ANALYZING DEMAND FOR DISPOSAL AND RECYCLING SERVICES:

A SYSTEMS APPROACH

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INTRODUCTION

For many years, cities and towns across the U.S. have been dealing with the dilemma of rising municipal solid waste (MSW) generation and declining capacity of aging landfills. In response, public officials have begun to implement new policies aimed at encouraging source reduction and waste diversion through increased recycling activity. Because the Resource Conservation and Recovery Act (RCRA) gives states the responsibility for nonhazardous waste management, these efforts have not been symmetric across the nation. Nonetheless, certain trends have become apparent, including the increased use of curbside services and the adoption of unit pricing schemes, or so-called "pay-as-you-throw" programs, to achieve local objectives.

Because of its market orientation, unit pricing, or variable-rate pricing as it is sometimes known, has become an important focus of recent economic research. The premise of unit pricing is simple. Each unit of waste disposed has an explicit price, such that the total fee paid for MSW services increases with the quantity of waste discards. Hence, the unit price acts as a disincentive to dispose excess waste and, in theory, can be adjusted to achieve state or local disposal targets. In the absence of such a pricing scheme, municipalities conventionally charge a flat fee for disposal services, which, by definition, is independent of waste generation. Under such an approach, the household faces a marginal price of zero for every unit of waste disposed beyond the first, which in turn means it has no economic incentive to lower generation or to divert waste through recycling. This problem is exacerbated if the flat fee is collected through property taxes and hence hidden from residents. The associated misperception is that the marginal price of *all* units of waste disposed – even the first – is zero. Since this flat fee approach ignores the true marginal costs of providing

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MSW services, the outcome is an inefficient solution with too many resources allocated to MSW disposal and hence greater stress on landfill capacity.

Although unit pricing is not new, it has become more commonplace in the last decade or so. According to a 1998 survey, there are over 4,100 municipalities in the U.S. using some type of unit pricing plan [Hui, 1999].[1] Predictably, as this policy reform has taken root, researchers have begun to investigate unit pricing along with complementary policy instruments to determine if the intended effect is being realized and, if so, to what extent. The provision of curbside recycling services is an example of a complementary, incentive-based instrument actively used at the local level. If a town picks up recyclables at the curb, it directly reduces the opportunity costs of recycling. The expected outcome is higher recycling levels and reduced disposal. In some research studies, the question under investigation is whether the presence of such curbside services affects the influence of unit pricing. Callan and Thomas [1997], for example, find that unit pricing has a significantly stronger effect on a community's recycling rate when curbside recycling is offered simultaneously.

Conventionally, researchers treat unit pricing and curbside services as exogenous variables when estimating recycling or disposal demand functions. However, in a recent demand analysis, Kinnaman and Fullerton [2000] show that these policy instruments ought to be modeled as endogenous variables, since they tend to vary with town attributes and household characteristics. The underlying argument is that public policy should be responsive to the constituency and to local conditions in the community.

Following this premise, this research examines the demand for disposal and the demand for recycling services for Massachusetts cities and towns, allowing for the endogeneity of unit pricing levels and the provision of MSW curbside services.[2] However, unlike Kinnaman and Fullerton [2000], who treat disposal demand and recycling demand as separate functions, we argue that these are simultaneously determined. To that end, we estimate these two demand functions at the community level of analysis, using a systems approach to allow for their simultaneous determination. We believe this approach and the associated results make an important contribution to this research area. Our model specifies a combination of socio-economic, demographic, and policy determinants, assuming endogeneity of unit pricing levels and curbside services for both disposal and recycling.

To give context to this study and to elucidate its contribution to MSW research, we provide an overview of the relevant literature in the next section. The theoretical model is subsequently presented and discussed, followed by an exposition of the empirical model and data. Next, we present the results of the estimation and close with concluding remarks.

THE RELEVANT LITERATURE

The literature dealing with the demand for MSW services has been evolving over the past decade. Early research focuses on the demand for disposal services, while more recent papers have begun to include some aspect of recycling activity. The objective is to develop a better understanding of how disposal and recycling decisions are related, which in turn can help motivate state and local policy initiatives. Some of these analyses examine MSW decisions at the household level, such as Fullerton and Kinnaman [1996], Nestor and Podolsky [1998], Hong [1999], and Hong and Adams [1999]. Others focus on the disposal and/or recycling activity of the community as a whole, such as Jenkins [1993], Miranda and Aldy [1998], Podolsky and Spiegel [1998], and Kinnaman and Fullerton [2000]. Three of these articles are of particular relevance to this research, so we discuss their salient points next.

Hong [1999] uses an international venue for his household-level study of unit pricing, employing survey data from 3,017 households in Korea.[3] Unique to this study is the development of a theoretical and empirical model that explicitly accounts for presumed simultaneity between generation and recycling. A particular focus is the presence of feedback effects between generation and recycling, which in turn are expected to influence the net effect of unit price changes. Hong's underlying hypothesis is that a higher recycling rate, which can arise from higher disposal fees, will in turn give rise to increased generation, since greater recycling activity may cause households to be less aggressive in pursuing source reduction practices. To assess the potential of such feedback effects, Hong specifies a two-equation model with generation and recycling as dependent variables. Unit price is assumed endogenous and appears in both equations. Recycling rate is allowed to influence waste generation, and waste generation appears as a regressor in the recycling equation.

