The Effects of Hazardous Waste Taxes on Generation and Disposal of Chlorinated Solvent Waste

by

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Abstract

In 1989, 30 states levied taxes on the generation or management of hazardous waste. These taxes constitute one of the broadest applications of an emissions tax in U.S. environmental policy and provide a natural experiment for studying the effects of such taxes. This paper examines the impacts on chlorinated solvent waste from metal cleaning, using plant-level data from EPA's 1987–89 Toxic Release Inventories. The results suggest that the taxes have an observable, but small, impact on total generation of solvent wastes. The taxes also reduce the frequency with which land disposal is used relative to incineration or other treatment.

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Taxes on pollutant emissions have recently attracted attention as a means of implementing environmental policy. Economic theory suggests that such "green taxes" can provide substantial benefits over conventional approaches to environmental regulation. There is little direct evidence about the effectiveness of these taxes in producing environmental improvements in practice, however. This paper examines the effects of one of the most significant applications of an emissions tax in U.S. environmental policy to date — state taxes on the generation and management of hazardous waste.

In the 1980s, hazardous waste regulation became a major component of U.S. environmental regulation, with compliance costs that are a significant fraction of the total cost of federal environmental programs (Portney, 1991). Like most of U.S. environmental policy, regulation of industrial hazardous waste has traditionally relied upon technology and performance standards. Recently, however, there have been calls for reform of these policies to rely more heavily on price-based policy mechanisms (Hahn, 1988). A national tax on waste generation and disposal was proposed as a funding mechanism for Superfund for the program's reauthorization in 1986 (CBO, 1985; EPA, 1984).[2] The cross-sectional variation in state taxes provides a natural experiment for assessing the empirical effects of the proposed taxes.

This paper examines the impact of state taxes on one type of waste, spent chlorinated solvents from metal cleaning. These solvents are one of the most common kinds of industrial hazardous waste generated in the United States. Disposal of these solvents may have substantial environmental costs; they are among the most common substances found migrating from Superfund sites and are considered highly toxic (NRC, 1991). EPA's 1987–89 Toxic Release Inventories provide data at the plant level on generation and off-site management of chlorinated solvent wastes.

The results suggest that the taxes have in fact altered the generation and management

[2]In the 1986 Superfund Amendment and Reauthorization Act (SARA), Congress chose not to adopt any of the waste-end tax proposals. Instead, it extended and increased the existing excise taxes on chemical feedstocks, primarily on petrochemicals, and added a corporate income tax as sources of Superfund financing (Mahler, 1992).

of chlorinated solvents. Higher taxes in the generator's state and in neighboring states reduce waste generated by plants. Because of the high costs of managing hazardous wastes, however, the effect of the taxes on total waste generation is small. State taxes also alter the management methods used for solvent wastes. Many states impose higher taxes on land disposal than other kinds of management in an attempt to discourage landfilling. The evidence in this paper suggests that they are successful: the taxes significantly reduce reliance on land disposal for wastes falling outside the federal land disposal restrictions.

The paper begins with a section that discusses the characteristics of state taxes on hazardous waste from 1987 to 1989. It also describes earlier engineering studies of the influence of these taxes on waste generation and management. The next section provides background on the specific group of wastes that is studied in this paper, chlorinated solvent wastes from cleaning and degreasing of metals. The uses and hazards of these chemicals are discussed briefly. This section also describes the data on these wastes in EPA's Toxic Release Inventory (TRI).

Section 3 uses data from TRI to examine the empirical implications of hazardous waste taxes. The estimation exploits the cross-sectional variation in these taxes to look at two aspects of waste generators' behavior: the amount of hazardous waste generated and the choice of waste management method. The effect of state taxes and proposed federal taxes on total chlorinated solvent waste generation and disposal is calculated based upon the estimates. A concluding section briefly discusses the desirability of waste-end taxes.

1 State hazardous waste taxes

Description of the taxes In 1989, 30 states funded at least part of their hazardous waste regulation or Superfund program through taxes on the amount of waste disposed or generated.[3] These taxes are sometimes referred to as "waste-end" taxes to distinguish them

[3]Many states also charge fees for the permits required for generators or waste management facilities; some permit fees have a tiered structure depending on the volume of waste treated in a year. Although these permit fees may alter firms' chosen level of waste generation, they are not discussed here because they will

from taxes on feedstock chemicals like the federal Superfund tax. Table 1 reports the tax rates on land disposal and incineration in 1987 and 1989.

Waste-end tax programs vary widely across states. Some states simply levy a flat fee on all waste that is generated or shipped off-site (for example, Connecticut and New Hampshire). Other state taxes reflect the degree of hazard posed by the type of waste or method that is used to manage it; California has the most dramatic example of this approach with multiple tiers depending upon the kind of waste and disposal method.

State taxes reflect perceived differences in environmental costs principally by charging a higher rate for land disposal than for other types of management practices. In 1989, 5 of the 30 states with waste-end taxes levied them only on land disposal. Another 15 states taxed other management technologies, but at lower rates than their land disposal fees. Although this approach appears to be in the spirit of Pigouvian taxes, there is little consistency in either the relative or absolute costs the taxes establish for different management activities across states.

Also distinguishing these taxes from true Pigouvian taxes, many states differentiate between wastes based upon their state of origin. In 1989, 8 states charged higher rates for wastes that were brought into the state for management than for wastes that were generated in-state.[4] Some states fix the rates for out-of-state wastes, while others require wastes generated out-of-state to pay the maximum of a specified rate or the rate in the state of origin. One state, California, also levies a tax on wastes which are shipped out-of-state for treatment and disposal at a reduced rate from in-state wastes.[5]

only effect marginal costs in rare cases.

[4]In June 1992, the U.S. Supreme Court struck down a $72 per ton surcharge levied by the state of Alabama on out-of-state wastes that landfilled there as a violation of the commerce clause of the Constitution. The ruling will probably force other states to eliminate the disparity between in-state and out-of-state rates.

