PACKAGE DEAL

The Economic Impacts of Recycling Standards for Packaging in Massachusetts

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EXECUTIVE SUMMARY

This report examines the economics of recycling. It consists of three related parts. Part One compares the costs of recycling with the costs of landfilling and incineration for a representative ton of materials found in municipal solid waste. In Part Two, we analyze the dynamics of recycling markets and determine that recycling standards are the critical mechanism for remedying deficiencies in demand for recovered materials. Part Three of the report evaluates the likely impacts of Massachusetts recycling standards for packaging (RSP), taking into account both microeconomic and macroeconomic effects.

PART ONE: RECYCLING PAYS, BUT BY HOW MUCH?

It is widely recognized that the recycling of materials confers a net benefit to society, but just how large is the social benefit? Casual estimates are typically based on the revenue from recycled materials plus the avoided tipping fee for incinerating or landfilling of the (otherwise waste) material. However, tipping fees bear no necessary relationship to the actual social costs of solid waste disposal, and the recycling of materials imposes costs that must also be included in the calculation.

For the purposes of this analysis, we assume that current market conditions and prices for recycled materials prevail. In fact, as we argue in Part Two, recycling standards for packaging are required precisely in order to realize this assumption, by maintaining viable markets for recycled materials.

The net social benefits of recycling can be derived from five elements:

(1) Revenues From Recyclers for Separated Materials: The current market values for separated and processed paper, glass, plastics, steel, and aluminum, adjusted for the projected composition in the year 2000 of a typical ton of Massachusetts municipal solid waste, yield an estimated revenue of $49/ton.

Plus: (2) Avoided Subsidy to Virgin Materials: Since the use of recycled materials reduces the need for virgin materials, the cost of government subsidies to producers of those materials--consisting of tax benefits, below cost sale of natural resources, and uncompensated technical support--is avoided. The magnitude of the subsidy is estimated to be approximately $3/ton.

Minus: (3) Costs of Collecting and Separating Materials for Recycling: The capital and operating costs needed for the collection and separation of recycled materials--based on current garbage collection costs, additional costs associated with collecting recyclables, and the experience of the Springfield Materials Recycling Facility--is estimated to be $86/ton.

Plus: (4) Avoided Disposal Costs of Incineration (for that share of municipal solid waste that is incinerated): The Commonwealth predicts that, by 1992, the ratio of incineration to landfilling will be 70% to 30%. Adding capital costs, Federal tax subsidies, the cost of remedial pollution control equipment, operating costs, ash disposal costs, and the social cost of environmental harm and disamenities, and subtracting revenues from the sale of electricity produced from solid waste combustion, yields a net cost of $289/ton of waste incinerated in Massachusetts facilities. 70% of that figure provides the avoided disposal cost of $202/ton.

Plus: (5) Avoided Disposal Costs of Landfilling (for that share of municipal solid waste that is landfilled): Capital costs, operating costs, clean-up and post-closure care costs, additional costs of impending landfill regulations, and the social cost of environmental harm and disamenities come to $209/ton. 30% of that figure provides the avoided disposal cost of $63/ton.

Based on the preceding estimates, we are now able to calculate the net social benefits of recycling, as applied to packaging material.

Recycling Revenues:	$49/ton	
Recycling Costs:	$86/ton	
Net Recycling Revenue:		$(-37)/ton
Avoided Subsidy to Virgin Material:		$ 3/ton
Avoided Cost/Ton of Incineration (for the share of waste incinerated)		$ 202/ton
Avoided Cost/Ton of Landfilling (for the share of waste landfilled)		$ 63/ton
Net Benefit of Recycling:		$ 231/ton

Appendix A of the report subjects the estimates cited above to a sensitivity analysis, in which each variable influencing the net benefit of recycling is allowed to assume a range of possible values. This analysis demonstrates how robust the $231/ton estimate is. With few exceptions, substituting the high and low values of a variable in place of the baseline value still results in a net benefit of recycling of between $200 and $265.

PART TWO: WHY RECYCLING STANDARDS FOR PACKAGING ARE NECESSARY

This section answers the following two related questions:

(1) If the benefits of recycling are so substantial ($231/ton), won't private markets provide the desired expansion of recycling activity (to its optimum level)?

(2) Why are recycling standards for packaging (RSP), or any other form of government intervention, needed?

Market imperfections plague recycling efforts. For a market to operate efficiently, economic agents must bear the full marginal social costs (and realize the full marginal social benefits) associated with their actions. Imperfections in solid waste disposal markets prevent this condition from being realized.

Because the price for solid waste disposal does not reflect the environmental harm and disamenities accompanying such activities, solid waste generators are able to escape these costs. The other source of the market failure arises from the way in which solid waste collection and disposal are financed. Local government typically finances market costs of collection and disposal from general tax revenues, making a household's *marginal* tax burden of discarding an additional unit of trash effectively zero, even though the associated market cost is not.

> *Example:* Suppose a town contains 6000 households, each paying $400 a year in taxes to collect and dispose of the 6000 pounds of solid waste it generates. The marginal cost to the town of each additional pound of trash is 6.7 cents, but the cost borne by each household in tax payments for each additional pound discarded is only 6.7/6000 cents, or approximately 1/1000 of a penny.

This discrepancy distorts incentives for individuals to reduce the amount of material they discard and results in an inadequate amount of recycling from a social perspective.

Government-mandated separation and collection of recyclable materials has fatal limitations. Until recovered materials are actually reused--until they are converted into new products and sold to new customers--no meaningful recycling has been achieved. It is the inability of government-mandated waste separation and collection programs to remedy deficiencies in demand for the recovered materials that will quickly cause them to fail. Some cities have already discovered that no markets exist for their recyclables.

Existing demand-side policies are ineffective. *Economic charges and taxes* (on household waste disposal, packaging, or virgin materials) face insurmountable practical problems concerning accuracy, fairness, effectiveness, and collection costs. *State procurement* constitutes too small a percentage of packaging sales to remedy deficient private demand for recyclable materials. *Unconditional product bans* eliminate the possibility of recycling the banned material or packaging and provide no additional demand for recovery of the material that replaces it; historically, unconditional bans have been applied to isolated materials and packaging in a relatively unsystematic manner, limiting their effect.

Recycling standards for packaging are the mechanism critical to remedying deficiencies in demand for recovered materials. Since packaging is the largest single source of municipal solid waste (MSW), comprising one-third of MSW, it is there where recycling standards would, in all likelihood, be most productively applied. RSP will stimulate recycling demand for the major types of materials used in packaging--paper, glass, plastics, steel, and aluminum. These materials account for 60% of MSW.

RSP should contain at least two provisions: that packaging consist of a given percentage of *recycled* material, and, alternatively, that packaging be made of *recyclable* materials (those which achieve a specified statewide recycling rate for all uses of the material). An important feature of the two provisions is their synergy, which causes the demand for recovered packaging materials to ratchet up.

The function of government should not be to replace the market but to organize and maintain a market that is not independently sustainable. Mandatory separation and collection, education of consumers and businesses, information clearinghouse functions, and state procurement take on added importance when complemented by RSP. The combination of these activities can provide the stability in recycling markets that private investors require and help develop a large-scale recycling infrastructure.

PART THREE: THE EFFECT OF RECYCLING STANDARDS FOR PACKAGING IN MASSACHUSETTS

Microeconomic Effects: The Benefits and Costs of RSP

(1) Net Social Benefits of Increased Recycling of Packaging Material Due to RSP: Although less than 10% of Massachusetts's 6.6 million annual tons of MSW is currently recycled, a larger proportion of packaging discards (estimated at 2.23 million tons) is recycled: approximately 16% by weight, or 357,000 tons per year.

For purposes of analysis, we assume that an aggressive, but realistic, RSP program can and will increase the recycling rate for discarded packaging to 50%. Not only have other countries met or exceeded this level, but most packaging materials now used in the U.S. have already reached or are anticipated to reach 50% recycling.

For all packaging in Massachusetts to comply with RSP by consisting of 50% recycled materials would require a total of 1.115 million tons of MSW to be recycled, or an increase of 758,000 tons per year from current levels. (We argue below that, for economic reasons, most additional recycled material processing and formulation will occur in-state.) Earlier, we calculated the net social benefit derived from recycling of packaging material at $231/ton. *Based on this figure, the net social benefit of RSP associated with the additional 758,000 tons per year of recycled MSW is approximately $175 million annually.*

(2) Ancillary Benefits of RSP: In addition to increasing the proportion of recycled materials in packaging, an RSP program will promote packaging reduction and reuse, as well as recycling of packaging materials from non-packaging uses. There is no reason these "ancillary" benefits might not exceed in magnitude the aforementioned benefits from recycled packaging.

For example, businesses might choose to comply with RSP by using recyclable packaging material--those that are achieving a statewide recycling rate of 50% from all uses. If all packaging were to comply with this criterion, half the 4 million tons of these materials discarded annually in Massachusetts would have to be recycled; just 700,000 tons are estimated to be recycled currently. We previously estimated the impact of the recycled content standard at 758,000 additional tons of recycling; satisfying the recyclability standard (2 million tons) would therefore require another 542,000 tons annually. *Using $231/ton as the net social benefit of recycling packaging material, the potential leveraged benefits of RSP due to the recyclability criterion are approximately an additional $125 million per year.*

Obviously, if some packaging complies with the recycled content standard and the remainder with the recyclability standard, then *the total social benefits will fall somewhere between $175 million and $300 million annually.*

(3) RSP Compliance Costs are the additional costs that firms incur to make their packaging meet packaging recycling standards. We expect these compliance costs to be small for a number of reasons, including:

* some packaging is already in compliance with RSP;

* firms modify their packaging, on average, every two to three years, so that RSP compliance will be part of the regular process of packaging revision;

* packagers will aggressively market their compliant packaging, reducing packaging buyers' need to spend resources seeking that information.

In addition, two by-products of RSP compliance will tend to minimize, or offset, RSP compliance costs:

* *joint production efficiencies*: the re-evaluation of production processes needed to achieve compliance with RSP will allow some firms to introduce simultaneous productivity improvements at the same time;

* *packaging and recycling innovations*: government regulation with the characteristics of RSP has been shown to stimulate the performance of industry.

(4) Administrative Costs of RSP include government's costs of developing, supervising, and enforcing an RSP program, as well as the costs businesses incur to verify and demonstrate their compliance. Because of its heavy reliance on market solutions, we anticipate that RSP will keep the government's administrative costs to a modest level. Competitors can be expected to challenge unwarranted exemption requests, while increased recycling will reduce governmental costs associated with other environmental programs. Retailers, meanwhile, will develop standard contract language requiring their suppliers to assume liability for any and all costs and penalties arising from delivered packaging in violation of RSP.

(5) Possibility of Product Withdrawals or Shortages: Simply put, there will be no vacant shelves in Massachusetts as the result of an RSP program. Although this prospect is raised by industry every time it is faced with stringent regulation, the functioning of economic markets prevents product withdrawals or shortages. Manufacturers of compliant packaging will rush in to fill the void left by non-compliant competitors, and packaging entrepreneurs will develop novel packaging solutions that better incorporate the new realities of the marketplace.

Macroeconomic Effects on Massachusetts Employment and Economy

(1) General Caveats: The analysis of any policy requires tracing the long-run consequences of that policy for all economic sectors, not merely the immediate effects of the policy or the effects on only one economic sector. For example, some manufacturers of non-compliant packaging will lose business and employees. But those losses will be offset by the additional business and employment created for manufacturers of recyclable or recycled-content packaging: recycling standards will result not in a loss of jobs, but in a diversion of jobs.

It should also be understood that just because an economic agent is "affected" by a policy or change in economic activity doesn't necessarily mean that the impact is negative. The purpose of the recycling standards is precisely to "affect" businesses and households by providing incentives to alter behavior in ways that promote recycling.

(2) Real and Implicit Tax Reductions: Every dollar an RSP program saves Massachusetts in solid waste disposal costs directly translates into a dollar reduction in tax burden for Massachusetts taxpayers.

Of the estimated \$175 - \$300 million net social benefit of an RSP program, approximately 42% is associated with the avoided out-of-pocket costs and the remaining 58% is derived from the avoided imputed costs of solid waste disposal. Thus, *the net social benefits of an RSP program translate into a tax reduction of \$75 - \$125 million annually for Massachusetts businesses and households, and an additional implicit tax benefit of \$100 - \$175 million* (which may appear in such areas as reductions in environmental hazards and their associated health and work-loss consequences).

Social benefit translate to tax reduction

These real and implicit tax reductions brought about by an RSP program will serve to stimulate the Massachusetts economy and employment in Massachusetts. Tax reductions (without corresponding loss of services) will attract both workers and industry to the state.

(3) Industry-Specific Effects: An RSP program will stimulate certain industries and cause others to contract. The stimulated activities will be conducted primarily in Massachusetts, while the industries adversely affected are primarily out-of-state. Although numerical projections of job gains and losses are necessarily uncertain and subject to analytic abuse, we are confident in concluding that recycling standards will have a positive effect on employment in Massachusetts. (Rough estimates of job gains are included, where relevant, in footnotes to this report.)

Our reasoning with respect to each affected industry is as follows:

Because *materials collection and sorting* are much more labor intensive than landfilling and incineration, the shift of economic activity to these local industries will create additional employment in Massachusetts.

Only about 18,000 Massachusetts *manufacturing jobs* are packaging-related. These jobs will not be lost as a result of recycling standards, but there will be some diversion of job activity to recycled-content or recyclable packaging.

The *packaging industry* itself employs approximately 22,000 workers in Massachusetts. Some packagers will be positively affected by RSP; some negatively. But these impacts are inherently off-setting: one packager's loss signals a competitor's gain, with the net effect on Massachusetts employment small.

Most importantly, however, the shift to recycled and recyclable packaging will boost Massachusetts employment in all materials processing and packaging-related businesses. The amount of economic activity in Massachusetts involving *virgin materials extraction and processing* (such as forestry and mining) is extremely small. Thus, any loss of economic activity in this area will have only a negligible effect on the state economy. Conversely, RSP-induced stimulation of *recycled materials formulating and processing* should have a substantial positive impact on employment. Because of the relatively high cost of transporting materials, additional formulation and processing will, for the most part, happen locally. In-state packagers who quickly adapt to the new market conditions will also enjoy competitive advantages.

(4) Other Effects and Considerations: The successful implementation of RSP in Massachusetts would surely provide the impetus for adoption of this program in other states. In addition, the pervasive benefits of recycling standards will act to reduce materials and production costs throughout the economy, thereby improving the competitiveness of Massachusetts and American industry. Finally, recycling standards for packaging will provide the means for a successful transition from a throw-away society to one that respects and values its resources.

PART ONE:
RECYCLING PAYS, BUT BY HOW MUCH?

It is widely recognized that the recycling of materials confers a net benefit to society, but just how large is the social benefit? Casual estimates are typically based on the revenue from recycled materials plus the avoided tipping fee for incineration or landfilling of the (otherwise waste) material. However, tipping fees bear no necessary relationship to the actual social costs of solid waste disposal, and the recycling of materials imposes costs that must also be included in the calculations.

Our objective, in the analysis that follows, is to determine the magnitude of the social benefits of recycling. For the purposes of this analysis, we shall assume that, broadly speaking, current market conditions and prices for recycled materials prevail. In fact, as demonstrated in Part Two of this study, recycling standards for packaging (RSP) are required precisely in order to realize this assumption (that is, a major reason recycling packaging standards are needed is to maintain a viable market for recycled materials).

Since our overall policy interests here concern recycling standards for packaging, we shall focus on the benefits of recycling per composite ton of packaging material. Note, however, that compliance with RSP can normally be achieved in ways other than by increasing the recyclability of packaging material. For example, two potential methods of compliance are to increase the recycled content of packaging or to increase the recycling rate of the types of material used in packaging (e.g., paper)--including non-packaging applications (e.g., newspaper)--above some threshold level. For this reason, recycling rates of materials used in packaging--both in packaging and non-packaging applications--will be relevant in the subsequent analysis. For convenience, our use of the term "package recycling" will, unless otherwise specified, refer to all possible packaging effects of RSP, to encompass the recyclability of packaging, the recycled content of packaging, and the recycling of materials used in packaging.

The net social benefits of recycling can be derived from five elements: (1) the revenues from recyclers for separated materials; plus (2) the avoided subsidy to virgin materials; minus (3) the costs of collecting and separating materials for recycling; plus (4) the avoided disposal costs of incineration (for that share of municipal solid waste that is incinerated); plus (5) the avoided disposal costs of landfilling (for that share of municipal solid waste that is landfilled).[1] Each element depends on a variety of factors that are likely

[1]We have attempted, to the extent possible, to capture all the social benefits and costs of recycling, even though these benefits and costs may not be reflected in market transactions. Thus, for example, government subsidies to develop virgin materials and the externalities generated by incineration and landfilling are included in the subsequent calculations. However, in order to prevent the analysis from becoming

to vary over time and from site to site.[2] Because of data limitations and other empirical difficulties, some estimates are based on simplifying (but, we believe, reasonable) assumptions.[3] Therefore, these calculations should be viewed as merely indicative of the actual social costs rather than as precise and definitive estimates. To avoid complicating the discussion unnecessarily, the ensuing text presents only our best estimate of the magnitude of each variable affecting the net social benefits of recycling, culminating in a single point estimate of the net social benefits of recycling. However, in Appendix A, we consider a range of possible values these variables may assume, re-estimate the net social benefits of recycling under these alternative assumptions, and evaluate the sensitivity of our results to changes in the values used in the calculations.

A. The Revenues from Recycling

Recall that our focus here is on the recycling of packaging materials in its broadest sense, to include both the recycling of packaging and the recycling of the types of material used in packaging. The composition of packaging by material by weight is provided in Column (b) of Table 1.[4] These percentages correspond very closely to the projected

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intractable, we did not consider the effect of externalities in primary materials extraction and processing relative to those in secondary materials collection and processing. One potential example of an externality in these markets is the consumption of depletable energy resources. Since materials recovered through recycling generally use substantially less energy than that required for the development of equivalent virgin materials (Office of Technology Assessment [1989], pages 142-184; Kovacs [1988], pages 543-544; and Stauffer [1989]), to the extent that the price of energy does not fully measure its cost of production (including the scarcity value of depletable resources used in energy production), the net benefits of recycling will be correspondingly understated in our calculations. The magnitude of the underestimation could be substantial.

[2]Whenever possible, we base our estimates on Massachusetts data or projections. Otherwise, in order of preference, we rely on national averages or on data from other states.

[3]We should also note that, except in calculating the revenues from recycling, we did not disaggregate our analysis on a material by material basis. Thus, our estimates may not be applicable to a specific type of packaging material in isolation. For example, collection costs for plastics will be higher than our estimates because a ton of plastics takes up more space relative to other packaging materials. For similar reasons, the cost of landfilling a ton of plastics will be higher than our estimates, which are based on a composite ton of packaging material.

[4]By comparison, packaging materials currently comprise the following percentages by weight of municipal solid waste: paper, 36%; glass, 8%; plastics, 7%; steel, 8.5%; and aluminum, .5%. (Source: Office of Technology Assessment [1989], page 5.)

TABLE 1

REVENUES FROM RECYCLED PACKAGING MATERIALS

(a) MATERIAL	(b) % BY WT.[1]	(c) % OF RECYCLED[2]	(d) PRICE/TON	(c) x (d) COMPOSITE
Paper	55%	53%	$15[3]	$7.95
Glass	22%	23%	$30[4]	$6.90
Plastics	11%	10%	$180[5]	$18.00
Steel	5%	13.5%	$75[6]	$10.12
Aluminum	3%	.5%	$1170[7]	$5.85
				$48.82

[1]Source: Franklin Associates (1988a).

[2]Source: Massachusetts Solid Waste Master Plan (1989), pages 81-87.

[3]Recycled paper prices/ton range from $-30 to $35 for newsprint; to $40 to $50 for cardboard; to $185 to $200 for Xerox paper. Sources: Barry (1989), Boston Business Journal (June 18, 1990), Massachusetts Solid Waste Master Plan (1989), and Armerding (1990).

[4]Recycled glass prices/ton range from $15 to $60 for clear glass to $15 to $35 for green or amber glass. Sources: Office of Technology Assessment (1989) and New York State, Department of Economic Development (1987).

[5]Recycled plastics prices/ton range from $40 to $140 for PET to $100 to $580 for HDPE. Sources: Recycling Times (reported in New York State, Department of Economic Development [1987]) and Wirka (1988).

[6]Recycled steel prices/ton range from $50 to $100. Sources: Resource Recycling (March 1990) and Office of Technology Assessment (1989).

[7]Recycled aluminum prices/ton range from $1000 to $1340. Source: Office of Technology Assessment (1989).

composition (in the year 2000) of a typical ton of recycled material[5]--for those materials used in packaging--by weight in Column (c) of Table 1.[6] Because these percentages are so similar, we shall use the latter projections to represent the overall composition of recycled packaging by material by weight (to be multiplied by the price/ton for those materials in the last column of Table 1).

The price/ton paid by recyclers for a given (separated and processed) packaging material is difficult to estimate because each class of material has so many grades and attributes that affect price.[7] In addition, the price for a given grade of material is susceptible to wide variations due to short-term shifts in supply or demand. Rough estimates of the average price/ton of a given packaging material are provided in Column (d) of Table 1. Multiplying these prices/ton by the composition of recycled packaging material by weight (from Column [c]) yields a composite price/ton for recycled packaging material of approximately $49 at the bottom of the last column of Table 1.[8] Thus, our estimate of the average revenue per ton of recycled packaging material is $49/ton.

B. The Avoided Subsidy to Virgin Materials

Virgin materials producers (for mining, timber, and petroleum, for example) enjoy (1) tax benefits, such as depletion allowances and special treatment of income, (2) below

[5]Note that the best measure of recycling rates would include all (interfirm) industrial recycling of materials, even those which do not become part of municipal solid waste. However, because of data limitations, most measures of recycling rates are based solely on recovery of materials that enter the solid waste stream. For this reason, throughout the study, we too will be forced to use the conventional, but inferior, MSW measure of recycling rates.