Employing a three-stage least squares (3SLS) approach, Hong generates estimates that suggest that higher fees promote increased recycling activity but do not statistically influence generation directly. He further finds that feedback effects do exist. Accordingly, he reports price and income elasticities that account for these feedback effects, using reduced-form equations, although the derivations are not apparent. Hong asserts that the price elasticity associated with generation is actually positive at 0.121 when feedback effects are considered, rather than negative as the price coefficient in the generation equation suggests. He also derives a cross-price recycling elasticity of 0.457, which is of higher magnitude when generated from the reduced-form equation, and an income-generation elasticity of 0.088, which is of lower magnitude when derived from a reduced form.[4]

Podolsky and Spiegel [1998], who use community-level data for 149 New Jersey municipalities, investigate the effect of unit pricing on MSW disposal demand. As suggested by their theoretical model, these researchers find statistical support for a negative relationship between the unit price level and the quantity demanded of disposal services. They further estimate that the price elasticity of demand is equal to -0.39, which aligns with the findings of Jenkins [1993] and others. However, what distinguishes this result is that it is based on a disposal demand equation in which recycling, assumed to be exogenous, is explicitly held constant. Hence, their elasticity estimate is truly measuring the price-induced change in disposal arising from adjustments in any disposal alternative *except* recycling.

In their empirical model, Podolsky and Spiegel hypothesize that a community's recycling activity affects disposal demand through two components. The first is a nonprice component, whereby a community's increased recycling activity should result in less waste disposal because the two activities are substitutes, holding price constant. The second is a price component, which they argue acts as an indirect price effect. This refers to the expectation that a higher price on disposal should encourage more recycling, which in turn would lower disposal activity. This indirect price effect is incremental to a direct price effect, whereby a price rise directly reduces disposal because it should encourage lower generation or source reduction. Podolsky and Spiegel attempt to capture the price component, or indirect price effect, through an interaction term between household recycling and a dummy variable for unit pricing. However, although both the nonprice component and the direct price effect are each found to be negative and significant, the indirect price effect is not statistically significant.

A more recent study by Kinnaman and Fullerton [2000] significantly advances the research in MSW demand. In this paper, the authors estimate separate demand functions for MSW disposal and recycling services using a sample of 908 U.S. communities. Critical to their analysis is the assumption that local policy decisions, specifically the unit price level and the provision of curbside recycling services, are endogenous. Since most existing studies in MSW demand assume that policy changes are exogenous, this research effectively calls into question these earlier results, most notably responses to unit pricing programs and associated estimates of price elasticities.

Because of the endogeneity assumption, the authors employ a two-stage least squares (2SLS) approach to conduct their estimation. Consistent with prior research studies, Kinnaman and Fullerton find that disposal demand is relatively price inelastic. Depending on the underlying assumptions, they present estimates ranging from –0.034 to –0.778 along with a calculated arc elasticity of –0.28. The authors suggest that their relatively large estimates of –0.28 and –0.778 are the result of treating local policies as endogenous. They further indicate, through a comparison of OLS and 2SLS results, that existing studies based on an assumption of price exogeneity may substantially underestimate the price responsiveness of MSW disposal demand.

From their recycling services equation, Kinnaman and Fullerton derive a point estimate of the cross-price elasticity of 0.22.[5] However, the parameter estimate on unit price in the recycling equation is not significant, so any assertion about the degree of substitutability between recycling and disposal services is not statistically supported in their 2SLS model. They also find that a community's decision to offer curbside recycling services has a significant effect on recycling demand, but no analogous relationship was found on the disposal side.[6]

THE THEORETICAL MODEL

A distinctive aspect of the present research is the specification of an MSW demand model that allows for the simultaneity of demand for disposal and recycling services.[7] The simultaneity is important in that it captures the concurrent nature of disposal and recycling decisions by households. The demand for illegal dumping is also part of this set of decisions, though it is not observed and hence not measurable. Consequently, the demand system for each community is modeled as follows:

(1) $Q_{DISP} = f(PersonH, Income, Educ, Age, Den, P_{DISP}, Freq_{REC}, Q_{REC})$, and

(2) $$Q_{REC} = f(PersonH, Income, Educ, Age, Den, P_{DISP}, Freq_{DISP}, Grant),$$

where equations (1) and (2) represent the demands for disposal and recycling, respectively. The dependent variables and demand determinants for each equation are defined in Table 1.

TABLE 1
List of MSW Variables and Definitions

Variable	Definition
Q_{DISP}	average number of tons of MSW disposed per person each year
Q_{REC}	average number of tons of MSW recycled per person each year
PersonH	average number of persons per household in the town
Income	income per capita in thousands of dollars
Educ	percentage of the town's population that has received a baccalaureate education
Age	median age of the town's residents
Den	housing density measured as the number of housing units per square mile of area
P_{DISP}	the average price in cents per gallon of waste disposed in the town[1]
$Freq_{REC}$	frequency of curbside recycling services quantified as number of pick-ups per month[2]
$Freq_{DISP}$	frequency of curbside disposal services quantified as number of pick-ups per month[3]
Grant	dollar value of state-funded grants per thousand residents that the town received for recycling equipment and/or educational materials

1. Following the recent literature, towns that do not use a unit pricing scheme are assigned a value of 0 for P_{DISP} [Podolsky and Spiegel, 1998; Kinnaman and Fullerton, 2000]. Also, to convert prices per pound to prices per gallon, we used a conversion following Repetto, Dower, Jenkins and Geoghegan [1992] as cited in Van Houtven and Morris [1999].
2. To avoid collinearity problems, this variable is formed as the product of two variables, one measuring the number of pick ups per month and the other a dummy variable to identify towns offering curbside services.
3. This variable is formed analogously to $Freq_{REC}$, which is described above.

