land, not suitable for most agricultural uses. Were the tax subsidies removed, growing timber might still be the best use for this land. In that event, removing the tax subsidies would lower the value of timber land, without affecting timber output and price. At the margin, there are undoubtedly some areas where timber growing does substitute for other uses, and where patterns of land use would change if the tax subsidies were removed. Therefore, in the long run, timber prices would increase to some degree if tax policy changes caused the private costs of growing timber to increase. 9/ However, it has not been possible to quantify the extent to which the tax changes would alter prices and output, and the extent to which they would only affect the value of timber land.

As noted in Chapter 2, reducing the tax preference to capital income from timber growing would shorten the optimal rotation period for timber stands. The immediate effect of this change could be an acceleration of timber cutting and an increase in the available supply of virgin woodpulp. However, the earlier harvest would mean a reduction in future supplies and a further reduction would occur if land were converted from timber growing to other uses.

The extremely long production period for timber products makes it very difficult to a infer long term relationship between changes in timber prices and changes in output from historical data. Absent available statistical studies that can be cited with even a minor degree of confidence, it is assumed that the reduction in the Federal subsidy to timber growing from removing the tax subsidies increases the price of standing timber by the full amount of the supply curve shift. This assumption provides a maximum estimate of the disincentives to recycling from timber tax subsidies. The reader should note that removing the tax subsidies may lower the price of virgin woodpulp in the short run, and may increase price in the long run by much less than is shown below.

Under this upper bound assumption, ending the tax subsidies would increase the price of timber by at most 76.7 percent. According to estimates supplied by ELI, timber accounts for between 6 and 12 percent of the price of virgin woodpulp. Thus, removing the tax subsidies could increase the price of woodpulp by as much as 9.2 percent, if there were no substitutability in production. Even if the price of timber rises by the full amount of the increase in growing cost, the increase in the price of woodpulp could still be as little as 3.3 percent (6 percent of a 55.5 percent increase in the timber price).

Effect on Recycling

It is possible to process wastepaper so that it is equivalent to paper made from virgin woodpulp. It is usually more expensive to manufacture paper of any quality from recyclable sources; therefore, wastepaper is sold to users who do not require an exact duplication of the characteristics of paper made from virgin woodpulp. For this reason, existing econometric studies of the market for recycled paper have treated wastepaper and virgin paper as distinct, though related goods.

ELI has estimated the demand and supply for wastepaper. Their estimated elasticities are: 0.40 for elasticity of supply of wastepaper, 0.17 for cross-elasticity of demand for wastepaper (with respect to woodpulp price), and -0.16 for elasticity of demand for wastepaper (with respect to wastepaper price). RTI estimates the elasticity of supply to be between 0.4 and 1.7, using process analysis. Equation (3.6) in the Appendix and the ELI elasticities imply that recycling would increase by 12 percent of the increase in the price of woodpulp. Because, as noted, removing the tax subsidies would increase the price of woodpulp by at most 9.2 percent, this would yield an increase in recycling of at most 1.2 percent. If RTI's highest supply elasticity is combined with all the other upper bound estimates, removing the tax subsidies could increase recycling by 1.4 percent.

ELI's econometric equations show low elasticities of demand and supply for wastepaper. While these estimates are consistent with the casual observation of low substitutability between wastepaper and virgin pulp, they may be biased downwards because of poor data in the estimating equations. In particular, the price data, based on list price, might not adequately capture changes in real transactions prices. However, even elasticity values substantially higher than those estimated by ELI do not lead to a conclusion that removing the tax subsidies would dramatically increase recycling. For example, if the relevant parameters were assumed to be 0.8 for the cross-elasticity of demand, 0.5 for the supply elasticity, and -0.5 for the demand elasticity, the percentage increase in recycling might be 31 percent of the increase in the woodpulp price, or a maximum of 3 percent above current law levels.

## VI. Conclusions

The quantitative impact of tax subsidies to virgin materials on the amount of recycling is uncertain, because the probable responsiveness of suppliers and users to changes in prices of virgin and scrap materials has not been quantified precisely. Nonetheless, illustrative calculations using the best available evidence show that current Federal tax subsidies to virgin materials do not have a major negative effect on recycling of scrap steel, scrap copper, and wastepaper under the most extreme assumptions, and most probably have very little effect. Similar conclusions have been reported in research performed by independent contractors for EPA, some of whose methodology and data have been used in this chapter. [10/]

However, these conclusions do not mean that tax subsidies to virgin materials production are insignificant. The tax preferences reviewed in Chapter 2 entail important equity concerns, and may also have a considerable impact on domestic output of some virgin materials. These effects, however important, are not a concern of this report.

## Footnotes to Chapter 3

[1/] A similar type of computation has been made by the Environmental Law Institute (hereafter referred to as ELI) in a study performed under contract to the U.S. Environmental Protection Agency. ELI's estimates of the impact of tax subsidies on the supply price differ from those developed in Chapter 2. This chapter combines the supply price effects from Chapter 2 with ELI's and alternative econometric estimates of supply and demand elasticities. See Robert C. Anderson and Richard D. Spiegelman, The Impact of The Federal Tax Code on Resource Recovery, report prepared at Environmental Law Institute for Office of Research and Development, U.S. Environmental Protection Agency, 1976.

[2/] If the price of an input is lowered by "x" percent by a tax subsidy, then it has become (1-x) times the initial price. Removing the subsidy would then raise the price by "x/(1-x)" percent of the post-subsidy price.

[3/] A demand elasticity of -1 implies that the total value of coal consumption would be unchanged for small changes in the price because the percentage increase in the price per unit would be matched by an equal percentage reduction in the quantity consumed. Absent available econometric estimates of the long run demand for coal, this assumption is reasonable; it falls within the range of demand elasticities estimated for other minerals.

A much higher value is used for the supply elasticity because accessible coal reserves are abundant and, in the long run, more coal could probably be mined without a substantial increase in unit costs. However, no long run supply elasticities for coal are available in the literature surveyed. A recent study by Charles River Associates (CRA) provides estimates of short run elasticities ranging from 0.33 to 2.36. The value used here is twice the maximum short run elasticity estimated by CRA. See Charles River Associates, Coal Price Formation, final report prepared for Electric Power Research Institute, December 1977.

If the supply elasticity is lower than the value used in these calculations, then the tax subsidies have a smaller effect on the price of coal and, hence, a smaller negative impact on recycling of scrap steel.

4/ Booz-Allen and Hamilton, An Evaluation of the Impact of Discriminatory Taxation on the Use of Primary and Secondary Raw Material, final report submitted to Environmental Protection Agency, Washington, D.C., June 28, 1974, and Robert C. Anderson and Richard D. Spiegelman, op. cit.

5/ The two studies use price data from different years, and production estimates from different sources.

6/ See Robert C. Anderson and Richard D. Spiegelman, op. cit. See also Robert C. Anderson and Richard D. Spiegelman, "Tax Policy and Secondary Material Use," Journal of Environmental Economics, volume 4, Number 1, March 1977.

[7/] A.K. Miedema, An Empirical Evaluation of the Market and Net Welfare Effects of A Product Disposal Charge, Research Triangle Institute (RTI), December 1977. For a review of the RTI work and other studies estimating supply elasticities for recyclable inputs, see ICF Incorporated, Estimates of Substitution and Supply Elasticities for Post-Consumer Waste Materials, draft report submitted to U.S. Environmental Protection Agency, August 11, 1978.

[8/] F. Fisher, P. Cootner, and N. Baily, "An Econometric Model of the World Copper Industry," Bell Journal of Economics and Management Science, August 1972.

[9/] In technical terms, if the supply curve were totally inelastic (i.e., timber output were unchanged if timber prices changed), removing the tax subsidies would simply lower the value of timber land. If, on the other hand, the supply curve were totally elastic, the price would increase by the full amount of the estimated cost increase.

[10/] See Environmental Law Institute, op. cit and Booz-Allen, Hamilton, op. cit.

# Chapter 4
## Recycling Subsidy Options

### I. Justifications commonly cited for subsidizing recycling activities.

Solid waste management involves two distinctive activities. First, collecting the debris of production and consumption; second, physically disposing of it by landfill or incineration, or subjecting it to some form of resource recovery process and then disposing of the residual solid waste. Both sets of solid waste management activities are subject to competitive conditions. The technologies for collection and for processing solid waste are widely known, and entry into these activities is not barred by patents. The resources required, labor and capital, have no limiting specialized characteristics. While there may be economies of scale in both sets of waste management activities, in neither does the condition of natural monopoly prevail. [1/]

If the activities of waste collection and processing fulfill the conditions of competitive markets, there is no *a priori* justification for public subsidies to any of these activities. However, proponents of resource recovery, including recycling, cite one or more of the following four justifications for subsidizing resource recovery from solid waste: it relieves communities of some solid waste management costs; it reduces environmental degradation; it offsets price-distorting effects of tax subsidies to virgin materials production; and it conserves finite resources and energy. We turn now to a critical review of these rationales for subsidizing resource recovery from solid waste.

A. Reduction in the burden of solid waste management borne by local governments.

In its Fourth Report to Congress: Resource Recovery and Waste Reduction, the Environmental Protection Agency has estimated that 134.8 million tons of municipal solid waste was disposed of in the United States in 1974 at an estimated total cost of nearly $4 billion. A major but unquantified fraction of this cost is financed by municipally operated collection and disposal systems; and a significant fraction, again unestimated, of the municipally controlled waste management is financed by general taxes. [2/] Disposing of the waste in an environmentally acceptable manner would have cost an estimated $1.6 billion more. The volume of municipal solid waste has been growing at an estimated annual rate of 1.9 percent, and will reach 166 million tons by 1985.

Although these facts indicate that solid waste disposal absorbs large amounts of resources, by themselves, they provide no basis for subsidizing recycling activities:

--Some local governments, with the consent of their voters, undertake solid waste management tasks and finance them by local taxes; others undertake the tasks and finance them with fees; still others contract with private firms and finance the work by appropriations from the general fund, or by fee assessments. In all these cases, communities decide how they wish to have solid waste management services performed and financed. Federal government subsidies which would reduce the costs of solid waste management merely transfer that burden from those who generate the waste to Federal taxpayers. If communities elect to have their governments perform services on their behalf and to finance them by taxes and fees, the resultant burdensome taxation is not a valid claim to Federal subsidy that would relieve these burdens. 3/

--The evidence does not support a conclusion that municipal solid waste management is any more a financing problem for local governments than other categories of expenditure. Even if the estimated $4 billion cost of solid waste management in 1974 were borne entirely by local governments, which was not the case, and we add to this the estimated $1.6 billion of unmet environmental protection costs, the total would be only 4 percent of all local governmental expenditures that year. Moreover, while local government expenditures have increased at an annual rate of 11 percent during the last decade, the inflation-adjusted rate of increase in municipal solid waste costs is but 3.5 percent.

B. Reduction in environmental degradation.

The Environmental Protection Administration has estimated that 92 percent of municipal solid waste in the United States is disposed of by landfill and more than two-thirds of land disposal sites do not meet environmental standards. These estimates imply that, under present conditions, waste disposal imposes a sizable social cost in degradation of the environment. As noted, it would have cost annually $1.6 billion (in 1974 dollars) to conform disposal systems to environmental standards. If the volume of waste requiring disposal could be reduced to zero by resource recovery, not only would the $1.6 billion of unmet environmental losses suffered by society be saved, but also the actual disposal costs incurred that year, estimated to be

$500 million. [4/] While subsidies to recycling cannot reduce disposal to zero, they can contribute to some reduction, and hence to a reduction in environmental damage.

The evasion of environmental laws in the disposal of solid waste by communities is deplorable, but does not warrant assumption by Federal taxpayers of the burden of maintaining local environmental quality through the funding of subsidies to recycling. Not only does a recycling subsidy violate the "polluter pays" principle, it does so in a costly manner. If the polluter pays principle is to be breached, the least costly way for the Federal government to assume some or all of the cost of environmental maintenance is directly, through grants or similar payments to local governments, per ton of waste collected; this payment might then be used by those governments <u>either</u> for disposal of solid waste in an environmentally acceptable manner, <u>or</u> for building and operating resource recovery facilities. To subsidize resource recovery generally, or recyclable materials only, is to bias unnecessarily the choice among disposal options. When environmentally acceptable disposal is cheaper, as it is in most places in the United States, to encourage resource recovery is a waste of scarce labor and capital resources.

Moreover, for reasons detailed in Chapters 1 and 3, the incremental cost per ton removed from the solid waste stream by a subsidy to recycling only is extremely high and rises rapidly as the volume to be removed from the waste stream increases. In 1974, the average disposal cost of municipal solid waste was estimated to be less than $4 per ton, and if all disposal had conformed with environmental standards, that cost might have increased by an average of $1.19. In contrast, the estimated <u>subsidy cost</u> of removing an additional ton of paper from the municipal solid waste stream is $395; a ton of ferrous scrap, $120 to $185; and a ton of copper scrap, $4,720. [5/] These estimates pertain only to removal of additional tonnages in the range of one or two percent of the quantities currently recycled and, hence, to even smaller fractions of municipal solid waste. Removing more would rapidly escalate these costs per ton.

In sum, avoidance of environmental degradation costs affords no basis for Federal subsidy to recycling. Nonetheless, if a Federal subsidy to local communities is to be provided to help them meet their obligations to maintain environmental quality while disposing of their solid waste in violation of the polluter pays principle, it should be provided at the point where collected municipal solid waste is available for disposal, whether by landfill, incineration, or resource recovery processing. Such a direct subsidy to local communities conditional on their avoidance of environmental damage in the disposal of solid waste will cost less than 0.1 to 1.0 percent of a subsidy to recycling for the same purpose.

C. Offset to price-distorting effects of tax subsidies.

Chapter 2 reviewed the Internal Revenue Code provisions that create a preference, or subsidy, for the production of virgin materials. Although many observers conclude that these subsidies justify compensatory subsidies to recyclable materials, Chapter 3 notes that the claim for compensatory subsidy assumes that subsidies to the domestic production of virgin materials results in lower prices of those materials and, thus, reduces demand for recyclable materials. But the degree to which domestic prices of virgin materials are reduced by production subsidies depends upon the character of world markets for these materials and the relative importance of U.S. consumption and production in those markets. Moreover, the induced reduction in demand for recyclable materials associated with any depression of virgin materials prices attributable to U.S. subsidies is greatly attenuated by the far less than perfect degree of substitutability of recyclable for virgin materials in production of the full spectrum of primary products derivable from these materials.

In sum, leaving aside the question, not dealt with in this report, whether subsidies for the domestic production of virgin materials is a justifiable governmental intervention in the allocation of scarce labor and capital resources, the evidence available does not support an inference that these subsidies, by their effect on domestic virgin material prices, deter resource recovery from solid waste to a degree that warrants a countervailing subsidy. For the three significant recyclable materials examined--ferrous scrap, copper and paper--the probable deterrence to recycling attributable to virgin material subsidies is in the range of 0.5 to 1.0 percent of the volume recycled. This is not a magnitude sufficient to warrant installing a countervailing subsidy program which is likely to have serious administrative problems, as discussed below. (See Section II, A, below).