[6]These percentages should not be confused with current recycling rates for these materials: paper, 22%; glass, 10%; plastics, 1%; steel, 21%; and aluminum 25%. (Sources: Franklin Associates [1988a] and Office of Technology Assessment [1989], pages 161-162.) Nor should they be confused with the current composition of a typical ton of recycled material used in packaging, which--based on the current recycling rate of these materials and their share of the municipal waste stream--is approximately as follows: paper, 74%; glass, 8%; plastics, 1%; steel, 16%; and aluminum, 1%.

[7]For example, there are 49 grades of wastepaper and 31 other specialty grades (Kovacs [1988], page 597). As another example, the price of steel in recycling markets depends on whether the scrap metal has been detinned.

[8]Note that average recycling revenues currently range from $5/ton to $25/ton (various sources, including Allan, Platt, and Morris [1989], New York State Department of Economic Development [1987], and telephone conversations with Springfield and Rhode Island MRFs). The discrepancy between our estimate and current recycling figures is explained by the dominance of paper in current recycling (over 75% at the MRFs) and the depressed price for newsprint (as low as $-30) during some periods in some markets. Note also that a negative price for recycled material (that is, paying recyclers to take the material) is certainly plausible if alternative methods of disposing of the material are even more costly.

cost sale of natural resources by the government, and (3) uncompensated technical support and services, such as provided by the Forest Service and the Department of the Interior, all of which are not available to producers of recycled materials. These government benefits subsidize the cost of virgin raw materials and constitute a type of social cost not reflected in market prices. The use of recycled materials, in effect, reduces the use of virgin materials and with it the social cost represented by these subsidies to producers of the virgin materials.

The size of the government subsidy to virgin materials is difficult to calculate. Crude estimates of the magnitude of the tax subsidy are equal to approximately 1 percent of the price of paper, 2 percent of the price of steel, and 5 percent of the price of aluminum.[9] These estimates do not take into account the non-tax subsidies, but these may be offset, more or less, by severance taxes[10] and the fact that recent changes in the tax code have tended to reduce tax benefits provided to the developers of virgin natural resources.[11]

Assuming that the size of the government subsidy is only about 2 percent of the price of virgin materials and that the price of a composite ton of virgin materials used in packaging is approximately $150, we estimate that each ton of recycled material eliminates a government subsidy to virgin materials of approximately $3.

C. The Costs Of Recycling

Estimates of the cost of collecting discarded materials *for waste disposal* range from $35 to $65 per ton.[12] We shall assume a mid-point figure of $50 per ton. In comparison to these costs, the process of collecting and separating materials *for recycling* often imposes additional economic costs. These additional costs are particularly likely to arise in cases

[9] These estimates were developed by the Environmental Law Institute (1976), as reported in Franklin Associates (1988b).

[10] Producers of virgin materials must sometimes pay additional taxes. The most prominent of these is a severance tax levied, usually at the state level, on either the quantity or value of output. However, there is some evidence that, even in those cases where a severance tax is levied, the tax has only one-third to one-tenth the impact on market price that the depletion allowance has. See Tietenberg (1988), page 186, and Anderson (1978), page 23.

[11] See Franklin Associates (1988b), pages 7-9.

[12] See Tufts University (1988), page 11; Office of Technology Assessment (1989), page 62; and Denison and Ruston (1990), page 140. Note that these collection costs do not affect the magnitude of the net social benefits of recycling since they arise both for waste disposal and recycling. However, they would be relevant in other contexts, such as in calculating the net social benefits of source reduction (e.g., reducing the amount of packaging).

where recyclable materials are not user separated and collected by individual type of recyclable material. Our estimate of the additional recycling costs in these cases is derived from data concerning the Springfield Materials Recycling Facility (MRF).[13]

As part of its materials recycling plan for the Western Region of Massachusetts (served by the Springfield MRF), the Commonwealth provided the communities in the region a total of $2,100,000 to defray their additional collection costs for recyclable materials. Most of the additional costs were for special collection trucks and collection containers.[14] Assuming a five-year life for this equipment and that the Springfield MRF processes 60,000 tons of recyclables per year (or 300,000 tons in five years), the average additional capital cost per ton for the collection equipment is $7. In addition, the investment in collection equipment either requires financing or diverts assets that could earn interest or otherwise be profitably employed.[15] Assuming a real interest rate of 6

[13]Unless otherwise specified, the information concerning the Springfield MRF was obtained in a telephone conversation with Steve Ellis of the Massachusetts Department of Environmental Protection on July 30, 1990.

[14]To the extent that the special collection trucks replace other solid waste collection vehicles, the reported costs overestimate recycling collection costs (since the costs of the trucks replaced should be subtracted). On the other hand, to the extent that the funding provided by the Commonwealth does not fully compensate the participating communities for the additional collection costs they incur, the reported costs underestimate the additional collection costs due to recycling.

[15]The issue of opportunity cost arises in the case of capital investments or whenever the benefits of an activity are realized in a time period different from the time period in which the associated costs are incurred. The interest charges in these cases will be estimated in relation to the timing of activities (and therefore relative to equivalent operating costs, which would not incur interest charges) according to the following formula:

$$C = \frac{P}{n} \times \sum_{1}^{n} ((1 + i)^{(n-1/2)} - 1)$$

where C is total interest charges; i is the real interest rate (the nominal interest rate minus the rate of inflation); n is the life of the investment; and P is the size of the investment. The average interest charge per ton is C/tons.

The logic of the equation can be illustrated by the following simplified example. Suppose a material costs $5 per unit to produce and 20 units are produced each year. Two years' worth of output would cost $200, payable when the units are produced. Assuming a continuous flow of output, the midpoint payment for the first year's costs occurs after 1/2 of the first year, and the midpoint payment for the second year's costs occurs after 1 1/2 years. By comparison, suppose production of a material requires an initial investment of $200, payable before production begins. Hypothetically, we can apportion the $200 equally among the years of production, or $100 of investment for each of the two years' production. Then, the interest costs for the first year of production, <u>when compared to the continuous flow example</u>, is $100 multiplied by the real interest rate for the additional half year duration between investment and production, and the interest costs for the second year of production, <u>when compared to the continuous flow example</u>, is $100 multiplied by the real interest rate for the addition 1 1/2 years duration between investment and production. Total interest costs are the sum of the interest costs for each year of the productive life of the investment.

percent per annum,[16] the average interest charge is $1 per ton.[17] Thus, the total additional collection cost, including interest charges, per ton of recyclables is $8.[18]

The additional cost of separating recyclables is made up of two components: capital costs and operating costs. The cost of constructing the Springfield MRF was $5,200,000. Assuming a 20-year life for the facility (in which 1,200,000 tons of recyclable material will be processed), the $5,200,000 capital investment imposes a per ton cost of approximately $4. Assuming a real interest rate of 6 percent, the interest charges per ton for the capital investment are an additional $4. Thus the total capital cost including interest, as reflected by the Springfield MRF, is $8/ton.[19]

The cost of operating the Springfield MRF involves the operating costs of the building, the operator fee, and an operator revenue incentive. The operating costs of the building are $480,000 per year, or $8 per ton of recyclables. The operator fee is approximately $14 per ton. The operator revenue incentive provides the operator with 35 percent of the revenues in excess of $29.88 per ton for recyclables and requires the operator to absorb 35 percent of the revenue shortfall below $29.88 per ton. Since we have estimated that the revenue per ton for recycled packaging material will be approximately $49, the associated operator revenue incentive will be equal to $7 per ton.[20] Hence, the total operating cost of processing materials for recycling, based on the experience of the Springfield MRF, will be $8/ton plus $14/ton plus $7/ton, or a total of $29/ton of recyclables.

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[16]The 6 percent real interest rate is based on a nominal interest rate of 10 percent per annum and a rate of inflation of 4 percent per annum.

[17]Applying the preceding formula yields interest charges for a five-year investment equal to 16.07 percent of the capital invested. For the $2,100,000 investment in collection equipment, the interest charges total $337,571. Dividing by the 300,000 tons of recyclables yields an interest charge per ton of approximately $1.

[18]Some confirmation that this estimate falls within an acceptable range was provided by Jamie Hill, Research Analyst for the National Solid Waste Management Association, during a telephone conversation on October 23, 1990. She reported that, based on rough figures from a sample of communities, the additional cost of curbside collection for recycling ranged from $8 to $32 per household per year, which is approximately equivalent to from $3 to $12 per ton.

[19]Estimates based on the Rhode Island MRF, which cost $4,500,000 to construct and has a capacity of 51,000 tons of recyclables per year (Glenn [1990]), would be virtually identical.

[20]Note, however, that the current revenue per ton received by the Springfield MRF is approximately $12, so that the operator revenue incentive currently requires the operator to pay back the Commonwealth approximately $6 per ton (a negative cost). For reasons indicated earlier, current recycling revenues underestimate projected future recycling revenues per ton.

Combining the additional collection costs of $8/ton with the additional separation costs of $8/ton for capital costs and $29/ton for operating costs yields a total additional cost for collecting and separating recyclables of $45/ton. However, recall that not all recyclables require additional collection and separation costs. Recyclable materials that are user separated and collected by individual type of recyclable material should be no more costly to process than waste material. Many recyclables from commercial activity--such as corrugated boxes--fit this description. As a result, we shall assume that only 80% of recyclables require additional collection and separation costs. The additional collection and separation cost for the average recyclable material is therefore $36/ton (that is, 80 percent of $45/ton). Finally, the total cost of collecting and separating material for recycling is $50/ton for the basic collection costs for discarded materials plus the additional $36/ton for collecting and separating materials for recycling, yielding a sum of $86/ton.

D. The Avoided Disposal Costs of Incineration

One of the social benefits from recycling is the avoidance of waste disposal costs. We assume that all packaging material wastes will either be incinerated or landfilled. In this section, we calculate the social costs of waste disposal by incineration; in the following section, we calculate the social costs of waste disposal by landfill. Since the Commonwealth predicts that, by 1992, the ratio of solid waste that is incinerated relative to landfilled will be 70 percent to 30 percent (Massachusetts Solid Waste Master Plan [1989], page 18), we shall assume the same proportions in estimating the avoided costs of packaging material waste disposal.

In addition to solid waste collection costs of $50/ton, the total social costs of incineration can be derived from seven separate elements: (1) capital costs; plus (2) the Federal tax subsidy; plus (3) the costs of additional (remedial) pollution control equipment; plus (4) operating costs; minus (5) revenues from the sale of electricity produced from solid waste combustion; plus (6) the costs of incinerator ash disposal; plus (7) the social cost of environmental harm and disamenities.

(1) Capital Costs

The capital costs and daily capacity of the nine Massachusetts solid waste combustion facilities are presented in Table 2. The capacity of these nine facilities, summarized in Column (b), totals 9,712 tons/day of solid waste. Assuming an efficiency

TABLE 2

COST OF MASSACHUSETTS INCINERATORS[1]

(a) LOCATION	(b) CAPACITY (TONS/DAY)	(c) COST (MILLIONS)	(d) TAX-EXEMPT BONDS (MILLIONS)
Rochester	1800	$208	$150
Milbury	1500	$205	$ .325
N. Andover	1500	$197	$160
Haverhill	1650	$268.8	$184[2]
Pittsfield	240	$ 11	$ 6.2
Springfield	360	$ 33[3]	$ 31[2]
Fall River	240	$ 5[4]	$ 0
Lawrence	922	$ 90[5]	$ 58.2
Saugus	1500	$ 48	$ 35
TOTAL	9712	$1065.8	$624.725

[1]Source: LeBlanc (1988), pages 19 and 35.

[2]Source: Massachusetts Department of Environmental Protection memo, April 1990.

[3]Source: Telephone conversation with representatives of the Springfield facility on October 22, 1990.

[4]Source: Telephone conversation with Raymond Reynolds, City Auditor for the City of Fall River, on October 24, 1990.

[5]Source: Telephone conversation with Jim Richie, representative of Refuse Fuels Associates, on October 24, 1990.

factor of 90 percent[21] and multiplying by 365 days, we calculate that the capacity/year for these Massachusetts incinerators is 3,190,392 tons. Over their expected 20 year lifetimes, they will incinerate 63,807,840 tons of solid waste.[22] The total capital cost of these nine facilities, presented in Column (c) of Table 2, is $1,065.8 million or approximately $17 per ton. Assuming a real rate of interest of 6 percent,[23] the interest charges for these incinerators is $15/ton. Thus, the total capital cost including interest for these seven incinerators is $32/ton of solid waste.

(2) <u>Federal Tax Subsidy</u>

The Federal tax structure provides a subsidy to incinerator developers in the form of accelerated depreciation and Investment Tax Credits. Again, this subsidy imposes social costs that are not measured in market prices. The magnitude of this Federal tax benefit has been estimated to equal $10 per ton of incinerated solid waste (LeBlanc [1988], page 19).

(3) <u>Installation of Pollution Control Equipment</u>

An additional cost of incineration, for some facilities, is the remedial installation of pollution control equipment. For example, the Saugus plant requires the installation of acid gas scrubbers, at a cost of $128 million (Armerding [1990]), or approximately $13 per

[21]Although the Massachusetts Department of Environmental Protection assumes that existing combustion facilities will operate at 95 percent efficiency (Commonwealth of Massachusetts Master Plan [1990], page 5), other sources (such as Denison and Ruston [1990], page 120, and LeBlanc [1988], page 15) assume efficiency factors of 85 percent. The latter source's estimate of efficiency factors is based on discussions with plant operators at five Massachusetts solid waste combustion facilities. In any case, we will assume an efficiency factor that is the average between the high and low estimates, or 90 percent.

[22]This is a generous assumption. Incineration of chlorinated substances produces hydrochloric acid, which creates serious corrosion problems for the incinerators themselves (Wirka [1988], page 47). In addition, the process of incineration puts a severe strain on incinerator machinery. For these reasons, the actual lifetime of an incinerator may be only a fraction of what its designers predict (LeBlanc [1988], pages 35-36).

[23]As indicated in Column (d) of Table 2, of the $1,065.8 million in capital costs for the nine Massachusetts incinerators, $624.7 million (or approximately 59 percent of the capital costs) was financed through state-arranged tax-exempt bonds. Assuming that tax-free status lowers the cost of borrowing by approximately one-third, the implied (nominal) interest rate for these bonds should be approximately 7 percent rather than 10 percent. However, tax-exempt bonds subsidize the capital costs of incinerators. The foregone taxes represent a type of social cost not captured in market prices. Therefore, the true social cost of borrowing (ignoring, here, the rate of inflation) is actually the market interest rate, estimated at 10 percent, rather than the rate for tax-exempt investments.

ton for that facility. Four of the other Massachusetts solid waste combustion facilities--North Andover, Pittsfield, Fall River, and Lawrence--will also require similar remedial pollution control equipment (Commonwealth Master Plan [1990], page 46).[24] Assuming that the remedial costs per ton at these four facilities are similar to those at the Saugus plant, the total remedial costs for the five facilities will be $375,637,000. Dividing by the lifetime capacity of the nine incinerators, which is 63,807,840 tons of solid waste, yields an additional investment cost of approximately $6/ton. Again assuming a real interest rate of 6 percent, the associated interest charges are $5/ton. Thus, the total cost, including interest charges, for remedial installation of pollution control equipment is $11/ton for the Massachusetts incinerators.[25]

(4) Operating Costs

Another cost of incineration is operating and maintenance expenses. These costs have been estimated to be between $18 and $30 per ton (Kovacs [1988], page 541). We shall use the mid-point estimate of $24/ton.

(5) Revenues from the Sale of Electricity

The costs of solid waste incineration are partially offset by revenues from the electricity generated during the process. Estimates of the net electricity produced by solid waste combustion facilities range from 466 to 606 kilowatt-hours (kWh) per ton of solid waste incinerated.[26] We shall use the mid-point estimate of 536 kWh per ton. The price

[24]The Saugus facility has a daily capacity of 1500 tons of solid waste. The North Andover, Pittsfield, Fall River, and Lawrence facilities have a combined daily capacity of 2902 tons of solid waste.

[25]Note that the additional cost per ton borne by operators of solid waste combustion facilities requiring remedial pollution control equipment is substantially larger (even if financing costs are subsidized by tax-free bonds) for two reasons. First, the costs per ton are not averaged over the capacity of incinerators not requiring these investments. Second, the investment costs can be spread only over the remaining lifetime capacity of the facility in question. It is presumably for these reasons that the incineration fee at the Saugus facility has risen by $58/ton in response to the required installation of pollution control equipment (Armerding [1990]).

Note also that our estimates of these incinerator costs are not really affected by the remedial nature of the investment. However, the fact that Massachusetts incinerators may operate for years with inadequate pollution control equipment does contribute to the social costs of environmental harm and disamenities.

[26]See Denison and Ruston (1990), page 143, and Getz (1990), page 26. In addition, in a telephone conversation on October 24, 1990, Jim Richie, representative of Refuse Fuels Associates, reported that RFA solid waste combustion facilities (which include the one in Lawrence, Massachusetts) produce from just under 500 kWh to 550 kWh per ton of solid waste incinerated.

per kWh is usually set by state regulatory agencies to reflect what the electric utility would otherwise have to spend to generate the electricity itself. These avoided costs vary from utility to utility and by time of day, season, and year. We shall assume that the solid waste combustion facilities receive $.04 per kWh (Denison and Ruston [1990], pages 119-123).

All of the Massachusetts solid waste combustion facilities produce electricity with the exception of the Fall River incinerator, which represents approximately 2.5 percent of the Massachusetts solid waste incinerator capacity.[27] Thus, the total revenue from electricity sales equals the product of .975 (the fraction of Massachusetts solid waste incinerated which generates electricity), 536 kWh (the electricity generated per ton of solid waste), and $.04 per kWh (the price of electricity)--for a total of approximately $21 per ton of solid waste incinerated.

(6) Incinerator Ash Disposal

Additional incineration costs are incurred for the transport and disposal (by landfill) of the ash residue of solid waste combustion. Incinerators are estimated to reduce solid waste by 75 percent, leaving 25 percent ash residue by weight.[28] Based on estimates of landfilling costs of $159/ton,[29] developed in the following section, and on estimates of transport costs of $18/ton, every ton of incinerated solid waste produces 1/4 ton of incinerator ash to be landfilled, at a cost of $44.[30]

[27]Of the 9712 tons/day of municipal solid waste incineration in Massachusetts, the Fall River facility accounts for 240 tons/day.

[28]Modern incinerators can reduce the volume of the solid waste they burn by 70 to 90 percent. However, unlike unburned waste, incinerator ash does not compact when landfilled. For this reason, the Massachusetts Division of Solid Waste uses weight, rather than volume, when computing landfill capacity for both ash and solid waste (LeBlanc [1988], page 31). Incinerators typically reduce the weight of solid waste by only 65 to 75 percent, leaving 25 percent to 35 percent ash residue by weight (Denison and Ruston [1990], page 63). We assume a 25 percent ash residue, which is achievable by the best U.S. incinerators.

[29]In order to avoid double counting, this estimate of landfilling costs is net of the $50 cost per ton of collecting discarded materials for waste disposal.

[30]This estimate assumes that ash can be safely disposed in a solid waste landfill. If incinerator ash were classified as hazardous waste (and over 90 percent of fly ash samples recently analyzed by EPA qualified as hazardous waste using EPA's toxicity criteria), the direct expenditures for its disposal would grow to $250/ton (LeBlanc [1988],pages 32-35), and the total social cost of its transport and disposal would almost double from $177/ton to $343/ton. In that case, the 1/4 ton of incinerator ash for every ton of incinerated solid waste would cost $86/ton rather than $44/ton.

(7) Environmental Harm and Disamenities

Finally, solid waste combustion facilities impose social costs in the form of environmental harm and disamenities. Incinerators emit dioxins, furans, toxic heavy metals, acid gases, and numerous toxic and carcinogenic organic compounds. Packaging materials contribute to the hazardous pollutants found in air emissions and ash from incinerators. Toxic metals, such as lead, cadmium, and chromium, are contained in a variety of additives used to make plastics. Lead and cadmium pigments in colored printing inks, frequently used in packaging, are a major source of these metals in combustible municipal solid waste. Since metals do not combust, they are present in both air emissions and ash residues. Chlorinated plastics, including PVC, also contribute to the chlorine present in municipal solid waste. The burning of chlorinated substances produces hydrochloric acid and dioxins. Hydrochloric acid is a corrosive that contributes to acid rain and combines with moisture to cause localized damage to vegetation, paint finishes, and ferrous metals. Dioxins are highly toxic chlorinated organic compounds; exposure to even minute amounts can cause birth defects, damage to the immune system, skin disorders, liver damage, cancer, or death (Commonwealth of Massachusetts [1985], pages 43-56). Dioxins have been detected in every incinerator surveyed by the U.S. Environmental Protection Agency and in incinerator ash (Wirka [1988], page 47).

Even if incinerators were equipped with state-of-the-art pollution control equipment and were operated at peak efficiency, they would still represent an environmental and human hazard and the largest source of air pollution in most communities.[31] However, many Massachusetts solid waste combustion facilities fall far short of this theoretical ideal, operating with inadequate air pollution control equipment and subject to ineffective monitoring (partially because testing of incinerator stack emissions is very expensive and partially because of limited engineering and scientific knowledge about the "safe" design and operation of incinerators).[32] Furthermore, the storage and transportation of incinerator ash is inadequately regulated, exposing those in the vicinity of the facility to the hazards posed by the airborne ash (LeBlanc [1988], page 33).[33] Finally, solid waste

[31]Furthermore, the better the control of incinerator air pollution, the more toxic the incinerator ash which must be disposed of.

[32]See LeBlanc [1988], pages 23-31.