[5]It does not appear that the variation in hazardous waste taxes can be explained solely by geographic variation in the environmental costs of these activities. One explanation of the variation is that the tax rates depend upon the number of abandoned hazardous wastes sites in that state. A few states explicitly set their tax rates based upon the revenue requirements of their Superfund programs. California is the strongest example; its rates are adjusted each year based on the previous year's revenue. The number of Superfund National Priorities List sites in the state can be used as an indicator of the state's current outlays (because states contribute funds to federal cleanups). However, the correlation coefficient between the number of NPL sites by state in 1989 and the tax rate in 1989 is only .0004. Thus, the geographical distribution of hazardous

Table 1: Tax rates on chlorinated solvent wastes generated in-state ($/ton)

	1987 rates		1989 rates		Higher out-of-state rates?
	Land disposal	Incineration	Land disposal	Incineration	
Alabama	1.00	0	9.00	0	
Arizona	2.00	2.00	2.00	2.00	
California	68.23	0	169.69	0	
Connecticut	15.00	15.00	15.00	15.00	
Delaware	12.00	2.00	12.00	2.00	
Idaho	21.00	1.00	21.00	1.00	
Illinois	2.40	0	14.25	2.40	
Indiana	9.50	9.50	11.50	11.50	yes
Iowa	50.00	10.00	50.00	10.00	
Kansas	4.28	0.86	4.28	0.86	
Kentucky	12.05	1.21	12.05	1.21	
Louisianna	5.00	0	10.00	0	yes
Maine	36.14	14.46	36.14	14.46	yes
Michigan	0	0	10.00	0	
Minnesota	77.11	19.28	77.11	19.28	
Mississippi	10.00	2.00	10.00	2.00	
Missouri	26.00	1.00	26.00	1.00	yes
New Hampshire	36.00	36.00	36.00	36.00	yes
New York	27.00	9.00	27.00	9.00	
Ohio	0	0	4.40	2.20	yes
Oregon	20.00	20.00	20.00	20.00	
Pennsylvania	16.00	9.00	16.00	9.00	
South Carolina	13.00	0	25.00	0	yes
Tennessee	5.00	2.50	5.00	2.50	
Texas	10.00	0	10.00	0	
Utah	3.00	3.00	8.00	8.00	yes
Vermont	112.00	56.00	112.00	56.00	
Wisconsin	0.14	0	0.50	0	

Source: state statutes and regulations.

Effects of waste-end taxes There is limited evidence about the effects of these taxes on hazardous waste generation and management. Only Deyle and Bretschneider (1990) look for an empirical effect of state taxes on generator behavior. Their study relies on weekly data on the weight of waste shipments from generators in the state of New York, based on the manifests required for all hazardous waste shipments. In June 1985, the waste-end taxes increased from $12 to $27 per ton on land disposal and $9 to $16 per ton on treatment, but stayed constant on incineration. In the following year, total wastes treated and disposed in New York declined from a mean above 1,550 metric tons a week to a mean of about 1,400 metric tons. Landfilling also fell dramatically in this year, while both incineration and recycling rose. For chlorinated solvents from degreasing, landfilling in-state by in-state generators declined by 15% and by out-of-state generators by 74%. However, several large policy shifts occurred in addition to the tax change, including the implementation of federal and state land disposal restrictions on free liquid waste disposal. Thus, it is difficult to know how important a role the tax change actually played in the observed declines.

Two engineering studies from the mid-1980s suggest that the state taxes may have had discernible effects on hazardous waste management. The CBO (1985a, 1985b) studied two tax policies that resemble current state taxes. One CBO policy taxes landfilling and underground injection exclusively, while the second taxes destructive treatment and recycling but at lower rates than land disposal. Although the CBO does use its optimistic scenario for total waste generation in these simulations, it has not built any waste generation elasticity into its model; a fixed amount of wastes is allocated among different management practices.

The EPA (1984) also estimated the effects of a national waste-end tax on waste management practices. The EPA tax policies charge for landfilling, underground injection and surface impoundments, but not for treatment and recycling. Table 2 shows EPA's simulations of the long-run implications of these taxes for land disposal; no information is provided

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wastes sites does not seem to explain the cross-sectional variation.

Another explanation is that the variation in these tax rates results from states trying to shift most of the burden of the Superfund programs to out-of-state payers. If the most of the burden falls on generators, states that import a large fraction of the wastes managed there might have higher tax rates. However, the same goal could be accomplished by charging higher rates for out-of-state wastes.

Table 2: Engineering estimates of the effects of waste-end taxes, by management method

	CBO analysis		EPA analysis			
	Policy 1	Policy 2	Policy 1	Policy 2	Policy 3	Policy 4
	Tax rates per ton					
Land disposal – no pretreatment	$22.69	$16.29	$4.54	$19.96	$45.37	$154.26
Land disposal – with pretreatment	$4.54	$16.29	$4.54	$19.96	$45.37	$154.26
Underground injection	$3.63	$4.36	$4.54	$19.96	$45.37	$154.26
Incineration/recycling/ reuse	0	$4.36	0	0	0	0
	Percent change over baseline after 5 years					
Landfill – total	-44.1	-52.9	-6.1	-61.5	-62.5	-63.1
Landfill – no pretreatment	0	+6.8	–	–	–	–
Landfill – with pretreatment	-58.9	-68.4	–	–	–	–
Underground injection	-6.3	-14.7	-24.1	-50.5	-100	-100
Surface impoundment – storage	–	–	-67.3	-87.9	-91.5	-99.8
Surface impoundment – disposal	-9.3	-9.3	-3.4	-4.4	-8.1	-99.2
Incineration	0	-6.7	–	–	–	–
Chemical treatment	+171.9	+33.3	–	–	–	–
Land treatment	-79.1	-85.4	–	–	–	–
Reuse as fuel	+8.9	+1.1	–	–	–	–
Recycling/material recovery	+140.6	+71.0	–	–	–	–
Discharge to sewers or water	+32.4	+94.2	–	–	–	–

Source: Author's calculations based on results in CBO (1985a) and (EPA, 1984).
All estimates distribute a fixed total amount of waste generated among management methods. Further details of the tax systems are as follows:
CBO policy 1: Higher rate applies to land disposal without pretreatment and long-term storage.
CBO policy 2: Higher rate ($16.29) applies to landfills, surface impoundments, waste piles, and land treatment. Lower rate ($4.36) for all other management at RCRA regulated facilities and waste export.
EPA policies: Single rate applies to land disposal, surface impoundment, and underground injection.

about the alternative management methods used for wastes that are no longer land disposed. Like the CBO, the EPA assumes a zero generation elasticity.[6]

The CBO studied a broader universe of wastes than the EPA, including some wastes like waste oils and PCBs that are not regulated under the federal RCRA program. In addition, the CBO's model suggests that more RCRA-regulated waste was generated than the EPA's survey found. Nonetheless, the results of the two studies are similar. For example, the 44% decline in landfill use in aggregate for CBO tax 1 is similar to the 62% decline predicted by the EPA for a tax at a comparable magnitude (tax 2). The studies also yield similar results for the reduction in the use of surface impoundments for disposal.