A few general observations are worthy of note. First, the theoretical framework for such MSW demand functions generated from utility maximization is supported in the literature and hence is not repeated here [Podolsky and Spiegel, 1998; Kinnaman and Fullerton, 2000]. Second, the variables included in these demand functions follow the MSW empirical literature. Third, each demand function is specified to reflect the influence of three sets of factors: (i) household characteristics – *PersonH, Income, Educ, Age*; (ii) a key town attribute – *Den*; and (iii) state and local policy instruments – P_{DISP}, $Freq_{REC}$, $Freq_{DISP}$, and *Grant*. The inclusion of household and demographic variables is necessary to assure that the model properly controls for differences in socio-economic conditions that might affect a community's MSW behavior.

Within this system, we recognize the endogeneity of certain MSW policy decisions, following Kinnaman and Fullerton [2000]. In our model, the relevant endogenous policy variables are P_{DISP}, $Freq_{REC}$, and $Freq_{DISP}$.[8] The logic of treating the unit price of disposal and the frequency of recycling and disposal curbside services as endogenous is that each of these policy instruments can and often does change in response to residents' behavior (which in turn is a function of household characteristics), as well as the demography of the town itself.

Beginning with the household characteristics, the *PersonH* variable captures the average household size in each municipality. Logically, we expect that total disposal increases with household size. However, since the dependent variables in this model, Q_{DISP} and Q_{REC}, are measured on a per capita basis, the *PersonH* measure could have a negative influence on demand as discovered by Jenkins [1993] and Podolsky and Spiegel [1998]. Podolsky and Spiegel add a quadratic term for this variable, and find that this economizing influence is not without limit.

Predicting the qualitative effect of the *Income* variable is more difficult. With regard to disposal demand, one expects that higher income households will consume more goods, which in turn implies more waste generation and thus a higher demand for disposal services. However, some argue that higher income families tend to donate rather than discard certain goods [Richardson and Havlicek, 1975; 1978; Rathje and Thompson, 1981], which implies a negative influence of income on MSW disposal demand. Hence, if both factors are present, it is possible that the *Income* variable will not significantly influence disposal demand.

On the recycling side, the expected effect of *Income* on demand is also ambiguous. Commonly discussed is the higher opportunity cost of recycling faced by higher income households, which in turn suggests that income and recycling are negatively related. However, there are other factors that work in the opposite direction, making the net effect indeterminate *a priori*. For example, higher income households generally possess the financial flexibility and opportunity to substitute more recyclable products for those that are not. Detail on such issues is reported in Saltzman, Duggal, and Williams [1993].

Education is expected to negatively influence disposal demand and positively affect recycling demand. More highly educated individuals tend to be more environmentally aware, which suggests greater source reduction activity and hence lower waste generation as well as more recycling [Van Liere and Dunlap, 1980; Granzin and Olsen, 1991; Lansana, 1992; Smith, 1995].

We anticipate that the *Age* variable will have a direct effect on disposal and recycling demand, since consumption levels tend to increase as people grow older, at least to a point. However, the empirical evidence on the effect of age on MSW services is limited. Some researchers do not specify age as a determinant of MSW demand functions, and among those that do, the results are not consistent. Podolsky and Spiegel [1998] find that median age is inversely related to disposal. However, Jenkins [1993] finds that age (measured as the proportion of the population between 18 and 49), positively affects disposal demand. Richardson and Havlicek [1978] argue that waste generation increases with age up through the middle years and then declines. We think the latter two cases are the most plausible.

We specify a measure of housing density, *Den*, to capture an important town attribute, as is conventionally done in the MSW literature. In this model, density represents the number of housing units per square mile. Housing density helps to characterize the community at large, including its opportunity for illegal dumping. Towns with a higher propensity to illegally dispose of wastes, such as high-density or low-density communities, are likely to have less demand for MSW disposal and recycling services.[9]

Chief among the policy variables is the price per unit of MSW disposed, P_{DISP}. Note that it enters the disposal demand function as own price and the recycling demand function as the price of a substitute service. Accordingly, in the disposal demand equation, P_{DISP} should negatively affect Q_{DISP}, and in recycling demand, P_{DISP} should positively affect Q_{REC}. The quantitative relationships between each of the two price responses are not necessarily offsetting, since a change in Q_{DISP} associated with a price change might arise from source reduction, illegal dumping, or recycling. Since illegal dumping is not observed, it cannot be directly measured. However, some inferences are possible by including Q_{REC} in the disposal demand equation as a control variable. In so doing, the response of Q_{DISP} to P_{DISP} can be measured holding Q_{REC} constant, which in turn captures any price-induced change in Q_{DISP} due to source reduction and/or illegal disposal.

