The Paradox of Rational Policies and Irrational Outcomes:A Case of Unexpected Policy Performance Caused by Information Delay

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Abstract

This study analyzes the impact of information network within the waste recycling market on the performance of public policies designed to develop the recycling market. Two typical policies are reviewed with an experimental procedure of *partial* and *whole* model tests. A System Dynamics model of waste recycling market is used as a laboratory setting for this study. The research findings suggests that well-intentioned policies can inadvertently lead to dysfunctional performance within a localized information environment. Delayed and distorted information feedback in the multi-stage structure of the recycling market further complicates problematic policy outcome, or market instability. This study proposes an information policy of integrating vertically the information network in the recycling market in order to improve the performance of market development policies.

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INTRODUCTION

The idea that better policy performance relies on good information is not new. It is central to the design of Information System (IS) within organizations and well-known to stock market management and insurance business. The idea is emphasized even in the public sector, such as social welfare reform [1], the implementation of environmental regulations [5], and integration of inter-organizational human service management [9].

Despite the prevalence of the idea, many policy makers and implementers are not paying enough attention to enhance information networks as a way of improving system-wide policy performance. Many studies observe that well-intentioned actions or locally-rational policies can inadvertently lead to dysfunctional or failing performance in a dynamic policy environment with information feedback. Delayed or distorted information feedback further complicates problematic policy outcomes [2] [3] [4] [7] [8].

These observations are applicable to recent efforts to develop waste recycling markets. In the presence of "waste crisis," various market development policies are introduced by public agencies. After implementing major development policies, however, recycling markets show unstable behavior in terms of production capacity and material price. In explaining the outcome, it is clearly unreasonable to assume that the market instability resulted from malicious public policies deliberately designed to cause financial loss in the market. A more satisfying explanation is to suggest that those policies, when implemented in the complex market system, produces unexpected and undesirable outcomes.

This study examines the impact that the information system embedded in the multi-stage structure of waste recycling markets has on the performance of market development policies. In other words, the market development policies and their performance are reviewed through the analytic lens of "information feedback" in the complex market structure. A computer simulation model is used as a laboratory setting for this study. In particular, a System Dynamics model of waste recycling market is created. This model displays a hypothesized information feedback system and decision-making structure of waste recycling markets in New York state region.

WASTE RECYCLING AND RECYCLING MARKET

As landfill space and incineration capacity rapidly decrease coupled with a growing volume of waste, waste recycling is recognized as a preferred way of managing the current "waste crisis." Waste recycling means more than just separation and collection of specific materials. It requires the introduction of recyclable materials into manufacturing processes, and finally to the end-users. That is, a successful waste recycling program depends on developing or finding strong and durable markets induced by the steady supply of recyclable materials with low contamination at price that varies within reasonable limits, as well as the stable demand for recycled materials.

In this regard, state and local governments have proposed or already implemented various market development policies; such as avoided cost subsidies, tax credits, direct financial assistance, government procurement, mandatory source separation, etc. Those policies are intended to expand the recycling market by stimulating either the demand or the supply sides of recycling markets, and inducing more capital investment in the market.

However, the policy expectation pay little attention to the complex market structure, the behavior of economic agents, and information network within the market. That is, most economic analyses assume that the business firm, viewed as an impersonal "black box," responds automatically to changes in the market condition, and that economic agents have a complete understanding of the market system and behave rationally with immediate and precise

information they need for their decision. These assumptions are far from describing the real market dynamics.

RECYCLING MARKET STRUCTURE

One of the distinctive features of the recycling market is its multi-stage structure. Waste recycling means more than a simple conversion of wastes to re-usable materials. It covers a stream of economic activities involving waste generation, collection and separation, recycling, and re-using. Thus, the market system can be considered as being composed of a set of four connected sectors; 1) waste generation and source separation, 2) waste recovery, 3) waste recycling, and 4) demand for recycled materials.