Both studies suggest that some of the state hazardous waste taxes in place in the late 1980s should have had an effect. A direct application of the results in table 2 would be inappropriate because the simulated taxes apply to all wastes generated, while most states restrict their taxation to off-site management. Different kinds of wastes are managed on-site than off-site, so the elasticities for the wastes affected by the state taxes may be quite different. Nonetheless, by 1987, 10 states' taxes exceeded the level of the second EPA tax in table 2, at which level the EPA predicts a 60% reduction in the use of land disposal. Thus, these studies suggest that state taxes may have a measurable impact on waste management.

However, it is possible that the studies failed to adequately account for the large increase in costs of alternatives to land disposal in the mid-1980s. Table 3 presents price information for various commercial waste management activities for 1987, with comparisons to 1984 when data are available. The costs are based upon EPA surveys of the 14 largest firms in the commercial hazardous waste management industry (ICF, 1988).

The chlorinated solvent wastes studied in this paper fall under high-BTU liquids in table 3. For this category a middle-of-the-range estimate of incineration costs is as high as $670/ton. This value can be compared to U.S. Army data on costs of waste management in fiscal year 1988 (Kim et al, 1991). The army reports an average cost for disposal of the four

[6]In its report, the EPA cites an engineering study of carbon tetrachloride production in which a $10 per ton tax on hazardous waste increased distillation of residues, reducing by 2.5% the total waste generated by these organic chemical producers.

solvents studied here of \$708/ton, consistent with the EPA data. These costs are surprisingly high in comparison to the 1984 costs when the mid-range cost was only \$54 per ton. Earlier, incinerators might even purchase high-BTU liquid wastes from their generators, because these wastes assist in the combustion of other wastes. However, table 3 may exaggerate the cost change if respondents failed to hold the quality of wastes constant across time. Incineration expanded dramatically during this period in response to federal programs to curb land disposal, so the average costs of incineration could have risen without any change in the cost of disposing a given type of waste.

Comparing the tax levels in table 1 to the costs of commercial disposal in table 3, the fees appear to be a small contributor to the total costs of disposing most kinds of hazardous waste in the late 1980s. In 1987, the average in-state tax rate on incineration was \$5, less than 1% of the middle-of-the range incineration costs. A greater effect on land disposal might be expected, where the mean tax rate was \$13, or about 10% of land disposal costs.

2 Chlorinated solvent waste

This paper examines the effect of state hazardous waste taxes on the generation and management of a single group of wastes — spent chlorinated solvent from metal parts cleaning. Four chemicals that make up the bulk of chlorinated solvents used for metal cleaning are studied: trichloroethylene (TCE), 1,1,1-trichloroethane (TCA), tetrachloroethane (PERC), and methylene chloride (METH). The sample is restricted to industries that involve metal parts in an attempt to focus on the use of these solvents for metal degreasing.

These wastes are a major focus of public policy toward hazardous waste. Degreasing was the most common process that generated wastes according to a 1986 EPA survey – 2,181 facilities (17% of the universe) generated some wastes through vapor degreasing and 2,087 through other cleaning and degreasing, the two leading activity categories by number of generators (EPA, 1991a). The contribution of halogenated solvents from degreasing to the total wastes generated by weight was not that large (only about .6%), but this measure is

Table 3: Cost of commercial hazardous waste management in 1984 and 1987

Management technology	Type of waste	Cost range ($ per ton) 1984	1987
Landfill	All	40–150	97–166
Incineration	Clean liquids, high BTU value	(12)–84	320–700
	Liquids, low BTU value		316–802
	Sludges and solids		1281–2031
	Highly toxic liquids	311–1008	560–1191
	PCB liquids		560–1030
	PCB solids		911–1938
Chemical treatment	Aqueous inorganic liquids		62–285
	Inorganic sludges and solids		104–833
Resource recovery	Aqueous organics		95–237
	Nonaqueous organics		90–579
	Oils		47–268
	All	(15)–720	
Deep well injection	Aqueous organics		21–119
	Oil wastewaters	17–67	21–119
	Other (toxic liquids)		36–149
Transportation	All	.14–.20/ton-mile	.23/ton-mile

Values are means of "low-end" and "high-end" estimates provided by surveyed firms. Source: ICF Incorporated, *Survey of Selected Firms in the Commercial Hazardous Waste Management Industry,* various years.

a poor reflection of the importance of these wastes in hazardous waste regulation because mildly toxic, easily treated wastewaters account for the preponderance of hazardous waste by weight.

In terms of the environmental costs, however, chlorinated solvent wastes are important. In 1988, TCE had been found at 42% of NPL sites, PERC at 28% and METH at 19% (NRC, 1991). Migration of these substances had been documented at over half these sites. For example, at the sites where it was found, TCE had contaminated groundwater at 51%, surface water at 16%, air at 11%, soil at 10%, and food at 5%. Exposure to chlorinated solvents can result in central nervous system depression and possibly, with chronic exposure, diseases of the liver or kidney. PERC and METH are also possible human carcinogens according to the International Agency for Research on Cancer. The National Research Council (1991) cites a few epidemiological studies of proximity to sites where solvent wastes have been disposed. The results of these studies are mixed as to whether exposure to the wastes elevated risks of cancer and adverse pregnancy outcomes.

This section includes some general background on the use of these solvents for metal cleaning and the management and regulation of solvent wastes. It then describes the data from EPA's Toxic Release Inventory that is used in section 3 to study the behavior of generators of hazardous wastes.

2.1 Use of chlorinated solvents for metal cleaning

METH, PERC, TCE, and TCA are used for a range of cleaning applications such as metal parts cleaning, electronic equipment defluxing, paint removal and dry cleaning (Wolf and Camm, 1987; Pekelney, 1990a).[7] These four chemicals make up the bulk of demand for chlorinated solvents in such cleaning uses. The principal use of these solvents in the industries studied here is fabricated metal parts cleaning and degreasing.[8]

[7]They are used less frequently in non-cleaning applications, for example, foam blowing, caffeine extraction from coffee, and production of photographic film.

