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The Impacts of Environmental Fees and Landfill Bans on the Disposal of Hazardous Wastes in New York State

An Intervention Analysis

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Hazardous wastes are nonproduct outputs, the value of which is less than the costs of collecting, processing, and transporting them for other use (Kneese & Bowler, 1979). The generation of hazardous wastes constitutes a negative externality. While hazardous wastes damage public health and overall environmental quality, the cost of their generation are not fully internalized in the cost of producing the goods and services that result in hazardous waste by-products. One of the easiest ways, except open dumping, to handle hazardous wastes has been landfilling. Nowadays, however, the rapid growth of hazardous waste generation and the depletion of landfill space all add to 'hazardous waste crisis' in many industrialized regions.

Typical governmental policy responses to such hazardous waste management problems have included regulatory landfill bans and environmental fee programs with differential fee schedules to discourage landfilling, while promoting changes in waste management practices to such high-end handling methods as treatment, incineration, and recycling. Particularly, New York State imposi-

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tioned a rather stringent ban on land disposal of selected hazardous wastes on April, 1984 and later expanded its restrictions on land disposal of wastes further. New York State also implemented a regulatory fee program since April, 1983 and doubled the fees for hazardous wastes disposal commencing April, 1985.

Since New York State is one of the few state governments that have implemented stringent landfill bans and environmental fee programs regarding hazardous waste disposal, its policy initiatives have experimental values not only for New York itself, but also for other state governments that have not implemented such policies yet. However, did those policy interventions in New York State achieve their intended impacts on hazardous waste management practices? How do we assess those policy impacts?

In an effort to assess the effectiveness of those policy interventions by New York State, this study analyzes time series data for hazardous wastes manifested in the state between June 1982 and February 1987 organized into four waste handling methods : (1) landfilling, (2) treatment, (3) incineration, and (4) recycling. An outlier detection approach and intervention analyses were employed to assess the nature and effectiveness of the policy interventions.

1. Hazardous Waste Policy in New York State

According to an investigation report by the State Legislative Commission on Solid Waste Management, New York State relied on landfilling for the disposal of 81 percent of the total municipal waste ; 17 percent is handled by recycling, waste-to-energy facilities, or incinerators ; and 2 percent is shipped out-of-state for disposal(NYS Department of Environmental Conservation, 1989). The report also predicted that, given the rapid growth of waste generation, landfills existing in New York State as of 1986 would be full and closed by the end of 1995. Indeed, New York State faced a 'hazardous waste crisis.'

〈Table 1〉 The Operating and Capital Costs of Different Waste Processing Technologies

	Operating cost (estimated $/ton)	Capital cost (estimated $/ton)
Open dumping	$0.96	
Sanitary landfill	1.25~ 2.50	1000~ 2000
Incineration	3.00~ 8.00	3500~10000
Composting	3.00~10.00	3500~10000
Pyrolysis	3.00~10.00	5000~10000
Rail haul	4.00~ 7.00	

(Sources : Gueron, 1972 : 189)

Meanwhile, the reduction in the dependence on landfilling and the promotion of such high-end waste handling alternatives as treatment, incineration, and recycling might well not be accomplished without significant policy initiatives. As shown in 〈Table 1〉, despite the advances in waste handling technologies, land disposal still seemed to be the easiest and lowest-costing way for generators to dispose wastes.

The Hazardous Waste Management Planning Law(1987) summarizes the objectives of the hazardous waste policy in New York as following :

1. Hazardous waste be reduced or eliminated wherever feasible ;
2. Hazardous waste be reused, recovered and recycled as much as possible ;
3. Hazardous waste that cannot be reduced, recovered or recycled be detoxified, treated or destroyed ;
4. Land disposal of industrial hazardous wastes, except treated residuals, be phased out.

Indeed, the law recapitulated what had been the general thrusts of hazardous waste policies in New York State since early 80's. Such policy platforms were inspired by the depletion of landfill space, and the growing recognition that burial was hardly an ideal way to dispose hazardous wastes since it could even result in further damaging influence on the environment, as dramatized by the accident in Love Canal.