Figure 1 shows the overview of waste recycling market structure. Each sector in the market interacts through information and material flows. The source separation sector separates recyclable wastes from other waste streams, and sends the separated wastes to the primary recovery sector in response to the demand for source separated wastes. The primary recovery sector gathers and sorts out source separated wastes, and sells the recovered wastes to the waste recycling sector. The economic activities of waste recovery depend on information on the prices of source separated and recovered wastes. The waste recycling sector produces materials using the recovered wastes provided form the primary recovery sector. Waste recycling is influenced by information on the demand and price conditions for the recycled materials in comparison with those of virgin materials.

ANALYSIS OF POLICY PERFORMANCE

In order to analyze the market behavior responding to policy implementations, two experimental procedures are followed; *partial* and. *whole* model tests [7]. The partial model test is intended to demonstrate how well each market development policy works within a sector of the recycling market independent of the other sectors. It points out the intended rationality of each policy by showing what is a policy's "expected" performance within a sector of the overall system, given that the other sectors are assumed to remain constant or uninfluential. The whole model test examines the overall market behavior in response to implementing market development policies together. In contrast with the partial model test, whole model test assume that each sector within the overall market system interacts with the others.

The rationale behind the comparison of the *partial* to the *whole* model tests is to show how a well-intentioned or locally-rational policy can produce unexpected and undesired results in a complex and dynamic policy environment where information feedback tends to be delayed and distorted. Two market development policies are examined in this study; first, an increase in the average waste disposal cost; second, an increase in the price of virgin materials.

Among the market development policies mentioned earlier, the policies selected in this study are most representative of recent efforts to develop recycling markets. Furthermore, each policy targets a specific sector within recycling markets. The first policy is expected to prime the supply side of the market, or the source separation sector, by making the cost of source separation relatively cheaper than the costs of landfill and incineration. The second policy is designed to stimulate the demand side of the market by making the price of recycled materials competitive to that of virgin materials.

Partial model test (1)

The first partial model test examines the behavior of the source separation sector in isolation, showing how the source separation rate and source separated materials respond to the market development policy of increasing the average waste disposal cost. To conduct this test, the source separation sector is isolated by setting the demand/supply ratio of the source separated wastes to one. This neutralizes the influences from the other sector, or the primary recovery sector. Figure 2 shows the system behavior of the source separation sector when the average waste disposal cost increases from $5 to $200 (/ton) at a constant rate during the simulation period of 1960 to 2010.