[8]Smaller amounts of TCA are used for electronic circuit-board defluxing and of METH for paint stripping. Further, METH may be used in a non-solvent application in the manufacture or photographic film, and for

Table 4: Use of chlorinated solvents (in tons) in 1989 by industry (SICs 33–38)

Industry	SIC	Number of plants	Mean waste generated	Mean maximum amount on-site
Primary metals	33	455	1.91	107.34
Fabricated metal products	34	1200	2.41	76.65
Industrial machinery	35	563	2.42	20.98
Electronic/electrical equipment	36	894	2.50	19.84
Transportation equipment	37	777	2.99	267.84
Measuring/photographic instruments	38	204	3.38	17.69
Total		4093	2.53	93.80

Plants may use chlorinated solvents for metal cleaning with two different techniques. Cold cleaning uses the solvents in liquid form at about room temperature in order to remove contaminants including drawing compounds, cutting and grinding fluids, polishing and buffing compounds, and miscellaneous contaminants like metal chips. The solvent may be applied by spraying the object or immersing it in a bath. The second metal cleaning technique is vapor degreasing, where heated solvent condenses on the object. Vapor degreasing is more efficient than cold cleaning, because of the purity of the solvent when it condenses and the advantage of cleaning at a higher temperature. However, it requires more elaborate cleaning tanks in which to heat the solvent and recapture the vapor.

Table 4 shows the distribution of industries that report using these solvents in the TRI from the subset of that report one SIC in 33 through 38. Metal fabrication accounts for the largest number of firms chlorinated solvent use, followed by electrical equipment and electronics. Within these industries, however, use of the solvents is fairly diffuse. The most frequently occurring industries were SIC 3471 (Plating, polishing, anodizing, and coloring) and SIC 3714 (Motor vehicle parts and accessories), which accounted for 6% and 5% of the facilities using these chemicals in 1989.

this reason, all observations in SIC 3861 (photographic equipment and supplies) are excluded from the sample in the next section.

2.2 Solvent wastes

Hazardous wastes from cold cleaning may be generated in the form of sludge that accumulates in the bottom of a bath, solvent that becomes too contaminated to use, and still bottoms from distillation of solvents for reuse. Firms have considerable flexibility in the amount of these wastes that they generate (EPA, 1989).[9] First, waste generation may be reduced by process changes that slow the time until the solvent becomes too contaminated to use. For example, solvent lifetimes may be prolonged by changing the way parts are handled previous to cleaning or by running parts through an earlier rinse with less pure solvents. Alternatively, the plant may introduce measures to increase the cleaning efficiency of solvent baths or sprays, for example, by combining them with mechanical agitation.

Because these solvents are generated in relatively moderate quantities by a large a number of plants, virtually all of the waste is managed off-site by commercial facilities.[10] There are several options for chlorinated solvent waste management. Chlorinated solvents have relatively high BTU value and may be incinerated or blended with other materials and reused as fuel in industrial boilers. Spent solvents may also be landfilled, typically in 55-gallon drums to reduce their mobility. In addition, many facilities recycle these solvents, either on or off-site. Data from waste manifests in California indicate that 69% of halogenated solvents shipped off-site in 1987 were recycled (Pekelney, 1990b). After recycling, purified solvents return to cleaning applications.

Public policy towards hazardous waste is almost exclusively directed towards the choice of waste management methods and the operation of management facilities (Dower, 1990).[11]

[9]There are also a number of opportunities to substitute other inputs for chlorinated solvents. Process changes may eliminate the need for cleaning. Alternatively, organic solvents may be replaced with aqueous cleaners or with mechanical cleaning methods. Unfortunately, substitution along these margins is difficult to observe in the TRI because plants are only required to report if they use toxic chemicals.

[10]This reliance on commercial disposal was one reason for choosing to study this group of wastes. Commercial costs are more likely to be uniform across firms than non-commercial alternatives and hence provide a somewhat cleaner experiment. In addition, fewer states tax on-site management.

[11]As Hahn (1991) notes, regulation of hazardous waste differs from regulation of traditional air and water pollutants in that no standards are set for how much hazardous waste may be generated by a plant engaged in specific activities. Instead, the program imposes restrictions on how the waste that is generated may be transported, treated, and disposed.

The Resource Conservation and Recovery Act (RCRA) sets standards for treatment, storage and disposal facilities. Land disposal facilities must install liners and leachate collection systems. Facilities that treat waste are required to accomplish specified levels of treatment; for example, incinerators must destroy 99.99% of each principal organic hazardous constituent and meet emissions requirements. RCRA also requires that facilities carry liability insurance and provide assurances that adequate financial resources will be available for the costs of maintaining the facilities after closure.

The second form of intervention has been to strongly curtail land disposal. In 1985, the RCRA reauthorization legislation created a rapid timetable for the elimination of land disposal of wastes that had not been treated to meet extremely stringent standards (EPA, 1987b). Chlorinated solvents were among the first wastes to be affected by this program: the "land ban" went into effect on November 7, 1986. However, small quantity generators (SQGs) — facilities that generate between 100 and 1000 kilograms of hazardous waste in any month — were granted an extension until November 8, 1988. The same extension was also granted to wastes that contain less that 1% solvent constituents by weight and to underground injection-well disposal. Plants that generate less than 100 kilograms of waste in every month are exempt from these and most other RCRA regulations.

Table 5 shows the waste management practices used by the facilities in TRI sample analyzed in the next section. As the table indicates, some land disposal of these spent chlorinated solvents wastes continued after the land ban. In 1987 and 1988, land disposal was used infrequently, accounting for 4% of the total shipments and 1% of the total wastes. Continued use of landfills appears largely to be the result of the later deadline for SQGs. Plants generating small amounts of waste were much more likely to use land disposal than those generating large amounts.[12] However, some plants that could not have qualified as SQGs still landfilled their waste; in 1987 and 1988, 4.9% and 3.8% of the shipments from these plants were landfilled. These plants may have qualified for an extension because their

[12]TRI does not provide enough information to distinguish SQGs from other plants because it reports the amount of the toxic chemicals rather than the amount of waste. However, it is possible rule out that some plants are SQGs because they generate more than 12000 kg of toxic chemicals per year.

waste was less than 1% solvent by weight or because EPA had granted them a special extension.[13]

Incineration led all other management methods, accounting for 40% of shipments and 25% of the waste over all years. Its relative importance grew over time, but the absolute amount incinerated remained stable. A large but declining number of records indicated only a temporary destination, such as storage or transfer to waste broker, or coded the management method in some ambiguous fashion, particularly "other treatment" or "unknown."[14]

Table 5 shows evidence of a fairly dramatic decline in the amount of spent solvent waste generated over the period 1987–1989.[15] The decline may result from increases in the cost of commercial treatment because of stricter RCRA regulations on management facilities after 1984 and because of increased demand for these services after the land disposal restriction.

