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AN ANALYSIS OF THE POTENTIAL EFFECT OF BEVERAGE CONTAINER DEPOSIT LEGISLATION ON MUNICIPAL RECYCLING PROGRAMS

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ABSTRACT

One argument used both for and against beverage container deposit legislation is its role in benefitting or retarding recycling. Using a computer simulation model for several model communities, this article analyzes the effect of deposit legislation on municipal recycling programs, with net benefit to the community's solid waste management system as the "bottom line." Deposit legislation does reduce the net benefit of recycling programs *per se*, but it is unlikely to cause severe damage to a recycling program with an adequate resource base. The net benefit to the community is substantially higher when both beverage container deposit legislation and active recycling programs are in place. Thus, the two complement each other and should be seen as compatible tools both for maximizing the results of expenditures for municipal solid waste management and for improving litter control.

One of the most confusing arguments in the controversy over the role of beverage container deposit legislation (BCDL, more commonly known as the "bottle bill") is the effect of such legislation on recycling efforts. On one hand, opponents of deposit legislation point to the fact that the bottle bill has reduced the amount of material available for recycling in several voluntary recycling centers around the country and submit that it can undermine recycling programs. On the other hand, proponents of deposit legislation point out that experience in various states demonstrates that it increases the level of recycling, often dramatically. In fact, these two perspectives are not mutually exclusive, and both often apply.

This article explores the effect of deposit legislation on municipal recycling and will attempt to resolve this paradox. It will do so using a computer model

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developed to assist communities in planning recycling programs [1]. It will also consider the role of recycling in municipal solid waste management (MSW) and litter control, which are the two problem areas that deposit legislation is most often designed to address.

THE ROLE OF MUNICIPAL RECYCLING IN SOLID WASTE MANAGEMENT

Municipal recycling as used in this article refers to programs devised by communities with the explicit aim of diverting a significant amount of material from the solid waste stream. Such programs are typically linked with municipal solid waste management systems, and many prominent examples exist. Some are run by the municipality in question; others are run by a private corporation (often the same contractor who picks up other refuse) under license or contract to the city. Municipal recycling in this context is distinguished from private volunteer programs, which are commonly small, designed primarily to make money for the volunteer organization, and are not linked in any way with municipal refuse management. Municipal programs differ from private volunteer programs in that they are larger and can profit greatly from benefits of scale. The "bottom line" of municipal recycling is the recognition by the city that recycling can save money in the municipal budget line for refuse collection and disposal.

This article focuses on municipal recycling because this is likely to be the most productive form in the long run. Recycling in general is labor-intensive. Therefore, small programs may be viable only if they have a large volunteer labor base that enables the program to profit on the sweat equity of the volunteers or if they can use labor paid by other sources, such as public assistance ("workfare") workers, people doing public service work to pay fines for misdemeanors, or university students getting course credit for their experiences. Large-scale programs that are fully self-supporting in the long run require a large population base and the active support and cooperation of the municipal service department.

Recycling from urban refuse was once common, and individuals could make a living doing it. However, as labor costs rose faster than the resource value of the recycled commodities, recycling became increasingly marginal, until it became all but impossible for people to survive on sales of recyclables from municipal refuse. More recently, however, costs of landfill space have been rising even faster than labor rates. Tipping fees at landfills are typically on the order of $10.00 per ton or more in urban areas, and some communities have seen these fees rise by 20 to 50 percent from one year to the next. At the same time, distances from urban areas to landfills have increased as older landfills have closed, escalating the transportation costs of solid waste management. Overall, the prognosis is for sharp increases in these costs over the foreseeable future, since

Table 1. Makeup of Typical Municipal Solid Waste in the United States, 1971-1975

Commodity	*Percentage in MSW*	*Ease of Recycling from MSW*
Paper	34.6 – 43.0	Moderate[a]
Glass	12.0 – 13.3	High
Ferrous Metals	10.2 – 10.8	High
Aluminum	0.8 – 1.0	High
Other Metals	0.4	Low
Plastics	4.2 – 4.6	Low
Rubber and Leather	3.3 – 3.8	Low
Textiles	1.7 – 2.1	Low
Wood	4.5 – 4.9	Low
Food Wastes	20.8 – 22.7	Nil

Source: OTA, 1979.

[a] Newspaper is easily recyclable; other forms of paper are much less so.

suitable landfill sites are limited. Many urban areas in the United States have considerably less than one decade of identified landfill space available for disposing solid wastes, and landfills have become a politically explosive matter in many communities. As a consequence, many communities have either adopted or are considering heat-recovery incinerators with substantially higher tipping fees. These represent a way for communities to become independent of increasingly scarce landfill space, while capping the tipping fee around double its current level.

The main advantage of recycling to a community is that diverting municipal solid wastes from the disposal stream represents a potential savings in refuse management costs, especially since tipping fees are rising even faster than labor costs. However, recycling is a commercial operation, and it requires a solid commercial base. Dealers will pay good money only for things they can use. They will rely on only those sources that can provide significant amounts of recyclable commodities that can meet resale specifications. For the broad range of materials found in municipal solid waste that are easily recyclable (see Table 1), only a city has sufficient infrastructure to carry out a large-scale recycling effort. Recycling seldom, if ever, *makes* money. It can *save* meaningful amounts of money for a city, but sales of recycled materials alone will seldom result in a net profit. Typically, about half of the benefits of recycling come from tipping and hauling fees that do not have to be paid for material that never reaches the landfill. These savings accrue only to the agency operating the refuse disposal

Table 2. Role of Beverage Containers in Typical Urban Refuse

Material	*Approximate Percent of Material in Beverage Containers*	*Percent of MSW in Beverage Containers of this Material*
Glass	46	6.0
Aluminum	50	0.5
Ferrous Metals	12	1.5

program. Any other agency recycling materials from municipal refuse diverts materials from the landfill, but receives no financial support (and typically no recognition of any sort) for having done so.

Beverage container deposit legislation appears, at least at first, to complement municipal efforts to use recycling as a mechanism to divert materials from the disposal stream. The notion of a politically viable mechanism for containing refuse disposal fees without materially altering consumer behavior patterns becomes increasingly attractive as tipping fees increase. This is especially true if beverage container deposit legislation complements recycling programs oriented toward other commodities.

The easily recyclable proportion of municipal refuse is on the order of 25 to 30 percent. Beverage containers account for one-third to one-fifth of this total, or about 8 percent of the total urban refuse load (see Table 2). This is a significant portion, but it is much less than the 25 to 30 percent portion that could be addressed by broader-based municipal recycling programs. If deposit legislation does, in fact, complement municipal recycling efforts, it may represent a cost-effective and politically effective mechanism for saving money from municipal refuse disposal budgets. But if it undermines recycling programs' ability to divert larger amounts of recyclable commodities from the disposal stream, it may actually reduce the benefits of recycling to communities.

RECYCLABLE COMMODITIES IN MUNICIPAL SOLID WASTE

The commodities in municipal solid waste that currently have a sufficiently developed market structure to be regarded as recyclable are those shown in Table 1 as having a high ease of recycling. Of these materials, however, only aluminum is so valuable that recycling is widely feasible for the private sector. Its price is sufficiently high that many scrapyards and satellites in places such as shopping centers and grocery stores buy back used aluminum beverage containers. Some have even installed machines that buy back aluminum cans. Other private agencies, including many private volunteer organizations, receive or buy aluminum from the public and rely on it for a major portion of their cash flow.

Most recycling operations collecting materials other than aluminum take in newspaper. Its unit value is low enough that few private recyclers actively collect it and "skim" the proportion of the MSW available for municipal recycling, but it is high enough that dependable profits can be assured for large-scale programs during most market conditions. Glass and ferrous metals are abundant in municipal refuse, but their value is so low that they are typically break-even items at best, and then only in integrated programs whose economics are justified by aluminum and paper.

