Evaluating the Process and Outcome of a Garbage Reduction Program in Taiwan

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Taiwan has launched a demonstration program for reducing the volume of garbage in a community to deal with the rapid accumulation of garbage. The purpose of this study is to evaluate the process and outcome of this program. Both qualitative and quantitative methods, integrated under the framework of theory-driven evaluation, were applied to enhancing the internal and external validity of this study.

EVALUATING THE PROCESS AND OUTCOME OF A GARBAGE REDUCTION PROGRAM IN TAIWAN

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Although it is universally recognized that economic development is desirable, the possibility of serious environmental damage and an impaired quality of life for current and future generations has generated increasing concern. Many serious environmental problems currently exist throughout the world and require urgent attention. Taiwan is no exception. Taiwan has been one of the exemplary cases of economic development in the past few decades. The development, unfortunately, engenders a variety of environmental problems. The generation of residential garbage stands out as the most urgent and unmanageable environmental problem.

Taiwan is a high-density island country. The total area of the island is 14,400 square miles with a population of about 21 million. Along with the rapid economic growth in the past three decades, garbage accumulation has increased exponentially at an alarmingly rapid rate. Daily garbage accumu-

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lation has increased from 13,954 tons in 1986 to 18,753 tons in 1990. Between 1986 and 1990, Taiwan's garbage growth rate (21.4%) has been ranked highest compared to the United States (16.13%), Japan (14.53%), France (11.4%), Switzerland (10.7%) and Canada (–1.57%) (EPA 1992).

On the other hand, the impact of garbage growth rate on environmental pollution is very evident. Throughout Taiwan, 26 rivers have been polluted due to garbage dumping (Wang 1993). Furthermore, the traditional strategy of using landfills to dispose of garbage has been attacked by legislators and citizens (Wang 1993, 1994). Residents are no longer receptive to new garbage dump sites in their community. It is impossible for the government to increase the number of landfill sites for garbage disposal. Managing the rapid accumulation of garbage has become a pressing policy issue in Taiwan.

Currently, the Environmental Protection Administration (EPA) in Taiwan considers garbage reduction and recycling as its top priorities. The EPA has initiated a number of programs to reduce the volume of garbage. One of the most notable efforts is the garbage reduction program (GRP) in Nei-fu.

Nei-fu is a suburb of Taipei (the capital city of Taiwan) with a population of 219,951 and an area of 31.97 square kilometers. Nei-fu was chosen as the demonstration site due to its reputation in adhering to EPA policies. The GRP has been in progress since June 1, 1993. If this demonstration program is successful, the EPA may apply the same strategy to other communities. As a result, this program has received much media coverage.

In April 1993, we proposed this study to the EPA and the program director of the sanitation department of the Nei-fu local government. They all agreed to provide necessary administrative support for carrying out the research. The purpose of this study is to evaluate both the implementation and the effectiveness of the program.

STRATEGIES FOR EVALUATING THE GARBAGE REDUCTION PROGRAM

The strategies for evaluating the GRP are based on the framework provided by the theory-driven evaluation perspective (Chen 1990). According to the theory-driven evaluation perspective, an action program usually is based on a set of assumptions for designing and implementing the program. These assumptions are called *program theory*. Program theory is very useful for helping evaluators to identify important issues and for integrating program stakeholders' concerns into evaluation processes. Possible sources of

program theory could be existing social science theory and knowledge or a program designer's hunch and experience. In the case of the GRP, program theory comes mainly from hunches and experience of the EPA program designer and the director of the sanitation department of the Nei-fu local government. In formulating program theory, the evaluators have reviewed all relevant documents and reports about the program and have carried out several intensive interviews with the program designer and director. The evaluators' aim is to understand the rationale behind and the purpose of the program, as well as the implementation process intended for the program.

The background and program theory of the GRP are as follows: Residents place their garbage bags in the designated spots or carts near their homes for collection every day. Garbage is collected daily by the sanitation workers of the local government in every community in Taiwan. The reasons for such frequent garbage collection are the lack of garbage disposal units in each home and an ineffective sewage system in the community. The food-related trash rots easily due to the warm temperatures in Taiwan. For health and sanitation reasons, the daily garbage collection has been a policy in Taiwan for more than four decades.