2.3 TRI data on chlorinated solvent waste

The data on generation and disposal of chlorinated solvent waste that are used in section 3 are derived from EPA's Toxics Release Inventory (TRI).[16] Congress began TRI as part of a "community right-to-know" program to make information about toxic chemicals available to local organizations. Since 1987, manufacturing plants that use prescribed quantities of any of about 300 chemicals must file reports. The reports include information about the plant's location, owner, and industry. Facilities must also report the amount of the toxic chemical that was released into air, water, and land and the amount of the chemical transferred to

[13]In 1989, after the extensions had expired, the number and amount of waste land disposed declined dramatically, but a small number of plants still reported landfilling the chlorinated solvent wastes. In 1989, 2% of shipments from plants with greater than 1200 kg of waste per year were still land disposed. Use of these chemicals in non-solvent applications may have allowed some wastes to avoid the land ban.

[14]Using the EPA identification number of the management facility, it is possible to find a list of services provided by the receiving facility. An informal examination of this list for "other treatment" suggest that some of these wastes were sent to recycling facilities, while others went to surface impoundments.

[15]The decline from 1987 to 1988 may be somewhat spurious because of confusion over reporting requirements. In particular, although TRI does not require reporting of recycling and reuse, a code for "reuse as fuel" is deceptively provided in the documentation for the TRI forms. Especially at the outset, this code tricked some facilities into reporting these quantities. In the empirical analysis, these observations are treated as zero for consistency with those firms that understood the requirements.

[16]For background on TRI and a summary of recent data, see EPA (1991b) and GAO (1991).

Table 5: Waste management methods used for chlorinated solvent wastes, 1987–1989

	1987				1988				1989			
	Shipments		Waste		Shipments		Waste		Shipments		Waste	
	Num	Pct	Amnt	Pct	Num	Pct	Amnt	Pct	Num	Pct	Amnt	Pct
Incineration	674	25.94	8.735	20.10	1118	44.90	8.891	25.96	1120	51.59	8.640	31.10
Landfill/land treatment	122	4.70	0.943	2.17	124	4.98	0.386	1.13	60	2.76	0.089	0.32
Other disposal	175	6.74	3.656	8.41	143	5.74	9.994	29.18	136	6.26	8.689	31.27
Other treatment	624	24.02	14.676	33.77	486	19.52	7.779	22.71	375	17.27	5.206	18.73
Reuse as fuel	291	11.20	4.243	9.76	70	2.81	0.766	2.24	26	1.20	0.365	1.31
Stabilization	31	1.19	0.079	0.18	22	0.88	0.145	0.42	14	0.64	0.057	0.21
Temporary storage	109	4.20	1.070	2.46	87	3.49	0.911	2.66	66	3.04	0.884	3.18
Transfer to waste broker	204	7.85	2.892	6.66	208	8.35	3.476	10.15	193	8.89	2.487	8.95
Underground injection	7	0.27	0.119	0.27	12	0.48	0.098	0.29	10	0.46	0.166	0.60
Unknown	336	12.93	6.620	15.23	195	7.83	1.701	4.97	149	6.86	1.079	3.88
Wastewater treatment	25	0.96	0.420	0.97	25	1.00	0.106	0.31	22	1.01	0.125	0.45
Total waste management	2598	100.00	43.454	100.00	2490	100.00	34.253	100.00	2171	100.00	27.787	100.00

Quantities in millions of pounds.

publicly-owned treatment works and commercial waste management facilities. When the chemical is transferred off-site, the name and location of the facility receiving the waste is provided, along with a description of the type of treatment or disposal the waste receives.

TRI requests information about the mass of the chemical released or transferred off-site. These quantities differ from the RCRA definition of the quantity of hazardous waste, which includes the amount of contaminated media as well as the toxic chemical. This difference poses a difficulty for the purposes of this paper because it is not possible to segregate large and small quantity generators according the RCRA definitions and thus identify the group for which land disposal was legal in 1987 and 1988. But, the TRI values may have the advantage that they are more closely related to environmental damages than the RCRA quantities and therefore provide a better metric for assessing policies.

The data used in the next section are taken from the 1987, 1988, and 1989 Toxic Release Inventories. The final sample consists of 12059 reports, each report reflecting the amount of a single chemical used by a facility in each year. Only facilities in SICs 33 to 38 were included to focus on cleaning applications for these chemicals. Plants outside the continental U.S. and a few that listed invalid RCRA identification numbers for waste management facilities were excluded. Of these 12059 records, 5388 report positive amounts of waste shipped off-site for disposal, with a few listing multiple off-site destinations (there were 6674 generator-facility pairs). 64% of the facilities reported to TRI in all 3 reporting years.

3 Empirical analysis of waste treatment and disposal

In this section, the geographical variation in hazardous waste taxes is used to study the effects of these taxes on two aspects of waste generators' behavior. The first subsection asks whether the taxes have reduced the total amount of these pollutants generated by the plants in the sample. The second subsection examines the influence of the taxes on the choice of management methods, specifically land disposal.

3.1 Generation equations

Table 6 presents equations that examine the effect of the taxes on the amount of waste each plant generates. Waste generation may be thought of as an input to the production process, whose factor price is the after-tax marginal cost of commercial waste management. Table 6 presents equations of the form:

$$\log(\text{waste}) = \beta_1 + \beta_2 \log(\text{price}) + \beta_3 \log(\text{output}) + \gamma(\text{other char}) + \epsilon. \quad (1)$$

The amount of waste generating depends upon the factor price, the output of the plant, and other characteristics. These other characteristics describe the technology available to the plant (in practice, dummies for the two digit industry) and factors that may influence the plant's perceived costs (in practice, dummies for the kind of chemical and the year).[17] A log-log form is chosen to allow the ratio of waste to output to be a function of price and other variables.

In the first few columns of table 6, the tax rate on incineration is the only source of variation in the cost of waste management. In the spirit of the constant elasticity assumption, the tax variable is the log of the tax rate plus a constant, the average cost of incineration from table 3. Column 1 shows the simplest version of the equation, with the log of waste generated modelled as a function of this cost variable. The coefficient on the tax on incineration is negative, but not significantly different from zero.