The bottom line for a successful municipal recycling program is the total benefit from the recycling operation, based both on sales and on tonnage diverted from the landfill. This reflects both the amount of material recycled as well as its unit value. In general, aluminum recycling removes very little material from the MSW stream, but what is removed is quite profitable. Glass and ferrous metals constitute around 20 to 25 percent of easily recyclable municipal refuse, but their unit value is so low that they contribute only marginally to the cash flow of a recycling operation. Newspaper has traditionally been the basis of municipal recycling programs, due to the fact that it is abundant in municipal wastes and has a fairly high unit value.

THE ROLE OF DEPOSIT LEGISLATION

The "bottle bill," like most legislation, is designed to solve a problem. However, different people view the problem it is supposed to solve in different ways, and there is no clear agreement on just what its function is. Moore and Scott identify several quite different functions [2]. Litter control has traditionally been a major goal of deposit legislation, and was the main argument in favor of the bill in Oregon, the first in the United States [3]. Other functions are to reduce costs associated with solid wastes, to save on the consumption of energy and natural resources, and to create jobs. As shown by several authors, deposit legislation has been largely successful in meeting all of these goals [2, 4, 5]. However, opponents have argued that there are better ways to control litter, that the savings on solid waste management costs, energy, and natural resources are trivial, and that the new jobs created by deposit legislation are unskilled, while it leads to loss of higher-paid skilled jobs.

Several viable ways exist to reduce litter; the bottle bill is clearly one of these [2]. A jurisdiction considering enacting deposit legislation would obviously want to compare the effectiveness of all of the approaches to litter control before enacting any bill. It is also true that the savings in energy and natural resources are small when compared with the total consumption of both in the United States. But if the savings that would be realized by enactment of national beverage container deposit legislation are only 0.24 percent of total national energy consumption [6], this is still equal to about ten large electric power plants of 1000 MW(e) size; this is hardly negligible. Beverage containers account for a substantial proportion of national aluminum production, aluminum is a fairly scarce resource [7], and recycling it is easy and straightforward. It is also true substituting refillable bottles for throwaways as a result of deposit legislation would erode the number of skilled jobs in the glassmaking industry just as it creates many more less skilled jobs in shops and agencies handling bottle returns. However, Rose has pointed out that one of our country's greatest needs is creation of entry-level unskilled jobs [5]; it is far easier to retrain a skilled worker for another skilled job than to train an unskilled worker for a skilled job. There is a tradeoff here, although it is not clear at this point where the balance stands.

This article addresses the question of the effect of deposit legislation on recycling as an integral part of municipal solid waste management. With tipping fees rising and landfill space at an increasing premium, solid waste considerations will probably replace litter control as the primary rationale for deposit legislation. Regardless of its impact on municipal or volunteer recycling programs, beverage containers represent a fraction of the solid waste stream that can be almost completely removed from the waste stream with very little bother to the consumer. The stimulus for the consumer to return deposit containers is a simple economic one with virtually no need for governmental administration [6, 8]. Experience has shown that consumers respond quickly to deposit legislation by raising returns to levels of 80 to 95 percent within a few months of implementation of the legislation, and other members of the community (particularly children) can be found to do the returns for those who do not want or are unable to do so [4].

Deposit legislation is obviously a tremendous boon to recycling in a community that has no recycling program. Almost without pain to the consumer, and with none of the bother of planning or the expenditure of capital that must precede a viable recycling program, the level of consumer recycling rises from 0 percent to almost 8 percent within a few months. But what is the impact of deposit legislation on recycling for communities that have gone through the planning and expense to establish a recycling program? Can a community increase this 8 percent to a larger amount? For them, beverage container deposit legislation may be more of a mixed blessing.

Recycling is not a simple activity (see Figure 1). The aspect that householders are most familiar with is source-separation in the home, in which they segregate one or more recyclable commodities from refuse and either take them to a dropoff or buyback center, or take them to the curb, where they are picked up by the community's municipal solid waste management system. Both the operation of the recycling center and the gearing of a municipal refuse collection system to handle source-separated recyclables are largely unseen by the householder, even though many householders are at least dimly aware of them.

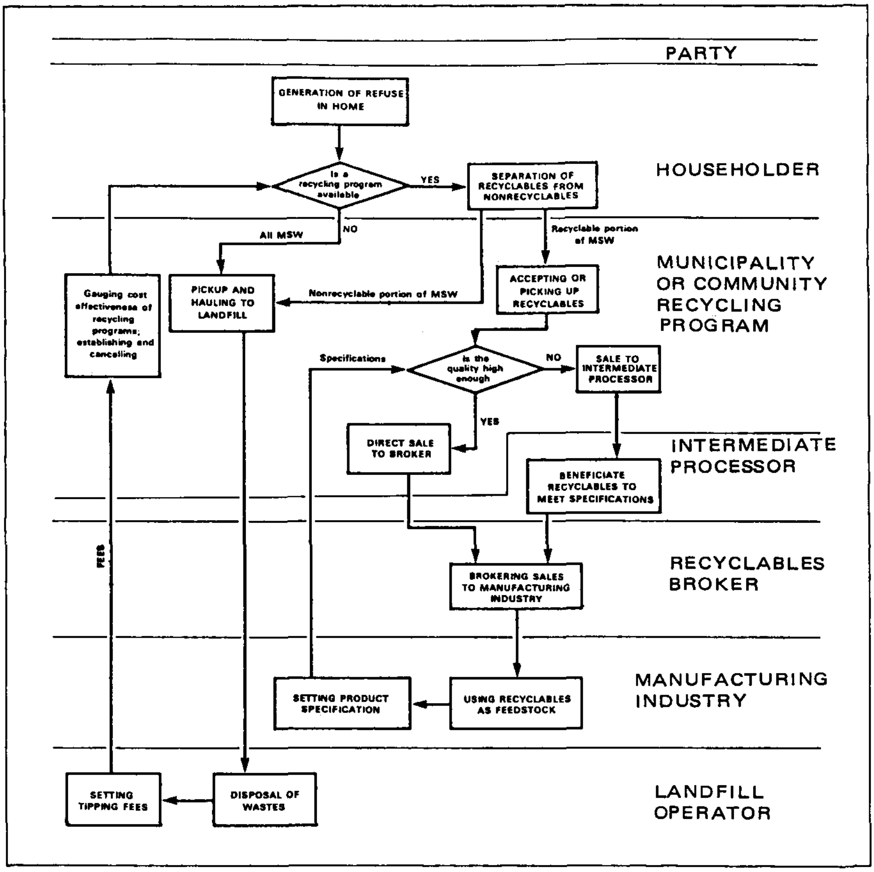

Figure 1. Simplified flow chart showing steps in a community-based recycling program, as well as the parties primarily responsible for each step. "Actions" are shown enclosed in rectangles; "choices" are indicated by diamonds. The parties responsible for performing actions and making choices are indicated on the right side of the diagram.

Few people other than those directly involved are aware of what goes on once recyclables have entered the recycling system. Recycling and buyback centers typically beneficiate their recyclables; that is, they process them to improve their value prior to resale. Metals are separated into aluminum, ferrous, and other metals and then shredded; glass is segregated by color and crushed; paper is baled, etc. Because tonnages handled are relatively small, storage time is seldom a major issue, and the center can invest in maximizing sale value. Municipal pickup programs typically have a very different strategy. They seldom process materials, but rather attempt to move them as quickly as possible. Their strategy is to concentrate on diverting materials from the landfill, maximizing tonnage diversion but minimizing handling and storage costs. Because they are typically operated as an adjunct to the municipal service department, their interest is much less in recycling as such than in refuse disposal.

Some of the most effective recycling systems are hybrids which involve both a curbside pickup program operated by the municipality or its refuse contractor and a recycling center. The recycling center may double as a transfer facility for the recyclables picked up at curbside [9]. An alternative hybrid is a pickup program that also involves beneficiation, whether or not the pickup program is connected with a recycling center. Such hybrids take the best of both approaches and have a dual interest in recycling and in solid waste management.