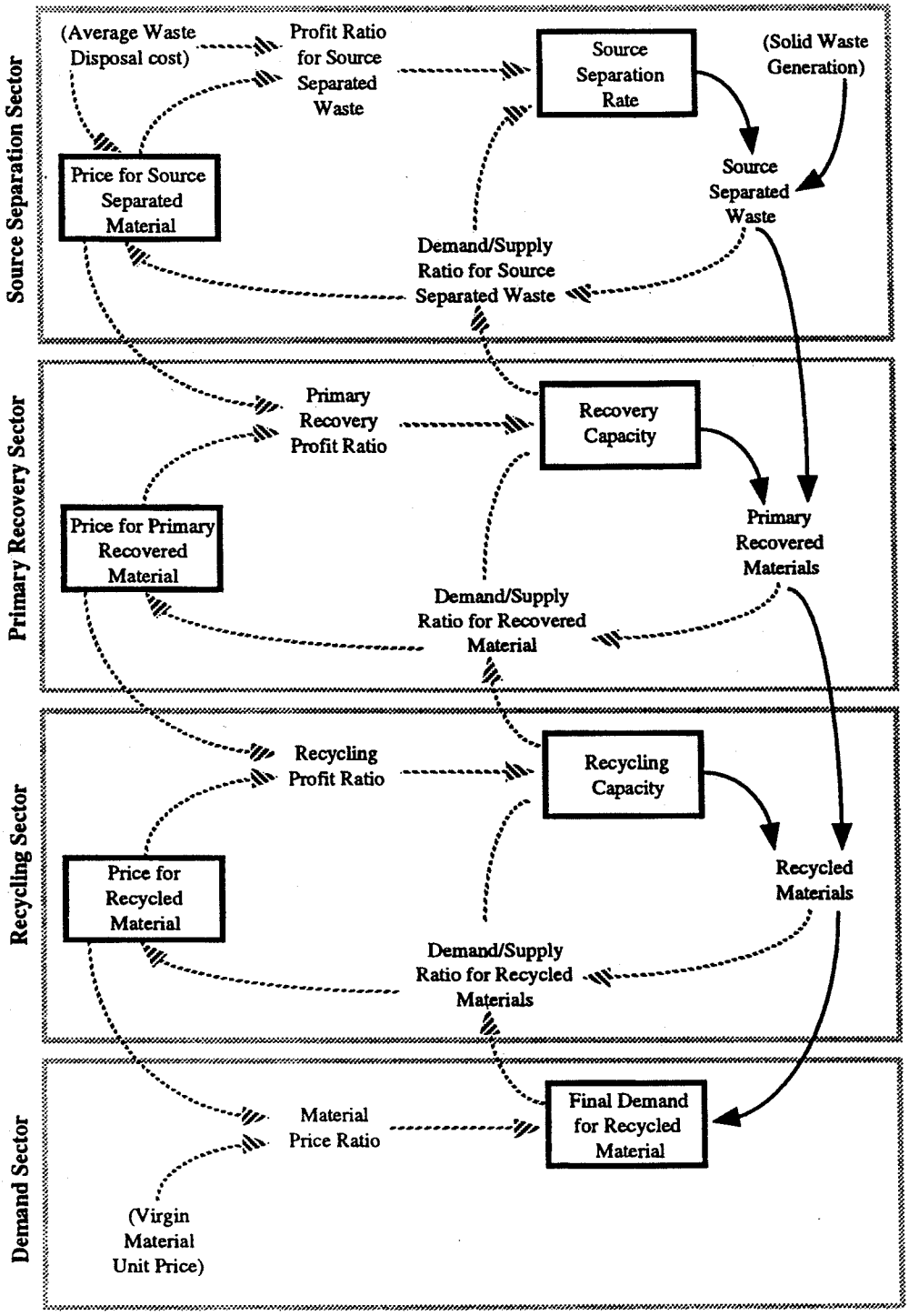

Figure 1: Flow Diagram of Waste Recycling Market

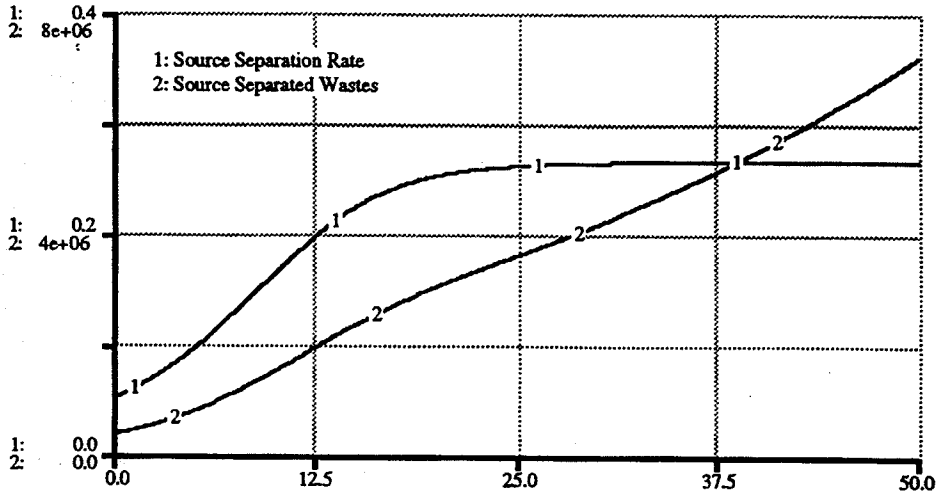

Figure 2

This represents the intended performance of the first market development policy when waste disposal costs increase under the assumption that other sectors are held constant. The resulted market behavior demonstrates intuitively correct system performance. This market development policy stimulates the supply side of the recycling market. A growing volume of source separated wastes is supplied continuously as the average disposal cost increases.