D. Conservation of "finite" resources and energy.

1. Finite resource conservation.

It is a truism that the earth's resources are finite, and it follows from this that if present generations "use-up" high-grade ores and other nonrenewable resources constituting the earth's crust, succeeding generations will have less. This being so, the argument continues, we should recover resources from solid waste for the benefit of future generations. Since much of the solid waste stream is presently disposed of, not processed as a source of material and energy, a strong case is therefore alleged to exist for subsidizing resource recovery. The extra resources invested in recycling by the present generation is to preserve for future generations their claim to the earth's resources.

There are three weak links in this chain of reasoning to justify a subsidy to resource recovery activities. First, although the earth's crust is "finite" it is vast. So little of it has been thoroughly surveyed geologically, no one can with reasonable confidence estimate its useful resource content. Unmeasured "finiteness" is not a satisfactory reason to constrain current rates of economic utilization of the natural endowment.

Second, living standards are determined by the stock of human and physical capital that embody the store of knowledge, as well as by the natural endowment. Growth in the stock of physical capital, and in its productivity, as well as accretion of knowledge--enhanced productivity of human capital--together substitute for depleting natural resources. The available evidence suggests that not only has the real cost of extracting minerals in the United States declined, but that the decline in cost of extraction is greater than the decline in real costs of other production. [6/] All this has occurred over the last century notwithstanding the fact that the grades of most ores exploited have declined. [7/]

Finally, it is not correct to assert that claims of future generations are unaccounted for in decisions made today. Individuals consume and save today according to their judgment of future needs. Each generation comprises persons of all ages; thus, each "generation" makes decisions that span an average of two or more decades, linking generations to each other in infinite sequence. Moreover, enterprises that make production decisions for a full spectrum of economic activities ranging from mining and forestry to retailing of consumer goods organize as corporations in order that they may operate with extremely long planning horizons. Well organized markets exist through which households and enterprises may execute their decisions spanning decades; these are called "capital markets" in which present claims are exchanged for future claims.

If, say, copper-trading enterprises believed that the world were in danger of running out of low cost ores, they would restrict current sales, preferring to hold inventories in the ground and in warehouses rather than to sell at current prices. If the cost of acquiring funds in capital markets is 10 percent, anyone who supposes the future growth in price of materials will be greater than 10 percent, compounded, will withhold current available supplies, raising current prices of the materials to "reflect the claims" of future consumers. Additionally, enterprises in the copper business will invest (acquire present claims to resources in capital markets in exchange for promises to make future payments) in finding new ore deposits and in reducing the cost of extracting and processing ores from existing deposits. While some contend that the market rate of discount which functionally links present and future generations is too high, *i.e.*, discounts future claims too much, this does not mean that the claims of future generations are disregarded.

In sum, the apparent finiteness of natural resources provides no compelling argument for expending society's scarce resources in a subsidized level of resource recovery. We don't know the magnitude of resources in the earth's crust; we continue to increase the rate at which we learn to extract useful minerals from rock; and we already have a reasonably useful mechanism for adapting current use of natural resources to likely future demands.

2. Energy conservation.

The energy conservation rationale for subsidizing resource recovery is based on the observation that the number of Btu's, or barrels of oil-equivalent energy, required to produce a unit of primary product--metal, paper, glass--from virgin materials exceeds the energy required to produce the same unit from recyclable materials. If we subsidize resource recovery, we save Btu's of energy.

There is some validity in this argument, but it rests on an inference that the effect of our oil, gas, and electric energy price controls is to cause the market prices of energy to be understated. If that inference is correct, then reducing usage of energy by one Btu saves more resources than is implied by the "saving" measured at the present market prices of energy. That is, the relative attractiveness of using recyclable materials, which embody less energy, is understated by the underpricing of energy.

On the other hand, there are reasons to believe that the inefficiencies of price regulation make energy prices higher than they would be in the absence of regulation: "rate of return" regulation of utility prices induces too capital intensive modes of electric energy generation and distribution; oil and gas price regulation has increased the costs of finding, processing, and distributing this form of energy so that what has been gained by suppressing prices at the well-head may be largely offset by increased costs elsewhere in the system. It is doubtful that mispricing of energy measurably biases choices against resource recovery; therefore, saving a Btu of energy through recycling does not result in a resource saving not already accounted for in the choice to recycle, rather than dispose of solid waste.

Energy is not some special resource external to the economic system, but simply an embodiment of capital, labor and the natural endowment in a particularly useful form. Economic policy should aim to minimize the total cost of production to improve our standard of living. We gain nothing by substituting an extra dollar's worth of resources in recycling material in order to save less than a dollar's worth of costs, whether those costs are for society's labor and capital in the form of energy, or other inputs. If it pays to recycle, one of the reasons it pays is that, among other things, recycling uses less energy. If, despite its lesser energy use, recycling does not pay, the energy saving due to recycling is irrelevant.

Summary.

If a subsidy corrects a failure of markets to allocate resources efficiently, it yields society a net gain. That is, should social valuation of the output of the economic system fail to be reflected in market prices, or should the costs of resources consumed in production fail to be accounted for by enterprises engaged in production, or should there be a barrier to utilization of least costly technology, government intervention to correct these failures results in a net benefit--increased standard of living. In such instances, the apparent cost of a subsidy financed by taxes is offset, in part or in whole, by a larger value of goods and services.

There are no glaring <u>market failures</u> which might be offset effectively by subsidies to recycling, or resource recovery.

--Solid waste management, recycling, and resource recovery are activities not characterized as natural monopolies. Technologies are widely known, and there are no market economies of scale or institutional barriers that limit entry. Recycling and resource recovery will take place whenever value of product justifies incurring production costs.

--Although municipalities frequently fail to price solid waste collection services to equate costs and benefits at the points where solid waste collection occurs, this is an exercise of constitutional rights reserved to states, not a manifestation of market failure.

--Although there are numerous instances in which solid wastes are disposed of in an environmentally unacceptable manner, these are failures to comply with Federal, state, and local environmental standards, not market failures.

--Although there are tax subsidies to virgin material production which reduce imports of certain materials and increase exports of others, recycling and resource recovery are not appreciably deterred. Additional subsidy to recycling therefore would not avoid resource wastage due to existing tax subsidies.

--There is no persuasive argument that markets for natural resources, including those convertible into energy, do not account for present and expected future scarcity.

In sum, subsidies to recycling and resource recovery do not ensure a more efficient allocation of resources. Instead they are likely to reduce total social welfare by devoting too many resources to recycling compared with the benefits received and too few resources to more economical means of waste disposal.

II. Considerations in the formulation of a subsidy to recycling.

Notwithstanding the absence of a justification for subsidizing recycling on the ground of improved overall allocation of society's resources of labor and capital, noneconomic considerations compel many to support institution of a system of recycling subsidies. Personal belief in a "conservation ethic" is a sufficient reason for some to urge public support for more recycling of solid waste than is justified on pure cost-benefit grounds. Others, engaged in the recycling process, have a pardonable pride in their activities, and they seek public recognition and support to expand their sphere of interest.

The remainder of this chapter reviews the issues in formulating a subsidy program to increase the recycling of solid waste: definition of the activity to be subsidized; the form of the subsidy; and how resolution of these questions interacts with the structure of activities engaged in recycling to determine the ultimate cost of achieving the declared objective.

A. Definition of recycling activities.

"Recycling" describes a process in which material things which have become worthless and therefore disposable are converted into materials usable in the production of things which do have value. Recycling is often thought to be restoration of the contents of trashbins and garbage pails to flows of raw materials, and this is the view taken in this report. But, for the purpose of evaluating a subsidy program, this is an over-simplified view of the way raw materials that have been fashioned into products move through the economic system.

Consider the variety of choice-paths that exist at each stage of the economic process. At the primary production stage referred to in Chapter 1, defective batches may become home scrap and reprocessed, or they may be salable, at lower prices, for use in less demanding product fabrication. At the fabrication stage, the same choice prevails for defective products: they may be salable as "seconds," they may be reworked, or they may be thrown in the trash pile. Similarly, when the first purchaser of a product finishes with his principal use of it, he may put it to secondary use--relegate his older car to utility use, add books and periodicals he has completed reading to his library shelves--or he may sell it to a dealer, or he may throw it into a trash heap, paying someone to collect it. Second-hand dealers may recondition articles for resale, discarding more or less of the original material in the process, or they may hold them in inventory for future resale. Finally, once the collectors of trashbins and garbage pails have acquired the contents, the choices available include processing the solid waste into recyclable materials, useful energy, and, possibly, other products, or disposing of the original volume. Even the resource recovery activity will generate solid waste, and this may be held in a kind of slag heap awaiting further processing, or it may be disposed of.

This diversity of paths traced by ultimately recyclable materials through the economic system raises two issues. First, in addition to the direct costs of a subsidy to increase recycling, a considerable additional indirect cost will be incurred that is in conflict with the conservation ethic; and second, the pragmatic difficulty of identifying both the agents to whom the subsidy will be paid, and the base on which the amount of subsidy will be computed.

1. Additional indirect costs of a recycling subsidy.

If, at all stages from primary production through consumption, there are choices between some continued use of a semi-finished product or finished good, or discarding it, subsidization of recycling will discourage continued use. When "seconds" and reconditioned products are made more valuable as grist for the recycling process, they will more readily be entered into solid waste streams. The "useful life" of products will be shortened by the introduction of a recycling subsidy. Thus given, a standard of living, one of the results of a recycling subsidy will be a tendency to increase the volume of solid waste generated. Part of the recycling subsidy therefore will be absorbed in more primary product production to sustain a given standard of living than would occur without the subsidy. The increased primary product production will induce an increase in virgin material usage that will offset some of the conservation achieved by recycling. Subsidizing recycling *per se* also discourages general resource recovery, including conversion of waste into useful energy. Thus, a subsidy policy narrowly aimed toward encouraging recycling of materials to replace virgin materials causes an induced waste of resources. The wasted resources include natural resources as well as capital and labor.

2. Identifying the agents and base for a recycling subsidy.

But, more importantly, the large numbers of transactors involved in the process affected by a recycling subsidy, and the variety of interrelated decisions that would be affected, implies a severity of operational administrative problems seldom given attention by recycling subsidy proponents. Given the objective of a recycling subsidy, the least ambiguous set of activities engaged in the process, and also one comprising the fewest economic units, is that in which recyclable material is incorporated into a primary product. To simply recount the numbers of trash collectors, dealers and brokers in "scrap," and reconditioners and salvagers of articles, and to consider the numbers of transactions which may be consummated between the discard of solid waste and its ultimate conversion into reusable material should be sufficient to disqualify any of these preliminary stages of the recycling process from consideration as feasible points at which to interject a subsidy.

For example, suppose the subsidy is $5 per ton of paper. If the subsidy is paid to the collector, how may it be ascertained that the collection is only from the waste discarder, and not a second collection of the same paper already bearing a $5 subsidy? The initial collector might sell the paper to a dealer who, after sorting and bailing it, has the paper collected a second time for delivery to a paper mill. Absent a subsidy, the functional identification of transactors is unnecessary: each party to a transaction is free to exchange. In the presence of a subsidy, a pre-identification procedure--some licensing scheme--becomes necessary; and to administer the subsidy, an elaborate licensee monitoring system is also necessary. Moreover, if the subsidy is injected at any point prior to actual use of the recyclable material in primary product production, there can be no assurance that the subsidy will go entirely to furthering of recycling rather than other disposal of the materials.

Although there are fewer primary product producers than there are entities that handle solid waste, thereby facilitating formal identification of points to which the subsidy will flow, the basis for awarding the subsidy remains difficult to define. Suppose that identification of a primary product producer is made. Ideally, the base for the subsidy would be the recyclable material content of his final product, for this is the only quantity of homogeneous material qualifying for the subsidy. Unfortunately, there is no way to determine from the physical and chemical characteristics of metals, paper, and glass which, if any, of the product's molecules were derived from virgin, and which from recycled materials.

The alternative is to measure inputs of recyclable materials to the primary production process. But this requires classifying of materials the physical identities of which are destroyed in the production process. Invoices and evidences of payment, which are sufficient to audit purchases and inventories of materials and supplies entering "cost of goods sold" in an income statement, or tax return, would not be adequate to distinguish between recyclable materials, which qualify for subsidy, and virgin materials, which do not. Physical identification of materials is possible only when they arrive on the premises of a qualified primary product producer; thus, administration of a recycling subsidy will require some mechanism, such as on-site inspectors, to examine materials, validate invoices, and ensure that a shipment of materials qualifying for subsidy is not resold or otherwise made eligible for resubsidization.

Now suppose that an appropriate mechanism for administering the subsidy is installed at the primary product producer level, the only practical point for injecting it. The next question is how to frame the subsidy. The subsidy might be some specific dollar amount per unit of recyclable material purchased, or it might be some percentage of the purchase price of the material. Recognizing that the purchase price of recyclable material depends on its degree of contamination and the distance it has been shipped, either of these two ways of providing the subsidy will have unintended distortionary consequences. If the subsidy is a fixed amount per unit, it will favor low-priced materials, those which are less pure and transported over shorter distances. If the subsidy is <u>ad valorem</u>, it will not affect the relative attractiveness of different grades of materials but it will encourage decontamination at sites other than the primary producers' premises. In either case, the subsidy causes changes in the location of activity that only increase the size and cost of the subsidy without increasing the amount of recycling.

In sum, specification of a subsidy program for recycling presents formidable problems. Injecting the subsidy at points where recyclable materials are converted into primary products minimizes these problems, but does not eliminate the need for some licensing procedure and the possible use of inspectors to monitor and to validate claims. However the subsidy is stated, whether as a specific or <u>ad valorem</u> bounty, it will induce a relocation of activity.

B. Subsidy mechanisms.

A subsidy is simply a payment by government which causes the price paid by the purchasers of a subsidized good or service to be <u>less</u> than the seller's net proceeds from the sale. As noted in Chapter 1, whether the subsidy payment goes to the seller or to the buyer, the result is the same. If the subsidy payment is to the buyer, his net outlay is less than the payment he makes to the seller. If he wishes to buy more of the now cheaper (to him) goods, he can afford to bid more to elicit additional supplies, if that is necessary, and still pay a (subsidized) price lower than he had previously. If the subsidy payment is to the seller, his profit per unit sold increases. To sell more of the now more profitable subsidized goods, he will have to exert more effort, incur some costs, or lower selling price. If a particular seller does not respond to the more profitable conditions created by the subsidy, his competitors will. Thus, whether the subsidy is handed over to the buyer or the seller, the result is an increased usage with the amount of the subsidy a "wedge" between the payment of the buyer and the net realization of the seller.