The specific policy responses by the state government to offset the reliance on landfilling largely consisted of landfill bans and differential taxation to induce further adoption of high-end waste handling methods. In March, 1983, Governor Mario Cuomo signed a law authorizing the New York State Department of Environment Conservation (DEC) to collect annual environmental fees from hazardous waste generators and waste treatment, storage, and disposal (TSD) facilities. The law went into effect from the next fiscal year beginning on April 1, 1983. By differentiating the tax rates in accordance with the volume of waste generated and waste handling methods, the law was designed in ways to suppress the total volume of hazardous wastes generated and promote the adoption of high-end waste handling technologies, like treatment and incineration. Besides, the law did not impose any environmental fee on recycling of wastes (<Table 2>). The collected environmental fees were supposed to finance the DEC's regulatory programs and the state's superfund (Sterman & Gormley, 1988).

In April, 1985, an amendment to the Environmental Conservation Law (Chapter 38, Laws of 1985) doubled the regulatory environmental fees for hazardous waste generators and TSD facilities. The law also specified a shift of liability determination for all fee categories from a state fiscal year basis to a calendar year basis. Hence, commencing in January 1986, hazardous waste fee liabilities were estimated for the calendar year based on the previous calendar year's report (McCaffrey & Miller, 1986).

Meanwhile, on April 30, 1984, the first regulatory ban was imposed on the disposal of wastes that contained more than five percent by weight of selected hazardous materials. For instance, none of waste types K016 (heavy ends or distillation residues from production of carbon tetrachloride) or K097 (vacuum stripper discharge from chlordane chlorinator in production of chlordane) was

〈Table 2〉 Regulatory Environmental Fee Schedule(1983)

Generators	Program fees($)
15～100 tons per year	500
101～500 tons per year	3,000
501～1000 tons per year	10,000
More than 1001 tons per year	20,000
Treatment, Storage, and Disposal Facilities	
A. Base Facility Fee	
0 to 1000 tons per year handled	6,000
More than 1000 tons handled	15,000
B. Special Facility Fees (per fertility)	
Landfills, not generator owned	100,000
Landfills, generator owned	50,000
Incinerators(per unit)	5,000
Energy recovery facilities(per unit)	5,000
Surface impoundments(per facility)	12,000

(Source : Environmental Conservation Law of 1983, Chapter 15)

allowed to be landfilled after 1984. Due to the landfill ban, the volume of type F001 waste(spent halogenated solvents from degreasing operations and sludges from their recovery) disposed at instate landfills by out-of-state generators shrank by about 50 percent from 1984 to 1985(Bretschneider & Deyle, 1990). The initial landfill ban of April, 1984 was further expanded and imposed commencing on December 31, 1985.

2. Data Analysis and Modeling Strategy

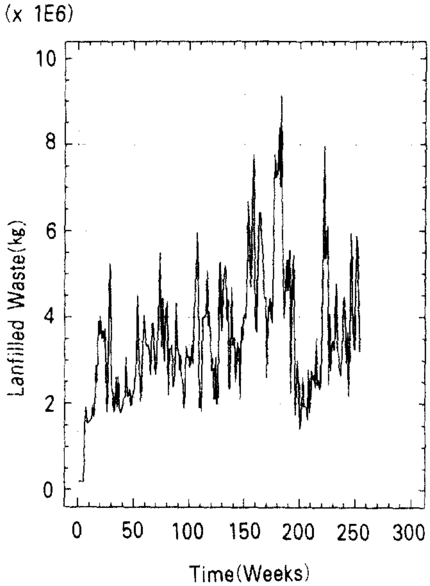
The time series data analyzed in this study include about 295,000 individual shipments of hazardous wastes to offsite treatment, recycling, or disposal facilities by instate and out-of-state generators for the period of June, 1982 to

February, 1987. Each shipment was classified by handling methods, i.e., landfilling, incineration, treatment, and recycling. All manifest volumes were converted to kilograms and aggregated by week to yield a times series data set containing 254 weekly observations.

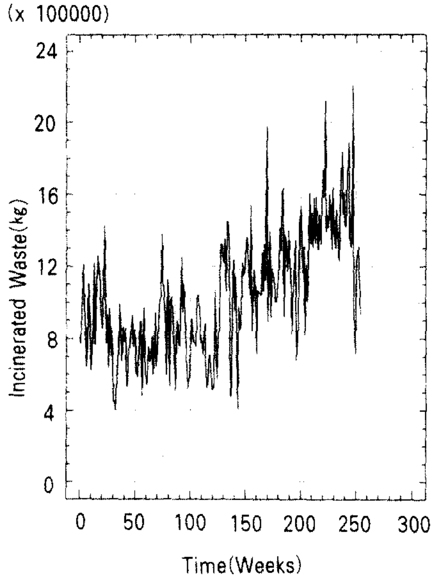
The analysis conducted in this study can largely be divided into three stages : (1) modeling of each time series, (2) outlier detection and matching of outliers with policy interventions, and (3) reestimation of the models with dummy variables for policy interventions and unmatched outliers. The interpretability of the outlier detection and parameter estimation for the policy intervention dummy variables heavily depends on the adequateness of the original modeling of the memory patterns in the time series. Thus, developing plausible models for the series is essential for the analysis. After model identification and estimation were finished, the unit root tests were conducted within the context of SCA program package to make sure that the parameter matrices were invertible and the residuals from the models were stationary.