More formally, this specification allows us to estimate both the direct effect of P_{DISP} on Q_{DISP} and the indirect effect of P_{DISP} on Q_{DISP}, where the latter operates through Q_{REC}, as theorized by Podolsky and Spiegel [1998]. We also can assess the nonprice influence of Q_{REC} on Q_{DISP}, which is expected to be negative due to the predicted substitutability between disposal and recycling, holding P_{DISP} constant. Lastly, because Q_{REC} is present in the Q_{DISP} equation, the model allows for an analogous assessment of direct and indirect effects with respect to other variables common to both functions, such as income and education.[10]

Another key policy variable is the availability of curbside recycling services, which is captured by the $Freq_{REC}$ variable in the Q_{DISP} demand equation. In Massachusetts, 78 percent of local communities have access to such services [Commonwealth of Massachusetts, December 20, 2000, 2-10]. Of interest is to determine if the frequency of curbside recycling services negatively influences the demand for disposal, as expected, and if so, to what extent. Kinnaman and Fullerton [2000] include a variable for curbside recycling in their disposal equation and find that it is insignificant in both their 2SLS and OLS specifications. For symmetry and completeness, we include $Freq_{DISP}$ in the recycling demand equation. Providing curbside disposal services is quite common in most municipalities. Yet, this service likely acts as a disincentive to recycling activity, so the expected qualitative effect of $Freq_{DISP}$ on Q_{REC} is also negative.[11]

Specific to the recycling demand equation is another policy variable, *Grant*. Like other states around the nation, the Commonwealth of Massachusetts tries to encourage recycling activity by providing funding for recycling equipment and educational materials, an effort that is to be continued under its new *Beyond 2000 Solid Waste Master Plan*. To date, the Commonwealth has awarded over $17 million in grant funding to 331 communities [Commonwealth of Massachusetts, December 20, 2000, 2-11]. If this effort has been successful, we should expect the *Grant* variable to positively influence recycling demand.

THE EMPIRICAL MODEL AND DATA

We estimate the two household demand equations for Q_{DISP} and Q_{REC} as a system. The empirical specification of this system is:

$$
\begin{aligned}
Q_{DISP} = \alpha_0 + \alpha_1 PersonH + \alpha_2 PersonH^2 + \alpha_3 Income + \\
\alpha_4 Educ + \alpha_5 Age + \alpha_6 Den + \alpha_7 Den^2 + \\
\alpha_8 P_{DISP} + \alpha_9 Freq_{REC} + \alpha_{10} Q_{REC} + \mu_1
\end{aligned} \tag{3}
$$

$$
\begin{aligned}
Q_{REC} = \beta_0 + \beta_1 PersonH + \beta_2 PersonH^2 + \beta_3 Income + \\
\beta_4 Educ + \beta_5 Educ^2 + \beta_6 Age + \beta_7 Den + \beta_8 Den^2 + \\
\beta_9 P_{DISP} + \beta_{10} Freq_{DISP} + \beta_{11} Grant + \mu_2
\end{aligned} \tag{4}
$$

where μ_1 and μ_2 represent the respective disturbance terms for each equation.

Note that in the model, *PersonH*, *Den*, and *Educ* (in the recycling equation), enter as quadratic terms, which is commonly done in the literature. Doing so allows the model to capture any nonlinearity in the effect of each of these variables on the respective quantity measures. We did attempt to include squared terms for other demand determinants, including *Educ* in the disposal equation, *Age*, and *Income*, but these efforts were unproductive, generating parameters that were not significant and giving overall weaker results.

The inclusion of Q_{REC} in the Q_{DISP} equation allows us to decompose the influence of P_{DISP} on disposal demand into its direct effect and indirect effect through Q_{REC}, as explained previously. This was the theoretical intent of Podolsky and Spiegel [1998], though they were unable to support the endogeneity of Q_{REC} in their model. Based on this specification, the price elasticity of disposal demand is measured as:

$$
\begin{aligned}
\varepsilon_{Q_{DISP}P_{DISP}} &= \left(\frac{dQ_{DISP}}{dP_{DISP}}\right)\left(\frac{P_{DISP}}{Q_{DISP}}\right) \\
&= \left(\frac{\partial Q_{DISP}}{\partial P_{DISP}}\right)\left(\frac{P_{DISP}}{Q_{DISP}}\right) + \left[\left(\frac{\partial Q_{DISP}}{\partial Q_{REC}}\right)\left(\frac{\partial Q_{REC}}{\partial P_{DISP}}\right)\right]\left(\frac{P_{DISP}}{Q_{DISP}}\right) \\
&= \alpha_8\left(\frac{P_{DISP}}{Q_{DISP}}\right) + \alpha_{10}\beta_9\left(\frac{P_{DISP}}{Q_{DISP}}\right) \\
&= (\alpha_8 + \alpha_{10}\beta_9)\left(\frac{P_{DISP}}{Q_{DISP}}\right)
\end{aligned} \tag{5}
$$

The first term in equation (5), $(\partial Q_{DISP} / \partial P_{DISP})(P_{DISP} / Q_{DISP})$, or $\alpha_8 (P_{DISP} / Q_{DISP})$, represents the direct effect of unit price changes on disposal demand, with recycling held constant. Consequently, this term captures any illegal disposal and/or source reduction activity that households engage in when faced with increases in the unit price level. The second term in the equation, $\left[(\partial Q_{DISP} / \partial Q_{REC})(\partial Q_{REC} / \partial P_{DISP})\right](P_{DISP} / Q_{DISP})$, or $\alpha_{10}\beta_9(P_{DISP}/Q_{DISP})$, is essentially derived from the reduced form equation for Q_{DISP}. It estimates the indirect effect of price on disposal demand, i.e., the change in disposal activity that arises from adjustments in recycling due to a change in the unit price level.[12] Note that without Q_{REC} in the Q_{DISP} function, the model could not discern what type of adjustment had occurred to give rise to an observed change in waste disposal.