Partial model test (2)

The second partial model test examines the behavior of the waste recycling sector in isolation. It shows how the recycling capacity and the recycling rate change in response to increases in the price of virgin materials. To control the influences from the other sectors, the demand/supply ratio of the primary recovered materials is set to one. This means that any change in the recycling capacity and the recycling rate depend on only the demand for the recycled materials, and that the supply of the recovered materials is assumed to be always available for the waste recycling. Figure 3 shows the system behavior of the waste recycling sector when the price of virgin materials increases from $100 to $300 (/ton) at a constant rate during the same simulation period.

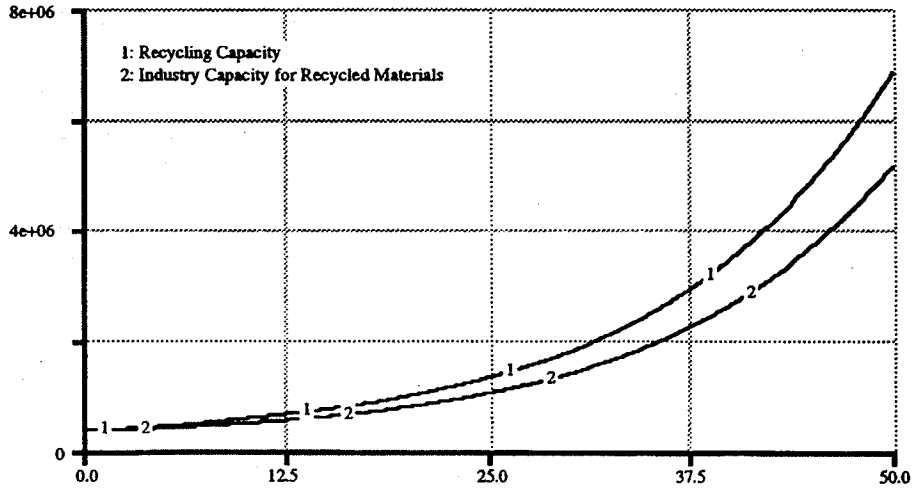

Figure 3

This represents the intended performance of the second market development policy which increases the price of virgin materials under the assumption that the supply of recovered materials is sufficient for producing the increasing volume of recycled materials. The second policy is design to make the recycled material price competitive to the price of virgin materials, and to increase the demand for the recycled materials.

Whole model test

The partial model tests demonstrated that each sector responded in a sensible way to the implementations of the major policies. In contrast with the partial model tests, the whole model test examines the overall market behavior when each sector in the recycling market are put together and the major policies are also implemented simultaneously. That is, the whole model test examines an intuitive policy expectation that the combination of the increased supply of recyclable wastes and the increased demand for recycled materials lead to overall market development.

Figure 4 shows the overall market behavior resulting from the whole model test. With strong economic incentives in the demand and the supply sides of the recycling market, the material production capacities are increasing.