Columns 2–4 experiment with various measures of plant output. In column 2, 1987 Census of Manufactures data on value added by plants was matched to TRI facilities by county and industry. When the Census reported data at the detailed SIC level for county, these data were used, otherwise the data were matched at the two-digit SIC level for each

[17]Other state environmental policies may also influence the amount of hazardous waste that plants generate. While strict federal RCRA standards have limited inter-state variations in hazardous waste regulations, other policies are not as consistent. Sigman (1992) examines the proposition that air toxics control influences the generation of chlorinated solvent wastes. The results suggest that these policies are important, but the magnitude of the coefficients on state taxes with these variables included are consistent those found in table 6.

Table 6: Effect of tax rates on quantities of waste generated

	Dependent variable: Log (Waste generated)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(Tax on incineration)	-3.77	-6.26	-5.81	-5.15	-7.42	–	-5.00	-6.40
	(2.79)	(3.18)	(4.57)	(2.89)	(4.08)		(3.24)	(4.13)
Log (Weighted neighbors' incineration tax)	–	–	–	–	-8.98	–	–	-8.58
					(5.13)			(5.29)
Log (Minimum incineration tax)	–	–	–	–	–	-20.4	–	–
						(36.0)		
Log(Tax on landfilling)	–	–	–	–	–	–	-.492	-.361
							(.179)	(.212)
Log (Weighted neighbors' landfill tax)	–	–	–	–	–	–	–	.729
								(.434)
Log (Value added)	–	.009	–	–	-.085	-.031	.013	-.075
		(.063)			(.080)	(.065)	(.062)	(.080)
TCA	.14	.19	.32	.17	.27	.20	.19	.27
	(.09)	(.13)	(.14)	(.09)	(.18)	(.18)	(.13)	(.17)
METH	-.15	.04	.06	-.07	.13	.14	.02	.12
	(.11)	(.13)	(.16)	(.11)	(.21)	(.16)	(.16)	(.21)
TCE	.15	.18	.29	.13	.26	.22	.14	.24
	(.10)	(.14)	(.16)	(.10)	(.19)	(.15)	(.14)	(.19)
1988	-.30	-.28	-.26	-.30	–	-.32	-.27	–
	(.06)	(.08)	(.09)	(.06)		(.08)	(.08)	
1989	-.40	-.46	-.41	-.42	-.17	-.46	-.44	-.17
	(.06)	(.08)	(.10)	(.06)	(.09)	(.09)	(.08)	(.09)
6 workforce size dummy variables	Excl.	Excl.	Incl.	Excl.	Excl.	Excl.	Excl.	Excl.
7 maximum amount on site dummies	Excl.	Excl.	Excl.	Incl.	Excl.	Excl.	Excl.	Excl.
N	5388	2905	2298	5054	1838	2619	2905	1838
R-squared	.016	.017	.031	.062	.011	.016	.020	.015

Heteroskedacity-robust standard errors in parentheses.
6 industry dummies are included in all equations; PERC and 1987 dummies are excluded.

county.[18] The variable is the average value added per facility with 20 or more employees in each SIC-county cell. The resulting value-added variable is very noisy because there may be many plants in a given SIC-county cell. The variable was not very successful in explaining the amount of waste that plants generated; it is never statistically different from zero in table 6 and frequently has a negative sign.

The TRI data were also matched to zip code level data from the 1987 Census of Manufactures in an attempt to find a better measure of plant output. The only information available at the zip code level is size of the plant's work-force; the number of full-time employees is indicated in 7 size classes, for example, 1–19 employees, 20–49 employees, etc. Unfortunately, only 7506 of 12059 TRI records could be matched according to their zip code and 4-digit SIC combination. Of those pairs that matched, however, 72% included only a single firm (or a few plants in one size class), so it is possible to say with some certainty the workforce size of the TRI facility. Column 3 uses only this group of plants, using a dummy for each workforce size class. The estimated coefficients on the workforce-size significantly different from one another but do not much increase the explanatory power of the equation.

As an alternative to these Census data, column 4 uses the one indication that the TRI gives about the amount of the chemical used by the plant: the maximum amount of the chemical on-site during the year. This information is provided in broad size classes that are included as dummies in column 4. There is not much dispersion available (90% of the plants are in the third and fourth size classes) but the coefficients are ranked in the expected manner. However, maximum amount on-site may be endogenous because a plant may respond to high-waste management costs by reducing its use of the chemical.

The remaining four columns of table 6 broaden the cost measures that are used. Interstate shipment of waste is widespread: only 35% of the waste (46% of shipments) was managed in the state it was generated. Thus, the tax rate in the generating state does not give a complete description of the relative tax costs of generating waste in one state versus others. Columns 5

[18]For many facilities, data at even this level of detail was not available, so the sample size decreases between columns 1 and 2.

and 6 look at the impact of neighboring states' incineration tax rates on generation, because neighboring states managed 49% of the waste (32% of shipments) in the sample in 1989.

In column 5, neighboring states tax rates are weighted by total chlorinated solvent waste managed in that state in the previous year.[19] The coefficient on neighbors' tax rate is similar in magnitude to that on in-state rates suggesting that neighbors' rates are highly relevant to generators' decisions, although the standard error on this coefficient is large. In column 6, the tax rate entered is the minimum rate on incineration in the generating state or any of its neighbors that had incineration capacity. This specification yields an unconvincing and statistically insignificant estimate for the responsiveness of generation to taxes.

The final two columns broaden the waste management technologies considered. In most of the equations, the tax on incineration creates all the cost variation because incineration is the most likely ultimate management method.[20] However, columns 7 and 8 add tax rates for land disposal into the equations. Land disposal is only used by a small number of generators, but these tax rates will be the relevant costs for this group; excluding them could bias the coefficients on the incineration tax because the two tax rates are correlated. In column 7, when this tax rate is added, the coefficient on the incineration tax is the same magnitude as before, but not statistically significant. The tax rate on land disposal is smaller in size, but significant. In column 7, the weighted measures of neighbors' tax rates for both incineration and land disposal are included. Although the coefficient estimates for the first three tax rates are consistent with their earlier values, the coefficient on neighbor's landfill taxes is positive.

Results In general, the results in table 6 suggest that waste generation is sensitive to the cost variation caused by taxes. The elasticity of generation to disposal costs appears to be quite high; point estimates range from -3.8 to -7.4. However, it will be shown later that high point estimates do not translate into large effects from the waste-end taxes, because

[19]All 1987 observations were therefore dropped and the sample size reduced.