Ultimately, the materials collected in a recycling program must be sold. Markets must exist, and institutions must be available to clean and beneficiate recyclables that are not sufficiently processed by the recycling program. A class of corporations termed intermediate processors accepts unprocessed or partially processed recyclables from cities or from recycling centers and makes them saleable in the market. Precisely how much processing is required depends on the nature of the market. The consumer does not care whether a particular recycled commodity (e.g., glass) is destined for remanufacture or for use in some other way. But the economics of a particular recycling operation depend very much on the orientation of the market (see, for example, Table 3), and the structure of the market is very different in different places.

In assessing the impact of a bottle bill on recycling programs, one must consider the effect on the entire system, since the long-term viability of a recycling program depends on the stability of all of the supporting parts, including intermediate processing concerns (if appropriate) and markets. Both can be affected by deposit legislation, and it is not always clear whether the effect is positive or negative.

Glass can easily be remelted for remanufacture of beverage containers. However, glass cullet is typically somewhat less than 50 percent of the charge in a glassmaking operation. In principle, the percentage of cullet can be higher than that, and increasing the cullet percentage does lower the melting temperature of the charge and hence saves on energy costs. However, cullet must compete in the marketplace with virgin sand and soda ash, both of which are relatively cheap. The result is that cullet prices are typically maintained at a fairly low level by the value of sand and soda ash, and the amount of cullet that can be consumed in a glassmaking facility manufacturing new beverage containers is significantly less than the amount of glass produced at the facility. As a result, beverage container deposit legislation that leads to a return rate of greater than about 50 percent of throwaway bottles can overwhelm the capacities of glass mills.

It has generally been argued in discussions of deposit legislation that throwaways would quickly give way to refillable bottles. This has been observed

Table 3. Orientations of Markets for Recycled Commodities

Commodities	*Market Orientation*	*Market Reaction to Deposit Legislation*
Glass	Remanufacture	Loss in market for containers; little change in markets for other glass products. Clear glass value would drop slightly; brown and green glass value would drop markedly.
	Materials Conversion: Insulation, fiberglass, lightweight concrete and asphalt	Little change in basic market conditions, except insofar as cullet value decreased by decline in value for remanufacture.
Steel	Remanufacture of Steel	Proportion of steel detinned is so low, and aluminum cans have so replaced steel that further reduction in steel use for beverage containers will make little difference.
Aluminum	Aluminum Remanufacture	Because aluminum scrap value is so high, stable markets are expected indefinitely. Beverage container deposit legislation should not affect scrap value much.
Plastics	Remanufacture	Recycled PET resins are not used for remanufacturing beverage containers. Deposit legislation may make no difference.
	Refabrication into new products (e.g., toys, clothing, structural materials, etc.)	Markets not well developed at this point. Several uses for recycled plastics can be visualized now, but none are widespread. Likely effect of deposit legislation would be positive.
Newspapers	Various uses: Remanufacture of newsprint, wallboard backing, packaging, cellulose insulation	Paper is less sensitive to final use than any other recycled market. Furthermore, recycled paper can be used in so many ways that it can be assumed insensitive to measures such as beverage container deposit legislation.

in some states [10], but it is not universal. Indeed, in parts of Massachusetts, it is difficult to find refillable bottles, yet numerous deposit redemption centers take in millions of aluminum cans. The distinction is significant for discussions of the role of deposit legislation on jobs or the structure of the bottling industry. But it makes very little difference in the bottle bill's impact on solid waste management. For this reason, this article will not concern itself with whether deposit legislation would result in a major increase in the use of refillable bottles. The point, at least for the municipality or municipal trash-hauler, is that the beverage containers do not appear in municipal refuse.

The greatest negative effect deposit legislation can have on recycling is when it results in a major increase in recyclables that overwhelms the existing structure. In New York, one result of deposit legislation has been that glass mills in New Jersey (the major supplier of glass containers to New York) are accepting throwaway containers returned from New York to account for 80 percent of their total cullet needs [11]. Several intermediate processors that had taken glass from New York for sale to mills in New Jersey have found that they are being shut out of the market. Cullet prices have been reduced to very low levels, and several intermediate processing plants have been closed. One intermediate processing concern in Wisconsin has even allegedly been driven out of business by the disruption of the cullet market that followed New York's adoption of the bottle bill [11].

Clean glass separated by color (i.e., clear, green, and brown) is needed for remanufacturing glass containers. However, most consumers who segregate glass for recycle keep it in mixed colors. Recycling centers typically have their customers separate their glass by color on site or accept it mixed and separate it themselves. Municipal pickup programs typically collect mixed-color glass and then sell it at a considerable discount over the separate-color price. Beverage container returns are automatically color-separated. In principle, deposit throwaway bottles represent an inexpensive mechanism for generating almost all of the needs of the glass industry for green and brown cullet. In the process, they undermine the intermediate processing industry, which had been the main vehicle by which mixed-color glass had been separated and then sold to market.

It must be borne in mind that beverage containers can supply only colored cullet, since almost all are either brown or green. Other glass products are clear, and they require clear cullet, which has traditionally commanded a higher market value than colored cullet. Deposit legislation would not encourage recycling of clear cullet. Indeed, its direct result might be to reduce the amount of clear cullet derived from consumers, because of its negative impact on the intermediate processing industry. Even so, industrial sources are now the chief source of clear cullet, and they would continue to be.

Other uses of glass do not require color-separation (Table 3), but the value of the recycled glass is only one-fourth to one-half of the value of glass destined for remanufacture. Thus, deposit legislation can be expected to reduce the need for intermediate processing and the supply for clear cullet, but it should make little difference in either the supply or the market for non-color-separated glass for other markets.

Steel once accounted for all beverage cans, but it has largely been supplanted by aluminum. From the viewpoint of recycling, this is fortunate, since the scrap value of aluminum is so high that it provides an excellent economic incentive to recycle. The economics of aluminum manufacture strongly favor recycling: remelted beer and pop cans are so much cheaper as a source of aluminum than virgin ore that the aluminum industry can only benefit from increased recycling. Nevertheless, steel cans are, in some ways, among the most energy-efficient of containers [6], and they are, in principle, quite recyclable.

However, the proportion detinned for remanufacture is so low, and the scrap value of steel is so low, that beverage cans are at best a break-even item in a recycling operation, and beverage container deposit legislation should make little or no difference in the market for recycling steel cans.

One of the most interesting potential effects of deposit legislation concerns plastic beverage containers. So far, these have become common only for quite large bottles (one quart or over). However, they are so much easier to handle than breakable glass that they are favored by deposit legislation. Already in New York, throwaway 16 ounce plastic bottles are increasing their market share rapidly at the expense of throwaway glass bottles. According to Seldman, not even the plastics industry thought that their gain in market share would be so rapid [11]. But beverage distributors have become major, and influential, nodes on the recycling system. Throwaway plastic is much easier for them to handle than throwaway glass, and their preferences have resulted in a rapid rise in the use of plastic bottles. Unfortunately, from the perspective of recycling, few companies are equipped to recycle post-consumer plastics, and the markets for recycled post-consumer plastics are at best poor, and are nonexistent in most places. Remanufacture of PET (polyethylene terephthalate, the only plastic material used to make whole beverage bottles) bottles is not done from recycled postconsumer bottles.

Thus, the net result of deposit legislation is more complex than is immediately apparent. It leads to dramatic increases in the return rates of beverage containers. Institutionally, the structure of the legislation provides enough benefit to most of those involved that most recycling-oriented actors in the system support it, or at least do not object to it very much. The major disruptive impact has been on intermediate processing concerns that have found their traditional markets usurped by distributors that have a large amount of glass that does not have to be processed since it is already color-separated. Where the bottling industry can increase its production of beverages in refillable containers, market forces will promote this increase. Where the nature of bottling plants militates against increases refillables, the makeup of the throwaway beverage bottle stream is changing to favor plastic and aluminum at the expense of glass.