〈Figure 1〉 to 〈Figure 4〉 represent the time sequence plots for the amount of landfilled, incinerated, treated and recycled wastes. The initial visual inspection of the time series plots and the numerical computations of means and variances for each series broken by years indicated that they all had drifting means and variances. Thus, log-transformation (base 2.718) and the first-order differencing became necessary for each series. Besides, the plots of the series indicated that they all exhibited a rough yearly seasonal behavior with approximately 52 weekly lags. Such a cyclical behavior seemed slightly more vivid for the incineration and recycling series. Following Box and Jenkin's (1976) iterative model identification approach, the modeling of each series was performed by iteratively identifying and estimating not only various pure ARIMA models, but also deterministic cosine function models combined with the ARIMA component for modeling residuals. As far as the cosine component models were concerned, the cosine function with five parameters turned out to be a better tradeoff between goodness-of-fit and model

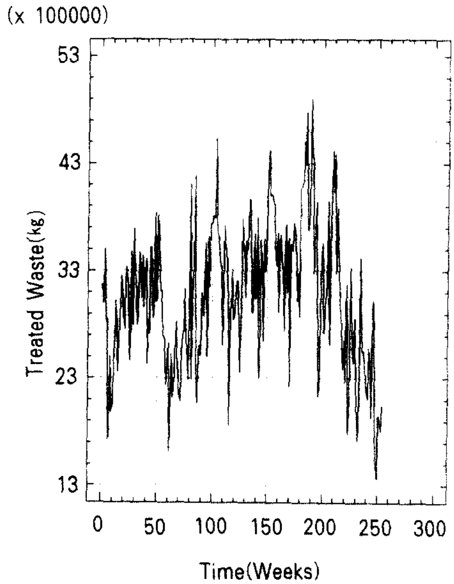
〈Figure 1〉 Landfilled Waste



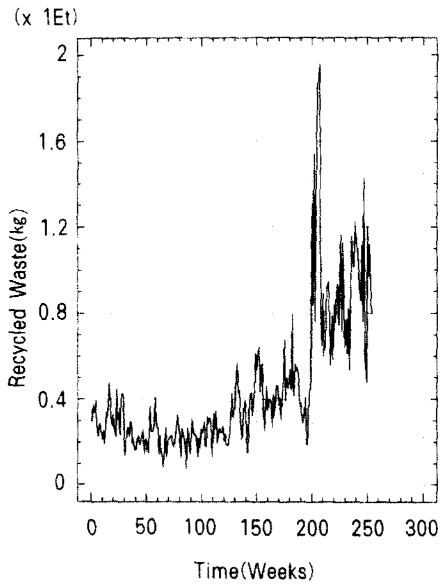
〈Figure 2〉 Incinerated Waste



〈Figure 3〉 Treated Waste



〈Figure 4〉 Recycled Waste



parsimony. The general form of the full intervention model used in this study can be expressed as following :

WV_{ti} = f (TRD, $COSINE_t$, $PI1_t$, $PI2_t$, $PI3_t$) + $\theta(B)/\psi(B)\ a_t$

Where,

WV_{ti} = waste volume at time t for handling method i

TRD = trend

$COSINE_t$ = cosine functions for seasonal behavior

$PI1_t$ = policy intervention 1 (initial program fees)

$PI2_t$ = policy intervention 2 (ban on land disposal)

$PI3_t$ = policy intervention 3 (increase in program fees)

$\theta(B)/\psi(B)\ a_t$ = ARIMA component

Once better models for the series were chosen, outlier detection was conducted within the context of the OESTIM procedure in the SCA statistical package. During the outlier detection procedure, the critical value was set to detect as outliers the observations that deviated more than three standard deviations from the predicted values. Outlier detection is useful not only because its results can be incorporated in the models to correct the biases in the OLS estimation caused by the outliers, but because it can delineate the impacts of policy interventions as outliers provided that their impacts are substantial enough.