[33]Furthermore, methods to prevent ash from becoming airborne create environmental hazards of their own. For example, watering the ash makes the liquid runoff a hazard. Even if controlled at the incinerator site, runoff from the wet ash is liable to leak from trucks during transport to the landfill.

combustion facilities are unattractive and produce unsightly and malodorous smoke emissions.

It is difficult to place a monetary value on the environmental hazards and disamenities associated with incineration. At a conceptual level, these social costs can be represented by the monetary payment to members of the community required to induce them to accept a solid waste combustion facility. The following thought-experiment would, in principle, elicit the desired willingness-to-accept sum: (1) each candidate community submits a sealed bid containing its willingness-to-accept value, which it will receive if it is the "winner"; (2) the winner of the sealed-bid auction is the low bid; and (3) the losing communities must pay the winning community its willingness-to-accept monetary sum, where each losing community's share is proportional to the relative size of its willing-to-accept bid. Several sealed-bid mechanisms of this type have been designed and analyzed in controlled laboratory experiments for hypothetical payoffs.[34] However, we have no empirical evidence of a community's willingness-to-accept value for an incinerator, since no sealed-bid auction for an incinerator siting has ever been conducted.[35]

Another method for placing a monetary value on environmental harm and disamenities is to impute the value from observed market transactions. For example, the proximity of a house to a solid waste combustion facility can be expected to expose its occupants to environmental hazards and disamenities, the magnitude of which might be reflected in the market price of the house. Although each house consists of a heterogeneous mix of characteristics which influence its value, a so-called "hedonic" model allows one to develop price functions for any individual characteristic.[36] According to the hedonic model, the slope of the price gradient with respect to any characteristic simultaneously measures the buyer's marginal willingness to pay for that attribute and the seller's or supplier's marginal offer price. The hedonic approach has been used to derive a market value for environmental factors such as air pollution and noise levels.[37] However, as a practical matter, this approach is subject to several modeling and estimation problems, particularly imperfect information on the part of buyers and sellers (e.g., they may not be aware of the actual environmental hazards) and non-linear or interactive relationships

[34]See, for example, Kunreuther and Kleindorfer (1986), Kunreuther *et al.* (1987), Kunreuther and Easterling (1990), and Kunreuther *et al.* (1990).

[35]Furthermore, it is not obvious how, in practice, a community determines or aggregates the willingness-to-accept values of its citizens.

[36]See, for example, Rosen (1974).

[37]Previous applications of the hedonics approach are discussed in Brookshire *et al.* (1982).

among the variables (e.g., an undesirable location is likely to affect both the type of homebuyer attracted and homeowner decisions that influence the market value of the house).

A third approach, the one employed here, is to use survey questions to derive homeowners' willingness to pay to avoid environmental hazards and disamenities.[38] Smith and Desvousges (1986) asked respondents from a sample of households in suburban Massachusetts to choose between two homes that were identical except for two attributes: the distance from a landfill containing hazardous wastes and the price of the house. The survey responses were used to estimate a demand function for distance from the hazardous waste facility, where this attribute reflects the associated environmental risk and disamenities. The econometric results, for which the coefficients for the marginal price (as a function of distance) and the housing price are statistically significant, imply that the average household would realize a consumer surplus of between $330 and $495 annually for each additional mile between its residence and the waste facility.

These results form the basis for our estimation of the social cost of incinerator-related environmental harm and disamenities. Although all incinerator waste is not hazardous, incinerators may be viewed as "quasi-hazardous" waste facilities because of the environmental risks indicated earlier. Accordingly, we shall assume that the value of the environmental harm and disamenities for an incinerator are half the value of those for a hazardous waste landfill. Taking half of the mid-point of the Smith-Desvousges estimates, which is $412, we obtain a value of $206 per year per additional mile of distance from an incinerator. The median distance from the hazardous waste landfill before respondents in the Smith-Desvousges would accept it is approximately 10 miles. We shall use this median point as our threshold distance.[39] Each household will therefore receive a consumer surplus of $206 annually per mile to increase its current distance from an incinerator to 10 miles. Once beyond the 10-mile threshold, additional distance from the incinerator provides no additional consumer surplus.

[38]Despite the fact that these survey responses cannot be considered as reliable as actual market responses, survey criteria developed in Cummings, Brookshire, and Schulze (1986) suggest the consistency and absence of strategic bias of the survey results that follow. Summaries of other applications of this survey approach to value public goods are provided in Brookshire *et al.* (1982) and Cummings, Brookshire, and Schulze (1986).

[39]Because incinerators disperse pollutants through the air, the environmental hazard extends over a much wider geographical range than in the case of a landfill. For this reason, we maintained the threshold distances derived for the hazardous waste landfill, even though the incinerator is only quasi-hazardous.

The average town or city in Massachusetts has a population of 17,000, which is equivalent to approximately 6,000 households.[40] On average, there is the equivalent of approximately 13 cities and towns within a 10-mile radius of any point in Massachusetts.[41] Therefore, 80,000 households, on average, will be located within that 10-mile radius. For these 80,000 households, their average distance from the facility will be approximately 7 miles.[42] The average household would derive benefits of $206 per mile annually were it 3 miles (the 10-mile threshold minus the average distance of 7 miles) further away from the facility. Therefore, the 80,000 households would each realize a benefit of $618 annually if they could avoid the environmental hazard and disamenities of incineration, for a total of $49.4 million per incinerator annually. Since the average solid waste combustion facility in Massachusetts incinerates approximately 354,488 tons of solid waste annually,[43] we estimate that the average environmental hazard and disamenities cost per ton of solid waste incinerated is approximately $139.[44]

[40]Massachusetts had 351 cities and towns and a population of 5,971,000 in 1989 (Massachusetts Master Plan [1989], pages 36, 43, 49, and 60), an average of 17,011 persons per city or town. Based on an average in Massachusetts of 2.78 persons per household (U.S. Department of Commerce [1980], page 45), the average number of households per city or town is 5,948.

[41]The area of Massachusetts is 8257 square miles. On average, each of the 351 Massachusetts cities and towns contains approximately 23.5 square miles. A circle with a 10-mile radius encompasses approximately 314 square miles, which equals the area of 13.4 cities and towns. Note that a strategy of siting incinerators only in the least populated areas in Massachusetts is undermined by the high cost per mile of transporting solid waste from the population centers to the facility.

[42]The average distance of 7 miles assumes that the households are uniformly distributed within the circle circumscribing the 10-mile radius. (The area of a circle with a 7-mile radius is 49Π, almost exactly half the area of a circle with a 10-mile radius.)

[43]Earlier we calculated that the annual capacity for the nine incinerators was 3,190,392 tons, or an average of 354,488 tons per incinerator.

[44]From Tables A-1 and A-2 in the Appendix, it is clear that the avoided cost of environmental hazards and disamenities, particularly those associated with incineration, is the category of social benefits most sensitive to different (but plausible) assumptions. Ideally, therefore, it would be preferable to have an independent, reliable benchmark of the range of legitimate values for avoided environmental hazards and disamenities--so as to be able to verify that our estimate of $139/ton is reasonable. Unfortunately, the inability of the market to reflect the risks of environmental harm and disamenities makes it difficult to develop such a benchmark. Nevertheless, three facts suggest that households do place a significant value on avoiding the environmental hazards and disamenities caused by solid waste incinerators. First, in a political context, is the fact that citizens invest considerable time and expense to challenge the siting of these hazardous facilities in their community. Second, the health consequences of the environmental hazards impose huge real market costs, in the form of medical treatment, lost productivity, and related costs of environmentally-related disease. (Furthermore, the property damage caused by an incinerator's chemical releases also imposes real market costs.) Third, of the possible environmental hazards, the public's opposition is largest when the risk is unnecessary (e.g., less hazardous technical solutions, such as recycling, are available) and when the safety of the facility cannot be assured because of inherent risks in the technology or because of the inability of regulators to monitor the

The social cost per ton of solid waste incinerated is summarized in Table 3 for the seven cost elements we considered plus the cost of collecting discarded materials for incineration. Every ton of solid waste incineration that recycling avoids provides a social benefit of $289. Since we have assumed that 70 percent of every ton of packaging material not recycled is incinerated, the avoided incineration cost is $202 per ton of recycled packaging material.

E. The Avoided Disposal Costs of Landfilling

The final social benefit of recycling is the avoided costs of landfilling 30 percent of the unrecycled packaging material solid waste. In addition to the costs of collecting discarded materials for landfilling, the total social costs of landfilling consist of five separate elements: (1) capital costs; (2) operating costs; (3) clean-up and post-closure care costs; (4) the costs imposed by stricter landfill regulations; and (5) the social cost of environmental harm and disamenities.

The capital costs, including interest, for a 55-acre landfill accepting 240 tons of waste per day over a 20-year lifetime have been estimated, according to a landfill model, to be approximately $25/ton; the cost of monitoring and operating such a landfill have been estimated to be approximately $35/ton (between $30 and $40 a ton).[45] Even after the landfill is closed, costs will be incurred to maintain the landfill's environmental monitoring systems and the leachate collection system. These post-closure costs are equal to approximately 15 percent of capital and operating costs (Glebs [1988]). In addition, the leaching of landfill wastes may impose significant clean-up costs. To estimate these costs, we use reported projections of "unanticipated costs," which are equal to approximately 10 percent of capital and operating costs (Glebs [1988]).[46] However, these post-closure and clean-up costs generally are incurred at the end of a landfill's useful life. Discounting these costs, again using a real rate of interest of 6 percent, reduces their magnitude from 25 percent to 13 percent of capital and operating costs, or approximately $8/ton.

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operator's performance (Kunreuther and Easterling [1990] and Kunreuther *et al.* [1990]). These precise conditions characterize solid waste incineration.

[45]See Tufts University (1988), pages 12-13.

[46]This may be a serious underestimate. The Commonwealth reports that of its 194 active landfills, only 28 are built with liners, and that over 40 percent of its active landfills threaten to pollute, or are polluting, surface and ground waters (Massachusetts Solid Waste Master Plan [1989], page 10). On the other hand, the additional clean-up costs required for these high-risk landfills may be offset, more or less, by their low (relative to our estimates) original construction costs.

TABLE 3

THE AVOIDED DISPOSAL COSTS OF INCINERATION

COST ELEMENT	COST/TON
Solid Waste Collection Costs for Incineration	$ 50
Capital Costs	$ 32
Federal Tax Subsidy	$ 10
Cost of Remedial Pollution Control Equipment	$ 11
Operating Costs	$ 24
Revenues from the Sale of Electricity	($ 21)
Cost of Incinerator Ash Disposal	$ 44
Cost of Environmental Hazards and Disamenities	$139
TOTAL	$289

The preceding landfill costs, totaling $68/ton, are for the construction of a landfill in 1988. However, stricter Federal and state regulations regarding landfill siting, basic design, closure, and long-term care, are estimated to increase landfill costs by approximately 23 percent;[47] the cost of stricter regulation is thus equal to $16/ton, increasing total landfill costs to $84/ton.[48]

Finally, solid waste landfills also impose social costs in the form of environmental harm and disamenities. An indication of the magnitude of the environmental risk is the fact that 20 percent of the sites on the National Priorities List (those sites designated by the U. S. Environmental Protection Agency, under the auspices of the Superfund program, as most in need of clean-up) are municipal solid waste landfills (Office of Technology Assessment [1989], page 42). Part of the environmental hazard posed by landfills is due to the presence of incinerator ash.[49] However, part of the hazard is due to directly-landfilled solid waste that pollutes, or threatens to pollute, the state's water resources. Packaging wastes contribute to the leaching problem. For example, plasticizers, which are used to make hard and brittle plastic resins flexible, are prone to leaching because they are used in high concentrations and tend to have a low compatibility with resins (Wirka [1988]).

In order to derive a monetary value for the environmental risks and disamenities posed by landfills, we will use the same methodology previously employed to estimate the social cost of solid waste incineration. We take as our starting point the earlier estimate of $206 as a household's consumer surplus per year for every additional mile of distance from an incinerator (which, in turn, was derived from the Smith-Desvousges estimate of consumer surplus realized by additional distance from a hazardous waste facility). Although the same packaging materials are involved, incineration poses a larger environmental hazard than landfilling because the process of incineration creates dioxins, hydrochloric acid, and other harmful organic compounds. For this reason, we will assume that the consumer surplus obtained for an additional mile of distance from a solid waste landfill is only $103, half the value per additional mile of distance from a solid waste

[47]This percentage is derived from data presented in Glebs (1988). The true costs of stricter regulation are likely to be larger for Massachusetts landfills, according to James Ducett, Environmental Analyst, Massachusetts Department of Environmental Protection, during a telephone conversation on October 9, 1990.

[48]The fact that many tipping fees for landfilling solid waste exceed $100 per ton, and are rising rapidly, provides some, albeit qualified, evidence that these estimates of landfill costs are not exaggerated. See Tufts University (1988), page 11.

[49]Incinerator ash is so hazardous that 94 percent of the fly ash samples analyzed exceeded limits for lead or cadmium or both under EPA's standard for defining hazardous waste. See Denison and Ruston (1990), page 183.

incinerator. Also, because the degree of hazard is lower and because the pollutants are generally not dispersed through the air, we reduce the threshold distance from the disposal facility from 10 miles for an incinerator to 4 miles for a solid waste landfill (sufficient to encompass the city or town containing the landfill and the bordering land in neighboring communities). On average, there is the equivalent of 2.14 full cities and towns within a 4-mile radius of any point in Massachusetts.[50]

Since the average Massachusetts city or town contains 6000 households, 2.14 cities and towns will contain approximately 12,840 households. For these households, their average distance from the landfill will be approximately 2.83 miles.[51] The average household within the 4-mile radius will derive benefits of $103 per mile annually up to a distance of 4 miles from the landfill. Since the average household is 2.83 miles from the landfill, the average number of miles over which households realize consumer surplus is 1.17 miles (that is, 4 miles minus 2.83 miles). Total annual environmental and disamenities costs per landfill are 12,840 households multiplied by 1.17 miles and $103 per mile, for a total of approximately $1,550,000 annually. Since the average landfill in Massachusetts disposes of 21,000 tons of solid waste annually,[52] the environmental harm and disamenities cost per ton of landfilled solid waste is approximately $75.

In Table 4, we combine this cost with the previous costs of landfilling and the cost of collecting discarded materials for landfilling to obtain a total cost of $209/ton. Thus, every ton of solid waste that is recycled rather than landfilled provides a social benefit of $209. Since we have assumed that 30 percent of every ton of packaging material not recycled is landfilled, the avoided landfilling cost is $63 per ton of recycled packaging material.

[50]On average, each city and town in Massachusetts has an area of approximately 23.5 square miles. A circle with a 4-mile radius encompasses approximately 50 square miles, which is equal to 2.14 Massachusetts cities or towns.

[51]A circle with a radius of 4 miles has an area of 16 Π square miles. A circle with a radius of approximately 2.83 miles would have an area of approximately 8 Π square miles--half the area of the circle with the 4-mile radius. Therefore, assuming that households are uniformly distributed within 4 miles of the landfill, the average distance from the landfill is 2.83 miles.

[52]In 1988, Massachusetts had 194 active landfills. Of the 6.6 million tons of municipal solid waste that year, 63 percent, or 4.15 million tons, was landfilled. Hence, on average, each of the active Massachusetts landfills disposed of approximately 21,000 tons in 1988. (Source: Commonwealth of Massachusetts Master Plan, [1989], pages 11-13.)

TABLE 4

THE AVOIDED DISPOSAL COSTS OF LANDFILLING

Cost Element	Cost/Ton
Solid Waste Collection Costs for Landfilling	$ 50
Capital Costs	$ 25
Operating Costs	$ 35
Clean-Up and Post-Closure Care Costs	$ 8
Costs of Stricter Federal Regulation	$ 16
Cost of Environmental Hazards and Disamenities	$ 75
TOTAL	$209

F. Conclusion

Based on the preceding estimates, we are now able to calculate the net social benefit of recycling, as applied to packaging material. Recycling by itself provides revenues of $49/ton and costs $86/ton, for a net loss of $37/ton. However, every ton of packaging material that is recycled avoids the payment of subsidies to virgin materials, the disposal costs of incineration, and the disposal costs of landfilling. The avoided subsidy to virgin materials was previously estimated to be $3/ton. The social cost of incineration we estimated to be $289 per ton incinerated. Since only 70 percent of packaging material waste is incinerated, the avoided incinerator cost from recycling packaging material is 70 percent of $289/ton, which equals $202/ton. The social cost of landfilling was estimated to be $209 per ton landfilled. Since only 30 percent of packaging material waste is landfilled, the avoided landfilling cost from recycling packaging material is 30 percent of $209/ton, which equals $63/ton. Thus, as summarized in Table 5, the net social benefit of recycling packaging material is $231/ton.

We are mindful of the argument posed that the public sometimes overestimates the environmental consequences of both incineration and landfilling. Such overestimation, if it exists, could be reflected in our willingness-to-pay measure of environmental harm and disamenities, with the effect of inflating those estimates. However, even if environmental harm and disamenities were zero, the net social benefit of recycling would still be $97/ton.

TABLE 5

THE NET SOCIAL BENEFITS OF RECYCLING

Source of the Benefit		$/Ton
Recycling Revenues	$49/ton	
Recycling Costs	- $86/ton	
Recycling Net Revenue		$-37
Avoided Subsidy to Virgin Materials		$ 3
Avoided Cost/Ton Incinerated	$289/ton	
Share of Discards Incinerated	x .70	
Avoided Cost of Incineration		$202
Avoided Cost/Ton Landfilled	$209/ton	
Share of Discards Landfilled	x .30	
Avoided Cost of Landfilling		$ 63
TOTAL		$231

PART TWO:
WHY RECYCLING STANDARDS FOR PACKAGING ARE NECESSARY

In Part One of this study, we estimated that the net social benefit of recycling is approximately $231 per ton of packaging material that is recycled rather than incinerated or landfilled. An obvious pair of questions immediately arise: (1) If the benefits of recycling are so substantial, then won't private markets provide the desired expansion of recycling activity (to its optimal level)? (2) Relatedly, if the unfettered marketplace promotes recycling, then why are recycling standards for packaging (RSP)--or any other form of government intervention, for that matter--needed? In the analysis that follows, we address these questions.

We begin by examining the market imperfections that plague recycling efforts. The predominant response of government to remedy the situation--to increase the separation and collection of recyclable materials--is examined and its fatal limitations noted. In addition, alternative policy instruments--in particular, economic charges, procurement preferences, and unconditional bans--are evaluated and found wanting. Finally, we introduce the concept of recycling standards for packaging and explain the operation of an RSP program both as a means of addressing the area in which recycling has been most vulnerable--the demand for recovered materials--and, in a larger context, as the centerpiece of government involvement needed to stimulate recycling.

A. Imperfections in Solid Waste Disposal Markets

For a market to operate efficiently, economic agents must bear the full marginal social costs (and realize the full marginal social benefits) associated with their actions.[53] In the context of recycling, this condition requires that economic agents incur the marginal social costs of disposing of the solid waste they create. In practice, however, imperfections in solid waste disposal markets prevent this condition from being realized.

The classic example of an externality, environmental pollution, accounts for part of the market failure.[54] Because the price for solid waste disposal does not reflect the environmental harm and disamenities accompanying such activities, solid waste generators

[53]See, for example, Baumol and Oates (1975), pages 16-24, or Tietenberg (1988), page 179.

[54]Externalities arise when the actions of one economic agent affect the utility or production function of another economic agent in the absence of any related economic transactions between the two parties. See Baumol and Oates (1975), pages 16-18; Spulber (1989), pages 46-48; and Varian (1978), pages 202-203.

are able to escape these costs.[55] The other source of the market failure arises from the way in which solid waste collection and disposal are financed. In the usual case, local government assumes responsibility for solid waste collection and disposal and incurs market costs in the provision of those services.[56] Local government typically finances these market costs from general tax revenues. Each household incurs, through taxation, approximately the market costs of material discards for the *average* household in the community. In other words, the size of a household's tax payment is not directly related to the amount of material it discards. Thus, a household's *marginal* tax burden of discarding an additional unit of trash is effectively zero, even though the associated market cost is not.[57]

To see this, consider the following simplified example. Suppose a town contains 6000 households and that each household pays $400 a year in taxes for the collection and disposal of the 6000 pounds of solid waste that it generates.[58] Assume further that total solid waste costs incurred in the market increase linearly with the amount of solid waste, so that the marginal cost to the town of each additional pound of trash collected and disposed is 6.7 cents. However, the cost borne by the household, in tax payments, for each additional pound of trash it discards is only 6.7/6000 cents, or .0011 cents, since the marginal cost is distributed equally over all the households through taxes. Thus, the household's internalized marginal cost is virtually zero (approximately 1/1000 of a penny per additional pound of trash it discards), although the town's marginal cost is 6.7 cents per pound. This discrepancy between the marginal cost borne by those who discard an additional unit of trash and the actual marginal cost of waste collection and disposal

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[55]Based on the calculations in Part One, the social cost of environmental hazards and disamenities is approximately $134 per ton of solid waste disposed. (The social cost of environmental hazards and disamenities is approximately $160 per ton of solid waste that is incinerated--including $21 of the $44 for the landfilling of incinerator ash--and $75 per ton of solid waste that is landfilled. It is predicted that 70 percent of solid waste in Massachusetts will be incinerated and 30 percent landfilled.)

[56]Based on the estimates developed in Part One, the government's out-of-pocket expenses for solid waste collection and disposal are, on average, approximately $130 per ton ($129 per ton in the case of incineration and $134 per ton in the case of landfilling).

[57]For further discussion on this point, see, for example, Page (1977), pages 89-91, or Tietenberg (1988), page 179.