As noted in Chapter 3, the degree to which a subsidy increases usage depends upon the responsiveness of demand for, and supply of, the subsidized goods. The more responsive, or price elastic, are demand and supply, the greater the change in usage due to the subsidy. The underlying conditions in recyclables markets make these elasticities small. Most of any recycling subsidy therefore will be absorbed in higher selling cost: reduction of selling price, net of subsidy, to penetrate markets, and/or higher costs to gather and decontaminate recyclables for reuse. These conditions of demand and supply of recyclables explain why the costs noted above of recycling an additional ton of paper, or ferrous and nonferrous material, are so high. We now turn to a critical examination of proposed ways to pay recycling subsidies.

1. The two ways to effect subsidy payments.

Governments may make subsidy payments in either of two ways which are equivalent, in principle. A government may make the payment in cash: for each ton of recyclable material, the government offers to pay a transactor X dollars on submission of evidence that an exchange has occurred. Alternatively, since virtually all possible transactors are taxpayers, the government may offer to reduce a transactor's tax liabilities otherwise due by X dollars per ton of recyclable material, again on submission of evidence that an exchange has occurred. In either case, the subsidized transactor and subsidizing government end up in the same position: the transactor has X dollars more in pocket per ton (he has either received a Treasury check for X dollars, or he has reduced his tax payment by X dollars); the government has increased its deficit by X dollars (it has expended X dollars, or it has reduced Treasury receipts by X dollars).

It is important to note that, whether the subsidy is paid in cash or is cleared through a qualified transactor's tax account, the economic consequences are also the same. In effect, the government, through the agency of the qualified transactor, has "purchased" X dollars of the resources embodied in a ton of the subsidized recyclable material and given them to private persons for private use. For each ton of subsidized recyclable materials ultimately used to produce goods and services, private parties are relieved of X dollars in resource costs, which are paid for by taxpayers without regard to their consumption. The deficit of X dollars per ton subsidized will either be made-up in reduced government expenditures for other purposes, or by additional tax imposed to cover the deficit. If the subsidy is not compensated for, the net deficit will be a source of inflation, if it is monetized, or a reduction in the savings available to finance private capital formation if it is not monetized. There is no free lunch. 8/

2. Differences between tax and appropriated subsidies.

Given a definition of the activity to be subsidized and a formula for determining the amount of the subsidy, the economics of the subsidy are the same. Its effect on the volume of subsidized activity and its using-up of productive resources, will be the same whether the subsidy is financed by appropriated funds or by reductions in tax otherwise due. But there are political and administrative differences between the two methods of payment which must be considered when framing a subsidy program.

Couching the subsidy as an expenditure program involves those Congressional committees that authorize and appropriate funds for the substantive program purpose of the subsidy, and the executive agency to administer the program will be one with assigned responsibility in the area. For appropriated recycling subsidies, Congressional committees with jurisdiction might be any of a number of committees and subcommittees concerned with commerce, resources and energy, or public works, and the likely administering agencies might be the Department of Commerce or the Environmental Protection Administration. In contrast, clearing the subsidy through tax accounts involves the House Ways and Means and Senate Finance Committees; and the administering agency is the Internal Revenue Service.

Although these differences should have no impact on the effectiveness of the subsidy program, or on the administrative mechanism by which it is implemented, as a practical matter there are significant differences between tax and expenditure subsidy programs. The weight of these differences are that subsidies financed with appropriated funds are superior to tax subsidies.

a. The cost of administering appropriated subsidies is lower.

If the costs of administering a subsidy program are to be compared, the quality of administration must be held constant. In order to achieve some level of fraud control, the purely technical tasks of defining and certifying recycling activities qualifying for the subsidy and monitoring quantities eligible for the subsidy will require specialized administrators. There is no existing tax administrative function within the Internal Revenue Service which requires any specialized knowledge of solid waste management, scrap materials handling, or recycling processes. If called upon, the Internal Revenue Service might hire and train such personnel. However, the "economy of administrative scale" suggests that the cost of building-up and supervising such an organization would be lower if this task were undertaken by an agency already administering programs related to recycling.

In order to maintain a given quality of administration, Executive and Congressional oversight is required. If the subsidy is appropriated, it becomes a program responsibility of an agency and has an explicit provision for administration and for systematic program evaluation, by both the agency and by Congressional committee staffs. If the program is funded as a tax subsidy, there is no corresponding provision in the IRS appropriation to assure the availability of manpower and facilities for administration and program evaluation. The IRS will naturally seek resources, but no sympathetic hearing from <u>its</u> appropriation committee can be expected. It is difficult to extract additional funds to administer the tax system when, as a result of the additional tax subsidies, the IRS is collecting less in tax. Moreover, if the subsidy is appropriated, the normal annual budget review provides an opportunity for Congressional scrutiny of the program, with the aid of congressional and executive agency staffs thoroughly familiar with the subject matter. If the subsidy is financed through the tax system, any review of its effectiveness will be in the extraordinarily complex context of tax legislative deliberations, with only perfunctory aid from Treasury and Joint Committee on Taxation staffs possessing minimal knowledge of the technical aspects of recycling.

These considerations lead to a conclusion that, for a given quality of administrative effectiveness - adherence to program goals and fraud tolerance - a recycling subsidy paid with appropriated funds is superior to one paid through the tax system.

b. Costs of appropriated subsidies are more controllable.

Tax subsidies are open-ended; any amount is payable according to the volume of subsidized activity for as long as the tax provision remains in effect. Some appropriated fund programs are also open-ended, but the requirement that Congress annually appropriate funds provides a ready means of regulating resources devoted to such programs. Most expenditure programs are funded in fixed amounts. Authorizations are for stipulated numbers of years, appropriations of obligational authority for specified time periods, usually one year.

c. Tax subsidies are generally formulated so that, for a given amount of subsidized activity, the budgetary cost is greater.

The tax subsidies to virgin materials production reviewed in Chapter 2 have one characteristic in common with all other tax subsidies, save one: they convey the payment to the subsidized entity in tax-exempt form. 9/ Percentage depletion, favorable treatment of exploration and development and reforestation expenditures, and capital gains treatment of timber all subsidize mining and forestry activities by reducing taxable income to provide the enterprise with more after-tax income. If these producers received subsidy payments in the market to cover their costs of production, those payments would enter taxable incomes. Instead, they are compensated by remissions of tax; in effect, they are remunerated in after-tax, or nontaxable dollars. This has two highly undesirable consequences:

i. Understatement of resource cost.

As previously noted, in our economic system, resource costs are always measured in market prices, and they become incomes to individuals who have supplied labor, capital, and other resources. In an economic system that features an income tax, nontaxable payments are literally worth more to the recipient than ordinary market payments for services. For example, suppose there is a uniform tax rate of 40 percent. If an individual were willing to provide a service for $1, after-tax -- because this measures the value of goods and services he in fact will be able to command as a result of his expenditure of effort--he would demand a market price of $1.67 to leave himself $1 after paying 40 percent, or $0.67, in tax. His services, measured in market prices, are worth $1.67.

Now, suppose the Federal government allows him a special 50 cent deduction in computing his taxable income provided he devotes his service to recycling. Given his tax rate of 40 percent, this deduction is equivalent to a 20 cent <u>nontaxable</u> subsidy. But, with this nontaxable subsidy he would be willing to sell his recycling service for $1.33 in the market, for, with the 50 cent recycling subsidy deduction, he will only pay 33 cents in tax after earning $1.33 in pre-tax income and have left his necessary $1 after-tax return.

In effect, conveying the subsidy of 20 cents in tax-exempt form accomplishes a 34 cent reduction (subsidy) in the market price of the service. If the subsidy were appropriated, the amount appropriated would have to be 34 cents to permit the seller to make available $1.67 in recycling services to purchasers at $1.33. Purchasers would pay $1.33, the government 34 cents; the subsidized seller would report \$1.67 of taxable income, pay 67 cents in tax, and have left the necessary \$1 in after-tax reward. Clearly, 34 cents is the correct cost measure of government subsidy support in this example. It is the market value of the resources which will generate 20 cents of after-tax reward to the subsidized seller, just as the \$1.33 paid by purchasers generates the remaining 80 cents of necessary after-tax reward to the seller.

Because tax subsidies are commonly evaluated as simply the "tax saving," 20 cents in this example, provided by artificial deductions, or by other means for reducing the taxability of income earned by the subsidized activity, the real cost of the subsidy is understated. Doubtlessly, "tax incentives" enjoy widespread popularity among legislators and taxpayers because the cost of the government program financed by tax subsidies is understated and therefore appears to cost less; and once the tax subsidy program is in effect, its impact on the size of the Budget is effectively disguised, for the "revenue loss" is not exhibited in the Budget.

ii. Implicit extra cost due to degradation of the tax structure.

In the example, a subsidy worth 34 cents in resources was shown to be provided by a 50 cent artificial deduction allowed the qualified enterprise. Suppose another qualified activity is operated by someone whose aggregate income places him in a 50 percent tax bracket. A \$1.67 pre-subsidy market price of the service nets this person an after-tax reward of 83.5 cents; and if he is engaged in the activity, this return is presumably sufficient to elicit his services. For this qualified enterprise, however, the 50 cent artificial deduction is worth 25 cents after-tax, replacing a market reward of 50 cents. A 50 cent artificial deduction is worth, after-tax, 25 percent more to a 50 percent taxpayer than to a 40 percent taxpayer. In terms of market prices, a 50 cent artificial deduction is worth 50 percent more to the 50 percent taxpayer than to the 40 percent taxpayer (50 cents compared with 34 cents). If a market price subsidy of 34 cents would accomplish the objective of the subsidy, then providing a 50 cent deduction to all qualified activities, when the tax rates to which the owners of the enterprises are subject progressively rise with their aggregate incomes, increases the real social cost of the tax subsidy as compared with an equivalent appropriated subsidy. More is paid to high-income subsidy agents through remission of tax than would be required to be paid as an appropriated subsidy.

This phenomenon is well-known in the case of bond yields for state and local government bond issues which are exempt from Federal income tax under Section 103 of the Internal Revenue Code. Because interest on these bonds is tax exempt, their market yields are lower than yields on comparable taxable issues. In fact, the "spread" between taxable and nontaxable bonds has ranged from 30 to 35 percent. Since yields, like all prices, are determined at the margin--the yield necessary to get the last dollar of tax-exempt bonds issued held by someone satisfied with his after-tax yield thereon--this spread suggests that the marginal tax rate of the marginal holder is somewhere in the neighborhood of 30 to 35 percent. [10/] Thus, all holders of tax-exempt bonds subject to tax rates above this range earn more subsidy than is effectively enjoyed by state and local government bond issuers, the presumed beneficiaries of the interest tax subsidy. Replacing tax-exemption of state and local bond issues with an appropriated cash subsidy to provide a 30-35 percent reduction in borrowing costs would reduce the budgetary cost of the financing subsidy now provided state and local governments. Alternatively, an appropriated interest subsidy with the same net budgetary cost as results from interest tax exemption would provide a larger net subsidy to state and local government borrowers.

C. Specifying a base for a tax subsidy to recycling.

As with appropriated subsidies, defining the recycling activity to be subsidized through the tax system presents one problem; specifying the base for the tax subsidy presents the other. The choice is between providing the subsidy to either the output, or total cost of production, or for some portion of the cost.

1. Total cost (price) as a base

In the discussion to this point, a possible recycling subsidy has been described as a bounty per unit of output of recyclable material. Such a subsidy might also be viewed as one which subsidizes all the input costs, wherever incurred, in getting the material out of the solid waste stream and into reusable form. Such a bounty, or "negative sales tax", on a base of recyclable materials purchased or sold is the most efficient--least costly--means of achieving the subsidy objective. Given the competitive characteristic of the several stages of recycling activities and the diversity in kinds of enterprises and technologies employed, the most efficient subsidy is one that does not prejudice choices among the numerous ways that the tasks of resource recovery may be accomplished. Capital-intensive and labor-intensive processes benefit equally from a bounty on total cost of recyclables; at each stage, enterprises have unaltered incentives to adopt the least cost way of carrying out their tasks.

2. Capital equipment as a base.

The efficiency of bounties on total cost contrast with the biases of "capital subsidies." In addition to percentage depletion allowances, such specialized subsidies include special investment credits, "rapid write-off" of investments in recycling machinery, and tax-exempt bond financing of qualified facilities. Although each of these forms of subsidy might be paid with appropriated funds, they are typically formulated as tax subsidies. The apparent reason for this is that so-called "business taxes" are essentially taxes on the income from capital. Thus, if a tax subsidy is provided via business income taxes, it invariably involves special tax treatment of capital expenditures. 11/

Capital subsidies are inferior to bounties to achieve narrowly defined objectives, such as to encourage recycling. They induce qualified enterprises to use more capital-intensive processes, thereby dissipating some of the subsidy in wasted productive resources. Moreover, the availability of capital subsidies to an enterprise depends on its having otherwise taxable income. A special deduction is useless to a taxpayer if he has no taxable income to reduce; a credit against tax is equally worthless if no tax is owed. 12/

Nor are capital subsidies for a narrowly defined objective easier to administer than bounties. All the problems of identifying qualified enterprises for bounties exist for capital subsidies. In place of the problems in determining recyclables eligible for the bounty, capital subsidies present the same problems in determining which assets are employed in recycling *per se*, how much of other assets are jointly used in recycling and other processes, and which assets are not eligible whatsoever. In principle, a careful monitoring of inputs and outputs would resolve the bounty problems; but no known method of economic analysis or cost accounting can resolve the problems of identifying capital used in recycling and eligible for subsidy.

Nevertheless, capital subsidies maintain an undeserved popularity among proponents of recycling subsidies. The remainder of this section reviews these incentives, one of which has been in effect since 1968, another enacted in 1978. In all cases, it is assumed that some arbitrary definition of "qualified activity and equipment," or that some certification procedure, has been established.

a. A percentage depletion allowance for recyclable materials.

As noted in Chapter 2, a percentage depletion allowance is a particular way to reduce the taxability of income from an enterprise. The qualified enterprise is permitted to deduct in computing taxable income an amount equal to some stated percentage of the value of the product being recycled. In this respect, a percentage depletion allowance resembles an <u>ad valorem</u> bounty and is subject to the same weakness: A subsidy proportional to the value of recyclable materials will induce a relocation of the several stages of recycling activities merely to maximize the subsidy; it will encourage prior decontamination, more transportation, etc. And because percentage depletion creates a subsidy by reducing taxable income, it carries the grave defects of all tax-exempt subsidies noted above: It leads to a budgetary understatement of the real resource cost of the subsidy program, and it wastes resources by over-rewarding those owners of subsidized enterprises who happen to have above average incomes.