Analogous decompositions are possible for other variables. For example, the education ($Educ$) elasticity of disposal demand is measured as

$$
\begin{aligned}
\varepsilon_{Q_{DISP}Educ} &= \left(\frac{dQ_{DISP}}{dEduc}\right)\left(\frac{Educ}{Q_{DISP}}\right) \\
&= \left(\frac{\partial Q_{DISP}}{\partial Educ}\right)\left(\frac{Educ}{Q_{DISP}}\right) + \left[\left(\frac{\partial Q_{DISP}}{\partial Q_{REC}}\right)\left(\frac{\partial Q_{REC}}{\partial Educ}\right)\right]\left(\frac{Educ}{Q_{DISP}}\right) \\
&= \alpha_4\left(\frac{Educ}{Q_{DISP}}\right) + \alpha_{10}\beta_4\left(\frac{Educ}{Q_{DISP}}\right) + 2\alpha_{10}\beta_5 Educ\left(\frac{Educ}{Q_{DISP}}\right) \\
&= (\alpha_4 + \alpha_{10}\beta_4 + 2\alpha_{10}\beta_5 Educ)\left(\frac{Educ}{Q_{DISP}}\right)
\end{aligned}
\tag{6}
$$

Here, the first term, $(\partial Q_{DISP}/\partial Educ)(Educ/Q_{DISP})$, or $\alpha_4(Educ/Q_{DISP})$, represents the sensitivity of disposal demand reacting directly to education changes, holding recycling constant. The second term, $(\partial Q_{DISP}/\partial Q_{REC})(\partial Q_{REC}/\partial Educ)(Educ/Q_{DISP})$, or $(\alpha_{10}\beta_4 + 2\alpha_{10}\beta_5 Educ)(Educ/Q_{DISP})$, is derived from the Q_{DISP} reduced-form equation. It estimates how changes in education influence recycling, which in turn affects disposal activity, i.e., an indirect effect.

The measures of quantity of MSW recycled per person, quantity of MSW disposed per person, unit pricing, and all other policy variables used in the estimation are formed from data obtained from the Massachusetts Department of Environmental Protection (DEP).[13] Variables for demographic and socio-economic measures are formed from 1990 census data [U.S. Department of Commerce, 1990; Horner, 1994]. All 351 Massachusetts cities and towns are included in the estimation. Descriptive statistics for each variable are provided in Table 2.

EMPIRICAL RESULTS AND INTERPRETATION

We use an instrumental variables procedure to obtain consistent parameter estimates, since each equation in the two-equation system is overidentified. A three-stage least squares (3SLS) approach is used to conduct the estimation in accordance with Zellner and Theil [1962]. The use of 3SLS implies rejection of the null hypothesis of zero correlation between the errors of the two demand equations and the absence of simultaneity, i.e., zero correlation between at least one explanatory variable and the error term in each equation.[14]

TABLE 2
Sample Statistics For MSW Variables

VARIABLE	MEAN (n = 351)	STANDARD DEVIATION
Q_{DISP}	0.6722	4.8911
Q_{REC}	0.1538	0.1118
P_{DISP}	1.1752	2.2863
$Freq_{DISP}$	1.8063	1.9617
$Freq_{REC}$	1.2564	1.5259
PersonH	2.6866	0.2319
Income	17.8392	5.1559
Educ	12.6160	5.0866
Age	35.2413	3.1381
Den	425.1032	835.9330
Grant	330.6515	1161.9500

NOTE: All annual policy variables are based on the state's fiscal year, which runs from July 1 to June 30.

In this model, we have effectively imposed correlation between one or more of the explanatory variables and the respective error terms because of the assumed endogeneity of P_{DISP}, $Freq_{REC}$, and $Freq_{DISP}$. Further, we anticipate cross-equation correlation of the errors because the demand for recycling and the demand for disposal are likely determined in part by common factors, some of which might be immeasurable [Maddala, 1977, 331; Pindyck and Rubinfeld, 1998, 359]. The results of the Hausman test bear this out [Hausman, 1978].[15]

Table 3 presents the parameter estimates for the two-equation demand system. Most of the results validate our expectations and are supported by existing literature. We begin by analyzing the results for the disposal demand, equation (3). From an overall perspective, we find that *PersonH*, $PersonH^2$, *Age*, $Freq_{REC}$, and $Q_{REC,}$ are statistically significant determinants of this demand function. Though the direct effect of P_{DISP} has the expected negative sign, it is not statistically significant. However, we do find that P_{DISP} indirectly affects disposal demand through its influence on recycling behavior and does so in a manner that is statistically significant.

The results show that the α_1 parameter on *PersonH* is negative and significant at the 5 percent level, which follows Jenkins [1993]. Also, the α_2 parameter on $PersonH^2$ is positive and significant at the 5 percent level. Holding recycling constant, these findings suggest that as household size grows, the quantity of disposal services demanded per capita decreases at a decreasing rate, which supports the findings of Podolsky and Spiegel [1998].[16] Because the estimated relationship is nonlinear, the implication is that very small and very large households tend to demand higher amounts of disposal services per capita. According to the α_1 and α_2 estimates, the point at which the quantity disposed would start to increase with household size is approximately 3 persons per household. Hence, there is an economizing effect up to that point.

We further find that the parameter on *Age*, α_5, is positive and significant at the 5 percent level. This indicates that, holding recycling constant, older individuals tend to have a greater demand for disposal services, which likely reflects rising consumption with age and hence increased waste generation. This is in keeping with the findings of Jenkins [1993]. We tried including a quadratic term for *Age* to test for a nonlinear relationship, but it was not significant, and its inclusion weakened the overall results.