[58]These are close approximations of the actual number of households in the average Massachusetts city or town, the number of tons generated per Massachusetts household (2.78 persons per household multiplied by 1.1 tons per person, assuming the commercial share of municipal solid waste is apportioned to households), and the government's annual cost per household for solid waste collection and disposal in Massachusetts ($130 per ton, in out-of-pocket costs, for collection and disposal, multiplied by 1.1 tons per person and 2.78 persons per household).

distorts the incentives of individuals to reduce the amount of material they discard and creates significant market inefficiencies.[59]

As demonstrated in simplified form in Figure 1, the presence of imperfections in solid waste disposal markets results in an inadequate amount of recycling from a social perspective. Economic agents, confronted with the alternatives of solid waste disposal or recycling, will select the option which is cheapest to them. Recycling activity will continue until the marginal cost of an additional unit of recycling (MC_R) exceeds the marginal *private* cost of disposing of that unit of solid waste (MC_P)--until Point Q_P in Figure 1. However, it would be socially preferable to increase the level of recycling to Point Q_S in Figure 1, where the marginal cost of recycling (MC_R) is equal to the marginal *social* cost of solid waste disposal (MC_S).

The range of economic activities which are affected by imperfections in solid waste disposal markets is illustrated in Figure 2, which tracks the flow of virgin and recycled materials. The market for recycled materials itself is affected by all of the economic activities in Figure 2. Some of the market relationships are obvious. For example, the supply of recycled materials is influenced by how the discarded materials of the various economic agents are separated and collected;[60] and the demand for recycled materials in packaging is ultimately derived from final demand for packaged products--which is then incorporated in product manufacturers' demand for packaging and packagers' demand for packaging materials. Other relationships are more subtle and complex. For example, virgin materials developers and processors are able to affect the supply of recycled materials by the way in which they design virgin materials (say, by adding antioxidants in resin formulation to overcome polymer deterioration during recycling, in the case of plastics). Similarly, packagers can design packaging to promote recycling (such as by using homogeneous materials that eliminate the difficulty and cost of separating the packaging, once discarded, according to its component materials). The important point to note here is

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[59]Another example, in a more familiar context, might help clarify this conclusion. Suppose 20 fraternity brothers go out for dinner at an expensive restaurant and agree beforehand to split the bill evenly among themselves. In that case, the cost to the individual of anything he orders is only 1/20th of the cost to the group. In general, this pricing arrangement induces the participants to make uneconomic decisions (peer pressure notwithstanding). Thus, for example, each individual might now order a $10 shrimp cocktail, which he would not have done under normal circumstances, since his order adds only $.50 to his share of the bill. The effects on the financing of solid waste costs are analogous, except that the number of participants diluting each individual's marginal cost is 6000 (in the earlier example) rather than 20. For an analysis of the general form of this problem (which, note, encompasses environmental pollution), see Olson (1974), pages 22-36.

[60]Note that, as indicated in Figure 2, the separation of discarded materials can occur both before and after the materials are collected.

FIGURE 1: THE MARKET FOR RECYCLING

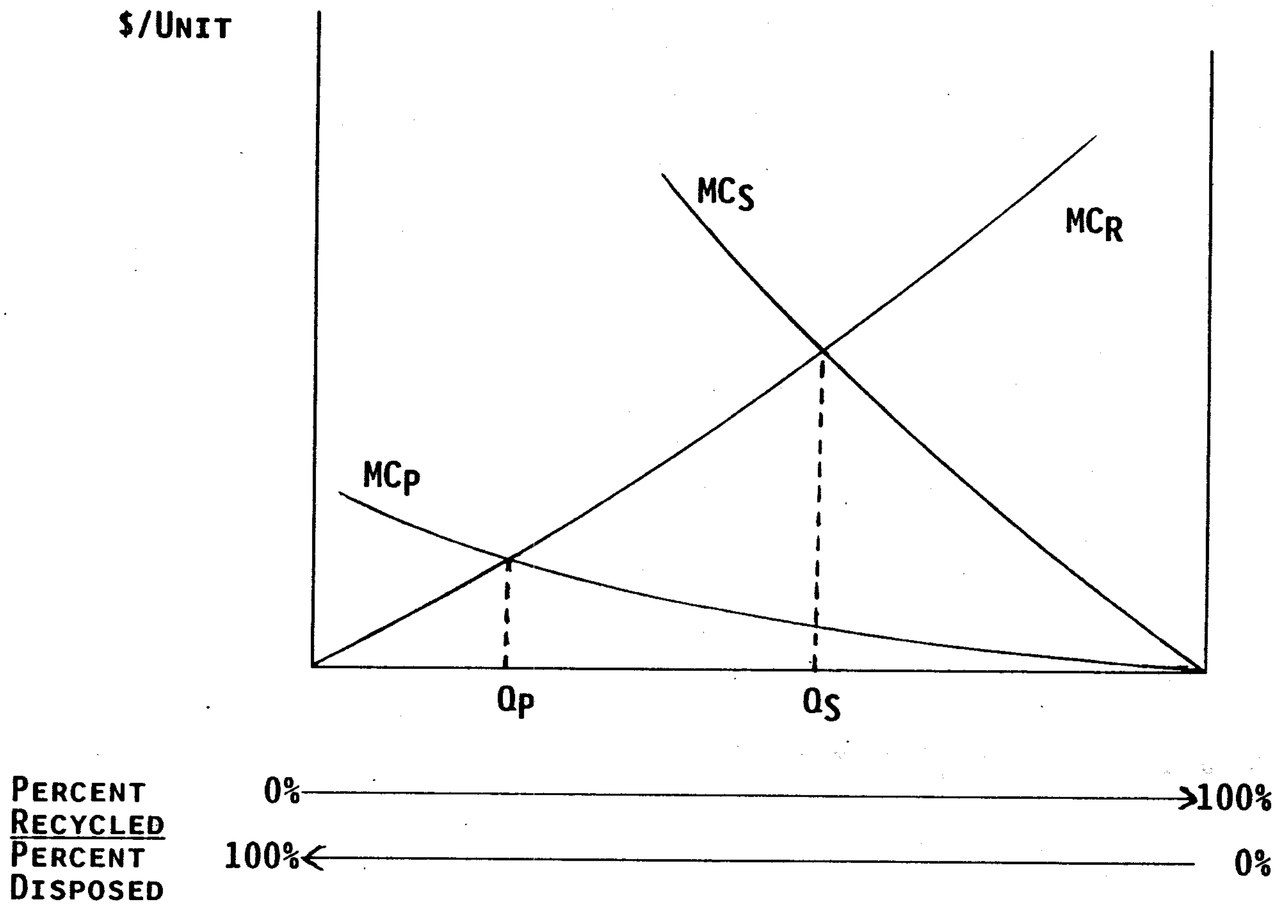
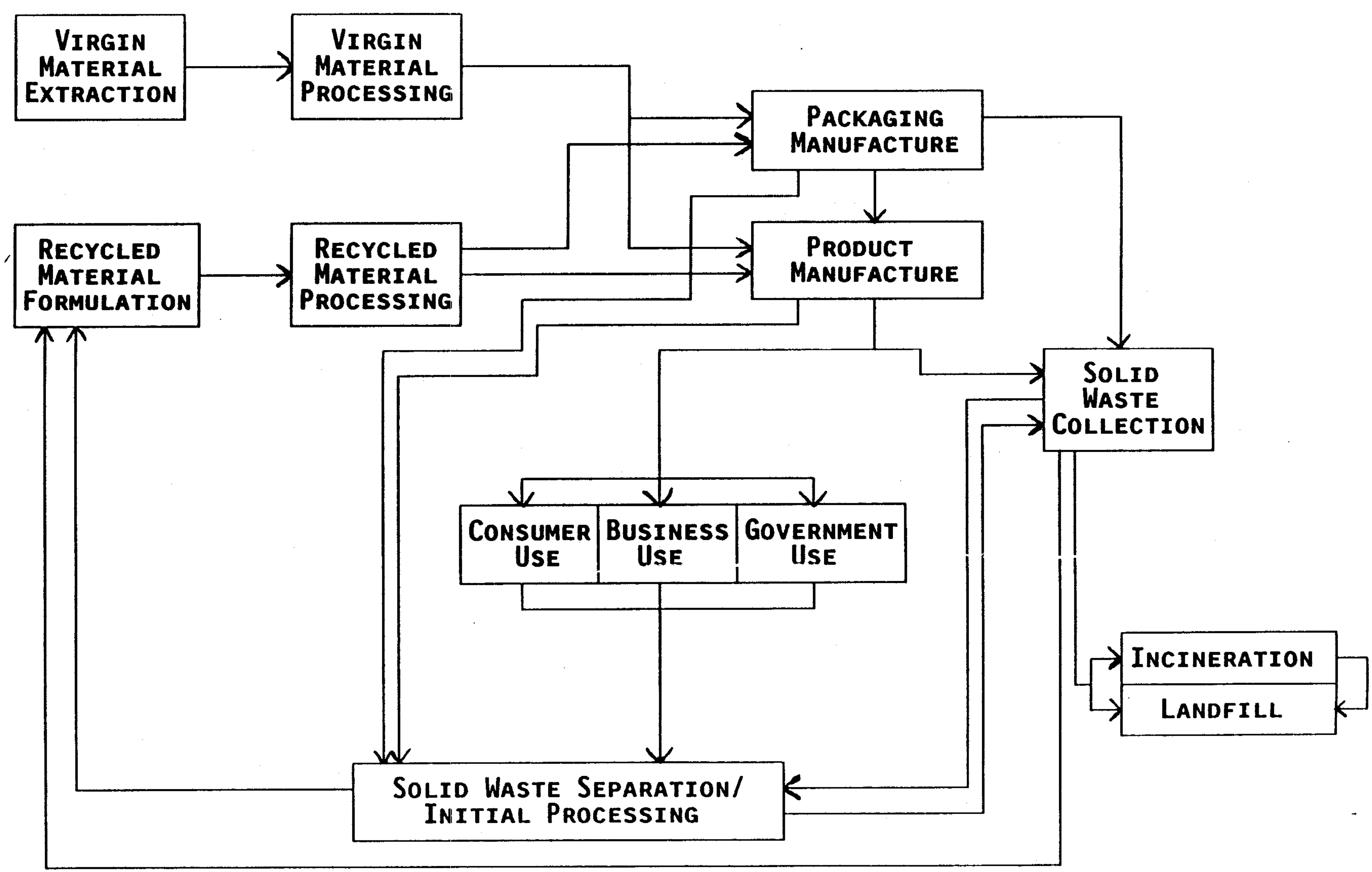


Figure 2: The Flow of Virgin/Recycled Materials



that the recycling incentives of all of the economic agents are adversely affected by the pricing distortions in solid waste disposal markets.

B. Government-Mandated Separation and Collection of Recyclable Materials

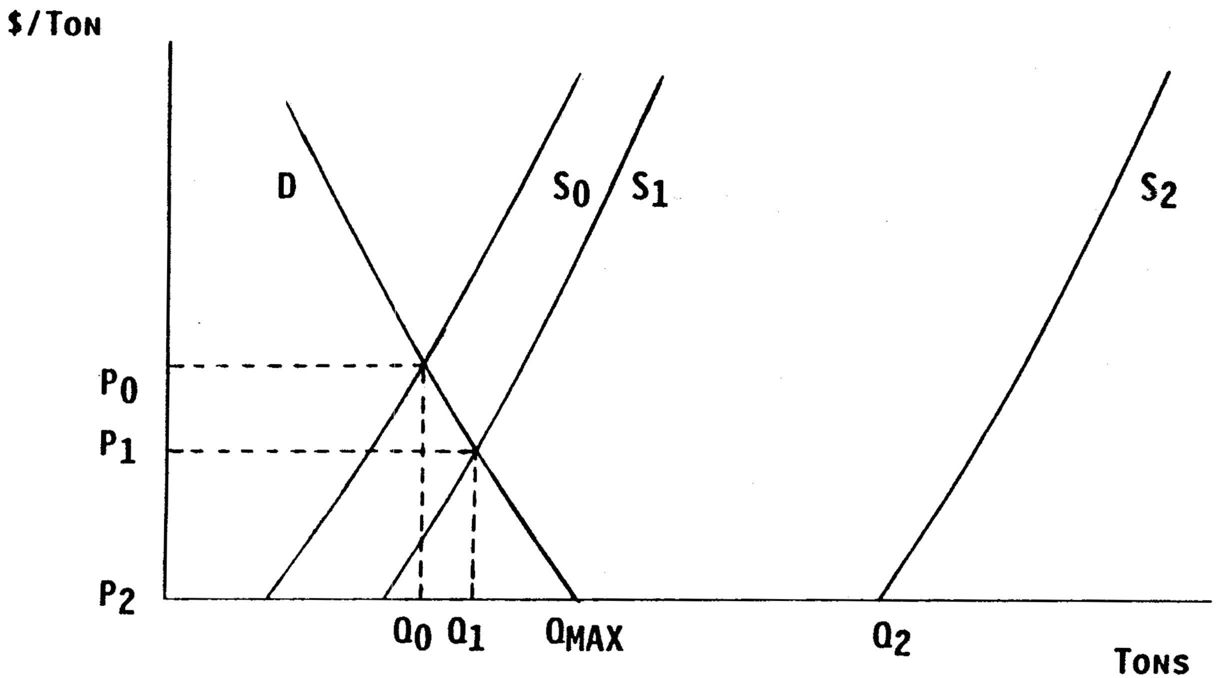
In order to enhance the impaired recycling activity taking place in private markets (and to help solve the solid waste crisis currently confronting them), state and local governments throughout the United States have established or expanded programs to separate and collect recyclable materials. In a sense, such programs parallel the popular conception of what recycling is: the removal of "reusable" materials from the solid waste stream. But until the recovered materials are actually reused--until they are converted into new products and sold to new customers--no meaningful recycling has been achieved. It is the inability of government-mandated waste separation and collection programs to remedy deficiencies in demand for the recovered materials that will quickly cause them to fail.

To see this, consider Figure 3, which represents the market for recycled materials. Prior to government intervention, the intersection of the demand curve for recovered materials (D) and the supply curve for recovered materials (S_0) results in an equilibrium amount of recycling of Q_0 and an equilibrium price for recovered material of P_0. If an isolated community or state mandated that its recyclable solid waste be separated and collected, such a program could succeed. The supply curve for recovered materials would shift to S_1, increasing the equilibrium amount of recycling to Q_1 and reducing the equilibrium price for recovered material to P_1. However, with numerous states and communities simultaneously separating and collecting recyclable solid waste, the supply curve for recovered materials would shift to S_2. The price for recovered material could not fall below P_2--a negative amount, equal to the cost of solid waste disposal--because below P_2, it would be cheaper to landfill or incinerate the recyclable material than to pay recyclers to take it. At a price of P_2 for recovered material, the maximum possible amount of recycling (given demand curve D) is Q_{MAX}. The residual quantity of separated and collected material, $Q_2 - Q_{MAX}$, would have to be disposed of as solid waste.

Could such a dire outcome actually occur in practice? It already has. The president of a leading wastepaper recycling corporation recently stated, "Cities have...discovered that no markets exist for their collected [recyclables]. The ultimate indignity is sending those collected materials to the landfill. And believe me, that has happened over and over again."[61]

[61]The statement was made by Don DeMeuse, president of Fort Howard Corporation, at the 9th National Recycling Congress (as reported in Breen [1990], pages 44-45).

FIGURE 3: THE EFFECT OF GOVERNMENT-MANDATED SEPARATION AND COLLECTION OF RECYCLABLE MATERIALS



The problem is that the amount of recycling currently taking place is relatively small in comparison to the quantity of recovered material that state waste separation and collection programs could unload on the market. For example, one study estimated that if Massachusetts and New Jersey enacted mandatory wastepaper separation and collection laws, the two states alone could produce a quarter of all the U.S. wastepaper consumed nationally and by export, and for the regional market consisting of the nine New England and mid-Atlantic states, over 100 percent of all mixed wastepaper, 46 percent of all corrugated paper, and 42 percent of used newspapers (then being used by the region).[62] As additional states institute programs to separate and collect recyclable materials, the price for recovered material will plummet, and eventually the market for recovered material will become saturated and collapse, when brokers require more money to haul off the material than sellers are willing to pay (below P_2 in Figure 3).[63]

The only way to avoid this outcome--while at the same time dramatically increasing recycling to levels warranted by its net social benefits--is to cause a dramatic shift in the demand for recovered materials. (Figure 4 illustrates the effect of a positive--rightward--shift in demand from D to D_2, which allows the market for recovered materials to accommodate the shift in supply to S_2 resulting from multistate government-mandated separation and collection of recyclable materials.) Any government program to promote recycling must therefore focus on stimulating the demand for recycled materials as its first order of business.

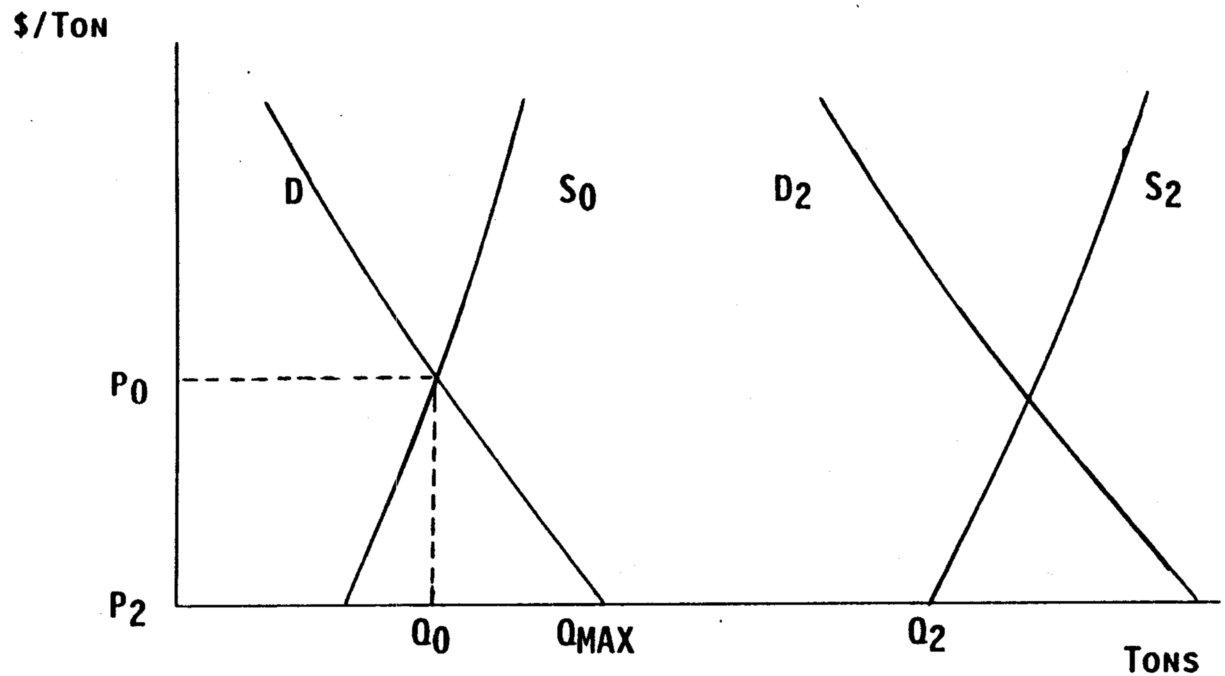
C. Available Demand-Side Policies

Many state and local governments have, in fact, proposed--and, in some cases, implemented--measures to increase the demand for recycled materials. Prominent among these measures are economic charges and taxes, government procurement policies, and unconditional bans. After briefly reviewing their relative merits, we consider a fourth alternative: recycling standards for packaging.

[62]See Nielson (1986) and also the description of the study in Kovacs (1988), pages 593-594. The level of wastepaper separation and collection to be attained by the laws, equal to 20 percent of their respective paper waste streams, was fairly modest.

[63]There is abundant evidence, both domestically and from abroad, of the destabilizing effects of a glut of recovered materials. For example, when West Germany's mandatory recycling legislation produced a massive oversupply of paper, the result was chaos in the usual paper markets. See Kovacs (1988), pages 565-566.

FIGURE 4: A SHIFT IN THE DEMAND FOR RECYCLED MATERIALS



(1) Economic Charges and Taxes

In theory, the ideal method of correcting resource misallocations stemming from a divergence between social cost and private cost is to introduce a user charge or tax so as to eliminate the divergence. Candidate charges or taxes to remedy inefficiencies in the pricing of solid waste disposal--and thereby to make recycling relatively less expensive as an alternative to disposal--include household charges for solid waste disposal, taxes on materials used to package products to reflect the social cost of their subsequent disposal, and taxes on virgin materials.[64] However, there are practical problems associated with each of these.

In the case of household charges for solid waste disposal,[65] if households are billed per (standard-sized) can of garbage, the amount of solid waste a household actually generates is very imprecisely measured. If households are charged by the weight of their garbage, then the metering costs may become prohibitive. In addition, the disposal costs depend to some extent on the composition of the solid waste, further diminishing the accuracy of household charges for solid waste disposal as a corrective measure. Finally, household charges for solid waste disposal may induce illegal dumping and other unauthorized disposal of solid waste (although the actual magnitude of this response in the United States appears not to have been subject to systematic analysis). Thus, these charges can be expected to have a limited and somewhat uncertain effect on consumer demand for recyclable products and packaging, or for less wasteful packaging.[66]

[64]In addition, government subsidies to promote recycling are possible. However, these are generally inferior to economic charges or taxes for at least two reasons. First, recycling subsidies create their own market inefficiencies, since the actual pricing distortion involves solid waste disposal, not recycling per se. Thus, recycling subsidies could create the anomaly of rewarding the recycling of a material when reducing the amount of material used in the first place would be socially preferable. Second, subsidies impose costs on government while economic charges and taxes are a source of government revenue. Furthermore, economic charges or taxes to correct divergences from marginal cost pricing are virtually unique among public finance mechanisms in eliminating rather than creating efficiency losses (Nichols [1984], pages 34-35).