Since percentage depletion provides approximately the same subsidy as could be provided by an appropriated bounty, and with the same administrative cost and difficulty, there is no reason to frame a recycling subsidy in this form.[13/]

b. Tax-exempt bond financing of qualified facilities.

Most economic activities undertaken by state and local governments are exempt from Federal income tax. Also, interest on bonds issued by state and local governments always has been exempt from tax. This treatment of state and local governmental activities -- many of which, such as solid waste management, the operation of electric, transportation, and water utilities, and liquor distribution, are also undertaken by private, taxable enterprises -- may be considered a generalized subsidy enjoyed by the customers of these governmentally owned and operated enterprises. To the extent that any of these activities is financed by taxes, the subsidized publicly-provided services are further subsidized by the allowance of deductions for these taxes in computing Federal tax liability.[14/]

One consequence of these Federal tax subsidies to local government operation and tax financing of economic activities is an inducement to use this institutional arrangement of providing solid waste management services that might otherwise be provided privately or publicly at prices, or fees, based on cost of service. Not only does this mechanism shift some of the costs from the beneficiaries of the service, it may also be used as a device for income redistribution. Households in many jurisdictions may enjoy waste collection and disposal services for which they are not directly charged, and the Federally unsubsidized costs are then borne by taxpayers within the community according to the burden distribution implied by the community's own tax system, not by their use of these services. While regrettable from the point of view which holds that individuals should pay for the resource costs of the services they enjoy, this result is an inherent consequence of the Constitutional reservation of rights to the states, and of the long-standing Federal tax deductibility of most state and local taxes.

As noted in Chapter 2, these advantages of municipally undertaken services are not a subsidy to solid waste management, or to resource recovery, *per se*. However, investments by private firms in solid waste disposal facilities are eligible for financing by tax-exempt bonds.[15/] Under the arrangements sanctioned in the tax law, a state or local government may, at its own discretion, agree to issue bonds, the proceeds of which will be used to finance a solid waste disposal facility to be operated by a private firm. The benefitting firm agrees to pay the governmental bond-issuing authority a periodic "rental," the proceeds of which will cover interest and retirement of the bonds. At the end of the lease term, the lessee firm owns the property. For all practical purposes, including taxation, the private firm "leasing" the facility is the owner as well. For tax purposes, the firm will be able to depreciate the portion of the facility's cost subject to wear-and-tear and obsolescence, and any qualified property in the plant will be eilgible for the investment credit. Because this preferential treatment of privately owned property financing has been restricted to only a few kinds of investment, including solid waste disposal, it is regarded as a tax subsidy.

The Treasury's administration of this subsidy program, and a similar subsidy to investment in pollution control facilities, illustrates the problems of definition described earlier. To implement the program, income tax regulations were issued which define solid waste as "property which is useless, unused, unwanted or discarded solid material which has no market or other value at the place where it is located." They also define a qualifying facility to be "any property used for the collection, storage, treatment, utilization, processing, or final disposal of solid waste." [Reg. sect. 1.103-8(f)(2)]. In practice, it has proved difficult to draw the line between normal, rational industrial processing -- in which the residue of one process is then subject to further processing to obtain valuable by-products -- and the processing of "waste." When is "slag", or other industrial waste, "solid waste," the processing of which is a qualified activity, and when is its further processing a simple extension of the firm's productive activity? The question has proved to be unanswerable. 16/ Ten years after enactment of the subsidy, efforts to develop clarifying regulations continue so that private firms and their bond counsel may have reasonable certainty which projects will qualify for the subsidy.

Resource recovery plants clearly qualify for tax-exempt bond financing, so we may use engineering estimates of their construction and operation to quantify this subsidy. A resource recovery plant is generally one which receives solid waste that would otherwise be disposed of, then separates incombustible solids, and converts the remainder into useful energy. The incombustibles may become recyclable materials, or they may be compacted and disposed of. On the basis of engineering estimates for such plants, we estimate that tax-exempt bond financing of such a privately owned plant provides a subsidy equal to an appropriated subsidy of 5 percent of total cost of operation.[17/] Of course, being a capital subsidy, this is less efficient than the equal cash grant.

The same plant run by a governmental authority would benefit by an additional 15 percentage point reduction in total cost of operation, assuming the same quality of management. The additional benefit to municipal plants reflects both the Federal income tax exemption and the lower borrowing cost of such a plant which enjoys the implicit quarantee to lenders provided by the issuer's taxing authority. [18/]

c. Subsidies for the acquisition of machinery and equipment used in recycling.

Other subsidies have been proposed to reduoe the capital cost portion of recycling costs, and thus the cost of recyclable materials. These are commonly thought of as tax subsidies because their "payment" has been traditionally financed through the tax accounts of qualified enterprises, and therefore are available only to taxable entities. Such subsidies include investment tax credits additional to the credit presently provided for investment in depreciable machinery and equipment, but not for structures, and "rapid write-off" of capital expenditures for tax purposes. Each of these forms of capital subsidy could be provided as easily in the form of cash grants which would measure the resource cost of the subsidy correctly and avoid the undesirable tax policy effects of a nontaxable subsidy. Providing the subsidy as a cash grant would also make possible its extension to nontaxable entities. In the following discussion of rapid-write-off schemes and additional investment credits, we therefore take cash-grant, or appropriated subsidy, equivalents as the comparative norm.

(i) "Rapid write-off" schemes.

(a) How "rapid write-offs" become a subsidy

In any economic system in which government operations, and subsidy programs, must be financed by taxes, only what is left after taxes is freely disposable by individuals--for consumption or investment in privately-owned capital. This is obvious in the case of sales or excise taxes: Sellers of taxed goods and services have only what is left after the sales taxes have been handed over to government to pay employees, suppliers, creditors and equity owners. The tax proceeds spent by government, plus the after-tax incomes of workers and capital owners, then become the wherewithal to purchase the goods and services sold at gross-of-tax prices.

This is equally true, but less obvious, when taxes are levied on incomes. In an income tax regime, goods and services exchange at gross-of-tax prices. Sellers allocate these revenues from the sales of output into wage payments, payments to suppliers, and the remaining share accruing to suppliers of the capital. These allocations of pre-tax incomes are also the pre-tax incomes of the participants in the economic process who are then required to pay the taxes to government. Then, government income tax collections, plus the <u>after-tax</u> personal incomes, suffices to purchase the output sold at gross of tax prices. This description shows the general equivalence of sales and income tax systems and also explains why sales taxes are frequently called "indirect," and income taxes "direct:" Under a sales tax system, individuals receive disposable income directly and are unaware how the taking of the government share "indirectly" has reduced their disposable incomes. Under an income tax system, individuals are first paid the gross-of-tax, market prices of their contribution to the economic process, and then are required "directly" to hand over to government its share.

In administering an income tax, particularly the tax on income from capital, it is important that the amount subject to tax be free of elements representing amounts on which income tax already has been paid. For example, when an enterprise purchases machinery and equipment, the funds used are, by definition, disposable (after-tax) resources of the persons supplying the funds. It is well-known that machinery and equipment are "used-up" during the period after it has been acquired. Physical wear-and-tear plus obsolescence assures that the value of plant and equipment will someday be zero. Thus, the sales prices of the products produced with the aid of this machinery and equipment must include amounts to cover this using-up, or depreciation, of the capital used, as well as a payment (taxable income) to the capital suppliers for providing the finance to make possible its initial acquisition and maintenance.

That portion of the sales proceeds of enterprises which represents depreciation, also called "recovery of capital," is a return of their previously tax-paid resources to the capital owners and, therefore, ought not to be subject to tax again. For this reason, in the computation of taxable incomes of enterprises, an "allowance" for depreciation is permitted as an allocation, or deduction, from gross revenues derived from sales, along with wages paid, etc., to avoid taxing again the resources on which tax has already been paid.

How the tax allowance for depreciation, or capital recovery, is determined is critical to investment decisions. If the allowable tax deductions reasonably match the actual disappearance of machinery and equipment value, the full burden of income tax will be borne by capital owners; they will pay their "fair share" of taxes. If tax allowances for depreciation _lag_ the occurrence of actual capital consumption, _i.e._, are less during some periods than the experienced loss of capital value, the enterprise will then pay tax on some income that includes at least some resources on which tax had already been paid. On the other hand, if tax allowances _precede_ the occurrence of depreciation, taxable income will _exclude_ some amount of pre-tax income.

Allowances for tax depreciation ultimately equal the acquisition cost of capital assets that eventually become worthless, or decline in value. The relation between tax depreciation allowances and experienced depreciation thus determines the timing of tax payments. When tax depreciation allowances _lag_, taxes are _pre-paid_; when tax depreciation allowances _precede_ experienced depreciation, taxes are _deferred_. Pre-payment of tax is always more burdensome, and "deferred payment" less burdensome, than paying amounts when due. Therefore, the characteristics of tax depreciation rules, _in combination with any set of legislated tax rates_, determines the effective tax burden imposed on the use of capital resources and, hence, the capital costs of producing particular goods and services. Artifically speeding-up the allowance for depreciation is thus a capital cost-reducing subsidy paid through the tax system.

(b) The variable subsidy value of five-year amortization

The most commonly prescribed rapid write-off form of subsidy is "five-year amortization." Rather than the normal tax depreciation pattern, the investor is permitted to deduct one-fifth the cost of the asset for five years. Obviously, the subsidy provided by this scheme depends on the normal tax depreciation pattern: The longer the normal pattern, the greater the deferral and, hence, subsidy. Table 4.1 shows the subsidies provided by five-year amortization of four categories of depreciable assets involved in recycling activities, expressed as equivalent appropriated cash grants, or asset price reductions.[19/]

Table 4.1

Capital Subsidies Implied by Five-Year Amortization a/

| Class of recycling property | Asset price reduction equivalent of subsidy if tax rate of owner is: 22% | 48% | 70% |
|---|---|---|---|
| | | (Percent) | |
| Vehicles | 0 | 0 | 0 |
| Machinery and equipment used in: | | | |
| Pulp and paper | 2.60 | 7.52 | 15.18 |
| Primary nonferrous metals manufacturing | 2.90 | 8.35 | 16.71 |
| Primary ferrous metals manufacturing | 4.84 | 13.45 | 25.49 |

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a/ Computations assume a 10% discount rate and allow full investment credit.

Investment in vehicles used in recycling activities would not benefit from five-year amortization. Five years of equal deductions, rather than accelerating the pattern of deductions and slowing-down the payment of income tax, decelerates deductions and accelerates tax payments, as compared with normal tax depreciation allowances for vehicles. In the cases of machinery used in paper and pulp, nonferrous and ferrous metals recycling, five-year amortization accelerates tax deductions and provides some net subsidy. But, for any given tax rate of the asset owner, the subsidy value of five-year amortization is least in pulp and paper, greatest in ferrous metals.

Five-year amortization not only yields unequal subsidies to different activities, but, for any given recycling activity, the subsidy value of five-year amortization dramatically increases with the tax rate of the owner. Small businesses, generally described by 22 percent tax rates, gain the least subsidy, investors subject to the maximum tax rate of 70 percent gain the greatest subsidy.

Few business owners are subject to the 70 percent rate. To arbitrage differences in subsidy value, equipment leasing arrangements will be devised. Under the terms of these leases, a group of wealthy passive limited partners will assume ownership of those types of recycling equipment adaptable to leasing, and recycling enterprises will "rent" the equipment for long terms. These arrangements enable the tax subsidy to be cleared through the tax accounts of high-income individuals subject to high tax rates. Such arrangements are called "shelters" because the limited partners use the artificially accelerated deductions to shelter their otherwise taxable incomes. To the extent that leasing occurs, the realized subsidy value will be between the amounts tabulated in the columns relating to 22 to 48 percent taxpayers and the amounts shown in the 70 percent taxpayer column. If the number of persons who would be subject to 70 percent tax rates were large and their wealth sufficient to finance the purchase of all leasable assets, the realized subsidies would be those in the 70 percent taxpayer column. Since this is not the case, the "marginal" ownership will be in a rate-bracket below 70 percent. Nevertheless there will be a tax revenue loss equal to the difference between lease rentals determined at the margin and the amounts shown in the 70 percent column representing a transfer of after-tax income to limited partners which does not go to reduce the cost of using recycling equipment. This is an example of extra tax subsidy cost like that described above in connection with tax-exempt bond interest.

Tax shelter formation makes the budget cost of such capital subsidies greater than cash grant subsidies for the same purpose. Thus, rapid write-off schemes are the least desirable of all tax subsidies for the acquisition of capital goods used in recycling: They provide differential benefits according to the kind of capital used, the material recycled, and the tax status of the investor; and they induce the formation of ownership arrangements whose only function is to increase the tax benefit realized without a corresponding increase in the subsidy to use of the capital.

(ii.) Investment credits.

(a) How an investment credit subsidizes, recycling.

An investment credit, properly structured, would be the exact equivalent of a cash-grant subsidy for the purchase (sale) of qualified capital goods. The enterprise purchasing the machinery and equipment, or other assets, receives a grant of, say, 10 percent of his purchase price; then, for each $1 of qualified goods he acquires, he pays only 90 cents of borrowed or equity resources. The result is a 10 percent reduction in the portion of capital costs thus subsidized: the enterprise need charge its customers an amount for recovery of capital, income taxes, and an after-tax rate of return equal to 90 percent of the charges otherwise required to justify the purchase and use of $1 worth of capital. To the extent that capital is used in recycling, this subsidy would reduce costs; and to the extent that use of recyclable materials is responsive to cost, such a subsidy would increase recycling.

An investment subsidy could achieve its objective whether it is paid in funds appropriated by Congress, or by permitting the investing enterprise to subtract the appropriate amount from his tax payments otherwise due. But the present investment credit, and the additional 10 percent credit that has been enacted for equipment used in recycling and for certain classes of "alternative" or "energy conserving" property, do not quite match the characteristics of a simple cash-grant subsidy. Both the normal and the additional 10 percent investment credit differ from a simple cash grant in 3 ways:

(1) If a cash grant of 10 percent had been made, the private firm could recover through depreciation deductions only the 90 percent of cost it had privately financed. Because the investment credit is considered a "reduction in tax," however, not a government grant, the investing enterprise is permitted to recover through tax depreciation deductions not only its own 90 cents of disposable resources expended to acquire the subsidized assets, but also the 10 cents financed by the government grant via the tax credit.[20/]

In the event there is an additional 10 percent credit, the investor pays 80 cents and is permitted to recover $1 in depreciation deductions.

(2) A cash grant would be uniform for all qualified recycling equipment, regardless of its expected life. However, partly because the taxpayer is permitted to take depreciation deductions for the cost of the asset financed by the government, only partial investment credit is allowable for assets with expected lives for tax depreciation purposes of less than seven years. [21/] As will be seen below, this introduces a discrimination between processes using different forms of capital.