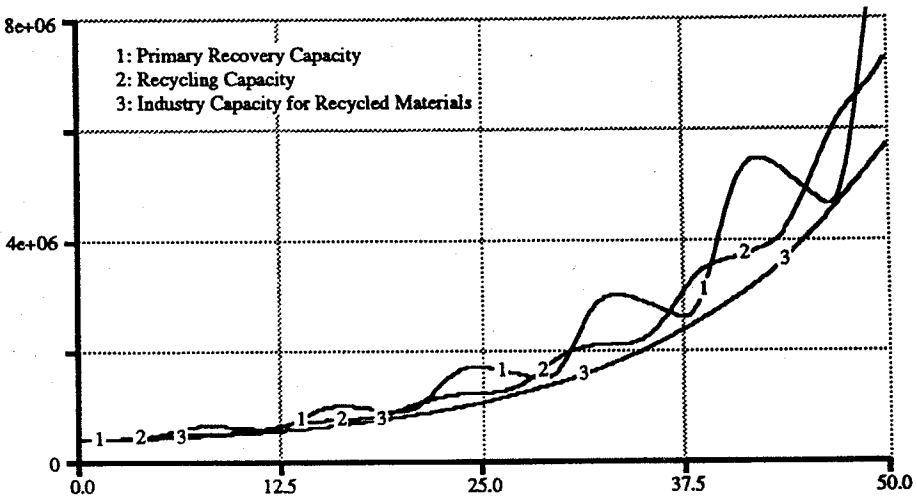

Figure 4

Table 1 summarizes the market behavior of the partial model and the whole model tests. The overall performance of the whole model test is lower than that of the partial model tests. The first partial model test demonstrates that about 177.9 million tons of waste are separated from other waste streams for waste recycling over the simulation; the average source separation rate is 24.1%. In the whole model test, the total amount of source separated waste is 104.8 million ton and the average rate is 14.2%. The overall recycling rate is also decreased. In the second partial model test, about 98.7 million tons of waste were recycled; the average recycling rate is 13.4%. The performance of the whole model shows that 86.1 million tons of solid waste are recycled and the average recycling rate is 11.7%.

Besides the lower performance, the whole model test shows market fluctuations in the levels of production capacities and material prices. The market dynamics underlying the unstable behavior demonstrated in the whole model test can be explained as follows. In response to the implementation of market development policies, both the demand for recycled materials and the supply of recyclable wastes are increased. However, the information on the demand and the supply levels does not transfer to each other directly and immediately because of the multi-stage stricture of the recycling market. That is, each sector in the market responds to the economic incentive provided by a specific policy on the basis of locally-available market information.

Furthermore, delayed information induces economic agents within each sector to over- or under-investment in material production capacities.

separation rate is 24.1%.

	Source Separated Waste	Source Separation Rate	Accumulated Source Separated Waste	Average Source Separation Rate	Recycled Material	Recycling Rate	Accumulated Recycled Material	Average Recycling Rate
	(ton/year)*	(%)*	(ton)#	(%)#	(ton/year)*	(%)*	(ton)#	(%)#
First Partial Model Test	7.2 Mill.	26.7%	177.9 Mill.	24.1%	NA	NA	NA	NA
Second Partial Model Test	NA	NA	NA	NA	6.8 Mill.	25.3%	98.7 Mill.	13.4%
Whole Model Test	6.3 Mill.	23.3%	104.8 Mill.	14.2%	6.3 Mill.	23.3%	86.1 Mill.	11.7%

* measured at the final year of simulation.
\# represents the whole period of simulation

Table 1

Vertical integration of market information

Based on the findings from the partial and the whole model tests, this study suggests a information policy which are expected to improve the performance of the major market development policies by providing a better information environment. It is to integrate vertically the information network embedded in the multi-stage structure of the recycling market.

Under the present information environment, the information on the demand (or supply) side of the market transfers to the supply (or demand) side through sector by sector. As the number of sector in the market increases, information on the market condition tend to be delayed and inaccurate. Thus, the information integration policy tries to reduce those information defects by integrating information network across sectors. This policy assumes that a centralized database on the market condition exists, and that timely and accurate market information is available and disseminated to economic agents in the market. The information integration policy is implemented in this simulation model by connecting information network of each sector.