ANALYSIS USING THE RECYCLING COMPUTER MODEL

To analyze the direct impact of deposit legislation on municipal recycling programs, we shall use a model developed to assist communities in planning recycling programs [1]. This model takes data describing a community's solid waste flow and compares the implications of sixty-four different recycling programs in five fundamentally different categories and suggests up to ten feasible options, two in each of the five categories. As a planning model, it allows users to assess the cash flow and net saving from recycling, the tonnage handled, and the commodity mix that will best benefit their communities.

For this article, the model has been modified to concentrate on two types of recycling programs: standard dropoff-donation recycling centers and municipal pickup. It considers three communities. Community A is a suburb with a greater than average educational level and a population of 50,000. Most of the data are taken from Cleveland Heights, Ohio. Community B is a district in a central city with average education and a population of 100,000. It is based on the Old Brooklyn neighborhood of Cleveland, Ohio. Community C is a suburb with a less than average educational level and a population of 25,000. It is based on East Cleveland, Ohio. Many other types of cities could obviously be analyzed, but these three should provide insight into the range of problems and opportunities facing real communities in the United States.

All three communities are assumed to have the same refuse composition, as summarized in Table 4. This refuse composition was measured at the Ridge Road transfer station in Cleveland, Ohio, and is a good estimate for actual municipal solid waste makeup for an urban area in the Great Lakes area in 1980 [12]. It would be useful to have more precise data for communities of different socioeconomic levels, since some other key variables are known to vary by economic or educational level, but data of this precision is not available. The market value of the recyclable commodities are assumed to be as in Table 5, which are roughly correct for the Cleveland area at this time. Other assumptions made for the model runs are summarized in Table 6. City-specific assumptions are derived from the communities on which the model communities are patterned; other assumptions are justified in the technical documentation of the model [13].

The model is run twice for each community. First comes a baseline run that assumes no bottle bill. Refuse composition is as in Table 4. The model computes net savings to the community from the most feasible recycling systems, based on sales of recyclables, cost savings in solid waste handling and disposal, and costs of labor, machinery, and space. The second run assumes that a bottle bill has been implemented. Forty-one percent of the glass, 11 percent of the ferrous metals, and 45 percent of the aluminum are subtracted from the solid

Table 4. Composition of Refuse Assumed for Model Runs

Commodity	*Percent*
Newspaper	10.4
Glass	7.5
Steel	4.0
Aluminum	0.3

Table 5. Market Values of Recycled Commodities Assumed for Model Runs

Commodity	*Market Value $/ton*
Newspaper	$30.00
Color-Separated Glass	35.00
Mixed-Color Glass	17.50
Steel	12.00
Aluminum	800.00
Mixed Cans (Steel and Aluminum)	15.00
Mixed Containers (Cans and Bottles)	13.00
Mixed Recyclables (Containers and Paper)	10.00

Table 6. Assumptions Made in Model Runs

Community	*A*	*B*	*C*
Residents in Community	50,000	100,000	25,000
Community's Educational Level	Above Average	Average	Below Average
Tons of Refuse Collected Annually	25,000	45,000	12,000
Miles of City Streets	125	275	75
Number of Daily Garbage Truck Routes	7	9	5
Workers on Garbage Truck Crews	1	3	3
Crews Paid by Route or Hour	Route	Hour	Hour
Size of Garbage Trucks Used (Yards)	12	20	16
Hourly Wage of Service Workers	$10.00	$10.00	$9.00
Side-Load or Rear-Load Garbage Trucks	Side	Rear	Rear

Street patterns in all communities are assumed to be suitable for trailers.
Work week for service workers in all communities is 40 hours.
All communities are assumed to have a transfer station.
Pickup cost of refuse per ton in all communities is $70.00.
Hauling cost of refuse per ton in all communities is $20.00.
Tipping fee for refuse per ton in all communities is $10.00.
Storage containers are assumed free for recycling centers in all communities.
Basic processing machinery for centers assumed free in all communities.
Space for recycling centers must be rented in all communities.
Space needs for pickup programs in all communities are assumed to be free.
Space for garaging trucks and trailers is assumed free in all communities.

waste stream. These figures correspond to approximately 90 percent of the proportions of these materials used for beverage containers in the current national mix of solid wastes. This assumes that 90 percent of the beverage containers now discarded will not be discarded, but will rather be returned for deposit. This level of return is based on the experiences of various states with deposit legislation [2]. The model calculates both net savings to the community attributable directly to the recycling operation and also the net savings to solid waste handling that stem from diversion of deposit containers out of the solid waste stream.

Model Runs

The results of the model runs are summarized in Tables 7 through 10. Tables 7 and 9 present results for "no-bottle-bill" runs; Tables 8 and 10 present "bottle-bill" runs. Tables 7 and 8 present runs for dropoff-donation recycling centers; Tables 9 and 10 present results for active municipal curbside pickup. In each case, the configuration shown represents the optimal system for the model community. The summary tables document the calculated materials recycled by this program, proceeds from sales of recycled materials, savings because of hauling costs and tipping fees that do not have to be paid, labor costs, and costs for space and equipment. In addition, Tables 7 through 10 show tonnage diverted from the municipal solid waste stream through beverage containers returned to stores under deposit legislation, as well as the savings to the community from hauling costs and tipping fees that do not have to be paid on these diverted materials. The tables also show the nature of the calculated best recycling option for each community, the total expenses and total income for this option in each community, the net savings from recycling alone, and the total savings from recycling and deposit legislation.

Table 7 emphasizes the tremendous benefits of scale in recycling center operations and the usefulness of a minimum community size for adequate support of a recycling program. Community C, with 25,000 residents, has a net savings about one-eighth that of Community B, even though it contains one-fourth the population. This is due both to the lower educational level (and hence to a lower likelihood of participating in a recycling program) of Community C as well as to the fact that the basic costs of a recycling operation impinge disproportionately on a small program when compared to a larger program. This table, as well as Figures 2 and 3, illustrate the relative contribution of the various recyclable commodities to the operations of the center.

Table 9 makes a similar statement from the perspective of municipal pickup of recyclables at curbside. Here, Community C has a net savings about one-fifth that of Community B. As shown in Figures 4 and 5, the net savings of the communities are much more parallel to the volumes of materials picked up than are the savings in recycling centers. The most likely reason is that the labor

Table 7. Model Run Results:
Dropoff-Donation Recycling Center, No Deposit Legislation

Community	*A*	*B*	*C*
RECYCLING –			
Tonnage Recycled at Center:			
Aluminum	8.4	13.4	2.4
Ferrous	97.5	154.4	28.1
Separated Glass	196.9	311.9	56.7
Newspaper	390.0	617.8	112.3
Miscellaneous	69.3	109.7	20.0
TOTAL TONNAGE	762.1	1,207.2	219.5
Credits to Recycling:			
Sales of Recyclables from Center:			
Aluminum	$ 6,750.00	$10,692.00	$ 1,944.00
Ferrous	1,170.00	1,853.28	336.96
Separated Glass	6,890.63	10,914.75	1,984.50
Newspaper	11,700.00	18,532.80	3,369.60
Miscellaneous	2,651.06	4,199.28	763.51
TOTAL SALES:	$29,161.69	$46,912.11	$ 8,398.57
Refuse Diversion Credits[a]	$28,197.47	$44,664.80	$ 8,120.87
TOTAL CREDITS:	$57,359.16	$90,856.91	$16,519.44
Expenses to Recycling:			
Labor Costs	$16,918.48	$26,798.88	$ 4,872.52
Space and Equipment Costs	8,001.98	12,675.14	5,250.00
TOTAL EXPENSES:	$24,920.46	$39,474.02	$10,122.52
NET SAVINGS FROM RECYCLING:	$32,438.70	$51,382.89	$ 6,396.92
BCDL –			
Tonnage Diverted through BCDL:	0.0	0.0	0.0
Diversion Credits for BCDL:	$ 0.00	$ 0.00	$ 0.00
GROSS SAVINGS FROM RECYCLING + BCDL:	$32,438.70	$51,382.89	$ 6,396.92

Programs:
Community A – Dropoff center open daily, complex multi-material.
Community B – Dropoff center open daily, complex multi-material.
Community C – Dropoff center open weekends, complex multi-material.