The implementation of the GRP at Nei-fu began on June 1, 1993. The intent of the program was to disrupt the garbage collection routine. The intervention strategy was to impose a no-garbage collection policy every Tuesday. Nei-fu residents were the target group of the policy. The sanitation workers still picked up the garbage from the collection sites of restaurants, supermarkets, shops, offices, and so on to avoid a public health hazard.

The sanitation department of Nei-fu started activities such as mailing letters to residents and launching a media campaign about the new program before its implementation. In addition, the department was responsible for implementing the program and ensuring that residents were not dumping their garbage at the collection spots on Tuesdays. In Nei-fu, there were 61 designated spots and 106 carts in the community. The sanitation department had 48 garbage collection cars with 199 full-time workers who could be deployed to implement the program.

The underlying theory of the program was that the new policy would force residents to store garbage in their homes. Because the great majority of city residents live in apartments or houses without a garage or a yard, the inconvenience or unpleasant smell of the household garbage would serve as a reminder to residents that the garbage problem is serious and that it is important for residents to reduce their garbage. The designer and director of the program anticipated that the residents' garbage reduction efforts would

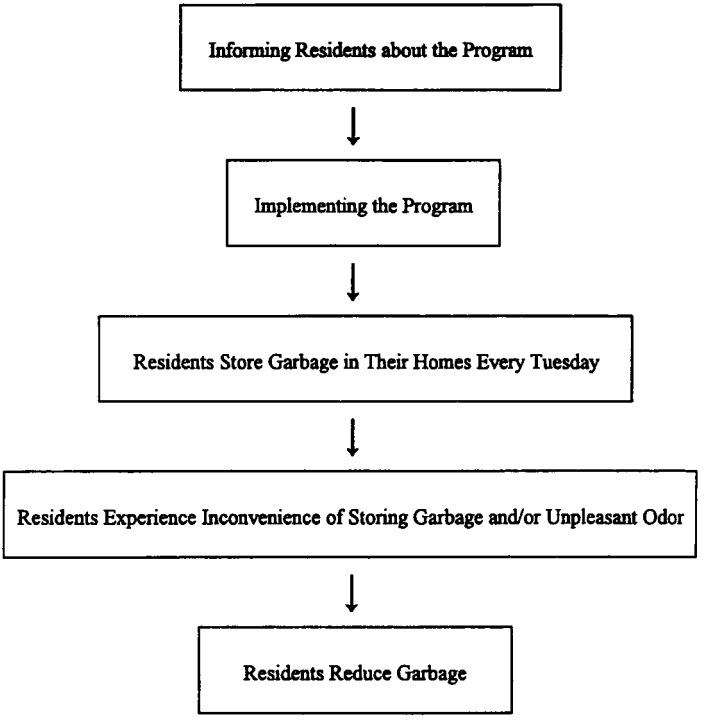

Figure 1: Causal Process in the Garbage Reduction Program

not be limited to Tuesdays, but would carry over to other days of the week as well. The causal processes of the program theory from implementation to effectiveness can be summarized in Figure 1.

Empirical verification of program theory as shown in Figure 1 requires the use of a composite type of evaluation that integrates a process evaluation and an outcome evaluation (Chen 1990, 1996). The composite type of evaluation can strengthen both internal and external validity (Chen 1990), which is important for evaluating a demonstration program such as the GRP. Under the composite type of evaluation, the outcome evaluation portion provides information on program effectiveness, and the process evaluation provides the following information that is important for the generalizability of the program: defining exactly what the program is, how the program is

implemented, why the program succeeds or fails, and what it would take to implement a similar program.

EVALUATING THE IMPLEMENTATION PROCESS

Data of the process evaluation were based on the following sources: site visits, field observation, daily sanitation reports on the volume of garbage from the sanitation department, the implementation documents and records in the files of the department, interviews with residents, and reports from major newspapers about this program. The research period of the process evaluation was from March to October 1993.

Based on the program theory as illustrated in Figure 1, the process evaluation focuses on the following issues.

INFORMING RESIDENTS OF THE NEW PROGRAM

Effective communication to the target group is one of the crucial steps in implementing any program. Before the implementation of the GRP, the program designer and director specified in the interview that the residents of Nei-fu would be well informed of the program through the following tactics: The department would mail two waves of letters to every residence, informing citizens about the GRP and asking for their cooperation and support of the garbage reduction goal before the intervention. The department also would plan to launch promotional campaigns for the program through newspapers. In addition, on all the major roads of the community, huge banners would be displayed to remind residents about the program before implementation.