[65]Note that household solid waste charges refer only to fees directly paid by the household for each additional unit of solid waste that it generates. The per-ton tipping fee for use of a solid waste disposal facility does not qualify because the charge is directly levied on the local community rather than on the individual household. A household's annual property tax apportionment for solid waste disposal does not qualify because its property taxes do not vary according to the amount of solid waste it generates. Therefore, for reasons discussed earlier, neither increases in tipping fees nor increases in property taxes to pay for solid waste disposal will stimulate consumer demand for recycling.

[66]Where household charges for solid waste disposal can have a considerable effect is on incentives to separate recyclable materials for collection. For example, in Seattle, where households are charged $13.50 a month for a one-can weekly pickup plus $9.00 per additional can, with recyclables hauled away for free, total solid waste landfilled declined by 22 percent in the first year and voluntary recycling rose from 22 percent to 36 percent. See Passell (1991), page C6.

Similar problems exist for taxes on products packaged in non-recyclable materials. Basing the tax on the weight of the packaging and the disposal costs of the specific materials comprising the packaging for each individual product would create appreciable administrative costs, as would collecting the tax at the point-of-sale. Employing a simple taxing formula would relieve administrative costs somewhat but would reduce the effectiveness of the tax as a corrective measure. In addition, the magnitude of the tax, if set equal to the cost of disposing of the packaging, would probably not exceed a few cents per packaged product; it is unclear whether such a small sum would have a significant effect on consumer demand for products in recyclable packaging. Nevertheless, the tax could have informational and symbolic value for those consumers with a preference for recyclable packaging, who would probably select the non-taxed product from among otherwise similar choices, regardless of the magnitude of the tax, as an expression of their support for recycling.

Taxes on virgin materials can easily be set equal to the cost of their ultimate disposal and would be relatively inexpensive to administer.[67] The problem with taxes on virgin materials is that, to be effective, they must be applied nationally. Therefore, taxes on virgin materials are not a viable policy option for individual state governments. Furthermore, as a federal policy option, it is questionable whether federal taxes on virgin materials of $200 per ton or more--if set equal to the social cost of disposal--would be politically feasible at this time.

In sum, while user charges and taxes can help to stimulate demand for recycled materials, because of the practical problems enumerated above, states cannot hope to remedy the deficient demand for recycled materials with these measures alone.

(2) State Procurement Policies

One promising method a state can employ to stimulate demand for recyclable materials is to increase its own demand for recyclable materials in the products it buys. For example, a state can require, as part of its procurement policy, that a certain percentage of

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[67]A more comprehensive and sophisticated version of a tax on virgin materials would be an externalities tax or "predisposal" tax on materials, presumably levied at the manufacturing level, which would be based on the magnitude of all externalities generated during the life-cycle of the product from extraction of virgin materials to ultimate disposal. In this case, the administrative costs (just to calculate the tax) would be much more substantial. However, its major defect is the same as for a tax on virgin materials: the state is not the appropriate jurisdiction in which to apply it.

its purchased products be recyclable or made of recycled material, or it can give price preferences to items containing recycled materials.

Such state procurement programs can obviously help to promote recycling. After all, state purchases represent approximately 12 to 13 percent of the U.S. Gross National Product.[68] On the other hand, for many material applications, such as product packaging, the state's purchases constitute a much smaller percentage and, in general, state purchases cannot remedy the deficient private demand for recyclable materials.

(3) Unconditional Package or Material Bans

Numerous states and local governments have banned or are considering banning specific packaging materials and containers thought to be egregious contributors to the solid waste disposal problems confronting them. For example, Maine has banned "brickpack" containers, and approximately thirty jurisdictions have banned polystyrene foam or other plastic packaging.[69] Note that these are unconditional bans untied to any performance standard; manufacturers of the materials or packaging in question therefore cannot take steps, other than political ones, to avoid the ban.

A major objective of these bans is to promote recycling and thereby to reduce the amount of solid waste that must be landfilled or incinerated. As a mechanism to increase the demand for recovered materials, however, such unconditional bans are largely ineffective. Unconditional bans eliminate the possibility of recycling the banned material (or packaging)[70] and provide no additional demand for recovery of the material that replaces it except to the extent that the substitute materials are themselves composed of recycled materials (and unconditional bans do not stimulate the use of recycled content in these applications). Indeed, the material substituted may itself be unrecyclable in that application (paper packaging contaminated with food, for instance). Furthermore, unconditional bans may actually exacerbate the solid waste problems they are attempting to solve.[71] For example, the substitute material or packaging could result in more food

[68]See Kovacs (1988), page 576.

[69]See Lifset and Chertow (1990) and Kovacs (1988), pages 581-582.

[70]Typically, unconditional bans are applied to products whose offending attribute is immutable. For example, deadly toxins may be banned from use in production because of the inherent health hazard they represent. By comparison, the recyclability of a package or material is generally capable of improvement, given the proper incentives.

[71]In some instances, bans of materials or packaging--particularly plastics--have been motivated by the fact that they are not biodegradable (Kovacs [1988], pages 582-583). However, the issue of biodegradability is

spoilage. Again, the unconditional nature of these bans works against making such subtle distinctions. Finally, unconditional bans historically have been applied to isolated materials and packaging in a relatively unsystematic manner. This has made unconditional bans appear arbitrary and unfair and has severely limited their range of effect (which is perhaps a blessing).

D. Recycling Standards for Packaging

Recycling standards are, in effect, conditional bans on materials and packaging in the sense that failure to comply ultimately carries the threat of market prohibition. That fact notwithstanding, recycling standards and unconditional bans are virtual opposites. The immediate objective of unconditional bans is to bar the usage of materials or packaging; the objective of recycling standards is to induce their usage through compliance. Unconditional bans are applied indiscriminately and unevenly to isolated materials; recycling standards are applied objectively and equally to an entire class of material use. Unconditional bans make, at best, a negligible and indirect contribution to the demand for recycling; recycling standards are specifically conditioned on achieving dramatic shifts in the demand for recovered materials.

Since packaging is the largest single source of municipal solid waste (MSW), comprising approximately one-third of the entire municipal solid waste stream, it is there where recycling standards would, in all likelihood, be most productively applied. Furthermore, recycling standards for packaging will stimulate recycling demand for the major types of material used in packaging--paper, glass, plastics, steel, and aluminum--whether in packaging or non-packaging applications. These materials account for sixty percent of MSW. By comparison, state-mandated recycled content standards for newspapers, while important in their own right, are restricted to one material and can account for no more than six percent of MSW.[72]

As we visualize them, recycling standards for packaging should contain at least two provisions; packaging satisfying either provision would be deemed in compliance with the recycling standards.[73] The first provision is that the packaging consist of a given

somewhat of a red herring, since none of the plastics substitutes degrade appreciably in a sanitary landfill either (Rathje [1989]). In addition, attempts to make plastics more biodegradable (say, by adding cornstarch to the polymer) will tend to make them unrecyclable.

[72]See Office of Technology Assessment (1989), page 80.

[73]Additional provisions could permit compliance by packaging reduction or packaging reuse.

percentage of recycled material. The second provision is that the packaging be made of recyclable materials--defined as those which achieve a specified statewide recycling rate, counting all applications of the materials, both packaging and non-packaging. The logic underlying the second provision is that it allows the state to leverage the requirement to recycle packaging to encompass the recycling of materials used in packaging, regardless of application. An important feature of the two provisions is their synergy, which causes the demand for recovered packaging materials to ratchet up. If a packaging material does not satisfy the threshold recycling rate to qualify as recyclable, a package can still comply by consisting of the specified percentage of that recycled material. However, compliance with the recycled content provision will also serve to increase the recycling rate of the packaging material toward the threshold recycling rate to qualify as recyclable.

Recycling standards for packaging are the mechanism critical to remedying deficiencies in demand for recovered materials.[74] As such, states need to develop an RSP program--however not, in our view, as a substitute for other government programs to promote recycling, but as the linchpin of a wide range of government activities to help design, stimulate, and coordinate the market for recycling. Government recycling activities--such as mandating separation and collection of recyclable materials, operating materials recycling facilities, educating consumers and businesses about solid waste reduction and separation opportunities, and serving as a clearinghouse of information about recycling markets--that heretofore were (or would be) thwarted by insufficient demand for recovered materials would take on added importance when complemented by recycling standards for packaging. Similarly, state procurement policies and economic charges could play a valuable supporting role in stimulating the demand for recovered materials. Furthermore, the state may develop recycling pacts with other states or participate in regional recycling programs.[75] Through the combination of these activities, state and local governments can promote the balanced growth of supply and demand in recycling markets, provide the stability in recycling markets that private investors require

[74]This is not to suggest that recycling standards for packaging are a perfect policy tool. They are subject to the common shortcomings of externally-imposed constraints. In particular, government standards are static in the sense that they do not automatically adjust to dynamic shifts in the economy (although the government can modify the standards as warranted over time), and they provide non-continuous incentives to the extent that economic agents are not motivated to exceed the standard (although economic charges and taxes can be phased in to furnish supplemental inducements). The point is that while recycling standards for packaging are a second-best solution, there is no first-best solution in the real world, and recycling standards for packaging appear vastly superior to the next best alternatives.

[75]In addition, the state will surely develop special resource recovery programs for other materials--such as yard wastes, batteries, white goods, and tires.

before making long-run financial commitments, and generally help develop a large-scale recycling infrastructure.

Some might object on ideological grounds to this type of government intervention. However, in the case of recycling, the function of government is not to replace the market but to organize and maintain a market that is not independently sustainable.[76] This concept of government's role as a generator of incentives to facilitate decentralized markets is being increasingly recognized.[77] Furthermore, recent research has noted that other industrial countries derive a competitive advantage over the United States because, in certain markets, their governments can coordinate economic activities in such a way that all parties can benefit, whereas in the United States government and industry have traditionally been cast as antagonists.[78] This need not be the case in recycling markets, where the active participation of government can provide positive externalities that the private market alone cannot duplicate.

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[76]Indeed, a major consequence of government programs to promote recycling will be to get government out the business of disposing of solid waste and private industry into the business of recycling it.

[77]See, for example, Ashford, Ayers, and Stone (1985); Reich (1988), pages 222-232; and Osborne (1990). In some circles, the role of government as a provider of incentives has been termed "entrepreneurial government," a concept which has been advocated by the Governor of Massachusetts, William Weld (see Osborne [1991]).

[78]See Dertouzos, Lester, and Solow (1990), pages 94-112.

PART THREE:
THE EFFECT OF RECYCLING STANDARDS FOR PACKAGING IN MASSACHUSETTS

We have previously argued (1) that in order to achieve a substantial increase in recycling activity, sufficient demand must be created to absorb the additional supply of secondary materials, and (2) that recycling standards for packaging (RSP), or their equivalent, are needed to stimulate the desired expansion of demand and thereby to sustain a viable market for recycled materials. In addition to its contribution to increased recycling, however, RSP will also incur costs to design and administer, as well as impose compliance costs on a variety of economic actors. Thus, until the various advantages and disadvantages of RSP are identified and assessed, the desirability of introducing RSP in Massachusetts cannot be assured.

Our objective in the following analysis is to evaluate the likely impacts of Massachusetts recycling standards for packaging, taking into account both microeconomic and macroeconomic effects. In Section A, using an applied microeconomics approach, we estimate the various costs and benefits of developing and implementing RSP in Massachusetts. Section B employs a macroeconomics perspective to examine the associated effects of RSP on Massachusetts employment levels and on the Massachusetts economy.

Estimating the effects of a specific set of packaging recycling standards--with explicit conditions and timetables for compliance, terms defined, and other particulars about the RSP program stipulated--would itself be an ambitious task. Our task below is all the more difficult because we shall be evaluating the effects of recycling standards for packaging as a concept rather than as a detailed policy initiative. As a result, much of the analysis is, of necessity, qualitative rather than quantitative.

We assume, for purposes of analysis, that the organizing principle of an RSP program is to require all packaging either to be made of (a specified percentage of) recycled materials or made of recyclable materials (those which achieve a statewide recycling rate of a specified percentage). In our view, intrinsic characteristics of an RSP program are (1) a market-oriented approach; (2) reinforcing/synergistic features; (3) technical feasibility; and (4) flexibility.

> Market-oriented approach: Although RSP may be supported by other policy instruments--such as information/education programs, solid waste collection/separation systems, and economic charges--an RSP approach intentionally avoids government-imposed packaging solutions. Instead, subject only

to the constraints of RSP, businesses are permitted to choose, through the process of the free market, whatever packaging they find most appropriate.

Reinforcing/synergistic features: The alternative conditions which would allow a given packaging material to comply with RSP should tend to reinforce each other. For example, if a given type of packaging material does not satisfy the threshold recycling rate, the same packaging would still qualify if it were composed of (a specified percentage of) recycled material. However, widespread compliance with the latter condition will act to increase the recycling rate of the packaging material, thereby helping to satisfy the former condition. Similarly, introducing packaging reuse or packaging reduction criteria as alternatives to recycling requirements would serve to promote the RSP objective of reducing the level of solid waste disposal.

Technical feasibility: Candidate RSP programs should be realistic and achievable in the sense that businesses are able to comply with the packaging standards without having to compromise the functions that packaging provides. Evidence to support the practicality of a packaging standard might include demonstrated attainment of the threshold recycling rate in other countries; the proven use of complying packaging in similar applications in the marketplace; or the availability or impending emergence of complying packaging technologies.

Flexibility: The RSP program should be flexible enough to exempt or to evaluate separately special sub-classes of packaging materials or packaging applications. For example, recycling standards may be applied to specific plastic resins (e.g., PET) or even to specific applications of a plastic resin (e.g., PET bottles) where the effect of the RSP refinement is expected to promote recycling. Similarly, in certain packaging applications, where compliance with RSP is incompatible with other overriding social objectives, RSP exceptions should be given. One possible example would be packaged products which provide highly-valued services (e.g., medicines) but which require special packaging incompatible with RSP. Another potential example would be important functions of the packaging (e.g., to prevent tampering with its contents) which are incompatible with RSP. A final possibility would be packaging applications for which compliance with RSP would actually damage the objectives of RSP (e.g., rejecting non-complying plastic wrap for food in favor of alternative complying packaging could, in principle, lead to more solid waste because of the consequent additional food spoilage).[79]

In the following analysis, we shall assume that any candidate RSP program possesses these aforementioned characteristics.

[79]The example of plastic wrap for food might equally qualify under the previous criterion, which concerns packaging functions incompatible with RSP. One of the central functions of most food packaging is the prevention of food spoilage. If the food preservation properties of plastic wrap are vastly superior to substitute food wrap materials, then plastic wrap for food might qualify for exemption on these grounds. (Note, however, that plastic wrap for food may be able to comply with recycling standards. See Stone, Ashford, and Lomax [1991], pages 32-34.)

A. The Benefits and Costs of RSP

Five distinct types of benefits and costs of RSP are analyzed below: (1) the net social benefits of increased recycling of packaging material due to RSP; (2) ancillary benefits of RSP (in addition to increased package recycling); (3) RSP compliance costs; (4) administrative costs of RSP; and (5) the possibility of product withdrawals or shortages due to RSP.

(1) The Net Social Benefits of Increased Recycling Due to RSP

In 1989, the Commonwealth of Massachusetts generated approximately 6.6 million tons of municipal solid waste (MSW), which is equal to approximately 1.1 tons of MSW per person annually or approximately 3.1 tons of MSW per household annually.[80] Of that total of 6.6 million tons of MSW, approximately 33.8 percent by weight,[81] or 2.23 million tons, consisted of packaging (including container) discards. Although it is estimated that 10 percent, by weight, of all municipal solid waste is recycled,[82] a larger proportion of packaging discards is recycled, approximately 16 percent by weight, as calculated in Table 6.[83] Thus, currently, approximately 357,000 tons of discarded packaging in Massachusetts are recycled each year.

[80]These estimates assume a Massachusetts population in 1989 of 5,971,000 (Massachusetts Master Plan [1990], page 12) and an average of 2.78 persons per household (U.S. Department of Commerce [1980], page 45). The estimate of 6.6 million tons of MSW for 1989 was provided in Massachusetts Master Plan (1990), page 12.

[81]This percentage is based on national estimates (Franklin Associates [1988a] as reported in Office of Technology Assessment [1989], page 114).

[82]This percentage reflects the national average (Franklin Associates [1988a] as reported in Office of Technology Assessment [1989], page 6). Actually, the recycling rate for MSW in Massachusetts is below the national average, approximately 7 percent (Massachusetts Master Plan [1989], pages 12-13).

[83]The larger recycling rate for packaging discards in Table 6 can be solely attributed to the fact that the materials comprising packaging (evaluated for a weighted average) are recycled at a higher rate than the average MSW material. Differential recycling rates (which could be either larger or smaller) between packaging and non-packaging, for a given material, are not considered in the calculations in Table 6.

Note that the recycling rates for packaging materials listed in Column (c) of Table 6--and in Column (c) of Table 7 that follows--differ from those presented in Stone, Ashford, and Lomax (1991). That study, which addresses the feasibility of compliance with RSP, considers recycling rates as defined under proposed Massachusetts legislation; the quoted recycling rates for paper, aluminum, and ferrous metals include industrial recycling of those materials in addition to diversion from municipal solid waste (MSW). Here, we use the traditional method of calculating recycling rates, ignoring industrial recycling that does not enter the MSW stream, because data limitations do not allow us to calculate rates of industrial recycling for all materials.

TABLE 6

RECYCLING RATES FOR PACKAGING DISCARDS[1]

(A) MATERIAL	(B) % OF PACKAGING[2]	(C) % RECYCLED[3]	(B) X (C) COMPOSITE
Paper	54.5%	22%	11.99%
Glass	22.1%	10%	2.21%
Plastics	10.8%	1%	.11%
Steel	5.3%	21%[4]	1.11%
Aluminum	3.1%	25%	.78%
Other	4.2%	2%	.08%
			16.28%

[1]These calculations assume that, for each material, the recycling rates for packaging discards and for non-packaging discards are approximately the same. For some materials, this assumption may not be realistic.

[2]Source: Franklin Associates (1988a).

[3]Source: Franklin Associates (1988a).

[4]Source: Office of Technology Assessment (1989), pages 161-162.

A central issue is what effect an RSP program will have on the level of recycling in Massachusetts. To some extent, this is a circular question, since its answer depends on the threshold recycling levels and other terms specified in any given RSP program. Nevertheless, at least provisionally, we shall assume that an aggressive, but realistic, RSP program will increase the recycling rate for discarded packaging in Massachusetts to 50 percent.[84] Several factors lend support to this assumption.

First, comparable rates have been achieved by other industrialized countries. Japan, for example, recycles between 30 and 50 percent of its MSW,[85] and an even larger percentage of packaging materials.[86]

Second, in the United States, most packaging materials, either in all or in major applications, have already reached or are soon anticipated to reach 50 percent recycling. For example, the glass industry has announced a goal of 50 percent recycled waste glass (cullet) usage and introduced a program to help achieve its objective.[87] The paper industry has already established a goal of 40 percent recycling by 1995 (American Paper Institute [1990]); the introduction of RSP will permit the paper industry to raise its sights to 50 percent recycling. The aluminum industry claims that it has already achieved an overall recycling rate in excess of 40 percent and a recycling rate of 60 percent for aluminum cans (the most significant source of aluminum in MSW).[88] Although only 15 percent of steel cans (the primary use of steel in packaging) are currently recycled nationwide, the steel industry has increased its recycling capacity to handle 25 percent of steel MSW, and some

[84]We note that recently proposed RSP-style programs have, in fact, advocated recycling standards of 50 percent or more. A proposed Massachusetts initiative petition scheduled for the state's 1990 elections (but overturned on a legal technicality prior to balloting) called for a threshold recycling rate of 50 percent by the year 2001. The Oregon Recycling Act, an initiative that was defeated in the state's 1990 elections, proposed a recycling rate of 60 percent by the year 2002.

[85]Reasons for the wide range of reported recycling rates in Japan include different definitions of MSW and certain data deficiencies. See Office of Technology Assessment (1989), pages 136 and 203-204.

[86]According to some studies, the Japanese recycle 95 percent of their newspapers, 50 percent of their paper products, 95 percent of their glass beer bottles, 73 percent of their aluminum cans, and 50 percent of their steel cans. See Kovacs (1988), page 542, and the references cited therein.

[87]See Gibboney (1990). The fact that the glass recycling rate in the United States increased from 10 percent in 1986 to 15 percent in 1988 (Office of Technology Assessment [1989], page 150) suggests the rapidity with which substantial increases in recycling can be attained.

[88]See Aluminum Association (1989) and (1990). Note, however, that other sources believe that the actual overall recycling rate for aluminum is substantially lower (perhaps as low as 25 percent in 1986). The cause of the discrepancy appears to be differing estimates of the proportion of aluminum in MSW that aluminum cans comprise. See Office of Technology (1989), page 153.

curbside collection programs which include steel cans have already achieved steel recycling rates approaching 50 percent.[89]

Third, and finally, even for packaging materials--in particular, plastics--for which a 50 percent recycling rate appears unreachable within the context of current recycling performance, there have been some promising developments.[90] In a related research effort, we enumerated the radical technological advances that have occurred in recent years in designing plastic packaging for reuse (e.g., increased environmental stress resistance, strengthening of polymers by addition of antioxidants, and introduction of other additives, such as compatibilizers, fillers, reinforcing materials, and reactive modifiers to promote reuse); in improving collection and resin separation (e.g., resin codes, single resin packaging, in-mold labeling, and floatation separation, hydroclone-based separation, and other separation process innovations); and in developing profitable end-markets (e.g., household and industrial chemical containers, corrugated piping, and trash bags).[91] As a result, dramatic shifts in plastics recycling--both for specific resins (such as PET and HDPE) and overall--are possible if the proper incentives, such as RSP, are introduced.[92] Furthermore, in many applications, if the plastic packaging were unable to comply with RSP, other packaging materials--with equivalent or nearly-equivalent functional properties and similar costs--could be substituted to satisfy recycling standards.