The SCA package allows for the detection of three types of outliers : additive outliers, innovational outliers, and level shifts. The additive outlier is the case when only one observation at the time t is affected, while an innovational outlier represents a shock at the time t that influences all future observations through a memory function as depicted by the model. In the case of a level shift, the level of all observations after the shock is affected by the same amount.

Once outliers were detected, they were tried to be matched with the policy interventions that were brought into focus in this study. Although the statistical procedure of outlier detection can be by no means a substitute for substantive knowledge about the policy interventions, the procedure helps find out the locations along the series where the impacts of the policy interventions indeed begin to take place, which are often blurred. The procedure can also help discover some significant abrupt changes in the series that are not, but should have been, considered by the research.

For the present study, the following outliers were detected in each of the landfilling, incineration, treatment, and recycling series(〈Table 3〉~〈Table 6〉).

As indicated in the 〈Table 3〉 through 〈Table 6〉, there is no outlier detected near by the initial imposition of state regulatory program fees on April 1, 1983(week 46). Meanwhile, innovational outliers are detected at week 109 in both landfill and recycling series with the lag of 5 weeks from New York State ban on land disposal of selected materials on April 30, 1984(week 104). The interpretation of the two outliers are rather less determinate. The negative innovational outlier in the landfill series looks to embrace the expectation that the landfill ban may have reduced the volume of landfilled hazardous wastes. However, why was the volume of recycled wastes reduced, at least temporarily, after such a policy intervention? The reason may be the economic recession that began in 1983 and extended into 1984(Bretschneider & Deyle, 1990), or some stochasticity involved in the series.

Innovational outliers are also detected in the landfilling, recycling, and treatment series within the range of few weekly lags from the beginning of the

〈Table 3〉 Outliers in Landfilling Data

Time	Estimate	T-Value	Type
6	1.76	7.16	IO
109	-0.79	-3.20	IO
192	-0.72	-3.20	AO
196	-0.81	-3.31	IO
226	-0.73	-3.61	AO

calendar year of 1986 in which the doubled program fee rates began to be applied in determining hazardous waste fee liabilities(week 196). The negative outlier in the landfilling series at week 196 appears to meet the expectation of

〈Table 4〉 Outliers in Incineration Data

Time	Estimate	T-Value	Type
82	1.13	3.66	IO
127	0.48	3.48	LS
143	-1.06	-4.18	AO

〈Table 5〉 Outliers in Recycling Data

Time	Estimate	T-Value	Type
30	-0.97	-3.64	IO
65	-0.75	-3.13	AO
86	-1.14	-4.75	AO
109	-0.83	-3.13	IO
141	-0.87	-3.25	IO
195	-0.82	-3.08	IO
200	1.15	4.33	IO

〈Table 6〉 Outliers in Treatment Data

Time	Estimate	T-Value	Type
6	-0.56	-4.01	IO
61	-0.49	-3.56	IO
80	0.44	3.57	AO
84	0.43	3.49	AO
115	-0.50	-4.09	AO
142	-0.43	-3.07	IO
170	-0.47	-3.85	AO
196	-0.49	-3.51	IO
223	-0.50	-3.61	IO
234	0.45	3.22	IO
248	-0.35	-3.25	LS

the policy interventions. As to the recycling series, the negative outlier at week 195 becomes offset by the surge of the positive innovational outlier at week 200. The reason for the negative outlier at week 196 in the treatment series is rather unclear. Possible explanations can include a calendar effect due to the year-end holiday season, local disturbances like the temporary malfunctioning of a major treatment facility, or some other stochasticity involved in the series.

3. Result and Discussion

Regarding New York State ban on land disposal of selected materials as of April 30, 1984 and the application of increased program fee rates in liability determination as of January 1, 1986, the results of the outlier analysis generally suggest that some policy impacts indeed began to occur shortly after or before the policy interventions. Accordingly, the policy dummy variables for the two policy interventions were set up to reflect such effective dates, week 104 and week 196, respectively. As to the initial imposition of state regulatory program fees, since its impacts were not traced by the outlier detection analysis, its policy dummy variable was set to have the effective date of April 1, 1983 (week 46) as officially declared.