Shortly after the program was implemented, the evaluation team visited the sanitation department and examined the governmental records. We confirmed that the two waves of the letters actually were sent to every residence before the implementation of the program. The mailing list included all residential units in Nei-fu. Our review of newspapers also found 11 articles that reported the program in six major newspapers. Each appeared in a visible section of the newspapers during the research period. In addition, the evaluators toured the main streets of the community and found that huge banners with big slogans about the program were visibly displayed on every major street. The messages in the banners were clearly visible with large words that

were easily read as residents passed the sign. The result of such an intensive campaign through media channels such as letters, newspapers, and banners made it impossible for residents not to be aware of the program.

ENFORCING THE POLICY ON THE RESIDENTIAL COLLECTION SITES

According to program theory, one of the crucial mechanisms for the program to work was that the residents were forced to keep the garbage at home, experiencing the inconvenience of storing garbage, accompanied by the unpleasant odor. For this reason, it was important to make sure that residents kept the garbage in their homes and did not dump it on the collection spots or any other place on Tuesday.

To enforce the policy, the sanitation department sent all its workers to guard or patrol collection spots. Any resident who attempted to dump the garbage was advised by the workers not to do so. Residents who were found to place garbage on the collection spot or street on Tuesday were subjected to a violation ticket of NT 4,500 (about U.S. $167).

For an assessment of how the policy was actually enforced, two research assistants were sent to the community to observe the enforcement every Tuesday for 3 months after the start of the program. Each assistant was assigned to observe 16 sites per month. The sites were randomly selected from a list. Field notes from the research assistants confirmed that sanitation workers guarded or patrolled the collection sites instead of collecting garbage on Tuesdays. On the first Tuesday, June 1, 1993, many residents attempted to dump their garbage on the collection sites; they were, however, advised not to do so by sanitation workers. The number of residents who attempted to dump garbage sharply decreased after the first Tuesday. In terms of fines, field notes indicated that very few fines actually were given, even if the violators were caught dumping garbage on the spots. They only were warned not to repeat.

The sanitation department did not collect the enforcement data until July 1993. According to the records, the monthly number of residents who attempted to dump their garbage but were advised against doing so by the sanitation workers from July to October were 258, 352, 258, and 212, respectively. The monthly figures of the fines issued in the same period were 13, 12, 13, and 11, respectively. The figures are generally consistent with our field observations.

In addition, each month one evaluator drove through all the collection sites on one of the Tuesdays and confirmed that few garbage deposits were placed on residential garbage collection sites. All of the above data consistently indicated that the sanitation department had rigorously implemented the policy of preventing residents from dumping the garbage on the residential collection sites on Tuesdays.

DUMPING THE GARBAGE ON THE COMMERCIAL SITES

Simply because the residents were prevented from using residential collection sites did not necessarily mean that they did not dump their garbage elsewhere, such as the commercial garbage collection sites, on Tuesdays. Like other communities in Taiwan, commercial buildings are interwoven with the residential areas. Commercial collection sites also are scattered around the community. These commercial collection spots were not guarded. It was still necessary to examine whether the residents were dumping their garbage on the commercial spots instead of keeping it at home.

The issue could have been addressed easily had the sanitation department kept a separate account of the daily volume of commercial and residential garbage. Unfortunately, this was not the case. The department did not separately weigh residential and commercial garbage. The evaluation team had to rely on the total volume of garbage as an indirect evidence of this issue. The argument is as follows: If the garbage volume dropped sharply on Tuesdays, then it would at least provide some evidence that many residents did not dump their garbage on the commercial collection spots. On the other hand, if the volume of garbage collected on Tuesdays remained about the same as before the intervention, then this indicates that most residents simply dumped their garbage in the commercial spots. The average Tuesday garbage volume before the intervention at Nei-fu was 208.82 tons. After the intervention, the average Tuesday garbage volume suddenly dropped to 135.18 tons. The sharp decline of 73.64 tons of garbage after the intervention indicated that many residents did not dump the garbage on the commercial sites, but kept the garbage in their homes.