Assuming then that an RSP program is able to bring about a 50 percent recycling rate for packaging in Massachusetts, into how many tons of recycled material per year does this translate? Because there are two basic ways of complying with recycling standards--by using packaging materials that are either recyclable or recycled--the answer depends on how the recycling standards are satisfied. Here, we make the conservative assumption that all packaging in Massachusetts complies with the recycling standards by consisting of 50 percent recycled materials.[93] Recall that we previously calculated that Massachusetts

[89]See Apotheker (1990) and *Resource Recycling* (1990).

[90]In fact, the Council of Solid Waste Solutions, an industry group formed by major plastics concerns, is planning to announce a recycling goal of 25 percent of all plastics packaging by 1995. See *Wall Street Journal* (1991).

[91]See Stone, Ashford, and Lomax (1991).

[92]For example, PET bottles have achieved a material recovery rate in excess of 20 percent nationwide (*Modern Plastics* [1990], page 32). In Massachusetts, because of its bottle return law, the PET bottle recycling rate is estimated to be 80 percent (Brewer [1989]).

[93]If, instead, packaging satisfied recycling standards by being made of <u>recyclable</u> materials, clearly the total amount of recycling in Massachusetts would be larger, since then the types of materials used in packaging-both in packaging and non-packaging applications--would have to be in compliance. Note that the assumption of compliance solely by means of recycled content was made only for the purpose of establishing a lower bound

generates approximately 2.23 million tons of packaging discards each year. For recycled materials to comprise 50 percent of those 2.23 million tons, in compliance with RSP, requires a total of 1,115,000 tons of MSW to be recycled. Since packaging currently accounts for approximately 357,000 tons of recycling, as previously calculated, an additional 758,000 tons of recycled MSW per year can be attributed to the RSP program.

Earlier, we calculated that the net social benefit derived from the recycling of packaging material is $231 per ton and determined that a major justification for implementing an RSP program is to sustain the value of recycled materials in the market.[97] Based on this $231 per ton figure, the net social benefits of RSP associated with the additional 758,000 tons per year of recycled MSW are approximately $175,000,000 annually.

2.23 x .5 = 1.115 - .357 = .758 mill tons x $231/ton = $175,000,000

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estimate of the effect of an RSP program on recycling levels. It is assuredly not a behavioral prediction of how industry will actually choose to comply with recycling standards (since we anticipate a significant percentage of compliance will be achieved through use of recyclable materials).

[94]In theory, the municipal solid waste that is recycled need not come from Massachusetts, so that the benefits of a Massachusetts recycling program might only partially accrue to Massachusetts. However, as explained in the subsequent analysis of macroeconomic effects in Section B, this possibility will not arise in practice.

[95]Recall that this estimate was based on national recycling rates. Since the recycling rate in Massachusetts is below the national average, current packaging recycling is presumably less than 357,000 tons annually. Our estimate of the increased recycled packaging due to RSP--equal to the difference between RSP's threshold level and the current level--will be correspondingly understated.

[96]These calculations obviously ignore the dampening effect of RSP exemptions on recycling activity. However, that effect should be offset, more or less, by the fact that some packaging will exceed the threshold level of recycling required for RSP compliance.

[97]The $231 per ton estimate of the net social benefits of recycling includes all effects captured in market transactions as well as all externalities associated with solid waste disposal. Embedded in the market effects are trade-offs in the quality and production costs of recycled versus virgin materials. These are reflected in the price obtained for recycled materials (relative to the price for virgin materials). What is not contained in the $231 per ton figure is externalities in primary materials extraction and processing relative to those in secondary materials collection and processing. Prominent examples of externalities in these markets are air pollution, water pollution, and the consumption of depletable energy resources (to the extent that the price of energy does not fully capture the scarcity value of depletable resources used in energy production). In general, the process of producing a ton of secondary material requires much less energy (Office of Technology Assessment [1989], pages 142-184; Kovacs [1988], page 544; and Stauffer [1989]) and causes much less air and water pollution (Wirka [1988], pages 29-32) than does the process of producing a ton of virgin material. As a result, the $231 per ton estimate will tend to understate the true net benefits of recycling.

(2) Ancillary Benefits of RSP

In addition to increasing the proportion of recycled materials in packaging, an RSP program will provide a variety of ancillary benefits, including those from reduced packaging, packaging reuse, and packaging material recycling. Although we use the term "ancillary" benefits, there is no reason they might not exceed in magnitude the aforementioned benefits from recycled packaging.

(a) Packaging Reduction

An RSP program should contain packaging reduction criteria, which would serve as an alternative to recycling standards. Thus, a firm could comply with RSP simply by reducing its packaging (per unit of product) by a specified amount (not necessarily as much as 50 percent).

There is good reason for including packaging reduction criteria as part of an RSP program.[98] In the hierarchy of solid waste management practices, source reduction, which encompasses packaging reduction, has top priority; recycling has second priority.[99] The logic underlying this hierarchy is compelling: it is preferable simply to eliminate unnecessary packaging rather than to recycle it. The preference given packaging reduction is indicated by its net social benefits--$281 per ton--relative to the net social benefits of recycling--$231 per ton--as derived in Part One. The $50 difference between the two reflects the costs of solid waste collection which must be incurred prior to recycling but which are avoidable for eliminated packaging.[100]

[98]Note, however, that the packaging reduction criteria need not be in the form of standards that parallel recycling standards. Because of the administrative costs of measuring a packaging reduction and because of the possibility of perverse outcomes (the firms best able to meet packaging reduction criteria are those with the most excessive packaging; manufacturers who have previously eliminated excessive packaging might be punished for their good efforts), it may be preferable to deal with packaging reduction on a case-by-case (or, possibly, on an industry-by-industry) basis as grounds for exemption rather than as a parallel legislative standard. On the other hand, such perverse outcomes could be avoided by crediting a firm with packaging reductions that it undertook voluntarily prior to the legal requirement to do so. Appending this type of grandfather clause to packaging reduction standards would probably minimize the need for extensive exemptions.

[99]See, for example, Massachusetts Master Plan (1989), page 11. See also Caldart and Ryan (1985), which discusses the primacy of source reduction as a strategy to reduce hazardous waste.

[100]The avoided costs of producing the packaging do not contribute to the social benefits of packaging reduction (relative to packaging recycling) because, for the marginal unit of packaging eliminated, its production costs are presumed to be just equal to its functional value.

We make no attempt here to quantify the total social benefits to be obtained from RSP-induced packaging reduction. However, the opportunities to reduce packaging would appear to be plentiful. To cite just one example, consider microwave packaging. Many manufacturers of microwave foods include a disposable (usually plastic) microwave cooking tray, which typically accounts for well over half of the microwave packaging by weight. Elimination of these disposable cooking trays would be a costless way of complying with RSP. Consumers would simply place the microwave food in a glass[101] tray of standardized size, which could be purchased separately and reused innumerable times.

(b) Packaging Reuse

A second type of ancillary benefit will arise from packaging reuse criteria, which should also be included in an RSP program as an alternative to recycling standards. "Discarded" (or returned) packaging that is reused a specified number of times would accordingly be considered to be in compliance with RSP. The net social benefits per ton of packaging reuse may be greater than, equal to, or less than those of package recycling--depending on their relative costs of collection and processing, how often the packaging is reused, and the disposition of the packaging when it can no longer be reused. We anticipate that the opportunities for packaging reuse are far less pervasive than those for packaging reduction, but some niches for packaging reuse do exist (particularly in cases where the other RSP options cannot be satisfied). One emerging example is reusable polyethylene foam stuffing employed to package fragile computer equipment. The crucial factor in facilitating reuse is the computer packaging collection and distribution system developed by computer companies and plastics manufacturers.[102]

(c) Packaging Material Recycling

Increased recycling of packaging material is another ancillary benefit that will be triggered by an RSP program. We previously assumed that packaging would comply with RSP by consisting of 50 percent recycled content. However, businesses might instead choose to comply with RSP by using recyclable packaging materials--those that are

[101]Glass is a superior microwavable material. Components of plastic microwave trays, including toxic plastic monomers, cyclic PET trimmers, plasticizers, and adhesives, have been found to leach into food during the microwave heating process. Elimination of the disposable plastic trays would also eliminate this consumer health hazard.

[102]See Stone, Ashford, and Lomax (1991), pages 28-29.

achieving a statewide recycling rate of 50 percent. For example, in order for a package made of paper to comply with the recyclability standard, 50 percent of all the discarded paper in Massachusetts, regardless of application (in other words, not just discarded paper packaging) would have to be recycled. To extend the example, the recyclability criterion might lead to efforts to increase office paper recycling in order to achieve the threshold recycling rate for paper. Thus, the recyclability criterion effectively leverages the recycling of discarded packaging to encompass the recycling of discarded package materials from all applications.

We can estimate the potential magnitude of these leveraged benefits with reasonable accuracy. As indicated earlier in Table 6, paper, glass, plastics, steel, and aluminum comprise over 95 percent of packaging. Column (b) of Table 7 shows that these five packaging materials account for 60 percent of the 6.6 million tons of MSW generated in Massachusetts each year, equal to approximately 4 million tons annually. If all packaging were to comply with the recyclability criterion, 50 percent of all paper, glass, plastic, steel, and aluminum discards in the state would have to be recycled, a total of approximately 2 million tons annually. The last column of Table 7 reveals that approximately 17.5 percent of these materials are currently recycled.[103] Thus, in Massachusetts, of the 4 million tons of these materials discarded each year, approximately 700,000 tons are recycled annually. In addition, we previously estimated that the benefits of RSP, assuming packaging attained 50 percent recycled content, would be 758,000 tons. Satisfying the recyclability standard, which would involve a total of 2 million tons of recycled packaging materials, would therefore require an additional 542,000 tons of recycling annually. Based on the estimate of $231 per ton as the net social benefit of recycling packaging material, the potential leveraged benefits of RSP due to the recyclability criterion are approximately an additional $125,000,000.

The extent to which these leveraged benefits are realized depends on the proportion of packaging that complies with the recyclability criterion rather than with the recycled content criterion. If all packaging complies with the recycled content standard, then the social benefits will be $175,000,000 annually. If all packaging complies with the recyclability standard, then the total leveraged benefits will be $300,000,000 annually ($175,000,000 of which would come at the expense of reduced recycled content benefits). Obviously, if some packaging complies with the recycled content standard and the

[103]Again, we note that this estimate reflects the national average. Applying this percentage to Massachusetts will tend to overestimate the state's recycling rate for these materials (and subsequently underestimate the leveraged benefits from the recyclability criterion), since the recycling rate in Massachusetts is below the national average.

TABLE 7

RECYCLING RATES FOR MAJOR MATERIALS USED IN PACKAGING

(A) MATERIAL	(B) % OF MSW[1]	(C) % OF PACKAGING MATERIAL[2]	(D) % RECYCLED[3]	(C) X (D) COMPOSITE
Paper	36%	60%	22%	13.20%
Glass	8%	13%	10%	1.13%
Plastics	7%	12%	1%	.12%
Steel	8.5%	14%	21%[4]	2.94%
Aluminum	.5%	1%	25%	.25%
	60%			17.64%

national averages

[1]Source: Office of Technology Assessment (1989), page 5.

[2]Percentages in Column (c) are equal to Column (b) divided by .6, which is the sum of the percentages in Column (b).

[3]Source: Franklin Associates (1988a).

[4]Source: Office of Technology Assessment (1989), pages 161-162.

remainder complies with the recyclability standard, then the total social benefits will fall somewhere between $175,000,000 and $300,000,000 annually.

(3) RSP Compliance Costs

RSP compliance costs are the additional costs that firms incur to make their packaging meet packaging recycling standards. Of course, a major component of RSP compliance costs--firms' costs of using recycled material rather than virgin material in packaging (in order to satisfy the recycled content provisions of RSP)--is included as part of the net social benefits of recycling, previously estimated to equal $231 per ton. However, firms will also incur costs to become acquainted with the provisions of the RSP program, to learn about and to evaluate packaging alternatives, and to modify aspects of production in order to comply with RSP.

For a variety of reasons, we expect these compliance costs to be small. First, a significant proportion of packaging is produced by large packagers or purchased by large manufacturers for whom the informational costs of the RSP program should be negligible.[104] Second, once the RSP program is initiated, developers and manufacturers of compliant packaging will surely market their products aggressively. In other words, most packaging buyers need not devote extensive resources to familiarize themselves with the RSP program, to interpret how RSP affects their business, or to search for complying packaging; packagers with RSP solutions will provide these services in order to attract new customers. Third, some packaging is already in compliance with RSP. Manufacturers and buyers of such packaging need not incur any product or process modification costs. Fourth, businesses are continuously changing their packaging independently of RSP, as part of their ongoing need to market products creatively. On average, firms modify their packaging every two to three years,[105] so that packaging changes to comply with RSP can be incorporated as part of the regular process of packaging revision. Therefore, dead-weight losses associated with having to scrap packaging prematurely will generally not arise. Fifth, other impending packaging legislation--intended to eliminate lead, cadmium, mercury, and other heavy metals from packaging so as to reduce environmental hazards in disposal or

[104]For example, International Paper, the largest U.S. packaging company, had domestic packaging sales of two billion dollars in 1984. The 50 largest U.S. packagers accounted for approximately half of the domestic packaging sales in 1984 (Rauch Associates [1986], pages 3-10). Large purchasers of packaging include firms such as Anheuser-Busch (the nation's largest consumer of packaging) and McDonalds. The informational costs of an RSP program would be a trivial amount in relation to these firms' revenues.

[105]See Tufts University (1988), pages 33-34.

recycling--will cause significant changes in packaging (particularly in pigments and inks and in materials additives).[106] Again, firms' reappraisal of their packaging in response to such environmental legislation geared toward packaging provides a relatively costless opportunity to consider RSP-inspired modifications at the same time.

In addition, two by-products of RSP compliance will tend to minimize, or even offset, RSP compliance costs. The first is joint production efficiencies, simultaneous and inseparable productivity improvements associated with RSP compliance. As an example, when AT&T recently changed its telephone and answering machine packaging, using corrugated cardboard in place of styrofoam (for product protection) to promote environmental objectives, the company was able, at the same time, to make its packaged products approximately one quarter smaller, since the corrugated cardboard is much less bulky than the styrofoam. As a result, AT&T is able to save on product shipping costs and the costs of hauling discarded packaging, and retailers are able to save on shelf space.[107] As another example, some firms will make productivity improvements that, although causally related to RSP compliance efforts, are not necessary to satisfy RSP. The classic reason for this phenomenon is indivisibilities in investment decisions; it is generally less costly to make multiple changes in production simultaneously rather than individually.[108] Therefore, an RSP program will provide the stimulus to make other production improvements, not justified or not perceived in isolation, in concert with compliance efforts.

The second positive by-product of RSP compliance is packaging and recycling innovations. A variety of research has demonstrated that regulation (or legislation) can stimulate the innovative performance of industry.[109] The regulations most likely to elicit an innovative response are those that set stringent standards, provide industry with maximum flexibility in meeting those standards, and are targeted at industries with the capacity to innovate.

[106]See, in particular, the model legislation proposed by the Coalition of Northeast Governors (CONEG) Source Reduction Task Force. In response to the model legislation, New Jersey (one of Massachusetts's CONEG partners) has already adopted a bill--State of New Jersey Senate Committee Substitute for Senate Bill No. 2261, Adopted September 24, 1990--whose purpose is to reduce the amount of toxic packaging and whose recommended methods specifically include banning the distribution or sale of toxic packaging in New Jersey.

[107]See *Boston Herald* (March 13, 1990).

[108]See, for example, Ashford and Caldart (1991), pages 242-243.

[109]See, in particular, Ashford, Ayers, and Stone (1985) and the references cited therein. For an examination of the innovation process itself, see Ashford and Stone (1991).

The type of RSP program under consideration here has precisely those characteristics. By setting ambitious, but achievable recycling targets and raising the possibility of packaging bans for non-compliance, stringent recycling standards will create market-driven, demand-pull opportunities for technical change.[110] In addition, RSP does not impose a specific packaging technology, but rather, allows businesses the flexibility of meeting any one of several alternative recycling criteria and, subject to the particular criterion selected, of using whatever packaging they prefer. Furthermore, the packaging industry is highly innovative.[111] By adding recycling dimensions to previous design considerations, an RSP program will "increase the problem space"[112] of the packager, thereby redirecting innovative activity toward simpler and more recyclable packaging. Finally, we note that the truly remarkable number of significant product and process innovations in the packaging and recycling industries in recent years has been due, at least in part, to the threat of possible packaging and materials bans and other stringent regulations in various cities and states throughout the United States.

While we make no attempt to quantify the joint production efficiencies and packaging and recycling innovations associated with RSP, we anticipate their benefits will be widespread and substantial.

(4) The Administrative Costs of RSP

RSP administrative costs are transaction costs that accompany an RSP program. They include the government's costs of developing, supervising, and enforcing an RSP program, as well as the costs businesses incur in order to verify and demonstrate their compliance.

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[110]Evidence from the effects of other stringent regulations supports this conclusion. For example, when the manufacture of polychlorinated biphenyls ("PCBs") was prohibited, industry responded by developing five PCB substitutes, constituting radical and comprehensive product innovations. In other cases, industry has found substitutes for lead used in gasoline and paints, for mercury in oil-based paints, and for the pesticide DDT. Conversely, regulation that is too lax discourages innovation; instead it elicits adoption of on-the-shelf technology (and usually add-on technology, such as an end-of-pipe pollution control device, which minimizes the technological response of the firm). See Ashford, Ayers, and Stone (1985), pages 429-443, and Ashford and Stone (1991).

[111]As an indication of the packaging industry's innovative performance, consider its response to the series of poisonings from tampered Tylenol bottles. To protect consumers and to eliminate their own potential liability exposure, the packaging industry moved quickly to develop and widely adopt tamper-proof packaging for food and drug products.

[112]See Allen *et al.* (1978).

Because of its heavy reliance on market solutions, we anticipate that RSP will minimize the government's involvement in firms' packaging decisions and keep administrative costs to a modest level. While significant resources may go into structuring an RSP program and in working out the details of its operation, such planning involves only a one-time effort, whose expense should be negligible when amortized over the life of the recycling program. In terms of everyday RSP functions, we envision the role of government being limited primarily to calculating recycling rates, evaluating possible packaging exemptions, and enforcing recycling standards. Regular calculation of recycling rates should involve only minor expenses and would be a valuable contribution to any recycling initiative, not just RSP. In principle, government could be swamped by costly exemption requests. In practice, however, they are likely to be few in number and easy to process. The reason is that, in order to expand their market share, competitors who have developed compliant packaging will challenge unwarranted requests for exemptions. Government's information-gathering and adjudicative expenses in processing exemption claims should therefore be minimal. Similarly, enforcement activities will probably be conducted mainly by private parties rather than government. Packaging competitors and public interest groups will find it in their interest to monitor the performance of packagers and to notify the government of RSP violations. Government can therefore focus its enforcement activities on the relatively low-cost tasks of verifying and penalizing reported RSP violations.

We should note, in addition, that the increased recycling occasioned by RSP will, over time, result in a reduction in the number of solid waste facilities needed in Massachusetts. Consequently, the government's costs of administering an RSP program will be offset, to a greater or lesser degree, by corresponding reductions in its costs of administering other environmental programs--in particular, those associated with the siting, construction, and operation of solid waste facilities and those associated with the clean up of air, water, and land resources damaged by toxic releases from solid waste disposal facilities.

Nor should businesses bear significant transaction costs to confirm their compliance with RSP (and most of those costs will be temporary, occurring during the period when the RSP program is first being activated). In principle, the one vulnerable party would be retailers, who might have serious difficulty in determining whether the packaged goods they receive from manufacturers and distributors, particularly those from out of state, are in compliance with RSP. Again, in practice, these potential transaction costs will not materialize, since retailers will simply develop standard contract language requiring their suppliers to assume liability for any and all costs and penalties arising from delivered packaging in violation of RSP. As to the transaction costs that complying packagers will incur in order to monitor the compliance of their competitors and to challenge their competitors' unwarranted claims for exemptions, we need not concern ourselves since the market will compensate them for their efforts in the form of additional business. In that sense, an RSP program will impose a self-regulating, efficient level of transaction costs on business.

(5) The Possibility of Product Withdrawals or Shortages Due to RSP

Whatever the benefits of an RSP program, they would surely prove insufficient were one of the consequences of RSP to be the withdrawal of products from the market or the emergence of discernible product shortages. It is important to consider, therefore, whether such deleterious results might not follow from the imposition of recycling standards.

It so happens that the prospect of products being withdrawn from the market or of product shortages is raised by industry virtually every time it is confronted with stringent regulation. For example, when the use of fully halogenated chlorofluorocarbons ("CFCs") in aerosol sprays was banned, manufacturers claimed that many aerosol products would have to be withdrawn from the market. In reality, the chemical industry developed a non-fluorocarbon propellent using CO_2 and firms outside the chemical industry developed a new pumping system (called "the pump") not dependent on propellents and cheaper than CFC propellents.[113] The only thing withdrawn from the market was what the regulators intended to be withdrawn--CFCs in aerosol sprays. The actual outcome is invariably the same in every case: substitutes for the regulated substance are found or developed, and unwelcome product withdrawals or shortages never materialize. What prevents product withdrawals or shortages, of course, is the functioning of economic markets. The essence of a market system is its ability to adapt to change. Changing factor prices or the imposition of resource constraints, for instance, create profitable opportunities for economic agents to satisfy the unmet demand arising from these market disturbances.