[a] Refuse Diversion Credits are the tipping fees and hauling costs not paid on materials diverted from the solid waste stream by recycling.

supply for curbside pickup is already working for the community, in its service department's sanitation crews. It should also be noted that the level of recycling with an active pickup program is typically about three times that of a dropoff-donation program. When it is easy for people to recycle, they will do so.

Figures 2 and 3 and a comparison of Tables 7 and 8 show the effect of beverage container deposit legislation on recycling centers. Tonnage intake of

Table 8. Model Run Results:
Dropoff-Donation Recycling Center, With Deposit Legislation

Community	*A*	*B*	*C*
RECYCLING –			
Tonnage Recycled at Center:			
Aluminum	4.6	7.4	1.3
Ferrous	86.8	137.5	25.0
Separated Glass	116.2	184.0	33.5
Newspaper	390.0	617.8	112.3
Miscellaneous	59.8	94.5	17.2
TOTAL TONNAGE;	657.4	1,041.2	189.3
Credits to Recycling:			
Sales of Recyclables from Center:			
Aluminum	$ 3,712.50	$ 5,880.60	$ 1,069.20
Ferrous	1,041.30	1,649.42	299.89
Separated Glass	2,439.28	3,863.82	702.51
Newspaper	11,700.00	18,532.80	3,369.60
Miscellaneous	1,889.31	2,992.67	544.13
TOTAL SALES:	$20,782.39	$32,919.31	$ 5,985.33
Refuse Diversion Credits[a]	$24,321.18	$38,524.75	$ 7,004.50
TOTAL CREDITS:	$45,103.57	$71,444.06	$12,989.83
Expenses to Recycling:			
Labor Costs	$14,592.71	$23,114.85	$ 4,202.70
Space and Equipment Costs	6,901.96	10,932.70	5,250.00
TOTAL EXPENSES:	$21,494.66	$34,047.55	$ 9,452.70
NET SAVINGS FROM RECYCLING:	$23,608.90	$37,396.51	$ 3,537.13
BCDL –			
Tonnage Diverted through BCDL:	821.3	1,041.2	394.2
Diversion Credits for BCDL:	$30,386.25	$54,695.25	$14,585.40
GROSS SAVINGS FROM RECYCLING + BCDL:	$53,995.15	$92,091.76	$18,122.53

Programs:
Community A – Dropoff center open daily, complex multi-material.
Community B – Dropoff center open daily, complex multi-material.
Community C – Dropoff center open weekends, complex multi-material.

[a] Refuse Diversion Credits are the tipping fees and hauling costs not paid on materials diverted from the solid waste stream by recycling.

recyclable materials drop by approximately 14 percent in all cases, and gross sales drop by almost 30 percent in all cases. Even though costs for labor and space drop approximately proportionately with the tonnage intake, the net savings from recycling with deposit legislation are approximately 25 to 45 percent less than in a recycling program without deposit legislation. The negative impact of deposit legislation on recycling is especially pronounced in the Community C, due to its small size and to its below average educational level.

Table 9. Model Run Results:
Municipal Curbside Pickup Program, No Deposit Legislation

Community	*A*	*B*	*C*
RECYCLING –			
Tonnage Recycled at Center:			
Mixed Containers	1,014.8	1,644.0	389.7
Newspaper	1,118.0	1,811.1	429.3
TOTAL TONNAGE:	2,132.8	3,455.1	819.0
Credits to Recycling:			
Sales of Recyclables from Center:			
Mixed Containers	$ 13,192.40	$ 21,371.70	$ 5,065.88
Newspaper	33,540.00	54,334.80	12,879.36
TOTAL SALES:	$ 46,732.40	$ 75,706.50	$17,945.24
Refuse Diversion Credits[a]	$ 63,984.00	$103,654.10	$24,569.86
TOTAL CREDITS:	$110,716.40	$179,360.60	$42,515.10
Expenses to Recycling:			
Labor Costs	$ 10,429.00	$ 10,429.00	$ 9,386.10
Space and Equipment Costs	600.00	1,800.00	1,000.00
TOTAL EXPENSES:	$ 11,029.00	$ 12,229.00	$10,386.10
NET SAVINGS FROM RECYCLING:	$ 99,687.40	$167,131.60	$32,129.00
BCDL –			
Tonnage Diverted through BCDL:	0.0	0.0	0.0
Diversion Credits for BCDL:	$ 0.00	$ 0.00	$ 0.00
GROSS SAVINGS FROM RECYCLING + BCDL	$ 99,687.40	$167,131.60	$32,129.00

Programs:
Community A – Racks-based pickup of paper, mixed glass and cans.
Community B – Trailer-based pickup of paper, mixed glass and cans.
Community C – Trailer-based pickup of paper, mixed glass and cans.

[a] Refuse Diversion Credits are the tipping fees and hauling costs not paid on materials diverted from the solid waste stream by recycling.

Figures 4 and 5, and a comparison of Tables 9 and 10, show the effect of beverage container deposit legislation on municipal pickup programs. Tonnage intake of recyclable materials drops by approximately 15 to 20 percent, as in the recycling centers, and gross sales drop by 15 to 25 percent. The erosion of sales is not as pronounced for pickup programs as for recycling centers, since the recyclables are sold as much lower-grade commodities that are less sensitive to market changes than color-separated glass cullet intended for remanufacture. Expenses in picking up recyclables are the same with or without deposit legislation, so that net savings from recycling with deposit legislation are approximately 15 to 25 percent less than for a recycling program without deposit legislation.

Table 10. Model Run Results:
Municipal Curbside Pickup Program, With Deposit Legislation

Community	*A*	*B*	*C*
RECYCLING –			
Tonnage Recycled at Center:			
Mixed Cans	0.0	494.8	0.0
Mixed Glass	0.0	587.8	0.0
Mixed Containers	700.9	0.0	269.1
Newspaper	1,118.0	1,726.9	429.3
TOTAL TONNAGE:	1,818.9	2,809.5	698.4
Credits to Recycling:			
Sales of Recyclables from Center:			
Mixed Cans	$ 0.00	$ 4,082.34	$ 0.00
Mixed Glass	0.00	8,743.77	0.00
Mixed Containers	3,644.68	0.00	1,399.56
Newspaper	33,540.00	51,807.60	12,879.36
TOTAL SALES:	$ 37,184.68	$ 64,633.71	$14,278.92
Refuse Diversion Credits[a]	$ 54,567.00	$ 84,286.98	$20,953.73
TOTAL CREDITS:	$ 91,751.68	$148,920.69	$35,232.65
Expenses to Recycling:			
Labor Costs	$ 10,429.00	$ 10,429.00	$ 9,386.10
Space and Equipment Costs	600.00	1,928.57	1,000.00
TOTAL EXPENSES:	$ 11,029.00	$ 12,357.57	$10,386.10
NET SAVINGS FROM RECYCLING:	$ 80,722.68	$136,563.12	$24,846.55
BCDL –			
Tonnage Diverted through BCDL:	821.3	1,478.3	394.2
Diversion Credits for BCDL:	$ 30,386.25	$ 54,695.25	$14,585.40
GROSS SAVINGS FROM RECYCLING + BCDL:	$111,108.93	$191,258.37	$39,431.95

Programs:
Community A – Rack-based pickup of paper, mixed glass and cans.
Community B – Trailer-based pickup of paper, mixed glass, mixed cans.
Community C – Trailer-based pickup of paper, mixed glass and cans.

[a] Refuse Diversion Credits are the tipping fees and hauling costs not paid on materials diverted from the solid waste stream by recycling.