(3) A cash grant would be paid regardless of the income status of the recycler; the amount of investment credit which can be taken in any year is limited by tax liability for the year, although excesses of credit eligibility may be carried back three years and forward seven. [22/]

A cash-grant capital subsidy has equal value to all investors, regardless of their taxable status, but the investment credit is like the other tax subsidies reviewed above in that it discriminates in favor of high income investors. This discrimination is due to the first and third departures from a cash grant just noted. The privilege of taking depreciation deductions for the government's share of capital cost provides the investor an additional stream of future deductions from taxable income, the value of which is directly dependent on the tax rate of the investor taking the deductions. Secondly, limiting the amount of subsidy to some portion of tax liability for a year also tends to favor the better-off.

Allowing the investor to depreciate the investment grant also makes the value of the subsidy dependent on the tax life of the qualified property. Tax depreciation deductions for short-lived assets are obtained quickly; the same total tax depreciation deductions accrue over a longer period for long-lived assets. Since the amount of bonus depreciation per dollar of subsidized assets is fixed by the investment credit rate, the bonus depreciation is worth more to owners of short-lived assets.

(b) Values of additional investment credit, by type of asset and taxability of owner.

The variability of an additional 10 percent investment credit subsidy as compared with an appropriated cash grant is illustrated in Table 4.2. Whereas a simple 10 percent cash subsidy would reduce the cost of using qualified capital uniformly by 10 percent, a 10 percent investment credit does not. For any given tax rate of the asset owner, vehicles are afforded a lesser subsidy because the fractional share of the credit they are allowed overcompensates for the bonus depreciation allowed; and although the subsidy differences are less marked among the other categories of recycling assets than was the case with five-year amortization, they remain, though reversed in sign: Longer lived assets gain less from the bonus depreciation. Again, tax rate sensitivity occurs, though less marked than in the five-year amortization cases. Because the investment credit has less severe inherent biases than depreciation acceleration, it is clearly a superior subsidy mechanism; however it remains inferior to cash grant subsidies.

Table 4.2

Capital Subsidies Implied by an Additional

10 Percent Investment Credit a/

| Class of recycling property | Price reduction equivalent of subsidy, if tax rate of owner is: | | |
|---|---|---|---|
| | 22% | 48% | 70% |
| Vehicles | 8.93 | 12.70 | 19.73 |
| Machinery and equipment used in: | | | |
| Pulp and paper manufacture | 13.43 | 17.84 | 24.70 |
| Nonferrous metal manufacture | 13.39 | 17.68 | 24.25 |
| Ferrous metal manufacture | 13.12 | 16.70 | 21.70 |

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a/ It is assumed the additional credit will be structured in the same way as the present 10 percent credit: assets with a tax life of 5 but less than 7 years receives 2/3 credit; there is no basis adjustment, and the bonus depreciation is evaluated with a discount rate of 10 percent.

D. Summary.

Despite the evidence that a subsidy to recycling cannot be justified on the ground that it will increase the standard of living by improving the allocation of resources, if a subsidy is to be provided:

--It should be based on the quantity of recyclable materials used in primary production--production of paper, metals, glass. This minimizes the difficulty of identifying a qualified recycler, but it nevertheless requires an elaborate administrative mechanism to identify recyclable inputs qualified for the subsidy.

--It should be paid with appropriated funds rather than through the tax system. This minimizes administrative cost to achieve a given quality of program administration, correctly presents the resource cost of the subsidy in the Budget, and avoids the extra cost (payments to above-average taxpayers) inherent in tax subsidies paid in after-tax dollars. In the case of capital subsidies, appropriated subsidies avoid inequality of subsidy values among assets of different durabilities inherent in such tax subsidies as rapid write-offs and investment credits.

Finally, it should be noted that, in addition to the budgetary cost of recycling subsidies, these interventions in markets induce additional resource waste, a reduction in the value of goods and services produced. Subsidizing recycling induces a shortening in the useful lives of products that might otherwise be put to secondary uses or be reconditioned and it disfavors recovery of energy from combustible portions of the solid waste stream.

## Footnotes to Chapter 4

1/ In solid waste collection, the basic operating unit is a vehicle and crew. Usually, the volume of waste to be collected is far greater than that which would keep a basic unit fully employed. Although some management economies may derive from operating multiple vehicle units, there is no evidence that the optimal size of a waste collection enterprise is so large that monopoly is a normal expectation. Indeed, private trash collection firms frequently coexist with governmental monopoly of certain kinds of collection activities. That many communities establish a governmental monopoly of solid waste collection may be regarded as a local preference for achieving some income distributional objectives within a political jurisdiction, i.e., by financing the conduct of waste management through a set of taxes based on local measures of "ability to pay" rather than charges based on quantity of service demanded.

In resource recovery, particularly when useful energy is at least one of the outputs sought, technological economies of scale may limit the number of such plants in a market. (See U.S. Congress, Office of Technology Assessment, Materials and Energy from Waste, 1978.) But since a resource recovery enterprise must always compete with disposal and with processes utilizing solid waste for the derivation of useful (recyclable) materials, the degree of monopoly power of a resource recovery enterprise must be negligible.

2/ A survey of 2,060 cities disclosed that 36 percent of them financed solid waste management by local taxes, but there is no indication whether this 36 percent accounted for 36 percent of the municipal solid waste, for more, or less. (p. 19 of "A Review of the Current Status of Municipal Solid Waste Management," in the Third Report of the Resource Conservation Committee, July, 1978).

3/ Congress has funded categorical grant programs as well as general revenue sharing. Grant programs may be justified on the ground that they permit cost-sharing in the implementation of Federal programs, and general revenue sharing may be justified on the ground that this provides a better utilization of the Federal tax base than the financing of Federal expenditure programs. Neither of these justifications appear to be applicable to municipal solid waste management, per se.

4/ The estimate is that 85 to 88 percent of municipal solid waste management costs are consumed in collection activities. Whatever happens to the waste after it is collected, this cost will have to be incurred. Thus, avoidance of disposal "saves" only 12 to 15 percent of municipal solid waste management costs plus the unrecognized environmental damage costs. See Third Report of the Resource Conservation Committee, July, 1978, p. 2 and sources cited.

5/ These estimates are based on the elasticities of supply and demand reported in Chapter 3 and the following unsubsidized prices and quantities of recyclable materials: paper, $45/ton, 16 million tons; ferrous, $75/ton, 40 million tons; copper, $1,100/ton, 400,000 tons.

6/ Barnett, Harold J., and Morse, Chandler, Scarcity and Growth: The Economics of Natural Resource Availability (Baltimore: The Johns Hopkins Press, 1963, Chapters 8 and 9. Although this study was completed before the recent (1972-74) cyclical upswing in raw materials prices, and subsequent downswing, there is no reason to believe the underlying long-term forces have radically changed.

7/ It has also been demonstrated that, on the basis of plausible estimates of the quality of exhaustible resources, with no change in technology, the mere substitution of capital and labor for resources makes possible a perpetual level of consumption (standard of living) in the face of declining resource quality (increasing cost of extraction) that is little less than could be attained if resource quality were unchanging (extraction cost constant). See Solow, Robert M. and Wan, Frederic Y., "Extraction Costs in the Theory of Exhaustible Resources," The Bell Journal of Economics, Vol. VII, No. 2 (1976), pp. 359-70.

8/ These observations hold whether the subsidy is paid through expenditure of appropriated funds or as "reductions in tax." Unfortunately, the accounting conventions governing Federal Budget presentations do not fairly present the economic consequences of subsidies financed through tax accounts. For example, if $100 million is expended on, say, agricultural subsidies, this is duly entered in the expenditure side of the Budget, and all observers can readily see that $100 million of resources are being used by government in support of agricultural programs. But, if the $100 million is paid out through a cancellation of farmers' tax otherwise due, the subsidy amount simply evaporates.

Suppose, that without the subsidy, government expenditures and revenues are $1 billion and that the subsidy will be financed by additional taxes. If the $100 million is financed as an expenditure, the new budget total will be $1.1 billion; if the $100 million is financed as a "tax subsidy" the new budget total, including the additional resources consumed by the subsidy, and also financed by $100 million in additional taxes, will still be $1 billion. Enactment of tax subsidies helps create the illusion that government intervention in resource allocation is costless. Indeed, this illusion is carried over into the National Income Accounts by the Bureau of

Economic Analysis, which also treats tax subsidies as "reductions in tax" and not elements of the government share of GNP.

9/ The one exception to this general rule of tax subsidies is the "New Jobs Credit" enacted in 1977, which has been replaced by a comparably structured "Targeted Jobs Credit" in the Revenue Act of 1978. This subsidy, designed to encourage expansion of employment in smaller enterprises, is a credit against income tax based on the employer's increase in payroll. However, the employer is required to reduce his current year's deduction for wages and salaries paid by the amount of the credit. In effect, the subsidy is paid out in taxable form, just as it would have been had the program been enacted as a Labor Department Manpower Program.

10/ There are significant institutional differences between the markets for state and local issues and others that suggest that 30-35 percent spread may be an understatement. The institutional differences have to do with term distributions of outstanding debt and with the ultimate incomparability of critical elements of bond indentures, such as collateral, or income flows, to which bondhold have legal claim.

11/ This is not essential if the income tax account is merely to be used as a device for clearing payments to a taxpayer. In the earlier discussion in this chapter, it was noted that a bounty per ton of recyclable material might be paid to a qualified enterprise by permitting him to offset the amount owed to him by the government against the tax he owes the government. The New Jobs Credit, described in a prior note is an example of such a non-capital related tax subsidy.

12/ Carry-back and -forward privileges mitigate this characteristic of tax subsidies. "Operating losses" due to excessive tax deductions may be carried back three years and forward five; most tax credits which exceed the taxpayer's current-year capacity to absorb them may be carried back three years and forward seven. But securing a future "refund" of unrequited losses or earned subsidies is less valuable than cash-in-hand.

13/ If the disadvantages of locating responsibilities for a recycling subsidy in the tax-writing comitttees and IRS are disregarded, the equivalent of a bounty can nevertheless be provided by clearing its payment through tax accounts. The amount of the subsidy for which a taxpayer qualifies would be computed by rules which are the same for a cash bounty or a percentage depletion deduction. However, in order to avoid the undesirable consequences of a nontaxable subsidy (artificial depletion deduction), the qualifying taxpayer could be reimbursed for the amount of the subsidy in the following way: the taxpayer would reduce his "cost of goods sold" deduction that year by the amount of the subsidy, thereby bringing the subsidy into the tax base as if it were a market payment; he would compute his tax liability and then reduce this by the amount of subsidy credit due him.

14/ If a municipality charges fees for particular services, payments of these fees would not be deductible in computing taxable income for they are not different in kind or substance from other dispositions of taxpayers' personal disposable income. In all cases, however, payments made by an enterprise in connection with its conduct of a business would be deductible in computing enterprise taxable income.

15/ Prior to 1968, virtually any private enterprise investment, at the discretion of a state or local government authority, might have been financed by issuance of tax-exempt bonds. In 1968, Congress amended Section 103 of the Internal Revenue Code to strictly limit the issuance of such bonds. However, among the exemptions from these new restrictions was the financing of "sewage or solid waste disposal facilities." [Section 103(b)(4)(E)] Since solid waste disposal facilities are among the few private activities eligible for tax-exempt financing, the privilege clearly becomes a specialized subsidy.

16/ A boiler system to recover useful energy from bark stripped from timber in a forestry products plant has been ruled to be a "solid waste" disposal facility qualifying for tax-exempt bond financing. On the other hand, a metal shredding machine installed in a jund yard has been ruled not to be qualified.

17/ Because resource recovery plants are likely to be operated by, or in conjunction with, electric utility enterprises, the financial structure of a utility was taken as the basis for computing the advantage provided by tax-exempt bond-financing. Basic parameters used in the calculation were:

(1) Debt/equity ratio: 53 percent debt.
(2) Borrowing rate: 10 percent taxable, 7 percent nontaxable.
(3) After-tax rate of return to equity: 15 percent.
(4) Composition of capital: 85 percent depreciable.
(5) Tax variables: Depreciable life: 12.5 years.
Tax rate: 46 percent.
10 percent credit for qualified property.
(6) Economic life of plant (to compute annualized capital cost per ton processed): 25 years.
(7) Non-capital costs per ton processed: $6.36.

18/ It was assumed that a municipal plant would operate with 70 percent debt, 30 percent equity (retained earnings)--like municipally owned electric plants. It was also assumed that the borrowing rate is 6 percent, less than the 7 percent effective rate payable by a private beneficiary of "revenue bonds."

19/ The computations assume a discount rate of 10 percent and do not reduce the investment credit allowable. Normally, assets with a depreciable life of 5 years may only qualify for 2/3 credit; but unless specific provision is made in the Code--as it has been in the case of certain pollution control facilities--5-year amortization property qualifies for no credit. Continued allowance of the credit for the computations above was assumed in order to highlight the dependence of rapid write-off schemes on the normal tax life of assets. Had the 5-year amortization option been deprived of investment credit, then only primary ferrous metal manufacturing machinery and equipment owned by 70 percent taxpayers would have derived a net subsidy; in all other cases loss of the credit would have been more costly to the investor than the gain from acceleration of tax depreciation deductions.

20/ When the investment credit was first introduced in 1962, taxpayers were required to reduce acquisition price, called "basis" in tax accounting terminology, by the amount of credit allowable for purposes of computing future tax depreciation allowances. However, because actual allowance of the credit was limited by the amount of tax liability of the taxpayer in the year he acquired the asset, in many instances taxpayers had not yet achieved the cash benefit of the credit but, nevertheless, "suffered" reductions in tax depreciation allowances. This was regarded as unfair as well as being a source of complex recordkeeping and tax recomputation in the event the asset was sold. Therefore, Congress repealed the requirement of a basis adjustment in 1964. Ironically, had Congress simply required the investment credit be treated as a cash grant (with a corresponding reduction of "basis"), all complexities would have disappeared.

21/ If the asset life is less than 3 years, no credit is allowed; if the life is 3 years, but less than 5, 1/3 credit is allowed; if the life is 5, but less than 7 years, 2/3 credit is allowed.

22/ The present annual limitation on investment credit allowed is the first $25,000 of tax liability plus 60 percent of tax liability in excess of $25,000. Under provisions of the Revenue Act of 1978, the 60 percent figure will rise to 90 percent by 1982.