The equilibrating properties of the market will surely operate in response to recycling standards. Manufacturers of compliant packaging will rush in to fill the void left by non-compliant competitors, and packaging entrepreneurs will develop novel packaging solutions that better incorporate the new realities of the marketplace. In fact, several features of an RSP program make the threat of product withdrawals or product shortages even more remote than usual. First, compliance with recycling standards will be technically

[113]See Ashford, Ayers, and Stone (1985), pages 433-434.

feasible; there is no risk that necessary packaging innovations will not be forthcoming. Second, the packaging industry is dynamic; it is characterized by frequent product redesign. By giving packagers and package buyers several years to respond to recycling standards, no product dislocations need occur. Third, in rare cases where compliant packaging is not available without compromising important packaging functions, the RSP program specifies that exemptions be granted. Finally, manufacturers do not really have the option of abandoning Massachusetts markets. What business would choose to exit a market the size of Massachusetts when its competitors are ready and able to absorb its customers? Furthermore, the imposition of packaging recycling standards is not an isolated event restricted to Massachusetts. A multitude of cities and states are confronting business with the threat of packaging restrictions, many of which--such as unqualified materials bans--would be far less desirable to industry than an RSP program.

Simply put, there will be no vacant shelves in Massachusetts as the result of an RSP program.

(6) Summary of the Microeconomic Effects of RSP

We have argued that an RSP program in Massachusetts will be able to achieve a 50 percent recycling rate for packaging. Under the conservative assumption that packaging will comply with recycling standards by consisting of 50 percent recycled content, then the associated social benefits of RSP in Massachusetts will be $175,000,000 annually. In addition, an RSP program in Massachusetts will provide ancillary benefits from reduced packaging, from packaging reuse, and--if firms comply with the recyclable packaging material standard (rather than with the recycled content standard)--from the recycling of packaging material in non-packaging applications. The last of these ancillary benefits alone could increase the social benefits of RSP by an additional $125,000,000 annually.

We have also found that the compliance costs of an RSP program are likely to be low and will be at least partially negated by joint production efficiencies and packaging and recycling innovations arising in response to RSP. Furthermore, we anticipate that the administrative costs of an RSP program will be modest because of RSP's reliance on market solutions and on the initiatives of private economic actors. Finally, an RSP program will not lead to product withdrawals or shortages.

We conclude that whatever the administrative and compliance costs of an RSP program, they will be more than offset by the ancillary benefits previously enumerated. Therefore, the net social benefits of an RSP program in Massachusetts should be at least $175,000,000 annually and might well reach $300,000,000 annually.

B. The Effects of RSP on Massachusetts Employment and on the Massachusetts Economy

We next consider the effects of an RSP program on Massachusetts employment and on the Massachusetts economy. Following some introductory comments concerning common pitfalls to avoid in conducting an analysis of macroeconomic impacts, we identify and evaluate two distinct types of effects at work: (1) those induced by the net social benefits of an RSP program, and (2) those arising from industry-specific effects of RSP as reflected in Massachusetts. In addition, we briefly consider some broader economic and non-economic effects of an RSP program.

(1) General Caveats

The assessment of macroeconomic effects, and particularly employment effects, is susceptible to abuse, sometimes by those with special interests in the outcome, sometimes by the sincere, but faulty reasoning of the analyst. In order to anticipate and thereby to forestall such abuse, we should like to preface our analysis of the macroeconomic effects of RSP with an examination of the types of specious and superficial reasoning to be avoided. To illustrate the principles involved, we begin by presenting "the fallacy of the broken window." We then consider the principles in more abstract terms and apply them to the macroeconomic analysis of an RSP program.

(a) The Fallacy of the Broken Window[114]

Suppose a malicious youth hurls a rock through the window of a grocery store. In considering the consequences of this destructive act, it is easy to conceive of a positive side as well. After all, the broken window will make some business for the glazier who replaces it. Furthermore, with the money received from the grocer, the glazier will purchase goods and services from other merchants, and these merchants will therefore have more to spend with still other merchants. The broken window will provide income and employment in ever-widening circles. The logical conclusion, according to this reasoning, is that the youth who threw the rock, far from being a public menace, is actually a public benefactor.

The flaw in this reasoning is that it is incomplete. It is true, of course, that the act of vandalism will create additional business for some glazier. But what has not been

[114]See Hazlitt (1962), pages 15-17.

considered is the merchandise--say, a new suit--the grocer was planning to purchase, but because of the cost of the replacement window, he will have to do without. In addition, the clothier's lost business will mean he has less to spend with other merchants, who will therefore have less to spend with still other merchants, and so on ad infinitum. In short, the glazier's gain of business is merely the clothier's loss of business. No additional income or employment has been created by the broken window. Furthermore, the grocer--the victim of the vandalism--is clearly worse off. Instead of a window and the new suit he was planning to buy, the grocer must now be content with only the window. Similarly, society has lost a new suit that might otherwise have come into being, and is just that much poorer.

(b) Applications to the Analysis of RSP

Perhaps the fallacy of attributing benefits to employment gains from destructive acts is so obvious as not to require explanation. Nevertheless, the analytic principles used to expose fallacies of this type are worth enumerating and examining within the context of an RSP program.

One fundamental principle is that analysis of a policy requires tracing the long-run consequences of that policy for all economic sectors, not merely the immediate effects of the policy or the effects on only one economic sector. It is virtually impossible to think of any policy or change in economic activity that doesn't involve some observable business or job loss for somebody. For example, the introduction of quartz-crystal watches harmed the manufacturers of spring-movement watches; video cassette recorders and the availability of video cassettes of movies injured movie theater sales; personal computers and word-processing software damaged the typewriter business; and so on. Therefore, simply identifying those economic agents who might be harmed by a policy does not by itself provide grounds for rejecting that policy; the main issue is whether the harms created by the policy can be justified by the benefits.

In the case of an RSP program, it is clear that some manufacturers of non-compliant packaging (those whose packaging is sold in Massachusetts and who are unable to modify the packaging they produce to achieve compliance) will lose business and employees. But those losses will be offset by the additional business and employment created for manufacturers of recyclable or recycled-content packaging. Thus, recycling standards will result not ~~in a net loss of jobs, but~~ in a diversion of jobs to recycling activities and to the manufacture of recycled products and packaging. If the transition to an RSP program is smooth enough, employment opportunities should adjust so that most workers who temporarily lose jobs will find alternative employment through a series of employment moves involving other workers in the economy.

Just because an economic agent is "affected" by a policy or change in economic activity doesn't necessarily mean that that economic agent, or others, will lose their job as a result. In the case of an RSP program, the manufacturers, distributors, and retailers of products sold in Massachusetts whose packaging is not currently in compliance will surely be "affected" by the recycling standards. Furthermore, the way in which Massachusetts businesses and households dispose of their packaging and other solid waste is likely to be "affected" as well. But that is precisely the purpose of the recycling standards: to provide incentives to alter behavior in ways that promote recycling. Thus, the consequence of "affecting" these economic agents is not lost business or employment, but rather compliance.

One might infer from the preceding discussion that public policy, such as an RSP program, is incapable of affecting employment levels or the level of economic activity in Massachusetts. Such a conclusion would obviously be incorrect, as the analysis below will demonstrate by example. Before examining the probable effects of recycling standards on the Massachusetts economy, however, we should make clear one important point. Although the net effect of an RSP program will be to create jobs in Massachusetts, that fact may be scant consolation to those few workers who might lose their job because of recycling standards and not find alternative employment. It would be callous to dismiss the fate of these individuals. Consequently, we encourage the state to take special efforts to assist any non-compliant manufacturers in shifting their business activities to compliant products and packaging, if possible, or to provide retraining assistance for their displaced workers.[115]

(2) Social Benefits of RSP: Real and Implicit Tax Reductions

A major effect of recycling standards on the Massachusetts economy and on employment in Massachusetts is directly related to the net social benefits arising from an RSP program. To see this, recall that the net social benefits of recycling consist primarily of the avoided out-of-pocket and imputed costs of solid waste disposal. The out-of-pocket costs of solid waste disposal are, for the most part, paid for by the state and its municipalities, but the revenues to cover these expenses are generated from taxes borne by

[115] It is generally a poor strategy for the state to attempt to protect inefficient firms or jobs in inefficient industries. The benefits are illusory and the costs are self-perpetuating. A far better approach is to help improve the performance of inefficient firms or industries or to help shift economic activity to more productive industries in the state.

Massachusetts businesses and households. Therefore, every dollar an RSP program saves Massachusetts in solid waste disposal expenditures directly translates into a dollar reduction in tax burden for Massachusetts taxpayers.[116] In the case of the imputed costs of solid waste disposal, Massachusetts citizens pay an implicit tax in the form of disposal-related environmental hazards and disamenities. Stated differently, the implicit tax is equal to the additional cost Massachusetts citizens must incur to achieve a given level of environmental safety and amenities.

We previously determined that a conservative estimate of the net social benefits of an RSP program is $175,000,000 annually and that the net social benefits could reach $300,000,000 annually. Of the net social benefits of recycling, approximately 42 percent is associated with the avoided out-of-pocket costs of solid waste disposal (after all direct benefits derived from solid waste disposal are subtracted out) and the remaining 58 percent is derived from the avoided imputed costs of solid waste disposal.[117] Thus, assuming annual social benefits of $175,000,000 from RSP, approximately $75,000,000 will be due to avoided out-of-pocket expenses from solid waste disposal, and $100,000,000 will be due to avoided imputed costs from solid waste disposal. Were the net social benefits of an RSP program $300,000,000 annually, approximately $125,000,000 would come from avoided out-of-pocket expenses and $175,000,000 from the avoided imputed costs of solid waste disposal.

Based on these figures, the net social benefits of an RSP program translate into a tax reduction of from $75,000,000 to $125,000,000 annually for Massachusetts businesses and households and an additional implicit tax benefit of from $100,000,000 to $175,000,000 annually for Massachusetts citizens. We should further note that much of what we term the "implicit" tax benefit, from a reduction in imputed solid waste disposal costs, may actually appear in the form of real out-of-pocket savings. For example, to the extent that the environmental hazards from solid waste disposal lead to adverse health consequences, the

[116]Needless to say, just because state and municipal operating costs are reduced does not guarantee that taxes will be correspondingly lowered. However, it is reasonable to assume that, over time, state and municipal taxes will tend to match their respective liabilities (net of other revenues and transfer payments). Even were taxes not reduced, the benefits of an RSP program will allow the state and municipal governments to fund other needed services.

[117]As calculated in Part One, of the net social benefits of $231 per ton of recycling, the avoided cost of environmental hazards and disamenities is $160 per ton of solid waste incinerated (including $21 of the $44 for the landfilling of incinerator ash) and $75 per ton of solid waste landfilled. Since it is predicted that, on average, 70 percent of solid waste will be incinerated and 30 percent landfilled, the composite avoided cost of environmental hazards and disamenities is $134 per ton of recycling, which is equal to approximately 58 percent of the $231 social benefit per ton of recycling. The residual 42 percent, or $97 per ton of recycling, is due to the avoided out-of-pocket expenses of solid waste disposal.

imputed benefits of recycling standards will be embodied in reduced medical treatment costs and fewer work-loss days.[118]

These real and implicit tax reductions brought about by an RSP program will serve to stimulate the Massachusetts economy and employment. Tax reductions (without corresponding loss of services) will attract both workers and industry to the state. People will find Massachusetts a more desirable place in which to live and work because lower taxes reduce their real cost of living in the state. Industry will be attracted to the state by the lower cost of doing business (both because of diminished business tax payments and because workers can be hired for lower wages when their real cost of living is lessened). Such tax benefits from an RSP program would be of special relief to Massachusetts at a time when the state is burdened by serious budget deficits and a reputation for excessive taxation.[119]

(3) Industry-Specific Effects of RSP as Reflected in Massachusetts

The other major effect of an RSP program on the Massachusetts economy and on employment in Massachusetts is related to how recycling standards alter the level of

[118]In addition, since medical care costs are heavily subsidized by government, some of these imputed benefits of an RSP program will actually further reduce the tax burden of Massachusetts taxpayers. See Ashford and Caldart (1991), page 229.

[119]We have intentionally avoided developing formal estimates of the effects of RSP social benefits on the Massachusetts economy and employment partially because of the uncertainties involved (e.g., such as the form in which the benefits of an RSP program will be reflected in Massachusetts's fiscal policy), partially because of the difficulty in doing so (e.g., it is unclear how to treat the macroeconomic effects of reduced environmental hazards and disamenities, which provide implicit but generally not actual tax savings), and partially because we do not want to commit the types of analytic abuses that we previously cautioned against.

However, under the assumption that the benefits of an RSP program would have the same effect as an equivalent reduction in Massachusetts taxes, we can develop rough estimates of the associated macroeconomic effects. The crucial variables in the estimation are the economic and employment multipliers in response to a tax reduction. Based on simulations using the Brookings Quarterly Econometric Model of the United States, the GNP multiplier for a tax reduction is approximately 1.4 *for the United States* (Duesenberry *et al.* [1969], pages 481-491). Thus, the $175,000,000 to $300,000,000 annual social benefits of an RSP program, if they operated entirely as a tax reduction, would provide an economic stimulus of from $245,000,000 to $420,000,000 annually. However, not all of the economic stimulus will accrue to Massachusetts. Based on simulations (for a direct stimulus in Missouri) using a "bottom-up" multistate interactive econometric model of the United States (developed by the Bureau of Economic Analysis for the U.S. Department of Commerce), approximately 60 percent of the economic multiplier accrues to the state in which the stimulus occurs (Ballard, Glickman, and Gustely [1980], pages 147-152). Thus, the economic stimulus to Massachusetts from its own RSP program should range from $147,000,000 to $252,000,000 annually. Based on simulations using a quarterly econometric model of Massachusetts, a tax reduction of from $175,000,000 to $300,000,000, in 1990 dollars, would yield a gain in Massachusetts employment of from 3,200 to 5,500 jobs (Friedlaender, Treyz, and Tresch [1975], pages 503-506).

activity of industries specific to Massachusetts. An RSP program will stimulate certain industries and cause others to contract. If--as we contend below--the stimulated activities are primarily conducted in Massachusetts and the industries adversely affected are primarily out-of-state, then recycling standards will have a positive effect on the Massachusetts economy and on employment in Massachusetts (in addition to the positive effects related to the social benefits of RSP, previously examined).

Often discussion of the effects of recycling on a local economy is restricted simply to the growth of materials collection and sorting activities,[120] usually taking into account the loss of economic activity in solid waste disposal. Of course, the effects on economic activity of recycling in general, and of an RSP program in particular, will be much broader. Packagers will be affected, as will businesses that use packaging. But, most important, economic activity will shift from businesses concerned with extracting and processing virgin materials to businesses concerned with formulating and processing recycled materials. The key issue is how these changes in industrial activity will affect the Massachusetts economy and Massachusetts employment.

Solid waste landfilling and incineration are principally local activities, as are materials collection and sorting. However, because the latter activities are much more labor intensive, the shift of economic activity in these industries, due to RSP, will create additional employment in Massachusetts.[121]

The economic activity of businesses in Massachusetts that use packaging has been explored in other studies.[122] Massachusetts manufacturers using packaging employ as many as 629,000 workers; if wholesalers and retailers are included, Massachusetts employment levels in these businesses rise to approximately 900,000 jobs. However, only about 18,000 of these jobs are packaging-related.[123] These jobs will not be lost as a result

[120]See, for example, Barry (1989), page 7.

[121]An examination of seven recycling programs found that recycling creates 1600 jobs for every million tons of solid waste collected and sorted, compared to 600 jobs for landfilling and 80 jobs for incinerating the same million tons of solid waste (Environmental Defense Fund [1988], page 18). Since, as estimated earlier, an RSP program will result in increased recycling of from 758,000 tons to 1,300,000 tons annually, the net gain in Massachusetts employment in these industries should range from 1,000 to 1,800 jobs.

[122]See Tufts University (1988), pages 35-38, and Temple, Barker & Sloane, Inc. (1990), pages IV-3 - IV-5.

[123]Most of Massachusetts manufacturing employment is in areas that are not packaging-intensive (such as machinery and electrical equipment and supplies). Conversely, packaging-intensive industries, such as "food and kindred products," are poorly represented in Massachusetts. See Tufts University (1988), pages 36-37.

of recycling standards,[124] although there will be some diversion of job activity to recycled-content or recyclable packaging.

These same studies also examine the packaging industry in Massachusetts, which employs approximately 22,000 workers.[125] In terms of an RSP program, some of the existing packagers in Massachusetts will be positively affected; some negatively.[126] However, the net effect on Massachusetts employment should be small.[127]

We turn now to the effect on Massachusetts employment of RSP-induced shifts in industrial activity from virgin materials extraction and processing to recycled materials formulating and processing. The amount of economic activity in Massachusetts involving virgin materials extraction and processing is extremely small. For example, the number of Massachusetts jobs in mining and forestry is less than 2000; by comparison, if Massachusetts economic activity in these industries were proportional to the national average (relative to total employment levels in the state), Massachusetts employment in these industries would be approximately 28,000.[128] What this means is that the loss of economic activity in virgin materials extraction and processing, due to RSP, will have only a negligible effect on the Massachusetts economy. (That is, since the number of jobs in Massachusetts associated with these industries is so small anyway, there are not many jobs to be lost as a result of recycling standards.) Conversely, RSP-induced stimulation of recycled materials formulating and processing should have a discernible effect on the Massachusetts economy. Because of the relatively high costs of transporting materials, the additional separated materials in Massachusetts due to RSP will, for the most part, be

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[124]The only exception will be job displacement due to whatever packaging reduction accompanies an RSP program.

[125]See Tufts University (1988), pages 38-40, and Temple, Barker & Sloane, Inc. (1990), pages IV-2 - IV-3.

[126]The composition of jobs in the packaging industry, by packaging material, in 1986 was paper (including paperboard containers), 11,141 (52%); glass, 250 (1%); metal, 1,120 (5%); plastic packaging, 7352 (33%); and other, 2076 (9%). See Temple, Barker & Sloane, Inc. (1990), page IV-2.

[127]Taking into account the possibility of some packaging reduction as well, the net effect is likely to be slightly negative.

[128]Massachusetts employment constitutes approximately 3.2 percent of total employment in the United States. However, in the mining and forestry industries, of the total of 865,000 jobs in the United States, only 1,800, or approximately .2 percent, are located in Massachusetts. See U.S. Department of Commerce (1988a), pages 16-19, and U.S. Department of Commerce (1988b), pages 3-66.

formulated and processed into recycled materials locally.[129] The associated gain in Massachusetts employment should be substantial.[130]

A detailed accounting of the industrial effects of an RSP program, including pertinent secondary and tertiary economic interactions among industries,[131] would require a full-fledged input-output analysis.[132] However, it should be clear from the previous discussion that an RSP program will have a decidedly positive effect on industrial activity in Massachusetts--principally due to the stimulative effect of RSP on recycled materials formulation and processing activities in the state, with other industrial effects in the state being relatively minor and largely cancelling themselves out.

(4) Other Effects and Considerations

The preceding analysis has been devoted to forecasting the economic effects on Massachusetts of an RSP program in the state. However, there are broader issues that also merit consideration.

[129]There are two reasons why--in response to a Massachusetts RSP program--recycling activity will take place in Massachusetts rather than elsewhere. First, before investing in local plant and equipment, recyclers need to be assured of a steady stream of sorted materials. An RSP program in Massachusetts will demonstrate the long-term commitment of the state to work with the recycling industry to sort materials as needed to promote recycling. Indeed, as indicated in Part Two of this study, a principal purpose of recycling standards is to develop recycling markets for the discarded materials that are collected and sorted in Massachusetts. Second, recyclers will be encouraged to use sorted materials from Massachusetts in order to satisfy the recyclable packaging materials standard. Again, because of the relatively high cost of transporting packaging materials, most recyclers using Massachusetts discards will have to locate in Massachusetts, in order to be near the source of the sorted materials.

[130]An RSP program will result in an additional 758,000 tons to 1,300,000 tons of discarded materials used in packaging being recycled annually, which equals from 19 percent to 33 percent of the packaging materials (paper, glass, plastics, steel, and aluminum) in MSW. If we use employment in mining and forestry as a (very) crude approximation of employment in virgin packaging materials extraction and processing and further assume that the jobs needed to produce from 758,000 tons to 1,300,000 tons of virgin material are diverted, one for one, to jobs to formulate and process recycled materials, then the increase in Massachusetts employment in these industries due to RSP will range from approximately 6,000 to 10,000 jobs.

[131]An example of the interindustry effects of an RSP program would include the negative impact on the energy sector of shifts from virgin material extraction and processing to recycled material formulation and processing, because of the substantially higher energy requirements of the former economic activities (Quigley [1988], page 46). Note, however, in this example, that the interindustry impact on the energy sector in Massachusetts is likely to be positive because virgin material extraction and processing activities in the state are so small relative to the projected Massachusetts gains in recycled material formulation and processing activities.

[132]Because of the demanding informational requirements concerning the direct industrial effects of an RSP program, an input-output analysis would not be warranted at this point. For an introduction to the workings of input-output analysis in a regional setting, see, for example, Heilbrun (1981), pages 170-182.

First, the issue of recycling is not restricted to Massachusetts. Many other states are confronted with immediate and significant solid waste disposal problems that a well-conceived recycling program could solve. The successful implementation of recycling standards for packaging in Massachusetts would surely provide the impetus for adoption of this program in other states.

Second, in focusing on the major industry-specific effects of an RSP program, we may have overlooked, or taken for granted, the more pervasive benefits of recycling standards--which will be to reduce materials and production costs throughout the economy and thereby to improve the competitiveness of Massachusetts and American industry. By recognizing and recapturing the valuable resources contained in our discarded materials, the United States will be able to export price-competitive finished products rather than solid waste, as it does today.[133]

Finally, while it is comforting to know that recycling makes good economic sense, much of the public support for recycling transcends dollars and cents. The majority of the Massachusetts citizenry is committed to a recycling ethic, and would continue to be even if they had to pay extra for products in recyclable packaging.[134] For them, solid waste is a wasteful, offensive, and simply wrong-headed concept. The solution, independent of cost, is to recycle. Recycling standards for packaging are the essential mechanism to make recycling work in Massachusetts and to help fuel a successful transition from a throw-away society to one that respects and values its resources. Waste is, after all, the visible face of industrial inefficiency.