TABLE 3
RESULTS OF 3SLS ESTIMATION OF THE DEMAND SYSTEM

Parameter	Variable	Estimate	Asymptotic Standard Error
	Disposal Demand Function		
α_0	Intercept	75.1816[b]	37.1128
α_1	*PersonH*	–57.2003[b]	26.2051
α_2	$PersonH^2$	9.9935[b]	4.8443
α_3	*Income*	0.0557	0.1227
α_4	*Educ*	0.0677	0.1265
α_5	*Age*	0.3237[b]	0.1603
α_6	*Den*	0.0021	0.0017
α_7	Den^2	–3.06E-7	2.522E-7
α_8	P_{DISP}	–0.1116	0.2331
α_9	$Freq_{REC}$	–1.9193[b]	0.9721
α_{10}	Q_{REC}	–31.3493[a]	8.3249
	Recycling Demand Function		
β_0	Intercept	1.1409[c]	0.5879
β_1	*PersonH*	–0.9773[b]	0.4184
β_2	$PersonH^2$	0.1736[b]	0.0780
β_3	*Income*	0.0025	0.0023
β_4	*Educ*	0.0165[a]	0.0057
β_5	$Educ^2$	–0.0004[c]	0.0002
β_6	*Age*	0.0058[b]	0.0026
β_7	*Den*	4.80E-5	3.60E-5
β_8	Den^2	–8.97E-9[c]	5.329E-9
β_9	P_{DISP}	0.0071[c]	0.0038
β_{10}	$Freq_{DISP}$	–0.0165	0.0127
β_{11}	*Grant*	8.121E-6	5.202E-6

a. significant at the .01 level, assuming a two-tailed test.
b. significant at the .05 level, assuming a two-tailed test.
c. significant at the .10 level, assuming a two-tailed test.
n = 351

Though the α_4 parameter on *Educ* is not statistically significant, we calculated the education elasticity values to assess the direct and indirect effects, as defined in equation (6). Interestingly, though the α_4 parameter is positive, the elasticity of disposal with respect to education is estimated to be negative, at –2.483. This is so because the indirect effect, estimated to be –3.752 is much larger than the direct effect, estimated at 1.270. Although we are unable to attribute statistical significance to these elasticity values, it is of interest to note that education might be negatively related to disposal because a more educated population tends to recycle more and hence dispose less. [17] The absence of statistical significance for education follows the findings of such researchers as Fullerton and Kinnaman [1996] and Hong and Adams [1999]. This outcome might be the result of collinearity among certain of the demographic variables, which is not an atypical problem in models of this type. We tried other specifications, including adding a quadratic term for *Educ* in the disposal equation, but no improvement was achieved.

We also do not find *Income* to be a significant determinant of disposal decisions. This, too, has been found in other research studies, such as Nestor and Podolsky [1998], for both curbside and offsite disposal, and Hong and Adams [1999]. In addition to collinearity among demographic variables, the lack of significance for *Income* might reflect the opposing influences of increased consumption and increased donation commonly linked to higher income levels, as noted previously.

Though not statistically significant, the algebraic signs of the town attributes measured through *Den* and Den^2 indicate that disposal demand increases at a decreasing rate with density, holding recycling constant. This suggests that sparsely populated communities, such as rural areas, and those that are very densely populated, such as urban areas, tend to be associated with lower disposal demand. Based on our quantitative estimates, the point at which disposal starts to decline with density occurs at 3,361 housing units per square mile. As suggested by Kinnaman and Fullerton [2000], such an outcome might reflect easier access to illegal dumping activities in rural and urban areas. Another possibility is that lower disposal in rural towns might reflect increased composting and other types of reuse activity, and lower disposal in urban areas might be linked to lower waste generation due to greater use of restaurants and other services outside the home.[18]

Notwithstanding the relative merits of socio-economic impacts on disposal demand, the most important findings are the policy results, specifically the parameters on P_{DISP} and $Freq_{REC}$. We begin with an analysis of the relationship between P_{DISP} and Q_{DISP}. First, using a one-tailed test, we observe that the joint parameter on P_{DISP}, $(\alpha_8 + \alpha_{10}\ \beta_9)$, is significant at the 10 percent level based on a standard error of 0.218. As stated in equation (5), the price elasticity of disposal demand is measured as $(\alpha_8 + \alpha_{10}\beta_9)(P_{DISP} / Q_{DISP})$, which is estimated to be –0.582. This magnitude supports the findings of other researchers, who also determine that disposal demand is price inelastic.[19] Table 4 presents this elasticity estimate and all key elasticity findings from the estimation.

In this model, we also can examine the two components of this elasticity, defined as $\alpha_8(P_{DISP} / Q_{DISP})$ and $\alpha_{10}\beta_9(P_{DISP} / Q_{DISP})$. According to the results, the estimate of the first component, $\alpha_8(P_{DISP}/Q_{DISP})$, evaluated at the point of means is –0.195, which represents the direct effect of price on disposal demand, holding recycling constant. This estimate is directly analogous to the estimate of –0.39 by Podolsky and Spiegel [1998], who explicitly hold recycling constant in their disposal demand equation. Assessing this –0.195 value from the point of means translates to an annual decline in disposal of about 2.62 pounds per person in direct response to a 1 percent rise in the unit price. However, the parameter on P_{DISP}, α_8, is not statistically significant in our model, which implies that the combination of illegal disposal and source reduction activities in direct response to price changes is not significantly different from zero. Hence, it might be the case that neither activity is present or that both activities are present but are statistically offsetting.