Beverage container deposit legislation has positive, as well as negative, impacts to a community's solid waste management budget. Tables 8 and 10 show the tonnage of materials diverted from the landfill by return of deposit containers. Indeed, Table 8 suggests that more recyclable refuse is diverted from the landfill by deposit legislation than through voluntary recycling centers, especially in smaller communities like Community C. Even in communities with active pickup programs which can recycle far more materials, diversion through deposit legislation accounts for about one-half of the diversion realized by active

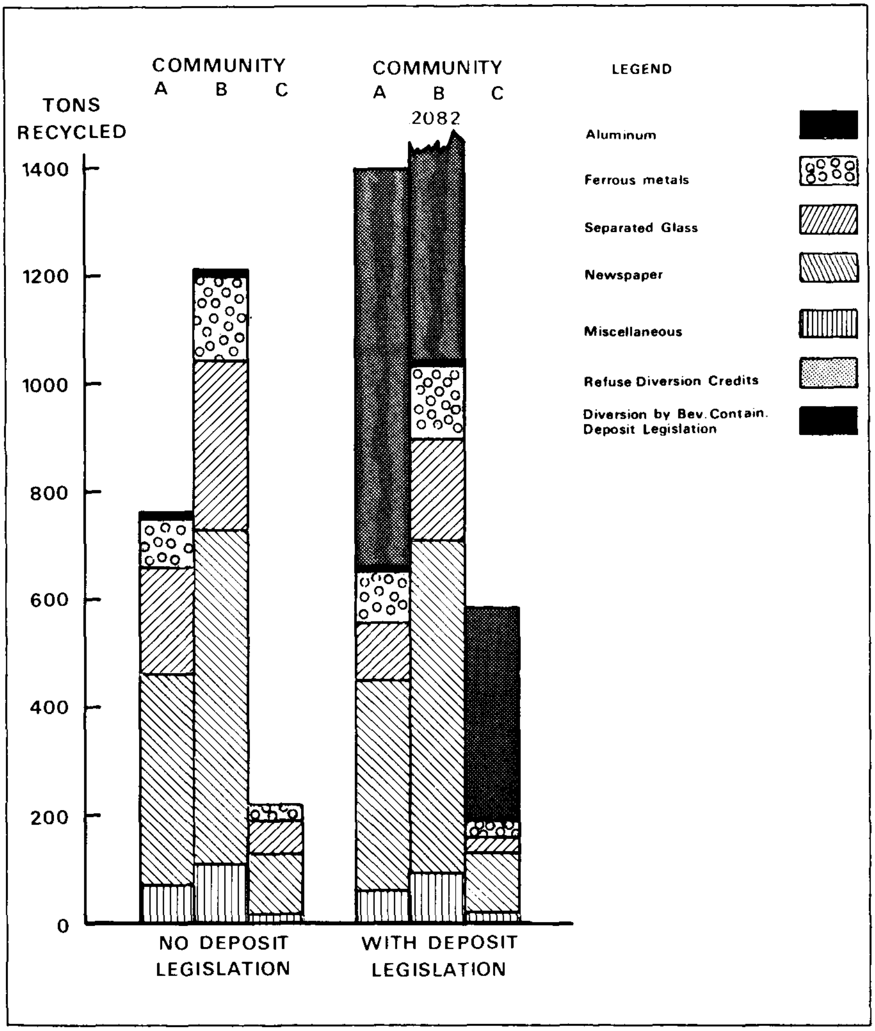

Figure 2. Amounts of different commodities recycled via dropoff-donation recycling centers in the three communities considered in this article with and without beverage container deposit legislation

recycling. Furthermore, diversion via deposit legislation does not increase costs to the municipal tax base, since it is totally between the householder and the retailer. In every case, the overall savings to the community from having both an active recycling program and deposit legislation are greater than either alone, regardless of whether recycling is via a voluntary dropoff-donation center or active municipal pickup. Either by itself can save money to a municipal refuse

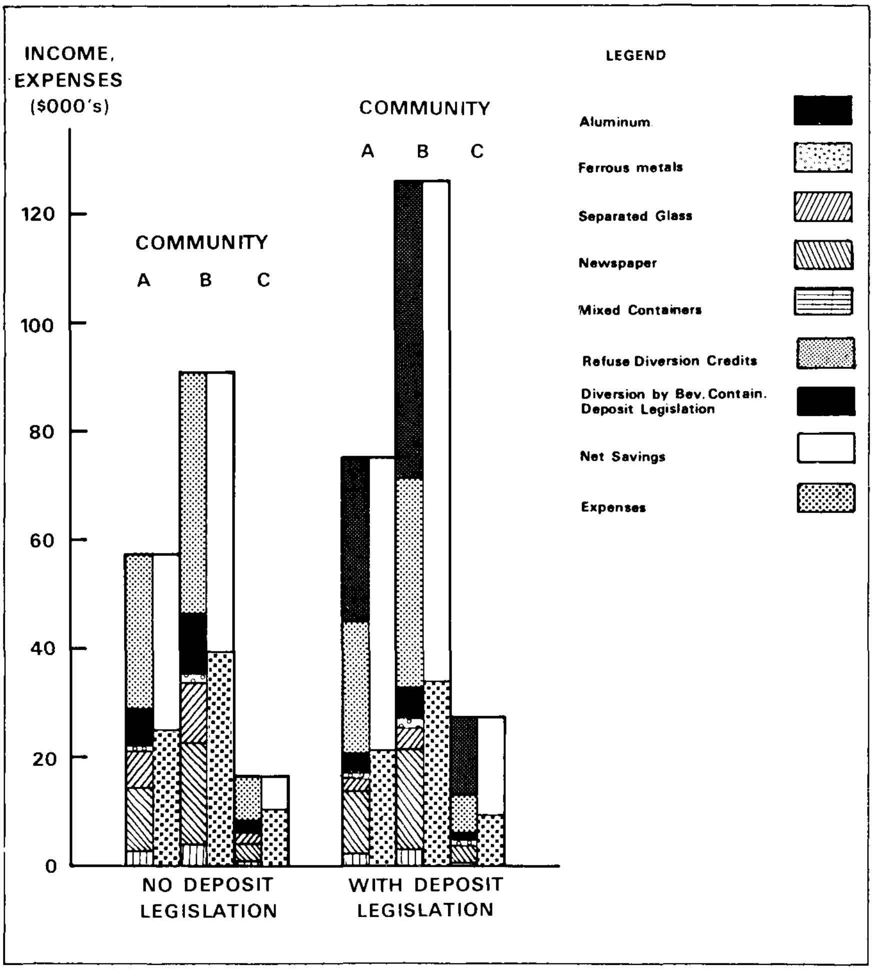

Figure 3. Cash flow data by commodity for dropoff-donation recycling centers in the three communities considered in this article with and without beverage container deposit legislation. The left-hand side of each bar represents income and credits; the right-hand side of each bar represents net cash flow.

management program; both together can save even more money. A summary overview of these calculations is shown in Table 11.