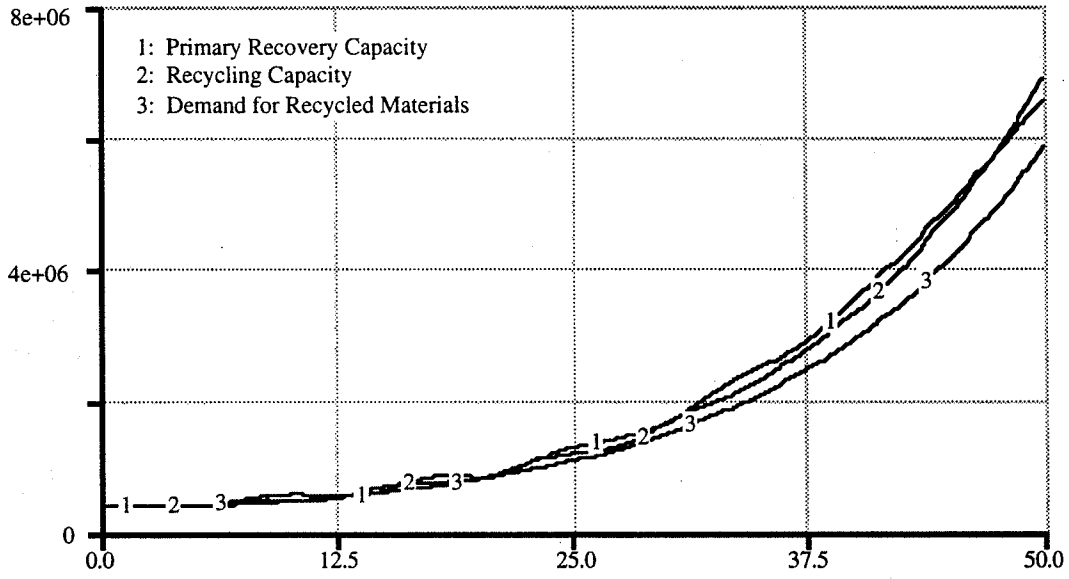

Figure 5

Figure 5 shows the market behavior with the implementation of the information integration policy. The fluctuations in the level of production capacities disappear. The production capacities are growing smoothly in comparison to the market behavior in the whole model test.

	Expansion			Stability +			Efficiency		
	Demand for Recycled Materials	Recycling Rate	Average Recycling Rate	Recovery Capacity Fluctuation	Recycling Capacity Fluctuation	Average Capacity Fluctuation	Recovery Capacity Utilization	Recycling Capacity Utilization	Average Capacity Utilization
	(tons/year)*	(%)*	(%)#	(tons/year)#	(tons/year)#	(tons/year)#	(%)#	(%)#	(%)#
Reference Run	3.1 Mill.	11.7%	7.8%	48,994	0	24,497	94.0%	93.4%	93.7%
Base Run (Policy 1 & 2)	5.7 Mill.	23.3%	11.7%	241,112	0	120,556	87.8%	90.8%	89.3%
Information Policy 1	5.6 Mill.	22.9%	11.6%	175,876	0	87,938	88.8%	91.4%	90.1%
Information Policy 2	5.8 Mill.	21.8%	11.6%	0	0	0	95.0%	95.0%	95.0%

+ The fluctuation of the production capacity is measured by the amplitude.

* measured at the final year of simulation
# represents the whole period of simulation

Table 2

Table 2 summarizes the market behavior before/after integrating market information in terms of expansion, stability, and efficiency. Although the average recycling rate and the demand for recycled materials do not change significantly, the levels of production capacities are much stabilized and production capacities are more efficiently utilized.

CONCLUSION

This study analyzed the impact of information system in the multi-stage structure of the recycling market on the performance of public policies designed to develop the market. The findings in this study support that a successful market development policy should take into account the complex and dynamic characteristics of the market structure and its information network, as well as the economic aspects of the recycling market.

It should be noted, however, a lack of accurate and timely information is neither the main cause of the current recycling market instability, nor is availability of the information a panacea for future market stabilization and expansion. An argument is made that a strategy for stable market development requires a system-wide or holistic approach.

Finally, this study emphasized the importance of information as a strategic resource to improve policy performance in a complex policy environment. Underlying the information integration policy is a re-defined role of public agencies. This means that public agencies as information creators, collectors, and providers are expected to play active roles in making relevant and up-to-date information available in specific policy areas.

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[Model equations are available from authors upon request.]