TABLE 4
ESTIMATED DISPOSAL AND RECYCLING DEMAND ELASTICITIES

Elasticity			Estimated Value
DISPOSAL			
	$\varepsilon_{Q_{DISP}P_{DISP}}$		–0.582
		direct effect	–0.195
		indirect effect	–0.387
	$\varepsilon_{Q_{DISP}Freq_{REC}}$		–3.588
RECYCLING			
	$\varepsilon_{Q_{REC}P_{DISP}}$		0.054
	$\varepsilon_{Q_{REC}Freq_{DISP}}$		–0.194
	$\varepsilon_{Q_{REC}Grant}$		0.017
	$\varepsilon_{Q_{REC}Educ}$		0.523

We further find that the second elasticity component, $\alpha_{10}\beta_9(P_{DISP}/Q_{DISP})$, which captures the indirect price effect, is estimated to be –0.387, with the parameter $(\alpha_{10}\beta_9)$ significant at the 10 percent level. This finding communicates that there is indeed a disposal response to unit price changes by Massachusetts communities, but the reaction operates through increased recycling. The specific magnitude, evaluated at the point of means, translates to an annual decline of about 5.2 pounds of disposal per person in response to a 1 percent price increase, which is quite reasonable.[20] To our knowledge, this response has not been measured heretofore in any MSW demand analysis, since no investigation has successfully decomposed the influence of unit price on disposal demand. Further, it is important to note that existing studies may seriously underestimate the price sensitivity of MSW disposal demand because of the assumption of price exogeneity, as pointed out by Kinnaman and Fullerton [2000].

Availability of curbside recycling services, measured through $Freq_{REC}$, is found to be a negative and significant determinant of disposal demand, as anticipated. Specifically, α_9 has an estimated value of –1.919 and is significant at the 5 percent level. This in turn suggests that if a municipality were to add one more pick up of recyclables per month, individuals would decrease disposal by 1.919 tons per year. Although this is a large magnitude, it bears noting that the mean value of $Freq_{REC}$ is 1.256. Hence, an increase of a single pick-up per month would represent an 80 percent increase in that service. As shown in Table 4, the relevant elasticity is estimated to be –3.588, which implies that a 1 percent increase in the average $Freq_{REC}$ for a given town would give rise to a 3.588 percent decline in disposal demand, or about 48.2 pounds per person each year.

Turning our attention to the recycling equation (4), we observe that *PersonH*, $PersonH^2$, *Educ*, $Educ^2$, *Age*, *Den*, Den^2, P_{DISP}, $Freq_{DISP}$, and *Grant* are found to be significant.[21] To provide some symmetry to the analysis, we begin again with an examination of the household characteristics.

Analogous to the disposal estimation, the parameters on *PersonH* and $PersonH^2$ in the recycling function, or β_1 and β_2 respectively, are statistically significant. Since β_1 is negative and β_2 is positive, the estimates imply that as household size increases, recycling demand decreases at a decreasing rate. The negative β_1 parameter is sensible, since Q_{REC} is measured on a per capita basis. As on the disposal side, the nonlinear relationship implies that very small and very large households tend to recycle more MSW per capita. This also suggests that waste generation is higher and or illegal disposal is lower for these groups. The specific values of β_1 and β_2 allow us to estimate that the point at which Q_{REC} starts to rise with household size is 3, analogous to the finding for disposal demand.

Unlike the results of the disposal estimation, we find that *Educ* is a significant determinant of recycling demand. We further find that the relationship between *Educ* and recycling demand is quadratic, suggesting that recycling per capita increases at a decreasing rate with *Educ*. The positive relationship supports the theory that more educated individuals tend to be more aware of the environmental risks of excess MSW disposal [Van Liere and Dunlap, 1980; Granzin and Olsen, 1991; Lansana, 1992; Smith, 1995]. The quadratic relationship suggests that the positive influence of education on recycling is not without limit and begins to diminish when the proportion of a town's residents with a baccalaureate education is greater than 21 percent.[22]

As noted in Table 4, the estimate of the education elasticity, $\varepsilon_{Q_{REC}Educ} = (\beta_4 + 2\beta_5 Educ)Educ / Q_{REC}$, is 0.523 evaluated at the point of means. This implies that the demand for recycling is relatively inelastic with respect to education. Specifically, for every 1 percentage increase in the education level of the town, recycling activity is expected to be higher by 0.523 percent, or 1.61 pounds per person each year.

Just as in the estimation of disposal demand, we find *Age* to be a significant determinant of recycling demand at the 5 percent level. Again, the parameter estimate is positive, which likely reflects increasing consumption and waste generation with age, and hence greater demand for all MSW services, including recycling. A specification including a quadratic term was tried, but the squared term was found to be insignificant.

We further find that the estimated parameter on *Income*, β_3, bears a positive sign. However, the lack of statistical significance suggests that recycling demand is independent of income. This is in keeping with other studies in the literature, such as Kinnaman and Fullerton [2000]. As to why this might be the case, it could be the result of the inherent collinearity of socio-economic variables, such as education and income. It is also possible that money income is simply not relevant to recycling decisions.

Moving on to town density, the β_7 and β_8 parameters on *Den* and Den^2, respectively, suggest that low- and high-density communities tend to engage in the least amount of recycling activity. This finding may be due to the greater access to illegal disposal locations available to residents in urban and rural areas. Other explanations are plausible, such as higher composting levels in rural areas, as discussed above. There might also be varying levels in environmental consciousness across these groups of communities.[23] In any case, using the specific values from the estimation, we find that recycling levels begin to decrease when density is approximately 2,676 housing units per square mile.