In general, the evidence from process evaluation clearly indicates that the program had been implemented successfully. The great majority of the residents in Nei-fu followed the new policy and kept their garbage at home every Tuesday after the intervention. However, the implementation success does not necessarily imply the program success. The outcome evaluation, discussed in the next section, will examine this issue.

RESIDENTS' REACTION TO THE PROGRAM

According to Figure 1, the program was expected to cause residents to feel inconvenience in keeping the garbage and to smell the unpleasant odor, which should have made them reduce their garbage. In August 1993, 2 months after the intervention, two additional research assistants were sent to Nei-fu to carry out a short semistructured interview with residents about their experience and reaction to the program. Twenty collection sites were randomly selected from the pools. Research assistants interviewed residents at these collection sites when they placed their garbage there either in the morning or evening on garbage collection days. One hundred residents were interviewed. The sample was not large, but their reactions to the program were consistent and informative. The overwhelming majority (93%) of them did not feel any inconvenience in storing garbage in their homes on Tuesdays. An even more interesting finding is that 97% of them did not smell the unpleasant odor of the food-related trash. They expressed that food-related items were stored in plastic bags and sealed airtight by a rubber band or strand. It appears that the crucial part of the program theory of the GRP was not working as expected.

THE DESIGN OF OUTCOME EVALUATION

The purpose of the outcome evaluation was to see whether the GRP actually influenced a decrease in the overall volume of garbage in Nei-fu. The strategies used to design the outcome evaluation were as follows.

RESEARCH DESIGN

The research design used in this study was a multiple time series design (Cook and Campbell 1979). This design contained two sets of time series data on the outcome variables. One of the data sets was an intervention community; the other set was a comparison community. Only the intervention community had the intervention in the middle of the time series. According to Cook and Campbell (1979), the multiple time series design is a strong quasi-experimental design used to rule out many threats to internal validity. This design is diagramed as follows:

Intervention community: O O O O O O O O O O X O O O O O O O O O
Comparison community: O O O O O O O O O O O O O O O O O O O O

In the diagram, "O" refers to the outcome measure at a specific point in time. "X" refers to the intervention.

In this study, the intervention community was the Nei-fu community. The comparison community was an adjacent community called Nan-kan. There were two important reasons to include a comparison community in this study. First, it strengthened internal validity. For example, the threat of history may be a problem in the univariate-interrupted time series design (Cook and Campbell 1979), but it is controlled for in the multiple-interrupted time series design. Second, a comparison community was included because there was a concern for construct validity. If the program had some impact, but the impact was the result of Nei-fu residents who dumped their garbage on the Nan-kan community on Tuesdays, the positive impact would not be impressive at all. This is an important issue to policy makers in Taiwan due to several incidents of garbage fracases among communities in the past. The inclusion of Nan-kan as a comparison community would allow us to examine this issue.

MEASUREMENT AND STATISTICAL MODEL

The outcome measure in this study was the volume of daily garbage from the records of the sanitation departments of Nei-fu and Nan-kan. The data, collected from March to October 1993, contained 242 observations. The garbage volume was measured by tons. The intervention variable was a dummy variable representing the period before and after the implementation of the program on June 1, 1993. That is, the time series data collected before June 1, 1993 were coded as 0 but thereafter coded as 1. This intervention variable provided an estimation of the overall impact of the program on the volume of garbage.

In terms of data analysis, because time series data tend to have the problem of autocorrelation (i.e., the residuals are correlated), the autocorrelation will bias the estimation of standard error. As a result, the *t* test of the intervention effect in an OLS regression model is biased. To deal with this problem, this study applied ARIMA models for the estimation of program effects (Cook and Campbell 1979).

ELABORATING THE PATTERNS OF THE INTERVENTION IMPACT

Validity of an evaluation can be strengthened by elaborating theoretical patterns of the impact (Chen 1990). Theoretically speaking, if the GRP worked, we would expect to see the following patterns:

1. The volume of garbage on Tuesdays would drop substantially after the intervention.
2. The volume of garbage on other days besides Tuesday also was expected to shift. The day that the garbage volume was most likely to change was Wednesday. The garbage volume of Wednesday would increase because residents would dispose of both Tuesday's and Wednesday's garbage on this day. In addition, residents also might have slightly increased their volume of garbage on Monday in an anticipation of no garbage collection on Tuesday. Nevertheless, if the program had an impact, the volume of the garbage reduction on Tuesdays should have been greater than the volume of an increase of garbage on other days in the week.
3. Residents of Nei-fu were not dumping garbage in the adjacent community after the intervention. That is, the garbage volume in the adjacent community would not suddenly increase after the intervention.