[20]In most states, the rate for incineration represents the rate for other forms of treatment as well, so this price is accurate for much of the sample.

the taxes are only a small fraction of the total cost of waste disposal.

Other empirical estimates of generation elasticities are not available. However, these results may be compared with elasticities from a simulation study by Wolf and Camm (1987). Wolf and Camm develop a model of demand for solvents that they parameterize with 1984 data and rough guesses of the relevant elasticities. For the four chemicals studied here, they find generation elasticities from the price of incineration that range from −.0026 for METH to −.0079 for TCE. The generation elasticities for the price of land disposal are somewhat higher, ranging from −.049 for METH to −.15 for TCE. Thus, these equations suggests a much larger role for price incentives in lowering the overall generation of hazardous waste.

The equations in table 6 present more mixed evidence about whether neighboring states' tax rates also influence to plants' behavior. The weighted neighbors' tax on incineration variable consistently produces negative coefficient estimates, although they are not estimated very precisely. Neighboring states' land disposal tax rate, however, does not enter with a coefficient of the expected sign. Finally, a persistent feature of these results is a strong trend away from waste generation, perhaps a response to the rapid increase in waste disposal costs in the mid-1980s.

3.2 Waste management equations

One of the goals of waste-end taxes in several states is to shift waste from management methods that are viewed as less desirable, in particular land disposal, to other management methods. This subsection examines how successful they have been.

The dependent variable is the probability that a waste shipment is land disposed. This probability depends upon the cost of land disposal in the state, which varies with the tax rate. It also depends upon the cost of the most likely substitute for land disposal, incineration, again captured by the tax rate. Dummies for the chemical and year are included because these may help determine the relative costs of the two alternatives. The industry of the generator is also included in case the cleaning needs of different industries produce wastes of systematically different characteristics. The results of this model with a probit specification are presented in tables 7 and 8.

Two tables of probit estimates are presented. In table 7, all observations are included because plants of all sizes are observed using land disposal. In table 8, however, the sample is restricted to just shipments that might have qualified for the small quantity generator (SQG) exception: those from plants that generated less than 12000 kg during of TRI chemicals during the year and only shipments in 1987 and 1988. These shipments have a higher rate of land disposal than the sample as a whole. The same equations are estimated for both groups.

The first column in both tables shows the results of the basic equations. The coefficients on the tax rate variables do not have the expected sign in either equation; a high land tax rate should reduce land disposal, while a high tax on its substitute, incineration, should increase it. However, as column 2 shows, this result is driven by the high use of land disposal in California. California has an extremely high land disposal tax ($170 in 1989 – the next highest rates are in Vermont ($112) and Minnesota ($77)). Nonetheless, land disposal is prevalent in California, perhaps because of its abundant landfill capacity. When a dummy for the state of California is added in column 2, not only is it significantly different than zero, but its inclusion also reverses the sign on the tax rate coefficients.

In the next column, landfill and incineration capacity in the state of generation are added as another measure of the relative costs of the two different management methods. The variables are EPA's assessment of commercial capacity available in each state in 1986 (EPA, 1987a).[21] Neither of these variables are statistically significant in tables 7 and 8; the coefficient on landfill capacity does not even enter with the expected sign.

The final two columns of tables 7 and 8 restrict the universe of shipments that is used. The equations in column 4 of both tables use only shipments generated in states with landfill and incineration capacity and disposed in that state (the states are California, Colorado, Illinois, Kentucky, Louisiana, New York, Ohio, South Carolina, Texas). Unlike the remainder of

[21] In some states, these figures may substantially underestimate true capacity because several large facilities withheld their data as confidential business information.

Table 7: Probit estimates: Effect of taxes on choice of land disposal for all shipments

	Dependent variable: 1 if land disposal used				
	All shipments			Capacity available	Only incin/land
	(1)	(2)	(3)	(4)	(5)
Tax on land disposal	.0061	-.0048	-.0046	-.0070	-.0098
	(.0007)	(.0019)	(.0019)	(.0028)	(.0034)
Tax on incineration	.00465	.024	.023	.062	.063
	(.0059)	(.006)	(.007)	(.019)	(.023)
Landfill capacity	–	–	-648	–	–
			(434)		
Incineration capacity	–	–	-2.45	–	–
			(1.58)		
TCA	.08	.11	.11	.16	.07
	(.10)	(.10)	(.10)	(.17)	(.22)
METH	.33	.38	.39	.60	.37
	(.11)	(.11)	(.11)	(.20)	(.25)
TCE	-.05	.04	.03	.46	.50
	(.12)	(.13)	(.12)	(.22)	(.27)
1988	-.04	.03	.07	-.0001	-.19
	(.06)	(.07)	(.06)	(.1239)	(.15)
1989	-.34	-.19	-.14	-.08	-.21
	(.07)	(.08)	(.08)	(.18)	(.20)
Dummy for California	–	1.25	1.13	1.52	2.18
		(.20)	(.20)	(.29)	(.37)
N	6866	6866	6866	1667	757

Standard errors in parentheses.
Observations included: columns 1–3 include all shipments; columns 4 and 5 include only wastes generated in states where both incineration and landfill capacity are available; column 5 includes only wastes land disposed or incinerated.
6 industry dummies are included in all equations.
Dummies for PERC and 1987 are excluded.

Table 8: Probit estimates: Effect of taxes on choice of land disposal for shipments that might qualify for the small quantity generator extension

	Dependent variable: 1 if land disposal used				
	All SQG shipments			Capacity available	Only incin/land
	(1)	(2)	(3)	(4)	(5)
Tax on land disposal	.0091	-.011	-.011	-.016	-.025
	(.0012)	(.005)	(.005)	(.010)	(.012)
Tax on incineration	-.012	.022	.021	.069	.077
	(.009)	(.011)	(.011)	(.035)	(.042)
Landfill capacity	–	–	-977	–	–
			(568)		
Incineration capacity	–	–	-1.59	–	–
			(1.98)		
TCA	-.02	.008	.01	.07	-.15
	(.13)	(.129)	(.13)	(.21)	(.28)
METH	.19	.24	.24	.31	-.02
	(.14)	(.14)	(.15)	(.26)	(.33)
TCE	-.08	-.03	-.03	.46	.39
	(.15)	(.15)	(.16)	(.28)	(.35)
1988	-.03	.08	.07	.08	.04
	(.07)	(.08)	(.08)	(.19)	(.22)
Dummy for California	–	1.73	1.82	2.16	3.17
		(.39)	(.40)	(.78)	(.94)
N	3592	3592	3592	852	396

Standard errors in parentheses.
Observations included: columns 1–3 include shipments in 1987–88 from plants that generated less than 12000 kg of waste in the year; from this group, columns 4 and 5 include only wastes generated in states where both incineration and landfill capacity are available; column 5 includes only wastes land disposed or incinerated.
6 industry dummies included in all equations.
Dummies for PERC and 1987 are excluded.

the observations, there is no ambiguity about which state's tax rates are relevant for this group. In column 5, the observations are further restricted to shipments that were either land disposed or incinerated, in response to concerns about the correct interpretation waste management categories like "other treatment."