## Appendix to Chapter 2

### Computation of Supply Curve Shifts for Minerals and Timber from Tax Preferences

### I. Supply Price Equations for Minerals

The required present value of gross revenues equals the present value of all costs, including operating costs, investment and taxes. In the equations below, the variables are defined as:

R = gross revenue
R* = gross revenue under neutral taxation
O = current outlays
S = royalties
S* = royalty payments if taxed as ordinary income
T = severance taxes
I = investment expenditures
E = amount of investment deducted as current expense
G = recapture of expensed investment
H = capital gains on land and depreciated assets
K = investment tax credit
d = depreciation
D = cost depletion under neutral taxation
u = statutory corporate income tax rate
r = statutory corporate tax rate on capital gains
a = statutory percentage depletion rate
PV( )= present value operator

Under current law, for corporations using percentage depletion, we can write:

$$PV(R) = PV(0) + PV(I) + PV(T) - PV(K) + PV(S) + u[(PV(R) - PV(S))(1-a) - PV(0) - PV(E) + PV(G) - PV(d) + (r/u)PV(H) - PV(T)] \quad \text{...Equation (2.1)}$$

Rearranging terms in Equation (2.1), we obtain:

$$PV(R) = PV(S) + \frac{1}{[1-u(1-a)]} \times [PV(0)(1-u) + PV(I) + PV(T) - PV(K) - u(PV(E) - PV(G) + PV(d) - (r/u)PV(H) + PV(T))] \quad \text{...Equation (2.2)}$$

Equation 2.2 is applied directly to compute the present value of gross revenue under current law.

Where the present value of statutory percentage depletion exceeds one-half the present value of otherwise taxable income, percentage depletion reduces the tax rate on taxable income, defined without taking any depletion, by one-half. Thus, the formula for computing PV(R) becomes:

$$PV(R) = \frac{1}{(1-u)} [PV(0)(1-(u/2)) + PV(I) + PV(T) - PV(K) - (u/2)(PV(E) - PV(G) + PV(d) - (r/u)PV(H)+PV(T))] + PV(S) \quad \text{....Equation (2.3)}$$

Under neutral treatment, required gross revenue from a mine can be written:

$$PV(R^*) = PV(0) + PV(I) + PV(S^*) - PV(K) + PV(T) + u(PV(R^*) - PV(0) - PV(d) - PV(D) - PV(S^*) - PV(T)) \quad \text{....Equation (2.4)}$$

where:

$PV(S^*) = \frac{(1-r)}{(1-u)} PV(S)$ is the before-tax royalty payments necessary to make after-tax royalties received the same as under current law

Rearranging terms, Equation (2.4) can be written as:

$$PV(R^*) = PV(0) + PV(S^*) + PV(T) + \frac{1}{(1-u)} [PV(I) - PV(K) - u(PV(d) + PV(D))] \qquad \text{...Equation (2.5)}$$

Equation (2.5) is used to compute required revenue under neutral taxation of mining investments.

II. Mineral Investment Profiles

The mineral industry profiles show different types of estimated expenses for every year of the operation of a "typical" mine. Expenses are subdivided into 13 categories: (1) structures, (2) machinery and equipment, (3) research and development, (4) land acquisition cost, (5) working capital, (6) maintenance materials, (7) maintenance labor, (8) materials and supplies, (9) rents and royalties (including severance taxes, where applicable), (10) utility services, (11) other services, (12) production labor, and (13) marketing and administration. These data were reclassified into current expenses, depreciable investments, and non-depreciable investments (land and working capital), and estimated depreciation schedules were applied to the depreciable capital. In addition, qualified investment under the investment tax credit (machinery and equipment) was identified, and the applicable credit computed, on the basis of the life of the investment. This method was used to convert the raw data supplied by the Bureau of Mines into annual estimates of current outlays, investment, depreciation, the investment tax credit, and cost depletion. Then, present values for all of these items were computed using a 10 percent discount rate.

Table 2A-1 reports the present value of all terms used in the calculations for each of the five mining profiles. In all the calculations, the corporate income tax rate used is 46 percent, the capital gains rate 28 percent. The percentage depletion rate is 10 percent for coal, and 15 percent for copper and taconite.

## III. Supply Price Equations for Timber

The required present value of revenues equals the sum of the present value of all current outlays, all investments, and all taxes. The variables in the equations below are defined as:

R = revenue required for 10 percent return on investment
I = investment
O = current outlays
D = cost depletion
a = fraction of investment that is expensed under current law
R* = revenue required for 10 percent return on investment with timber preferences removed
D* = allowable cost depletion with timber preferences removed
g = capital gains tax rate for corporations
u = income tax rate for corporations
PV( ) = present value operator

Table 2A-1

Data Derived From Mineral Industry Profiles

| | Profiles | | | | |
|---|---|---|---|---|---|
| Item | Eastern Coal [1] | Illinois Coal [2] | Western Coal [3] | Copper Mine [4] | Taconite Mine [5] |
| PV(0) | 59,532 | 59,548 | 62,834 | 532,834 | 557,741 |
| PV(S) | 9,238 | 30,652 | 44,035 | 0 | 0 |
| PV(I) | 32,051 | 35,774 | 41,791 | 320,645 | 259,117 |
| PV(E) | 91 | 155 | 227 | 38,532 | 1,509 |
| PV(H) | 108 | 0 | 69 | 0 | 0 |
| PV(K) | 1,536 | 3,079 | 3,544 | 12,617 | 13,620 |
| PV(d) | 11,366 | 16,984 | 21,035 | 126,133 | 106,562 |
| PV(D) | 1,736 | 53 | 75 | 13,776 | 409 |
| PV(T) | 6,572 | 9,002 | 22,505 | 0 | 0 |
| PV(G) | 68 | 128 | 188 | 6,872 | 876 |
| PV(S*) | 0 | 12,317 | 40,869 | 58,713 | 0 |

All values are in thousands of dollars. The variable definitions are: 0 = current outlays, S = royalties, I = investment, E = currently expensed investment, H = capital gains on final sales of land and depreciated assets, K = investment tax credit, d = depreciation, D =cost depletion, T = severance taxes, G = recapture of expensed investment, S* = royalty payments if taxed as ordinary income, and PV( ) = present value operator.

Under current law, the required present value can be expressed as:

$$PV(R) = PV(0) + PV(I) + g[PV(R) - PV(D)]$$

$$-u[PV(0) + aPV(I)] \qquad \text{....Equation (2.6)}$$

The first expression in brackets, which represents the present value of taxes paid, is multiplied by "g" instead of "u", because revenue from the sale of timber is taxed at the capital gains rate. The term aPV(I) represents the amount of investment that can be deducted as a current expense. These two items account for most of the tax subsidy. The term [PV(0) + aPV(I)] is multiplied by "u", reflecting the fact that it is deducted against ordinary income, rather than against capital gain in timber growing.

Rearranging the terms in Equation (2.6), the required present value of revenues can be expressed as:

$$PV(R) = \frac{1}{1-g}[PV(0)(1-u) + PV(I)(1-au) - gPV(D)] \qquad \text{....Equation (2.7)}$$

Equation (2.8) expresses the required present value of revenue if the special tax provisions were removed.

$$PV(R^*) = PV(0) + \frac{1}{1-u}[PV(I) - uPV(D^*)] \qquad \text{....Equation (2.8)}$$

In Equation (2.8), the income from the sale of timber is taxed at "u," the rate applied to ordinary income. There is no expensed investment. PV(D*), the present value of depletion, is greater than PV(D), because the previously expensed investments become part of the depletable basis. However, the present value of cost depletion is small, because depletion is only allowed at the time of final harvest.

## IV. Timber Profiles

The data used in the timber profiles are shown in Table 2A-2. The categories of expenses are the same for pulpwood rotations of 15, 20, and 25 years as for the 30 year rotation shown. The only difference is that prescribed burning for fire protection only occurs in years 10, 15 and 20 for the 25-year rotation; in years 10 and 15, for the 20-year rotation; and in year 10 for the 15-year rotation.

All costs are categorized as investments in the calculations. Overhead, land rental, property tax, and prescribed burning for fire protection are treated as expensed under current law, while clearing of site, site preparation, planting, and spraying are treated as capitalized. All costs are treated as capitalized under neutral taxation.

Table 2A-2

Model Southern Loblolly Pine Stand

(extensive cultivation for 30 year pulpwood rotation)

| Item (tax treatment) | Cost/acre | Year incurred |
|---|---|---|
| Overhead (exp) | $ 3.00 | Annual |
| Land rental (exp) | 20.00 | Annual |
| Property tax (exp) | 2.10 | Annual |
| Cleaning of site (cap) | 73.00 | 1 |
| Site preparation (cap) | 30.00 | 1 |
| Planting (cap) | 43.00 | 1 |
| Spraying (cap) | 15.00 | 2 |
| Prescribed burning for fire protection (exp) | 3.65 | 10,15,20,25 |

Timber can be cut at 15, 20, 25 or 30 years.

Table 2A-1 Footnotes

1/ 1.06 Million ton per year Eastern Underground Coal Mine, 72-inch coal, continuous miner and Coal Preparation Plant for Eastern Underground Mine.

2/ 2 Million ton per year Surface Mine in Illinois Basin and Coal Preparation Plant for Illinois Basin Mine.

3/ 5 Million ton per year Surface Mine, Powder River Basin.

4/ 245,000 ton per day Open-Pit Copper Mine and 98,000 ton per day Copper Concentrator

5/ Taconite Mine and Taconite Processing Plant.

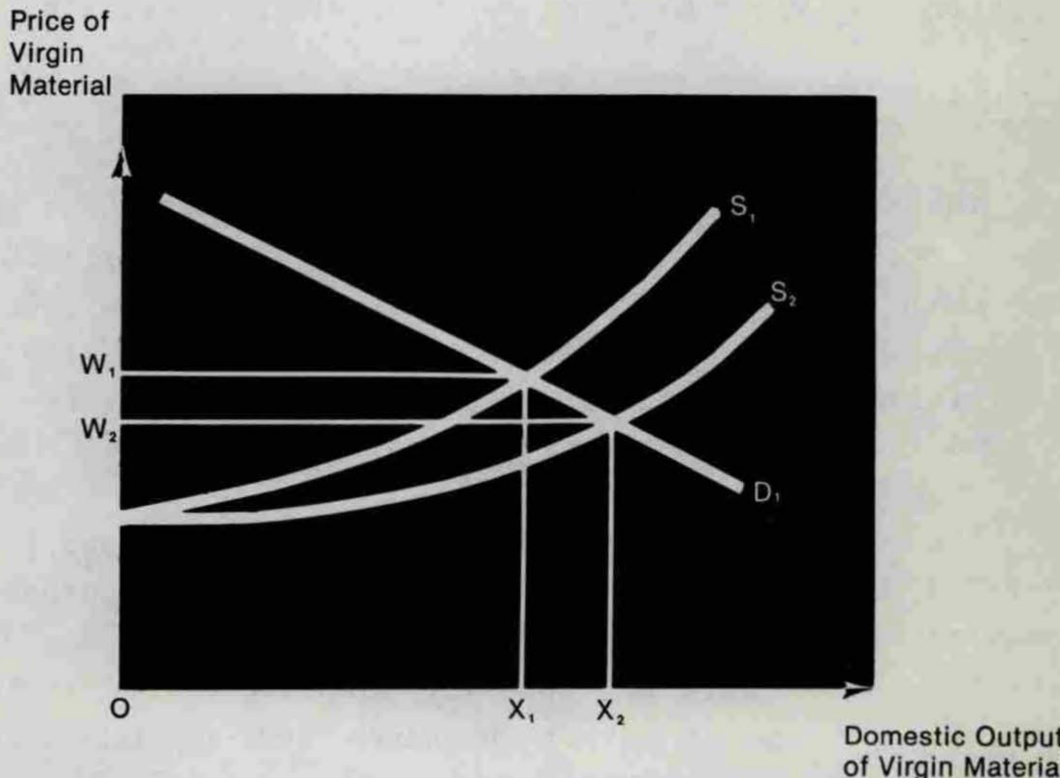
## Appendix to Chapter 3

### I. Effect of Tax Subsidy on Price of Virgin Materials

#### Graphical Illustrations

The tax subsidies to virgin materials shift their supply curves downward, lowering the private cost of production at any given level of output. The effect on virgin material prices is shown in Figure 3.1. Supply shifts down from $S_1$ to $S_2$, raising domestic output of the virgin material from $X_1$ to $X_2$, and lowering price from $W_1$ to $W_2$.

The relative size of the two effects of the supply curve shift -- the price effect and the output effect -- depends on the elasticity of the demand and supply curves for the virgin material. If the price elasticity of supply were infinite, i.e., if the annual output of mines and/or timber stands could be increased without increasing the unit cost, the price would decline by the same percentage as the downward shift in the supply curve. On the other hand, if supply were upward sloping and demand were perfectly elastic, price would remain unchanged. The supply curve shift would increase domestic output, but leave price unchanged. If the supply curve were vertical (i.e., output totally unresponsive to price), the tax subsidy would raise the price <u>received</u> by sellers, but would leave output and the price to buyers unchanged.




$X_1$ = output of virgin material in absence of tax subsidy

$X_2$ = output of virgin material with tax subsidy

$W_1$ = price of virgin material in absence of tax subsidy

$W_2$ = price of virgin material with tax subsidy

Figure 3.1 Effect of Tax Subsidies on Virgin Material Prices

These three cases are illustrated in Figure 3.2. In case 1, the demand curve is totally elastic. Price remains unchanged ($W_1 = W_2$), while output increases from $X_1$ to $X_2$.

In case 2, supply is infinitely elastic, and demand is downward sloping. Price declines by the full amount of the supply curve shift from $W_1$ to $W_2$, while output increases from $X_1$ to $X_2$.

In case 3, supply is totally inelastic, and demand is downward sloping. Both output and price paid by consumers remain unchanged. Eliminating the tax subsidies reduces after-tax revenue per unit of output received by producers from $R_1$ to $R_2$. Because producers do not alter their economic behavior, they absorb the full cost of the tax increase. (If new investors in a competitive capital market required an unchanged after-tax return to be induced to purchase mining or timber growing land, the cost of the tax increase to current owners would take the form of a reduction in land values.)