As mentioned earlier, the problem of garbage dumping in the adjacent community was handled by examining daily garbage patterns occurring in the adjacent community. The first two theoretical impact patterns were examined by decomposing the gross intervention variable into a set of 7-day dummy variables. That is, after the intervention, every Monday to Sunday in a week was coded as 1; otherwise, it was coded as 0.

STATISTICAL ANALYSIS AND FINDINGS

The daily data of garbage volumes in Nei-fu and Nan-kan are illustrated in Figure 2. Figure 2 shows that before intervention, with a few exceptions, the daily household waste in Nei-fu tended to fluctuate between 180 tons and 280 tons. However, the patterns clearly changed after intervention on June 1. After intervention, every Tuesday the amount of garbage suddenly dropped to around 100 to 150 tons, but every Wednesday the amount of trash suddenly surged to around 300 and 350 tons. On the contrary, garbage fluctuation patterns in Nan-kan were very similar before and after intervention. This unusual fluctuation of garbage volume in Nei-fu was clearly the result of the GRP.

The approach used in this study for data analysis was fundamentally an ARIMA impact assessment (McCleary and Hay 1980; Pack 1978). This type of modeling was used to relate a stochastic output series and a deterministic input variable.[1] In this study, in the stochastic output series, the volume of garbage was modeled as a function of its own past values and a "dummy"

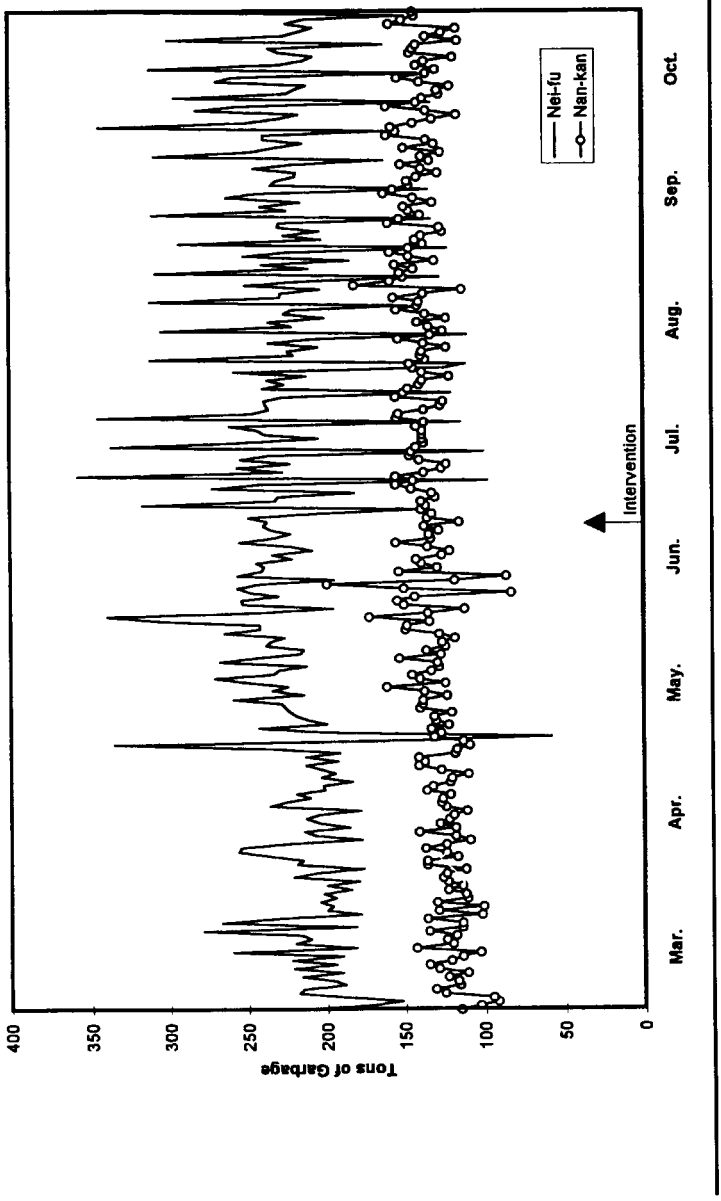

Figure 2: Volume of Daily Garbage in Nei-fu and Nan-kan (1993)