DISCUSSION AND CONCLUSIONS

There are many valid reasons to carry out a recycling program, just as there are many reasons to desire beverage container deposit legislation. The judgement criterion adopted in this article is net savings to a community, considering the

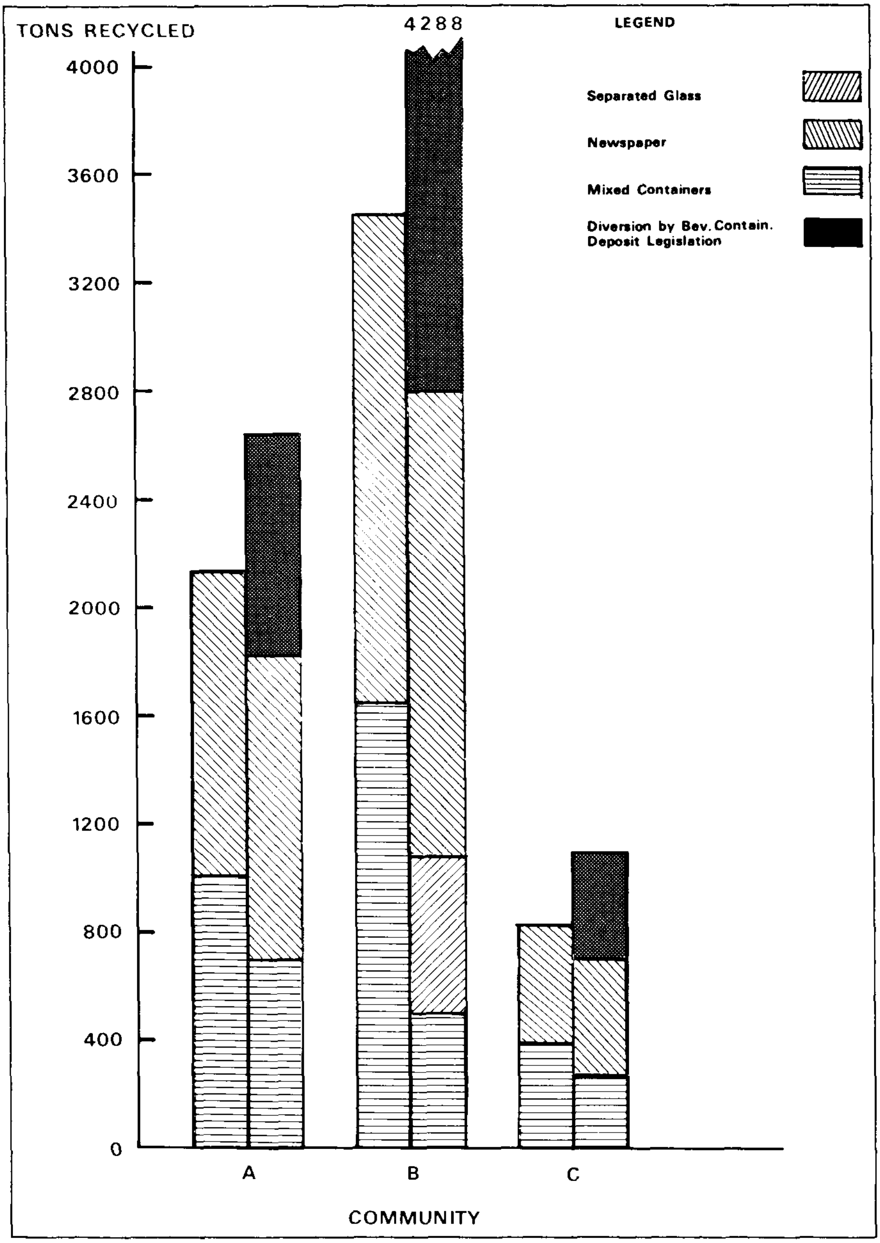

Figure 4. Amounts of different commodities recycled by municipal curbside pickup of recyclables in the three communities considered in this article with and without beverage container deposit legislation. For each community, the left- and right-hand bars represent recycling without and with deposit legislation, respectively.

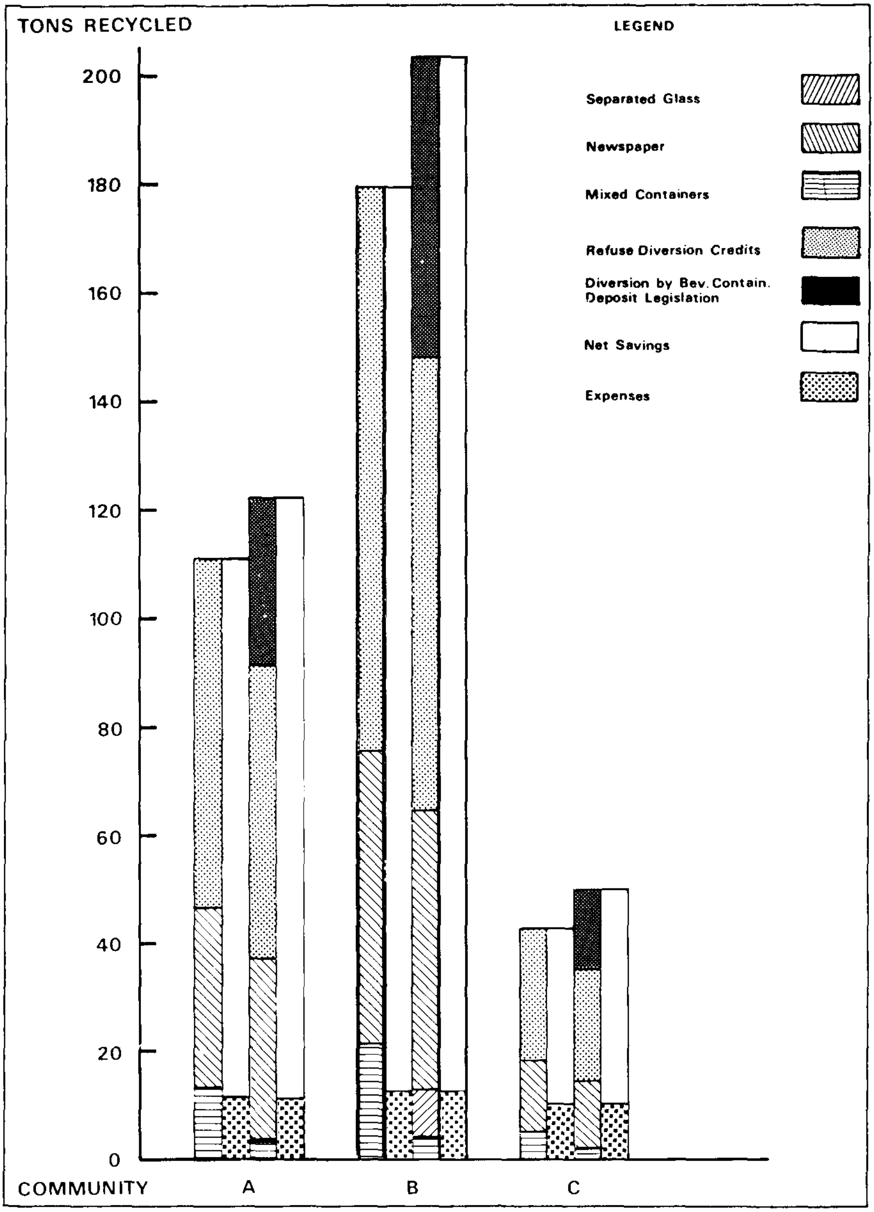

Figure 5. Cash flow data by commodity recycled via municipal curbside pickup in the three communities considered in this article with and without beverage container deposit legislation. For each community, the left and right-hand bars represent recycling without and with deposit legislation, respectively. For each community, the left and right-hand bars represent recycling without and with deposit legislation, respectively.

Table 11. Comparison of Basic Economic Results With and Without Beverage Container Deposit Legislation (BCDL) For Both Types of Recycling Programs: Based on Model Runs Presented in Tables 7 Through 10

	Percent		
Community	*A*	*B*	*C*
Recycling Center			
Net Recycling Savings w/o BCDL	100	100	100
Net Recycling Savings w/ BCDL	73	73	55
Diversion Credits for BCDL	94	106	228
Gross Savings from Recycling + BCDL	166	179	283
Municipal Curbside Pickup Program			
Net Recycling Savings w/o BCDL	100	100	100
Net Recycling Savings w/ BCDL	81	82	77
Diversion Credits for BCDL	30	33	45
Gross Savings from Recycling + BCDL	111	114	123

public benefits that are passed through to the private sector. Other criteria could be used, but this deals with the externalities in the system, and it directly addresses the costs to the taxpayer of carrying out (or not carrying out) a recycling program in a simple and meaningful way.