Algebraic Formulation

The effect of demand and supply elasticities on the price change resulting from a supply curve shift can be expressed algebraically. For conceptual simplicity, suppose that both supply and demand are constant elasticity functions. Then, the supply and demand curves can be written as:

$$\log(X) = c_0 + c_1 \log(W) + c_2 \log(Z_1) \qquad \text{(Supply)}$$

....Equation (3.1a)

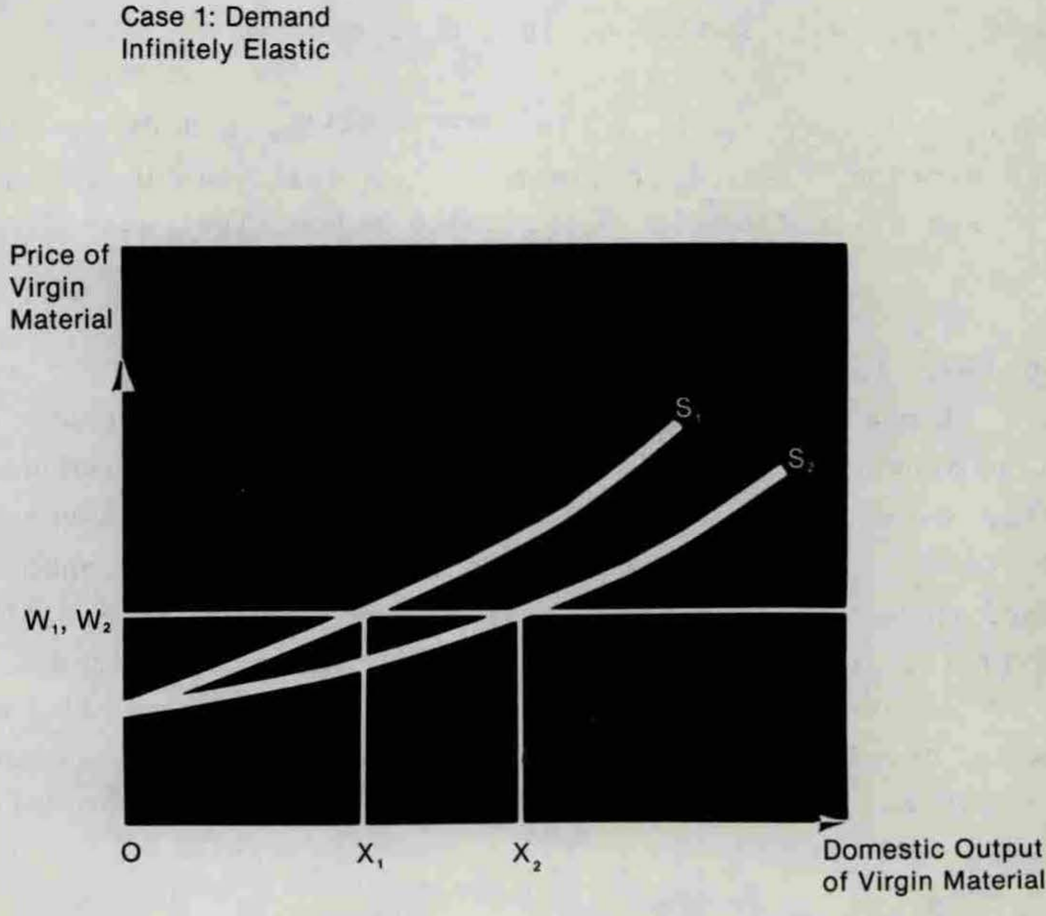
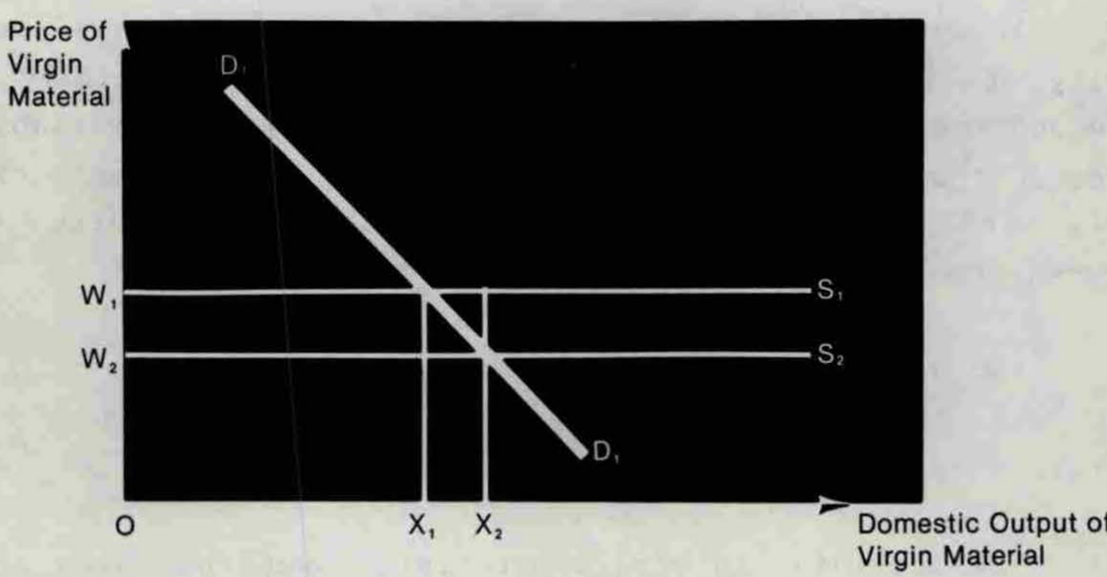



Figure 3.2

Effect of Tax Subsidies on Virgin Material Prices: Alternative Elasticity Assumptions

Case 2: Supply
Infinitely Elastic




Case 3: Supply
Totally Inelastic

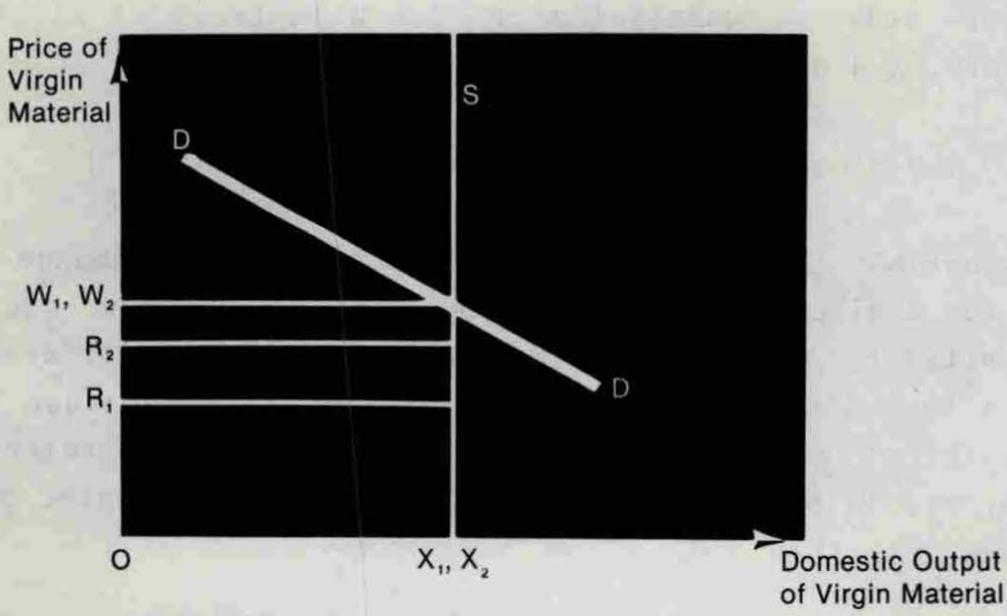



Figure 3.2 (Continued)

$$\log(X) = d_0 + d_1 \log(W) + d_2 \log(Z_2) \qquad \text{(Demand)}$$

....Equation (3.1b)

In Equations (3.1), X = output, W = price, $c_1$ = elasticity of supply of the virgin material; $d_1$ = elasticity of demand for the virgin material; $Z_1$ and $Z_2$ represent variables (other than price) that affect supply and demand, respectively; and $c_0$, $c_2$, $d_0$, and $d_2$ are constants. Rearranging terms, the supply equation can be written:

$$\log(W) = K + (1/c_1) \log(X) \qquad \text{....Equation (3.2)}$$

where $K = (-1/c_1)\ (c_0 + c_2 \log(Z_2))$

The subsidies to virgin materials lower the value of K in Equation (3.2), because they lower the supply price for any level of output of the virgin material. A 10 percent reduction in the supply curve means that K is reduced by 10 percent. Solving Equations (3.1) for W in terms of all the constants, and differentiating with respect to K, we obtain:

$$(d\log W/d\log K) = c_1/(c_1 - d_1) \qquad \text{....Equation (3.3)}$$

Equation (3.3) states that the percentage change in price for a given percentage shift in the supply curve equals the elasticity of supply divided by the algebraic difference between the elasticities of supply and demand. Because the elasticity of supply, $c_1$, is positive and the elasticity of demand, $d_1$, is negative, (dlogW/dlogK) is always greater than zero and less than one.

As the elasticity of supply approaches infinity (i.e., a flat supply curve), or the elasticity of demand approaches zero (i.e., a vertical demand curve) the percentage change in price becomes equal to the percentage shift in the supply curve (dlogW/dlogK = 1). For very high absolute values of the elasticity of demand (i.e., a flat demand curve indicating a constant market price for any level of domestic output), or for very low values of the elasticity of supply (i.e., a vertical supply curve), the percentage change in price approaches zero.

## II. Effects of International Markets on Price Change from Tax Subsidy

### Tax Subsidy on an Exported Product

Consider the situation in which the United States subsidizes a commodity which it normally exports, for instance, coal. We assume that exchange rates are either free to float or are adjusted from time to time, and that prior to the subsidy the U.S. balance of payments is in equilibrium. The coal market is depicted in Figure 3.3.

The pre-subsidy long-run domestic supply curve for coal is represented by S. The demand curve from domestic users is shown by D. The world demand for coal facing U.S. producers is given by W, and is assumed for now to be perfectly elastic. This means that U.S. producers account for such a small fraction of world coal output that they cannot affect the world price. In the absence of international trade, the U.S. would produce quantity q of coal at price $P_0$. Because the world price of coal, $P_1$, is higher than $P_0$, the U.S. consumes quantity $c_0$ of coal, produces quantity $a_0$, and exports quantity $c_0a_0$. The U.S. now provides a subsidy on coal equal to amount $t_0$. The subsidy will increase the supply curve or shift it downwards by the amount of the subsidy, $t_0$, to S*. Exports increase to quantity $c_0a_1$, but

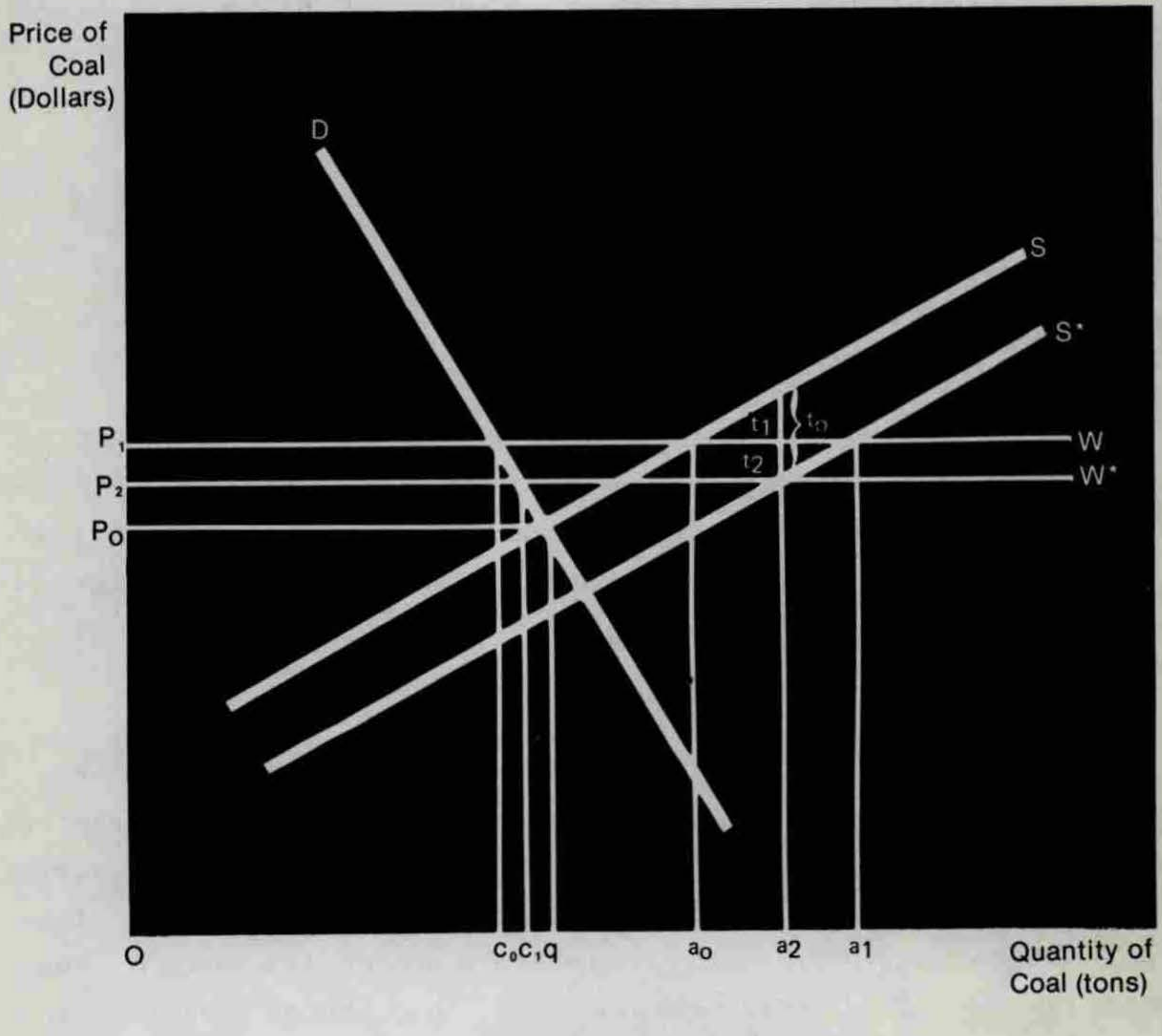



Figure 3.3 Partial equilibrium effect of a subsidy on an exported product

the world price, which is determined by world demand and supply conditions, remains constant at $P_1$. In the short run, since world price is constant, producers receive the benefit of the entire subsidy, $t_0$.

In the long run, the dollar must appreciate to eliminate the payments imbalance caused by the subsidy and increased exports. However, since the appreciation will restrain a variety of exports and stimulate a variety of imports, the dollar price of exported coal will not fall by as much as the amount of the subsidy. Because foreign currencies are worth less in terms of the dollar, the world demand curve, measured in dollars, shifts downwards to W*. The new dollar price of coal, at the appreciated exchange rate, is $P_2$. At this price, consumption increases to $c_1$, production declines to $a_2$, and exports of coal decrease from the short-run post-subsidy, but pre-adjustment level of $c_0a_1$ to quantity $c_1a_2$. Because of the subsidy, and the corresponding exchange rate adjustment, U.S. consumption has increased from $c_0$ to $c_1$, U.S. production has increased from $a_0$ to $a_2$, and U.S. exports of coal have increased from $c_0a_0$ to $c_1a_2$.

It is clear that exports have increased because the initial impact of the subsidy, before any exchange rate adjustment, is to keep consumption at $c_0$ and increase production to $a_1$. Exports are clearly larger than at the initial equilibrium $c_0a_0$. The induced appreciation in the exchange rate will not completely offset the rise in coal exports, because the impact of the exchange rate change will be spread over all U.S. exports and all U.S. imports. In equilibrium, additional U.S. coal exports will be partly offset by smaller exports of other products and larger U.S. imports of various goods. Thus, the coal subsidy encourages coal exports.