TABLE 1: Autocorrelations for the Preintervention Period

Lags 1-8	.226	−.023	.147	.274	.172	.085	.194	.068
SE	.088	.093	.093	.095	.101	.103	.103	.106
Lags 9-16	.073	.151	.211	.105	.064	.166	.073	.094
SE	.107	.107	.109	.112	.113	.113	.115	.115
Lags 17-21	.114	.095	.061	.072	.228			
SE	.116	.117	.117	.117	.118			

variable, the GRP. The GRP was represented by a series of 0s, with the value of 1 from the time period when the program was implemented.

The identification procedure for models of this type is as follows. The first step is to develop an ARIMA model for the output series. This model is developed for the preintervention series. Forecasts from this model can then be plotted against the actual values to determine the nature of the intervention effect. The deviations of the forecasts from the actual values would be an indication of the effect of the intervention. The form of the transfer function between the output series and the intervention variable is suggested by this effect.

The data in Figure 1 show a very distinct weekly recurring pattern. Note that the volume of the Nei-fu garbage collection stayed relatively stable with only minor fluctuations until the GRP was implemented on June 1, 1993. The methodology for time series analysis can easily be applied to this kind of seasonal series. Due to the weekly cycle in our daily routine, it is reasonable to expect a 7-day pattern in the garbage collection (i.e., similarities in observations of the same day in different weeks). Thus we would expect observations 7 days apart to be highly correlated. Table 1 shows the autocorrelation coefficients with various lags.

As can be seen from the table, the autocorrelation coefficients associated with lags of 7, 14, and 21 are consistently high, suggesting that the volume of garbage generated and collected each day had a 7-day periodic cycle. We can express this seasonal relationship with the simple autoregressive model

$$(1 - aB^7)(y_t - u) = e_t,$$

where y_t = the garbage collection series, u = the mean of the stationary series, B = the backshift operator, a = the autoregressive coefficient, and e_t = the random shock. Following the Box and Jenkins (1976) iterative approach to model building by repeating the identification, estimation, and diagnostic checking, a final ARIMA model eventually emerges for Nei-fu's preintervention data, as shown in Table 2.[2]

TABLE 2: ARIMA Model for the Preintervention Period

	Lag	*Coefficient*	t-*Ratio*
M		222.64	54.50
Autoregressive	7	.22	2.40
Residual and model statistics			
Sum of squares: 1,445.72			
Degrees of freedom: 119			
Mean square: 12.15			
Number of residuals: 121			
R^2: .46			

TABLE 3: The Overall Intervention Model

Parameter	*Estimate*	SE	t-*Ratio*	*Lag*
M	213.9384	7.4144	28.85	0
Intervention	6.6183	9.5791	.69	0
Autoregressive	.6755	.0498	13.56	7
Variance estimate	1,153.63			
SE estimate	33.97			
R^2	.45			

To test the effectiveness of Nei-fu's GRP, a transfer function model between Nei-fu's garbage output and the intervention variable can be established as follows:

$$(1 - aB^7)(y_t - u) = bX_t + e_t,$$

where y_t = the garbage collection series, u = the mean of the stationary output, B = the backshift operator, X_t = the intervention, a = the autoregressive coefficient, b = the intervention coefficient, and e_t = random shock. In this model, the intervention coefficient indicates the magnitude of the impact. The t-ratio of the coefficient provides a test of whether the impact of the intervention is statistically significant. The resulting model is shown in Table 3.

The t-ratio associated with the intervention coefficient is only .69, indicating that, overall, the impact of the GRP was not significant. To understand why the program failed to have overall effectiveness, the intervention variable was decomposed into seven interventions representing various days in a week. In this model, each dummy represented a particular day in a week—for example, Sunday—with a value of 1 for every Sunday in the

TABLE 4: The Decomposed Intervention Model

Parameter	*Estimate*	SE	t-*Ratio*	*Lag*
M	218.4773	3.1371	69.64	0
Autoregressive	.1977	.0647	3.05	7
Intervention: Monday	8.2722	8.9285	.93	0
Intervention: Tuesday	−87.2352	8.7151	−10.01	0
Intervention: Wednesday	92.2100	8.7161	10.58	0
Intervention: Thursday	10.8136	8.9301	1.21	0
Intervention: Friday	9.5823	8.9321	1.07	0
Intervention: Saturday	−9.1232	8.9312	−1.02	0
Intervention: Sunday	7.9735	8.9329	.89	0
Variance estimate	793.3347			
SE estimate	28.1662			
R^2	.58			

postintervention period. The result of this decomposed intervention model is shown in Table 4.