This article began with the question of whether beverage container deposit legislation would undermine municipal recycling programs. The model runs suggest that deposit legislation will, in fact, reduce income to such a program, sometimes substantially. However, deposit legislation changed the type of program judged by the model to be the "best" recycling option in only one model run (Community B, pickup, where the commodity mix changed from 2-commodity to 3-commodity). In the worst case (Community C, recycling center), the net savings from the "no-bottle-bill" case was probably sufficiently low that the center would likely never have been opened in any case. In all other cases, the net savings from recycling were such that a community willing to consider recycling would probably find the numbers appealing with or without a bottle bill. Perhaps the biggest reason is that, as shown in Figures 2 through 5, the largest single commodity recycled in a community program is not aluminum or other high-value metal. It is newspaper, a commodity that is unaffected by deposit legislation. Indeed, a municipal pickup program based on newspaper is one of the easiest types of recycling programs to initiate and carry out.

The analysis presented in this article suggests also that an inverse relationship exists between the size of a program and its vulnerability to undermining by deposit legislation. This is due both to benefits of scale which affect municipal recycling operations and also to the fact that larger programs are likely to bring in a larger volume of non-beverage container glass and steel which are not affected by deposit legislation. A small voluntary recycling center is negatively affected more than a large recycling center. This is especially true for private volunteer recycling centers, which are more marginal to begin with, and for which a loss of income on the order of 25 percent may be devastating. A recycling center of any size is affected more than a pickup program. The analysis presented here suggests that efficient and flexible municipal programs should be able to survive deposit legislation.

It is significant that about half of the income stream to a recycling program comes from the credits for hauling and tipping fees that do not have to be paid for materials that never pass through the transfer station. These credits can be considered only for programs integrated into the normal refuse handling system. Many recycling programs that have been negatively affected by deposit legislation have either been private volunteer programs that have never received credit for these savings or municipal programs in which only the direct sales were considered as income. Ignoring the savings to a community when hauling costs and tipping fees do not have to be paid is very shortsighted. Failure of a recycling program whose gross sales are approximately equal to or even a bit less than gross costs forces the community to support a more expensive refuse management system: there are no sales of recyclable goods, and hauling costs and tipping fees must be paid on materials that had formerly been recycled.

Deposit legislation has had some profound effects on private for-profit recycling operations. As mentioned earlier, implementation of deposit legislation in New York has been blamed for closing intermediate processing operations in New Jersey and even in Wisconsin [11]. There are other consumer-oriented recycling operations in the private sector that would suffer disproportionately with widespread enactment of beverage container deposit legislation. None are more vulnerable than for-profit recycling of post-consumer aluminum. While the profit margin is currently quite acceptable, deposit legislation would immediately remove about half of the material supply (the most easily recycled portion at that). This would presumably drive the business into extinction. Many scrapyards would doubtless continue to operate, concentrating on industrial and construction sources for aluminum, but the share of post-consumer aluminum would be very much less.

This does not mean that the deposit legislation is anti-recycling or that there is not a place for both. Indeed, for most communities, beverage container deposit legislation can complement recycling efforts. Return rates under the "bottle bill" are typically over 90 percent. Few if any recycling operations of any sort have participation rates approaching this level (indeed, few have

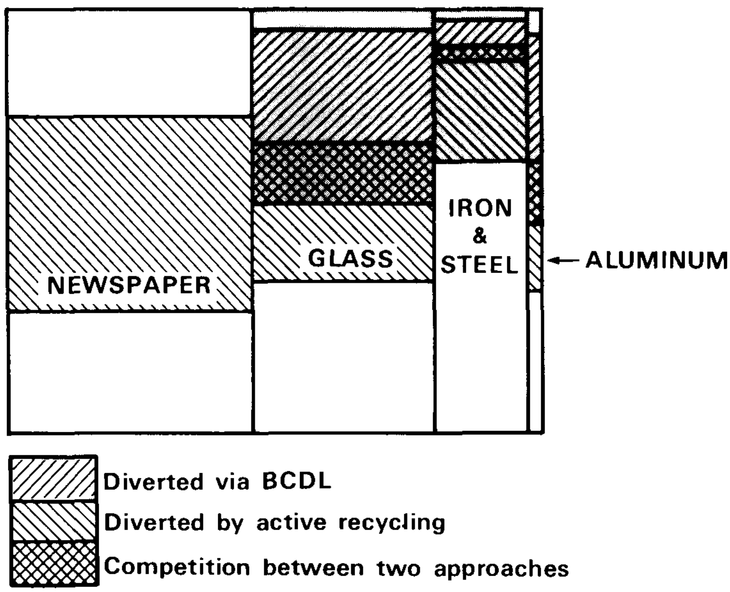

Figure 6. Schematic diagram of solid wastes potentially diverted through active recycling programs and through beverage container deposit legislation. The figure represents the 20 to 25 percent of municipal solid waste that is easily recyclable. The proportion of this comprising beverage cans is indicated by shading. Note the proportion of the overlap between wastes recycled both by active recycling programs and by beverage container deposit legislation. This is the only way in which deposit legislation can be regarded as "parasitic" on recycling programs.

participation rates half this figure!). This means that a substantial number of people participate in container return that do not participate in organized recycling. Likewise, municipal recycling designed to reduce solid waste management expenditures are oriented toward newspaper, a commodity that is not affected by deposit legislation. Aluminum, while valuable, does not constitute a great proportion of the municipal solid waste load, and glass, which constitutes a significant proportion of municipal refuse, is so low in value that it is typically a break-even item.

As shown in Figure 6, the only competition between deposit legislation and municipal recycling for sources of recyclable commodities is for the beer and pop bottles used by those people who are committed to participation in recycling. This is typically much less than half of the total intake of solid wastes recycled by consumers, and it is also less than half of the total proportion of containers returned to deposit redemption centers. It is not even clear (although there is no hard evidence to tell one way or the other) that the educational effects of deposit legislation would not counteract at least some of the losses to a recycling program. Indeed, the observed drop in roadside litter following enactment of deposit legislation in most states suggests strongly that people who return bottles and cans to a redemption center become aware of the problems posed by other solid wastes [2, 6], and that they may become more inclined to participate in a recycling program.

Even if this were not true, Table 11 emphasizes that deposit legislation and municipal recycling complement each other quite well when the goal is to reduce expenditures for refuse management. Both together are able to remove more recyclable wastes from the solid waste stream than either separately. On a public cost-effectiveness basis, deposit legislation is obviously superior, since it requires virtually no expenditures. Moderate to large recycling programs, on the other hand, can require considerable planning and capital investment in order to work, although a large-scale pickup program can recycle considerably more material than a deposit program.

On the other hand, deposit legislation does involve more expenditures by the private sector, although it could be argued that these expenditures simply balance the externalities generated by the production of the containers in the first place. Large-scale municipal recycling has been accused of unfair competition with the private sector, and in fact the National Association of Recycling Industries has sued the litter control offices of several states for establishing recycling centers that were perceived to compete with their members. Of course, this competition is not seen universally, and some communities do (and certainly can) establish good working relationships with private recyclers. The results of this cooperation is that private entrepreneurs concentrate on their traditional industrial base, and cities concentrate on the consumer source. The city gets perceived as another (dependable) industrial source for the recycling industry. This minimizes management costs for the private sector while insuring a larger input of recyclable materials, and it leaves the municipal service department or contractor as the primary conduit for household refuse materials, both recycled and discarded.

In summary, municipal solid waste management can benefit from both active recycling and beverage container deposit legislation. The competition between the two methods of recycling is not as large as the verbiage of many opposed to deposit legislation would indicate, although it is significant. Because of the capital involved, an active recycling program presents more risks to a community than deposit legislation, which is virtually without impact on tax expenditures. This is especially true in small communities and for curbside pickup programs. Indeed, for small communities, unattended voluntary recycling at the public landfill site may be the only form of recycling that is feasible, although beverage container deposit legislation will reduce demand on the dump at no cost to the community. For larger communities, pickup programs become quite attractive, and they may be able to divert several times the quantity of solid wastes diverted by deposit legislation.

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