The final models and their parameter estimates for the four series are summarized in ⟨Table 7⟩ through ⟨Table 10⟩. The unrestricted models incorporate the unaccounted outliers as the dummy variables, while the restricted models neglect the outliers.

The unrestricted models with outlier adjustment generally result in better goodness-of-fit than the restricted models without outlier adjustment. However, they have produced quite similar results in terms of the parameter estimates for the policy dummy variables, except one case. While the unrestricted model indicates that New York State ban on land disposal (D2) at week

104 had statistically significant negative impacts on the volume of hazardous wastes incinerated, the restricted model suggests that such relationship is not statistically significant. How should such conflicting results be accounted for? The restricted model might indeed embrace an expectation that the ban on land disposal of selected materials would not logically decrease the volume of wastes incinerated. Whereas, the unrestricted model presumably resulted in a less biased parameter estimate due to the outlier adjustment given that the

〈Table 7〉 Model Estimation for Landfilled Hazardous Waste

Equation

ln(LWASTE) = c+(b1)trend+(W1)L1+(W2)L2+(W3)L3+(W5)L5+(R1)D1
+(R2)D2+(R3)D3+(1-Q1*B-Q2*B**2)/(1-P1*B)NOISE

Where,

L(k) are outlier dummy variables ; D1, D2, and D3 are policy intervention dummy variables : (a) D1 - initial imposition of state regulatory program fees (week 46), (b) D2 - NYS ban on land disposal of selected hazardous waste (week 104), (c) D3 - increase in state regulatory program fees (week 196)

Parameter Estimation

		With outlier adjustment		Without outlier adjustment	
Label	Order	Estimate	T-Value	Estimate	T-Value
C	0	14.660	86.98	14.651	95.15
b1	0	0.005	2.35	0.005	2.54
W1	0	0.977	4.66		
W2	0	-0.583	-2.83		
W3	0	-0.706	-3.43		
W5	0	-0.724	-3.51		
R1	0	-0.093	-0.54	-0.095	-0.57
R2	0	0.078	0.43	0.019	0.11
R3	0	-0.689	-3.87	-0.686	-3.92
Q1	1(MA)	0.168	2.39	0.260	3.66
Q2	2(MA)	0.283	4.28	0.254	3.88
P1	1(D-AR)	0.843	25.93	0.829	23.85
		R-Square = 0.796		R-Square = 0.755	

estimation procedure employs the ordinary-least-square criteria. However, such less comprehensible policy implications of the parameter estimate in the unrestricted model raise a suspicion that the interpretability of the estimate may be confounded by some other factors not explicitly taken into consideration in the present study. Indeed, the recession in New York State that extended through 1984 may have been a confounding factor. Incineration is a

〈Table 8〉 Model Estimation for Incinerated Hazardous Waste

Equation

ln(IWASTE)((1-B), (1-B**52)) = (W1)L1+(W2)L2((1-B), (1-B**52))
+(W3)L3+(R1)D1((1-B), (1-B**52))
+(R2)D2((1-B), (1-B**52))
+(R3)D3((1-B), (1-B**52))
+(1-T1*B-T2*B**2)
+(1-T52*B**52)NOISE.

Where,
L(k) are outlier dummy variables ; D1, D2, and D3 are policy intervention dummy variables : (a) D1 - initial imposition of state regulatory program fees (week 46), (b) D2 - NYS ban on land disposal of selected hazardous waste (week 104), (c) D3 - increase in state regulatory program fees (week 196)

Parameter Estimation

		With outlier adjustment		Without outlier adjustment	
Label	Order	Estimate	T-Value	Estimate	T-Value
W1	0	0.346	2.89		
W2	0	0.365	3.39		
W3	0	-0.120	-1.10		
R1	0	0.005	0.04	0.053	0.29
R2	0	-0.255	-2.24	0.045	0.25
R3	0	0.102	0.93	-0.131	-0.75
T1	1	0.625	9.04	0.502	7.45
T2	2	0.375	5.38	0.313	4.61
T52	52	0.899	15.68	0.899	16.11
		R-Square = 0.523		R-Square = 0.455	

〈Table 9〉 Model Estimation for Recycled Hazardous Waste

Equation

ln(RWASTE)=C+(B1)TRD+(A1)S1+(A13)S13+(A26)S26+(A39)S39
+(A51)S51+(W1)L1+(W2)L2+(W3)L3+(W4)L4+(W5)L5
+(R1)D1+(R2)D2+(R3)D3+(1-Q1*B)/(1-P1*B)NOISE