Results The results in both tables provide evidence that the tax rates have affected the use of land disposal. Land disposal taxes have the desired effect, reducing the reliance on land disposal. On the other hand, taxes on incineration encourage land disposal. A comparison of tables 7 and 8 suggests that the effect of land disposal taxes may be stronger in plants eligible for the small quantity generator extension of the land ban than for other plants, although the difference is not statistically significant.

3.3 Effects on overall waste generation and disposal

The empirical results suggest that state taxes have altered generators' behavior. More information is necessary, however, to assess how successful these taxes have been in reducing pollution. Table 9 reports the implications of equations from tables 6 and 8 for waste generation in the absence of any taxes and in the presence of the national taxes analyzed by the EPA and CBO.[22] The predictions in table 9 suggest that the taxes had only a very small effect on total generation, reducing generation by only about 5%. [23] This result arises despite high elasticity estimates in table 6 because the taxes represent only a small share of the total cost of waste management.

Table 9 suggests that the waste-end taxes did have a substantial effect on reliance on land disposal. The results are presented only for plants that might have been subject to the

[22]Predicted generation falls substantially below actual generation because the dependent variable is in logs. Although the log of actual generation and log of predicted generation are very similar, when the equations are converted back to levels predictions from observations with positive residuals are much further from the mark than those with negative residuals.

[23]This prediction is based on the equation that includes both land disposal and incineration tax rates (column 7 in table 7) and therefore suggests a greater impact than other equations. When just the tax on incineration (column 1 in table 7) enters the equation, existing taxes reduce generation by only about 2%. In this case, the EPA taxes have no impact because they are levied only on land disposal.

Table 9: Implications of waste-end taxes for waste generation and land disposal in 1988

	Waste generation		Land disposal by small quantity generators		
	Quantity (mill. lbs.)	Percent of 1988 predicted	Percent of shipments	Quantity (mill. lbs.)	Percent of 1988 predicted
1988 actual	25.8	–	5.41	.592	–
1988 predicted	7.43	100.0	5.41	.782	100.0
No taxes	8.05	108.4	8.08	1.184	151.4
EPA policy 2 land disposal: $19.96	7.12	95.9	4.18	.599	76.6
EPA policy 3 land disposal: $45.37	6.68	89.9	2.76	.391	50.0
CBO policy 2 land disposal: $16.29 incineration: $4.36	7.03	94.7	5.14	.737	94.1

Predictions are based on the equations in column 7 of table 6 and column 2 of table 8. National taxes rebate existing state taxes, so the rates are the maximum of national and state rates. More detail on the tax proposals is provided in table 2.

small quantity generator exemption from land disposal restrictions. Without existing taxes, the number of shipments land disposed would have been about 50% higher. The taxes may also have caused the same percentage reduction in the total amount land disposed, but these results may be less reliable because the equation does not accurately recreate the ratio of SQG land disposal to total waste. Even the lower of the two EPA taxes, at $19.96/ton, reduces land disposal by over 20% in either model. The CBO tax at $16.26/ton does not have the same impact, because it includes a $4.36/ton tax on incineration. The probability of land disposal is very sensitive to the cost of incineration, so the predicted reduction from this tax is much smaller.

The empirical evidence for chlorinated solvents is roughly consistent with the engineering estimates presented in table 2 for the effect of national waste-end taxes on all hazardous waste. In particular, the EPA estimated that EPA policy 2 and 3 would both reduce landfilling by about 60%. The reductions predicted by this analysis for the same two taxes are smaller, 23% and 50%. EPA's analysis was based upon a much larger group of waste than studied here, so these reductions would not be expected to be identical. Rather, the evidence is consistent in suggesting that waste management practices may be quite sensitive to taxes.

4 Conclusion

This study provides evidence that taxes on emissions can alter the behavior of polluters. Plants that generate chlorinated solvent wastes respond to state taxes on hazardous waste by reducing the total amount of waste they generated and by switching from highly taxed land disposal to incineration and other treatment of wastes. The tax rates are low relative to overall waste management costs, however, so their effect on the total quantity of chlorinated solvent waste is limited. In contrast, state taxes may substantially reduce reliance on land disposal for those generators who had land disposal as an option. The empirical evidence suggests that earlier estimates accurately depict the sensitivity of landfilling to tax changes, despite a rapid increase in the apparent costs of alternatives in the intervening years.

States' experience thus suggests that waste-end taxes provide an alternative to the quantity restrictions that are currently used for hazardous waste regulation. These taxes, however, may not be an ideal policy instrument for several reasons. First, waste-end taxes may encourage illegal disposal of hazardous wastes. No systematic evidence is available about the extent of illegal disposal or its sensitivity to the costs of legal disposal.[24] Because illegal dumping can be much more damaging to the environment than legal waste management, a small increase in this activity may have important consequences for the desirability of policy intervention. In the presence of illegal disposal, a deposit/refund may be substantially less costly than a waste-end tax.

Second, waste-end taxes provide only an approximate means of differentiating among the environmental costs of various activities. A tax system directed at environmental releases (for example, air emissions from incineration, groundwater contamination from landfills) would signal environmental costs more accurately to generators and waste management facilities. Such a system could also reflect geographical variations in the costs of pollutant releases. Thus, further analysis is required to assess the desirability of waste-end taxes relative to other instruments for hazardous waste policy.

[24]Anecdotal evidence, however, suggests that it may be widespread. For example, a New York police sting operation that attempt to sell illegal dumping services to businesses was surprised by the degrees of organization in the market (Barnabel, 1992). The police were able to sell their services for an average of $40 per drum, while the cost for legally disposing waste was an average of $568 per drum.

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