The long-run incidence of the subsidy is $t_1$ on U.S. producers and $t_2$ on U.S. consumers, with $t_0 = t_1 + t_2$. The subsidy partly increases the return to producers and partly decreases coal prices. If the U.S. were a large supplier of coal on world markets, the world demand would be less than perfectly elastic, and the increased exports could only be sold at a lower world price, with part of the subsidy going to foreign consumers of coal.

The effect of the tax subsidy on coal prices will be small if increased U.S. coal exports:

(1) have a minor effect on the foreign exchange value of the dollar; and

(2) can be sold at the going world price.

Under these conditions the tax subsidy is dissipated in increased output with little or no shift in relative prices favoring virgin materials consumption. The main effect of the subsidy is to increase our exports of coal.

Tax Subsidy on an Imported Product

The analysis is symmetrical with respect to an imported product, such as bauxite. This situation is depicted in Figure 3.4. If there were no international trade in bauxite, domestic demand and supply would be in equilibrium at price $P_0$ and quantity q. But since the world price, $P_1$, is below $P_0$, the U.S. imports quantity $a_0c_0$ of bauxite. The world supply of bauxite imports also is assumed, in this case, to be perfectly elastic.

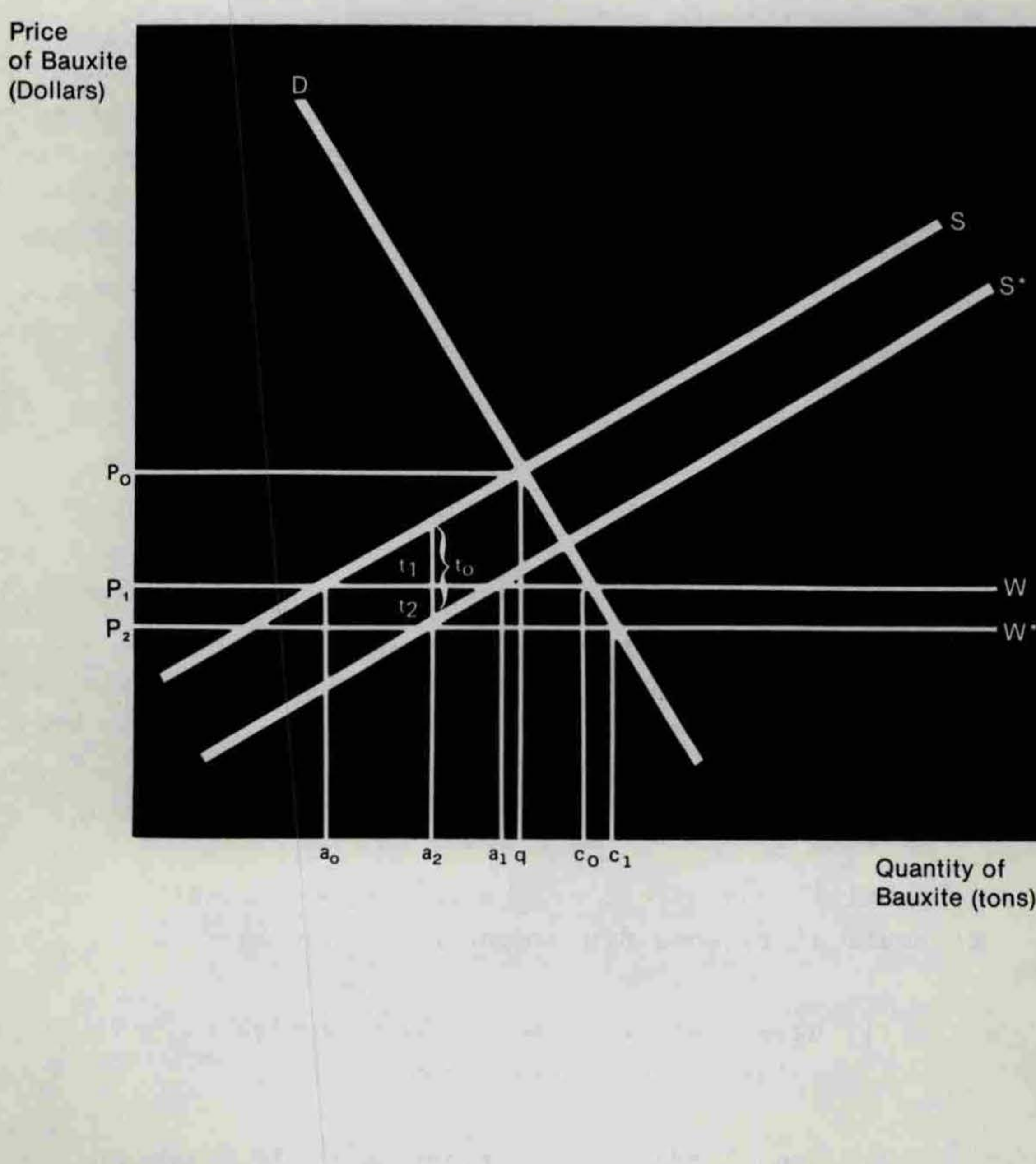



Figure 3.4 Partial equilibrium effect of a subsidy on an imported product

Suppose the U.S. provides a subsidy equal to $t_0$ for the mining of bauxite. As before, the domestic supply curve increases or shifts downward to S* because of the subsidy. Imports fall to $a_1c_0$, and in the short-run pre-adjustment period, the producer gets the full benefit of the subsidy. The reduced imports cause an appreciation in the dollar and a consequent fall in the world price of imports to $P_2$. At this new long-run equilibrium price, the U.S. imports quantity $a_2c_1$ of bauxite. Because of the subsidy and corresponding exchange rate adjustment, U.S. consumption has increased from $c_0$ to $c_1$, production has increased from $a_0$ to $a_2$, and imports of bauxite have fallen from $a_0c_0$ to $a_2c_1$. The conclusion that imports have fallen is based on the same reasoning that led to the conclusion that a subsidy induced an export increase.

The long run incidence of the subsidy is $t_1$ on U.S. producers and $t_2$ on U.S. consumers. This subsidy partly increases the return to domestic producers and partly decreases world bauxite prices. If the U.S. were a large importer of bauxite, the world supply would be less than perfectly elastic, and the reduced volume of imports could be purchased at a lower world price. Then, the subsidy would lower the world price of bauxite, both by its effect on the exchange rate, and by retarding the demand for imports.

Still, the effect of the subsidy on bauxite prices would be small if reduced U.S. imports of bauxite:

(1) have a minor effect on the foreign exchange value of the dollar, and

(2) have little or no effect on world prices.

Under these conditions, the tax subsidy is dissipated in increased output, with little or no shift in relative prices favoring virgin material consumption. The main effect of the subsidy is to reduce bauxite imports.

Rough Approximation of Effect of International Markets on Domestic Price Change

To compute the effect of international markets on materials price changes reported in Chapter 3, we applied Equation (3.3), with a modified value of the elasticity of demand. The modified demand elasticity, $d_1$* was assumed to equal $d_1/(Q/D)$, where $d_1$ is the world demand elasticity for the commodity, and Q/D is the share of world output accounted for by U.S. producers. The term "$d_1$*" is meant to represent the elasticity of demand facing U.S. producers from the entire world.

The rationalization of this approximation is as follows. The world is viewed as a single market for the commodity, with the U.S. accounting for a fraction of world output. If the U.S. accounted for 25 percent of world output of coal, and U.S. output rose by 10 percent, world output would rise by about 2.5 percent. If the world elasticity of demand were -1.0, a 2.5 percent rise in world output, corresponding to a 10 percent rise in U.S. output, would depress price by only 2.5 percent. In effect, the elasticity of demand facing U.S. producers is about four times the elasticity of demand in the entire world market. At one extreme, if U.S. producers accounted for a miniscule share of world output, changes in U.S. output would have no effect on world price, and producers would face an infinitely elastic demand curve. At the other extreme, if U.S. producers accounted for the entire world market, they would face the world demand elasticity.

The revised elasticity estimate, $d_1*$, is then substituted for $d_1$ in Equation (3.3) to compute the effect on the world price of a shift in the domestic supply curve. Because the absolute value of $d_1*$ is greater than the absolute value of $d_1$, Equation (3.3) yields a smaller price effect.

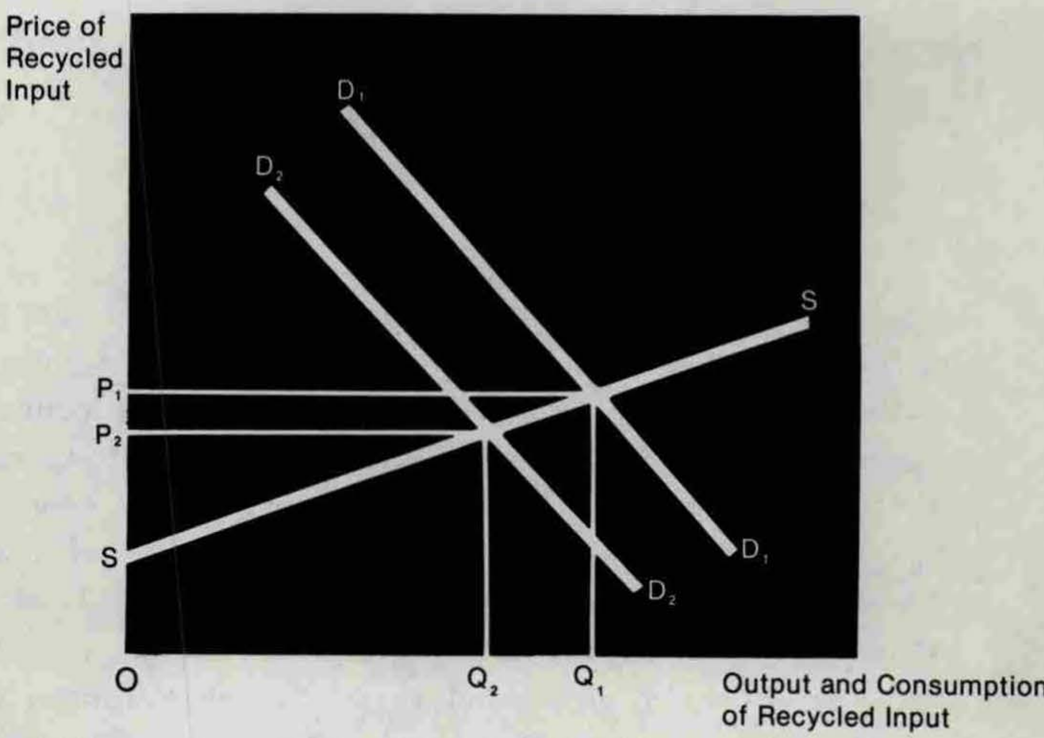
The exchange rate effect discussed above was ignored in these computations, because it is probably very small. This may slightly understate the price effect; however, the price effect is overstated by ignoring the effects of changes in the world price on output supplied from other countries.

## III. Effect of Change in Price of Virgin Input on Recycling

### Recyclable Input Treated as Imperfect Substitute for Virgin Input

As noted in the text, econometric models estimated in the literature generally treat virgin and recyclable materials as separate goods, each with a distinct demand and supply curve. This section illustrates the effect, in such models, of the change in the price of a virgin material input on the equilibrium level of output and price of the recyclable input.

Figure 3.5 illustrates the impact of virgin material price changes on the amount of recycling. A reduction in the price of virgin materials lowers the demand for recyclable inputs from $D_1$ to $D_2$, reducing their price and output. The decline in output is relatively greater the more elastic (flatter) the supply curve, and the less elastic (steeper) the demand curve.




$D_1$ = demand curve for recycled inputs at initial virgin mineral prices

$D_2$ = demand curve for recycled inputs at lower virgin material prices

$P_1$,$P_2$ = pre-subsidy and post-subsidy prices of recycled inputs

$Q_1$,$Q_2$ = pre-subsidy and post-subsidy output and consumption of recycled inputs

S = supply curve for recycled inputs

Figure 3.5 Effect of Reduction in Virgin Material Prices on Recycling

The effect of changes in virgin material prices on the amount of recycling can be derived from a two-equation model of the market for recyclable inputs:

Supply: $\log(Q) = a_0 + a_1\log(P) + a_2V_1$

...Equation (3.4)

Demand: $\log(Q) = b_0 + b_1\log(P) + b_2\log(W) + b_3V_2$

...Equation (3.5)

In equations (3.4) and (3.5), W is the price of virgin materials; P is the price of recyclable inputs, Q is the quantity of recyclable inputs produced and consumed; $V_1$ and $V_2$ are vectors of exogenous variables affecting supply of and demand for recyclable inputs, respectively; and $a_0$, $a_1$, $a_2$, $b_0$, $b_1$, $b_2$, and $b_3$ are constants. The term $a_1$ represents the supply elasticity of recyclable inputs, $b_1$ is the own-price elasticity of demand for recyclable inputs, and $b_2$ is the cross-elasticity of demand for recyclable inputs with respect to the virgin material price. The supply equation expresses quantity of recyclable inputs as a function of their price, and other variables, including consumption of the finished goods, which generates scrap potential. The demand equation expresses use in production of recyclable inputs as a function of their price, the price of competing virgin materials, and other variables, including current primary product production.

Solving Equations (3.4) and (3.5) for Q, we obtain:

$$\log(Q) = \frac{a_0b_1 + a_1b_3V_2 - a_0V_1 - a_2V_1b_1}{(a_1 - b_1)} + \frac{a_1b_2 \log(W)}{(a_1 - b_1)}$$

Finally, differentiating with respect to W, the percentage change in recycling for any percentage change in the price of the competing virgin material can be expressed as:

$$(d\log(Q)/d\log(W) = (a_1 b_2)/(a_1 - b_1) \quad \text{....Equation (3.6)}$$

where $(d\log(Q)/d\log(W))$ is the elasticity of amount of recycling with respect to virgin material price. Because $a_1$ and $b_2$ are positive and $b_1$ is negative, $(d\log(Q)/d\log(W))$ is positive, i.e., a reduction in the virgin material price reduces the amount of recycling. It can be seen from Equation (3.6) that the effect of virgin material price changes on the amount of recycling is larger for higher values of the elasticity of supply of recyclable materials ($a_1$) and the cross-elasticity of demand for recyclable materials ($b_2$), and for lower absolute values of the own price elasticity of demand for recyclable materials ($b_1$).

Recyclable and Virgin Inputs as Perfect Substitutes

As the text notes, virgin and scrap copper can be regarded as perfect substitutes. In this case, the percentage change in recycling equals the percentage change in the price of the material, multiplied by the supply elasticity of the recyclable material ($d\log(Q) = a_1 d\log(W)$). The price of the material will be the same whether obtained from a virgin natural resource or by recycling.

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