Where,
S1=COS(2*3.14159*1*trd/52);
S3=COS(2*3.14159*13*trd/52);
S26=COS(2*3.14159*26*trd/52);
S39=COS(2*3.14159*39*trd/52);
S51=COS(2*3.14159*51*trd/52);
L(k) are outlier dummy variables; D1, D2, and D3 are policy intervention dummy variables: (a) D1 - initial imposition of state regulatory program fees (week 46), (b) D2 - NYS ban on land disposal of selected hazardous waste (week 104), (c) D3 - increase in state regulatory program fees (week 196)

Parameter Estimation

		With outlier adjustment		Without outlier adjustment	
Label	Order	Estimate	T-Value	Estimate	T-Value
C	0	12.338	112.96	12.332	114.27
B1	0	0.005	2.72	0.005	2.70
A1	0	-2.473	-0.10	1.809	0.08
A13	0	-23.727	-2.16	-29.298	-2.45
A26	0	-0.006	-0.43	-0.008	-0.57
A39	0	23.697	2.15	29.282	2.45
A51	0	2.483	0.10	-1.785	-0.07
W1	0	-0.712	-2.75		
W2	0	-0.724	-2.83		
W3	0	-1.145	-4.45		
W5	0	-0.537	-2.09		
R1	0	-0.383	-2.48	-0.419	-2.68
R2	0	0.109	0.67	0.130	0.78
R3	0	0.473	2.88	0.483	2.87
Q1	1(MA)	0.249	2.09	0.211	1.66
P1	1(D-AR)	0.679	7.46	0.633	6.25
		R-Square = 0.796		R-Square = 0.764	

〈Table 10〉 Model Estimation for Treated Hazardous Waste

Equation

ln(TWASTE)((1-B)) = (W1)L1+(W2)L2+(W3)L3+(W4)L4
+(W5)L5+(W6)L6+(W7)L7+(W8)L8+(W9)L9
+(W10)L10(1-B)+(R1)D1(1-B)+(R2)D2(1-B)
+(R3)D3(1-B)+(1-T1*B-T2*B**2)NOISE

Where,
L(k) are outlier dummy variables ; D1, D2, and D3 are policy intervention dummy variables : (a) D1 - initial imposition of state regulatory program fees (week 46), (b) D2 - NYS ban on land disposal of selected hazardous waste (week 104), (c) D3 - increase in state regulatory program fees (week 196)

Parameter Estimation

		With outlier adjustment		Without outlier adjustment	
Label	Order	Estimate	T-Value	Estimate	T-Value
W1	0	-0.403	-3.16		
W2	0	-0.282	-2.23		
W3	0	0.201	1.56		
W4	0	-0.022	-0.17		
W5	0	-0.283	-2.25		
W6	0	-0.232	-1.84		
W7	0	-0.191	-1.52		
W8	0	-0.287	-2.28		
W9	0	-0.297	2.34		
W10	0	-0.358	-2.83		
R1	0	-0.047	-0.37	-0.040	0.31
R2	0	-0.120	-0.95	-0.108	-0.84
R3	0	0.321	-2.54	-3.000	-2.37
T1	1(MA)	-0.441	7.04	0.461	7.59
T2	2(MA)	-0.195	3.11	0.266	4.36
		R-Square = 0.556		R-Square = 0.478	

proven technology to remove the toxicity of hazardous wastes and reduce their volume by 80 to 85 percent safely. However, it is also an expensive way of handling wastes compared to other alternatives(Greenberg, 1976). The impacts of the economic recession may have inhibited generators from relying on such an expensive technological alternative.

The results of the intervention analysis generally suggest that the initial imposition of regulatory program fees and the state ban on land disposal of selected materials were ineffective, if not negative, in achieving their policy objectives, i.e., the reduction in the reliance on landfilling and the increase in the use of treatment, incineration, or recycling. Some of the reasons for such ineffectiveness may lie in the policy designs themselves. The annual environmental fee of $ 50,000 for a generator-owned landfilling facility may have been too small to influence significantly the waste management practices of the industrial waste generators. The types of hazardous materials banned from landfilling may have been defined too narrowly to affect the total volume of wastes landfilled. Otherwise, the enforcement of those policies may not have been so administratively feasible. Regarding this enforcement issue, McCaffrey and Miller(1986) pointed out that during the early 80's the administrative capacity of the New York State Department of Environmental Conservation(DEC) fell much short of being able to implement the fee program adequately. Specifically, the DEC's information base to deal with individual generators was incomplete or inaccurate that the DEC could not trace adequately the volumes and characteristics of wastes produced by individual generators and frequently over or under-assessed the fee liabilities.