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[133] See Kovacs (1988), pages 542-544.

[134] See Martilla and Kiley (1989). For a similar response nationally, see *Packaging Magazine* (1989).

APPENDIX A
SENSITIVITY ANALYSIS:
THE NET BENEFITS OF RECYCLING

Part One of the study develops a point estimate of $231/ton as the net benefit of recycling. In this Appendix, we reconsider the key variables influencing the net benefit of recycling and allow them to assume a range of possible values. Table A-1 presents the net benefits of recycling under these alternative assumptions. Table A-2 presents the change in the net benefits of recycling, relative to the baseline value of $231/ton, under these alternative assumptions. In all cases, only one variable is changed at a time.[1]

The choice of the range of plausible values we allowed a variable to assume was based, where possible, on arguments presented in the text or footnotes in Part One.[2] In other cases, we relied on common or logical ranges for a variable.[3] Finally, in the remaining cases, where the possible range of values for a variable was unclear, we halved and doubled the baseline value to obtain the boundary values.[4] The "high" and "low" values for each variable were categorized only on the basis of their effects on the net benefits of recycling relative to the baseline.[5] If an increase in the nominal value of a variable decreased the net benefits of recycling, then the upper range of the variable was reported as the "low" value, meaning it resulted in the lowest net benefits of recycling. Conversely, if a decrease in the nominal value of a variable increased the net benefits of recycling, then the lower range of the variable was reported as the "high" value.

An examination of the last two columns of Table A-1 and Table A-2 indicates how robust the $231/ton estimate of the net benefit of recycling is with regard to almost all of the variables in question. With only a couple of exceptions, substituting the high and low values of a variable in place of the baseline value still results in a net benefit of recycling

[1]The only exception is when a set of variables totals to a fixed value. For example, the composition of packaging materials must total to 100 percent. In such situations, the set of variables is grouped together in Tables A-1 and A-2.

[2]For example, the rationale for having the percentage efficiency of incinerators range from 85% to 95% is provided in a footnote to the text discussion concerning incinerator efficiency.

[3]For example, this was the basis for allowing the real interest rate to vary from 3 percent to 9 percent.

[4]For example, taking the baseline cost of $4/ton for material separation equipment, we halved the cost to $2/ton and doubled the cost to $8/ton to obtain the range of values.

[5]The reason for categorizing the high and low ranges on this basis was to prevent the effects of changes in multiple variables, ostensibly in one direction, from cancelling themselves out.

between $200 and $265. The only variables that the net benefit of recycling is really sensitive to are the degree of hazard of the incinerator and the threshold distance (in miles from the incinerator) at which households would be indifferent to being further away from the incinerator. Even for these variables, the lower bounds for the net benefits of recycling are $182 and $146, respectively.

Finally, we estimated the net benefit of recycling when all the variables were assigned their high value and then their low value. Although these results are clearly unrealistic (the net benefit in the former case exceeding $1000/ton), the net benefit of recycling is still positive ($10/ton) when all of the variables are assigned their lowest plausible value.[6]

[6] In this latter case, the total revenue from recycling is estimated to be $19/ton; the avoided subsidy to virgin materials, $1/ton; the additional cost of recycling, $48/ton; the avoided cost of incineration, $10/ton (including $7/ton incinerated for environmental risk and disamenities); and the avoided cost of landfilling, $28/ton (including $10/ton landfilled for environmental risk and disamenities).

TABLE A-1
NET BENEFITS OF RECYCLING
UNDER ALTERNATIVE ASSUMPTIONS

Variable	Value			Net Benefit of Recycling	
	Baseline	High	Low	High	Low
Composition of Materials				$252	$225
Paper	53%	50%	65%		
Glass	23%	25%	19%		
Plastics	10%	11%	8%		
Steel	13.5%	11%	7.5%		
Aluminum	.5%	3%	.5%		
Price/Ton of Materials				$255	$213
Paper	$ 15	$ 30	$ 0		
Glass	$ 30	$ 45	$ 15		
Plastics	$ 180	$ 360	$ 90		
Steel	$ 75	$ 100	$ 50		
Aluminum	$1170	$1340	$1000		
% Subsidy to Virgin Materials	2%	3%	1%	$232	$229
Price/Ton for Virgin Materials	$150	$200	$100	$232	$230
Real Interest Rate	6%	9%	3%	$239	$226
Cost/Ton for Collection Equipment	$7	$3	$14	$234	$224
Cost/Ton for Separation Equipment	$4	$2	$8	$234	$224
Operating Costs/Ton-Material Separation	$8	$4	$16	$234	$224
Share of Recyclables Requiring Additional Collection and Separation	80%	70%	90%	$235	$226
Relative Share of Incin. to Landfill				$235	$223
Incineration	70%	75%	60%		
Landfill	30%	25%	40%		
Percentage Efficiency of Incinerators	90%	85%	95%	$238	$224
Federal Tax Subsidy to Incinerators	$10	$20	$5	$238	$227
Cost/Ton of Incin. Pollution Control (Remedial)	$6	$8	$4	$233	$228
Operating Costs/Ton-Incineration	$24	$30	$18	$235	$227
KWh/Ton of Electricity-Incineration	536	466	606	$233	$229

TABLE A-1
(Continued)

Variable	Value			Net Benefit of Recycling	
	Baseline	High	Low	High	Low
Price Per kWh of Electricity	$.04	$.02	$.08	$238	$216
% of Incin. Waste Left as Ash Residue	25%	35%	10%	$243	$212
Capital Cost/Ton for Ash Transport	$7	$14	$3	$232	$230
Operating Costs/Ton-Ash Transport	$10	$15	$5	$232	$230
Benefit/Mile/Household/Year Distance from Hazardous Waste Facility	$412	$495	$330	$258	$204
Degree of Hazard of Incinerator	50%	100%	25%	$328	$182
Threshold Distance (Miles) from Incin. Where Consumer Surplus Ends	10	15	5	$462	$146
Capital Costs/Ton for Landfill	$25	$35	$15	$237	$224
Operating Cost/Ton-Landfill	$35	$40	$30	$234	$228
Postclosure Costs/Ton as % of Landfill Cap. & Oper. Costs	15%	20%	10%	$232	$230
Clean-up Costs/Ton as % of Other Landfill Market Costs	10%	25%	5%	$234	$230
Landfill Costs/Ton from Stricter Regs. as % of Other Landfill Market Costs	23%	30%	20%	$233	$230
Degree of Hazard of M.S.W. Landfill	25%	33%	10%	$242	$209
Threshold Distance (Miles) from Landfill Where Consumer Surplus Ends	4	5	3	$265	$210

TABLE A-2
CHANGE RELATIVE TO THE BASELINE
OF THE NET BENEFITS OF RECYCLING
UNDER ALTERNATIVE ASSUMPTIONS

Variable	Value			Change From Baseline	
	Baseline	High	Low	High	Low
Composition of Materials				+ $21	- $6
Paper	53%	50%	65%		
Glass	23%	25%	19%		
Plastics	10%	11%	8%		
Steel	13.5%	11%	7.5%		
Aluminum	.5%	3%	.5%		
Price/Ton of Materials				+ $24	- $18
Paper	$ 15	$ 30	$ 0		
Glass	$ 30	$ 45	$ 15		
Plastics	$ 180	$ 360	$ 90		
Steel	$ 75	$ 100	$ 50		
Aluminum	$1170	$1340	$1000		
% Subsidy to Virgin Materials	2%	3%	1%	+ $1	- $2
Price/Ton for Virgin Materials	$150	$200	$100	+ $1	- $1
Real Interest Rate	6%	9%	3%	+ $8	- $5
Cost/Ton for Collection Equipment	$7	$3	$14	+ $3	- $7
Cost/Ton for Separation Equipment	$4	$2	$8	+ $3	- $7
Operating Costs/Ton-Material Separation	$8	$4	$16	+ $3	- $7
Share of Recyclables Requiring Additional Collection and Separation	80%	70%	90%	+ $4	- $5
Relative Share of Incin. to Landfill				+ $4	- $8
Incineration	70%	75%	60%		
Landfill	30%	25%	40%		
Percentage Efficiency of Incinerators	90%	85%	95%	+ $7	- $7
Federal Tax Subsidy to Incinerators	$10	$20	$5	+ $7	- $4
Cost/Ton of Incin. Pollution Control (Remedial)	$6	$8	$4	+ $2	- $3
Operating Costs/Ton-Incineration	$24	$30	$18	+ $4	- $4
KWh/Ton of Electricity-Incineration	536	466	606	+ $2	- $2

TABLE A-2

(Continued)

Variable	Value			Net Benefit of Recycling	
	Baseline	High	Low	High	Low
Price Per kWh of Electricity	$.04	$.02	$.08	+ $7	- $15
% of Incin. Waste Left as Ash Residue	25%	35%	10%	+ $12	- $19
Capital Cost/Ton for Ash Transport	$7	$14	$3	+ $1	- $1
Operating Costs/Ton-Ash Transport	$10	$15	$5	+ $1	- $1
Benefit/Mile/Household/Year Distance for Hazardous Waste Facility	$412	$495	$330	+ $27	- $27
Degree of Hazard of Incinerator	50%	100%	25%	+ $97	- $49
Threshold Distance (Miles) from Incin. Where Consumer Surplus Ends	10	15	5	+ $231	- $85
Capital Costs/Ton for Landfill	$25	$35	$15	+ $6	- $7
Operating Cost/Ton-Landfill	$35	$40	$30	+ $3	- $3
Postclosure Costs/Ton as % of Landfill Cap. & Oper. Costs	15%	20%	10%	+ $1	- $1
Clean-up Costs/Ton as % of Other Landfill Market Costs	10%	25%	5%	+ $3	- $1
Landfill Costs/Ton from Stricter Regs. as % of Other Landfill Market Costs	23%	30%	20%	+ $2	- $1
Degree of Hazard of M.S.W. Landfill	25%	33%	10%	+ $11	- $22
Threshold Distance (Miles) from Landfill Where Consumer Surplus Ends	4	5	3	+ $34	- $21

REFERENCES

Allan, Theresa, Brenda Platt, and David Morris. April 1989. *Beyond 25 Percent: Materials Recovery Comes of Age*, Washington D.C.: The Institute for Local Self-Reliance.

Allen, T., J. Utterback, M. Sirbu, N. A. Ashford, and J. H. Holloman. April 1978. "Government Influence on the Process of Innovation in Europe and Japan," *Research Policy*, 7, pages 41-47.

Aluminum Association. 1989. "Aluminum Recycling: Your Next Assignment," Washington, D.C.: The Aluminum Association.

Aluminum Association. 1990. "Aluminum Can Recycling Hits Record High," Press Release, Washington, D.C.: The Aluminum Association.

American Paper Institute. 1990. *Paper Recycling: The View to 1995 Summary Report*. New York: American Paper Institute.

Anderson, Robert C. September 1978. "Evaluation of Economic Benefits of Resource Conservation," U. S. Environmental Protection Agency Report EPA-60015-78-015.

Apotheker, Steve. March 1990. "Recycle Steel Cans: Can Do," *Resource Recycling*, pages 22-24, 79.

Armerding, Taylor. March 4, 1990. "Recycling Revisited," *North Shore Sunday Newspaper*.

Ashford, Nicholas A., Christine Ayers, and Robert F. Stone. 1985. "Using Regulation to Change the Market for Innovation," *Harvard Environmental Law Review*, *9*, pages 419-465.

Ashford, Nicholas A. and Charles C. Caldart. 1991. *Technology, Law, and the Working Environment*. New York: Van Nostrand Reinhold.

Ashford, Nicholas A. and Robert F. Stone. 1991 (forthcoming). "Liability, Innovation, and Safety in the Chemical Industry," in Peter Huber and Robert Litan (eds.), *Corporate Cold Feet: The Impact of Liability Law on Safety and Innovation*, Washington D.C.: The Brookings Institution.

Ballard, Kenneth P., Norman J. Glickman, and Richard D. Gustely. 1980. "A Bottom-Up Approach to Multiregional Modeling: NRIES," in F. Gerard Adams and Norman J. Glickman (eds.), *Modeling the Multiregional Economic System*, Lexington, Massachusetts: Lexington Books.

Barry, Patrick. December 1989. "No Time to Waste," *The Neighborhood Works*.

Baumol, William J., and Wallace E. Oates. 1975. *The Theory of Environmental Policy*. Englewood Cliffs, New Jersey: Prentice-Hall.

Boston Herald. March 13, 1990. "AT&T Consumer Packaging Material Now Biodegradable."

Breen, Bill. November/December 1990. "Selling It!: The Making of Markets for Recyclables," *Garbage*, pages 44-49.

Brewer, Gretchen. 1989. "Plastics Recycling Action Plan for Massachusetts," *Journal of Environmental Systems, 18:3*, pages 213-264.

Brookshire, David S., Mark A. Thayer, William D. Schulze, and Ralph C. d'Arge. March 1982. "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches," *American Economic Review*, 72:1, pages 165-177.

Caldart, Charles C. and C. William Ryan. 1985. "Waste Generation Reduction: A First Step Toward Developing a Regulatory Policy to Encourage Hazardous Substance Management Through Production Process Change," *Hazardous Waste & Hazardous Materials*, 2:3, pages 309-331.

Commonwealth of Massachusetts, Department of Environmental Protection, Division of Solid Waste Management. September 1989. *The Massachusetts Solid Waste Master Plan: "Toward a System of Integrated Solid Waste Management,"* (Second Draft).

Commonwealth of Massachusetts, Department of Environmental Protection. June 1990. *Toward a System of Integrated Solid Waste Management: The Commonwealth Master Plan.*

Commonwealth of Massachusetts, Department of Environmental Quality Engineering. December 1985. *Dioxin: An Assessment of Sources and Health Effects in the Commonwealth of Massachusetts.*

Cummings, R. G., D. S. Brookshire, and W. D. Schulze. 1986. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method*, Towata, New Jersey: Rowman & Allanheld.

Denison, Richard A. and John Ruston. 1990. *Recycling & Incineration: Evaluating the Choices.* Washington, D.C.: Island Press.

Dertouzos, Michael L., Richard K. Lester, and Robert M. Solow. 1990. *Made in America: Regaining the Productive Edge.* New York: HarperPerennial.

Duesenberry, James S., Gary Fromm, Lawrence R. Klein, and Edwin Kuh. 1969. *The Brookings Model: Some Further Results.* Chicago: Rand McNally & Company.

Environmental Defense Fund. 1988. *Developing Markets for Recycled Materials.* Washington, D.C.

Environmental Law Institute. 1976. *Impact of the Federal Tax Code on Resource Recovery.* Washington, D.C.

Franklin Associates, Ltd. 1988a. *Characteristics of Municipal Solid Waste in the United States, 1960 to 2000 (Update 1988),* report prepared for the U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Prairie Village, Kansas.

Franklin Associates, Ltd. 1988b. "Economic Incentives and Disincentives for Recycling of Municipal Solid Waste," contract prepared for U.S. Congress, Office of Technology Assessment, Prairie Village, Kansas.

Friedlaender, Ann F., George Treyz, and Richard Tresch. 1975. "A Quarterly Econometric Model of Massachusetts and Its Fiscal Structure," study undertaken under the joint sponsorship of the Massachusetts Senate Ways and Means Committee and the Executive Office of Administration and Finance.

Getz, Norman. February 1990. "One Family's Air Pollution," *Solid Waste and Power*, pages 24-26.

Gibboney, D. April 1990. "Closing the Loop with Glass Recycling," *Bio Cycle*.

Glebs, Robert T. 1988. "Subtitle D: How Will It Affect Landfills," *Waste Alternatives*, pages 56-64.

Glenn, Jim. January 1990. "New Look in Materials Processing," *BioCycle*, pages 28-30.

Hazlitt, Henry. 1962. *Economics in One Lesson*. New York: MacFadden.

Heilbrun, James. 1981. *Urban Economics and Public Policy*. New York: St. Martin's Press.

Kovacs, William L. 1988. "The Coming Era of Conservation and Industrial Utilization of Recyclable Materials," *Ecology Law Quarterly*, 15:4, pages 537-625.

Kunreuther, Howard and Douglas Easterling. May 1990. "Are Risk-Benefit Tradeoffs Possible in Siting Hazardous Facilities?" *American Economic Association Papers and Proceedings*, 80:2, pages 252-256.

Kunreuther, Howard, Douglas Easterling, William Desvousges, and Paul Slovic. December 1990. "Public Attitude Toward Siting a High-Level Nuclear Waste Repository in Nevada," *Risk Analysis*, *10:4*, pages 469-484.

Kunreuther, Howard and Paul R. Kleindorfer. May 1986. "A Sealed-Bid Auction Mechanism for Siting Noxious Facilities," *American Economic Association Papers and Proceedings*, 76:2, pages 295-299.

Kunreuther, Howard, Paul Kleindorfer, Peter J. Knez, and Rudy Yaksick. 1987. "A Compensation Mechanism for Siting Noxious Facilities: Theory and Experimental Design," *Journal of Environmental Economics and Management*, 14, pages 371-383.

LeBlanc, Stephen J. February 1988. *Up In Smoke: Will Massachusetts Gamble on Incineration and Forfeit a Recycling/Composting Future*. Boston: The Massachusetts Public Interest Research Group.

Lifset, Reid and Marian Chertow. Fall 1990. "Changing the Waste Makers: Product Bans and the New Politics of Garbage," *The American Prospect*, pages 83-88.

Martilla and Kiley. August 1989. "A Survey of Massachusetts Voters."

Modern Plastics. 1990. "Waste Solutions," Supplement to the April 1990 issue of *Modern Plastics*.

New York State, Department of Economic Development. August 4, 1989. "Market Status for Paper, Glass, Metals and Plastics."

Nichols, Albert L. 1984. *Targeting Economic Incentives for Environmental Protection*. Cambridge, Massachusetts: MIT Press.

Nielson, W. September 18, 1986. The Effect of Mandatory Recycling Programs on the Paperstock Industry (presented to the Third Annual National Solid Waste Forum in Los Angeles).

Olson, Mancur. 1974. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, Massachusetts: Harvard University Press.

Osborne, David. 1990. *Laboratories of Democracy*. Boston, Massachusetts: Harvard Business School Press.

Osborne, David. January 13, 1991. "Governing in the '90s: How Governor William Weld Intends to 'Reinvent' State Government," *Boston Sunday Globe*, pages 65 and 68.

Packaging Magazine. August 1989. "Packaging: Special Report."

Page, Talbot. 1977. *Conservation and Economic Efficiency: An Approach to Materials Policy*. Baltimore: Johns Hopkins University Press.

Passell, Peter. February 26, 1991. "The Garbage Problem: It May Be Politics, Not Nature," *New York Times*, pages C1 and C6.

Pess, George. 1985. "Thermoplastics in the Postconsumer Waste Stream," Environmental Action Coalition.

Quigley, Jim. March 1988. "Employment Impact of Recycling," *BioCycle*, pages 44-47.

Rathje, William L. December 1989. "Rubbish," *Atlantic Monthly*, pages 99-109.

Rauch Associates, Inc. 1986. *The Rauch Guide to the U.S. Packaging Industry*. Bridgewater, New Jersey: Rauch Associates.

Rauch Associates, Inc. 1987. *The Rauch Guide to the U.S. Plastics Industry*. Bridgewater, New Jersey: Rauch Associates.

Reich, Robert B. 1988. *Tales of a New America*. New York: Random House.

Resource Recycling. March 1990. "AGM Resources Sees a Healthy Future in the Detinning Industry."

Rosen, Sherwin. January/February 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, 82, pages 34-55.

Smith, V. Kerry, and William H. Desvousges. 1986. "The Value of Avoiding a *LULU*: Hazardous Waste Disposal Sites," *Review of Economics and Statistics*, pages 293-299.

Spulber, Daniel F. 1989. *Regulation and Markets*. Cambridge, Massachusetts: MIT Press.

Stauffer, Roberta Forsell. January-February 1989. "Energy Savings from Recycling," *Resource Recycling*, pages 24-60.

Stone, Robert F., Nicholas A. Ashford, and Geoffrey Lomax. February 1991. *The Art of the Possible: The Feasibility of Recycling Standards for Packaging*. Boston: The Massachusetts Public Interest Research Group.

Temple, Barker & Sloane, Inc. 1990. *Initial Analysis of the Impacts of Proposed Initiative Petition 89-39*. Lexington, Massachusetts: TBS.

Tietenberg, Tom. 1988. *Environmental and Natural Resource Economics*. Glenview, Illinois: Scott, Foresman and Company.

Tufts University, Department of Urban and Environmental Policy. 1988. "Packaging Waste."

United States Congress, Office of Technology Assessment. October, 1989. *Facing America's Trash: What Next for Municipal Solid Waste*, OTA-O-424, Washington D.C.: U.S. Government Printing Office.

United States Department of Commerce (Bureau of the Census). 1980. *Statistical Abstract of the United States*. Washington D.C.: U.S. Government Printing Office.

United States Department of Commerce (Bureau of the Census). 1988a. *County Business Patterns, 1986, Massachusetts*. Washington D.C.: U.S. Government Printing Office.

United States Department of Commerce (Bureau of the Census). 1988b. *County Business Patterns, 1986, United States*. Washington D.C.: U.S. Government Printing Office.

Varian, Hal R. 1979. *Microeconomic Analysis*. New York: W. W. Norton and Company.

Wall Street Journal. March 19, 1991. "Plastics Firms to Set Recycling Goal for '95," page C18.

Wirka, Jeanne. 1988. *Wrapped in Plastics: The Environmental Case for Reducing Plastics Packaging*. Washington D.C.: Environmental Action Foundation.