It is evident that the only significant dummies were those for Tuesdays and Wednesdays. The GRP did show a significant negative impact on garbage collection on Tuesdays. The coefficient of the Tuesday intervention indicates that the garbage volume had been reduced by 87.2 tons after intervention. However, the coefficient of the Wednesday intervention indicates that the garbage volume had increased by about 92.2 tons after intervention. It appears that the decrease of the garbage volume on Tuesdays was offset by the surge on Wednesdays. This offset hypothesis was formally tested by using a *t*-test. In the test, the null hypothesis was the equality between Tuesday and Wednesday coefficients. The test yielded a *t*-ratio of .194, which indicates that the null hypothesis cannot be statistically rejected. In other words, residents did not reduce the actual amount of garbage but simply saved their garbage on Tuesday for the Wednesday collection. Overall, the GRP failed to make the residents reduce their garbage on Tuesdays or on any other day.

Because there was no garbage reduction in Nei-fu, we expected to find that garbage dumping in the adjacent community was not a problem. The analysis of data of the adjacent community, Nan-kan, confirms this expectation. In brief, after differencing the data, the ARIMA model of Nan-kan was found to be an autoregressive model with a lag of 7. The coefficient of intervention was .598 with a *t*-ratio of .19 that indicated, as expected, that the intervention imposed on Nei-fu had no impact on the garbage volume in Nan-kan.

CONCLUSION AND DISCUSSION

The process evaluation indicated that the garbage reduction program in Nei-fu had been implemented successfully. Furthermore, it would not be difficult for other communities to replicate the implementation procedures of Nei-fu's experience. Program elements for implementation identified in this study include mailing letters to each resident, placing banners in the major streets to inform the residents about the program, using a media campaign, and guarding or patrolling the collection sites. These procedures could be easily followed by other communities. However, the financial and manpower resources would render it prohibitive. The sanitation department in Nei-fu is one of few departments that has received strong financial support from the EPA and other governmental sources. Few sanitation departments in Taiwan have the same high level of resources as does Nei-fu. If the EPA imposed the same program on other communities, the financial and manpower problems would need to be solved first.

This study indicates that the major problem of the program is not in the implementation but in its effectiveness. The results from the outcome evaluation are disappointing. It appears that, in spite of the implementation efforts, the program had no impact on reducing the volume of garbage. Overall, residents generated about the same amount of garbage before and after the intervention. As a reaction to the intervention, residents simply saved the same volume of Tuesday garbage and disposed it at the collection sites on Wednesday. The reason for program ineffectiveness may result from part of the program theory not operating as expected. Residents neither felt inconvenience in storing garbage at home on Tuesday nor smelled the unpleasant odor of the garbage. To reduce residential garbage, the EPA needs to explore other more effective strategies. Education is a good alternative (Wang 1993) but usually takes a long time before its fruition. A quick fix would be to require residents to pay for garbage collection according to the amount of garbage they generate. An experiment of such a program in a few Japanese communities has shown a promising result (Department of Health, Japan 1993). However, due to cultural and institutional differences, when designing such a program in Taiwan, the EPA would need to consider preventing residents from dumping garbage on their neighbors' property or public places to reduce the payment. Nevertheless, in designing an environmental program in the future, the EPA can benefit from having a clearer conceptualization of the problem, intervention strategy, causal mechanisms underlying the strategy, and potential public reactions. This is another area where program evaluators can make a useful contribution (Chen 1994).

NOTES

1. For a more detailed discussion of the approach, see McCleary and Hay (1980).
2. The iterative cycle of identification, estimation, and diagnostic checking is repeated until a suitable representation is found. For a more detailed discussion of the approach, see Box and Jenkins (1976) or Pindyck and Rubinfeld (1991).

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