They also argued that what made the law enforcement situation worse was that the DEC had to bill in advance for the fiscal year's fee liabilities on the basis of the previous year's information. So, in each year waste generators could contest fee liability assessment as being based on the data that did not reflect current waste outputs. Indeed, the early 80's comprises an infant stage of the DEC's hazardous waste management activity as the state's first

Hazardous Waste Management Act had been passed only few years ago(1978). The ineffectiveness of the initial imposition of regulatory program fees and the ban on land disposal of selected wastes may as well be attributable to the lack of the DEC's administrative capacity, as well as the relatively week incentives in the original policy designs.

Meanwhile, the intervention analysis for the landfill series strongly suggests that the doubled increase in the state regulatory program fees(D3) at week 196 had a significant discouraging impacts on the amount of wastes landfilled. The policy intervention also coincided with the significant increase in the amount of recycled wastes. To some extent, the coincidence may be attributable to the differential fee schedule in the policy design, which favors

recycling by imposing no regulatory program fee. However, such a direct causation can be confounded by the fact that at least twenty one new recycling facilities were built and became operative in New York State during 1985 and 1986(Bretschneider & Deyle, 1990). In other words, the increase in the reliance on the recycling alternative may be attributable to the sheer increase in the availability of recycling facilities and the subsequent cost reduction for recycling, as well as the differential fee schedule. Still, one could argue that the building of the new recycling facilities by manufacturing firms is itself related with or caused by the doubled increase in program fees and the differential fee schedule. In the context of the present research design, however, it may not be so feasible to infer determinate causal relationships among the policy intervention, the building of new recycling facilities, and the increase in the recycled volume vis-a-vis the reduction in the landfilled volume.

Meanwhile, the significant positive impacts of the doubled program fees on the reduction in the landfilled volume can be attributed not only to the amount of the fee increase and the differential fee schedule, but also to the enhanced

administrative capacity of the DEC to implement the policy appropriately. Indeed, the DEC's information system to monitor the handling of wastes by individual generators and assess their program fees improved significantly, being constantly challenged by businesses for its inadequate liability determination(McCaffrey & Miller, 1986).

4. Conclusion

The outlier detection and intervention analyses indicate that the initial imposition of regulatory program fees in 1983 and the ban on land disposal of selected materials in 1984 were largely ineffective in reducing the reliance on landfilling and increasing the use of safer technological alternatives, like treatment, incineration, or recycling. The reasons for the ineffectiveness may include (1) the insufficient policy incentives as revealed in the less punitive program fee schedule, (2) the lack of administrative capacity to enforce the policies effectively on the part of the New York State Department of Environmental Conservation in its early stages of hazardous waste management, and (3) the state-wide economic recession during 1983 and 1984.

Whereas, the doubled increase in state regulatory program fees in 1985 turned out to have significantly discouraged the reliance on landfilling to dispose hazardous wastes. Its success may largely be attributable to the stringency in the policy design(the doubling of program fees) and the improved law-enforcement capability of the Department of Environmental Conservation. The policy intervention also coincided with the increased reliance on the recycling alternative. The reason may have been the differential fee schedule design, which favored recycling by imposing no program fees. However, such a direct causation is confounded by the fact that about twenty one recycling facilities were newly built and became operative during 1985 and 1986.

This study investigated the time series data of landfilled, incinerated, treated and recycled wastes separately using the outlier detection and intervention analysis approach. The intervention analysis offers quantitative evidence of the directions and magnitudes of policy impacts on targeted spheres. In nature, the intervention analysis may particularly perform well when policy impacts are rather abrupt or large in magnitude. In the context of the present study, the intervention analyses successfully delineated that the intended policy impacts indeed occurred in the landfilling and recycling of wastes. However, this study does not claim that it has investigated the impacts of the three policy interventions in an exhaustive manner. Sometimes, policy impacts are abrupt and easily noticeable, but, often times, they are rather subtle. As to the hazardous waste policies focused in this study, their subtle impacts may have been reflected in the changing relationships among the landfilling, incineration, treatment, and recycling series, which were not adequately dealt with by the current intervention analyses. Thus, the agendas for future research on this subject should include an analysis of changing correlations among the four time series.

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