Worthy of note are the results for the three policy instruments included in the recycling equation, P_{DISP}, $Freq_{DISP}$, and *Grant*. This set of outcomes should prove very valuable to state and local public officials. Of particular interest is the finding that the β_9 parameter on P_{DISP} is positive, as expected, and significant at the 10 percent level. Its magnitude communicates that a 1 cent increase in the unit price per gallon will give rise to an increase of 0.007 tons, or 14 pounds, of recycling per person each year. Such a finding should help public officials justify the use of unit pricing programs to their constituents. The associated cross-price elasticity, $\varepsilon_{Q_{REC}P_{DISP}} = \beta_9(P_{DISP} / Q_{REC})$, evaluated at the mean equals 0.054. Its positive magnitude is sensible, given that disposal services and recycling services are hypothesized to be substitute goods. Moreover, the fact that its value is less than unity is in keeping with analogous estimates cited in the literature, such as U.S. EPA [1990], Fullerton and Kinnaman [1996], and Hong [1999]. The inelasticity might reflect the difficulty some residents have substituting recycling for disposal because of space considerations associated with recycling activity or the opportunity costs of associated tasks such as collection and storage.

With regard to frequency of curbside disposal services, the estimated β_{10} parameter of –0.017 is significant at the 10 percent level, using a one-tailed test. The negative sign is intuitively logical, and the quantitative magnitude implies that if a municipality offers one less curbside disposal pick up each month, recycling per person will increase by 0.017 tons or 34 pounds per year. Notice that the response is considerably smaller than the reaction to curbside recycling changes estimated in the disposal equation. The associated elasticity value, $\varepsilon_{Q_{REC}Freq_{DISP}} = \beta_{10}(Freq_{DISP} / Q_{REC})$,evaluated at the point of means is –0.194. Hence, a 10 percent decrease in the average frequency of curbside disposal services would give rise to a 1.94 percent rise in recycling activity.

The effect of grant awards on the demand for recycling services is significant at the 10 percent level, using a one-tailed test, and the β_{11} parameter bears the expected positive sign. This direct relationship implies that individuals in communities receiving recycling grant monies for education or equipment are recycling more waste each year than those who live in towns not funded by these grant awards. Because the *Grant* variable is defined relative to town population, it captures the relative influence of the award on the individual resident. Using the specific parameter estimates, we calculate the relevant elasticity as $\varepsilon_{Q_{REC}Grant} = \beta_{11}(Grant / Q_{REC})$, which in this case equals 0.017 evaluated at the point of means. This value indicates that a 10 percent increase in grant dollars awarded per 1,000 people in a town (or, equivalently, a 0.01 percent increase in grant dollars per capita), is expected to increase recycling by 0.52 pounds per person. Such a finding should be of particular value to state and local officials in establishing and implementing interjurisdictional grant programs.

CONCLUSIONS AND POLICY IMPLICATIONS

From a broad perspective, this research offers new findings on MSW disposal and recycling demand based on a systems approach, which heretofore has not been employed in this context. In so doing, we believe that the model specification and the empirical results offer important contributions to the growing literature in MSW demand analysis, which we hope will encourage further study. At the same time, our parameter estimates and associated demand elasticities have a practical application for state and local public officials who are designing and implementing MSW management programs and policies. Not only might the quantitative results aid in projecting the gains of MSW policy reform, but they also might help to communicate the expected benefits of policy to various constituencies.

With regard to the model specification employed in this study, two critical observations are worthy of note. First, the model explicitly acknowledges the endogeneity of the unit price level and the provision of both disposal and recycling curbside services. While endogeneity is addressed by Hong [1999] and by Kinnaman and Fullerton [2000], many other research studies have assumed otherwise, calling into question qualitative and quantitative demand findings in earlier literature. Consequently, more work is needed to determine the impact of this critical assumption in other contexts. Second, the model explicitly recognizes the close relationship between disposal and recycling decisions. The expected simultaneity results in cross-equation error correlation, which in turn necessitates a systems approach to estimating the model. This approach, coupled with the use of an intrastate data set of 351 municipalities, allows us to investigate responses to public policy instruments in a well-defined empirical context, which by construction improves the efficiency of the results.

Notwithstanding the value of our findings on socio-economic demand determinants, the most critical empirical results are those that directly address MSW policy. As others have suggested, though sometimes without statistical support, we find that disposal decisions are negatively related to changes in the unit price level and that recycling activity is positively related. However, because of our model's specification, we are able to distinguish those disposal decisions in *direct* response to price from those that arise as an *indirect* response to price through recycling activity. This distinction sheds new light on the important interaction of recycling and disposal, which is not totally unrelated to Hong's [1999] finding of a feedback effect between recycling and generation. Furthermore, because of the identification of a direct and indirect effect, we can make some inferences about source reduction and illegal disposal, though the absence of data on illegal disposal at the community level prevents any sweeping conclusions.

At the local level in Massachusetts, it appears that the primary disposal reaction to unit price changes comes about because of individual access to and participation in recycling as an alternative to disposal. Indeed, the parameter estimates in this model indicate that a 1 percent increase in unit pricing achieves an annual reduction of 5.2 pounds of waste disposed per person solely because individuals move toward the relatively cheaper substitute activity of recycling, though the exact disposition of the displaced disposal is not identifiable. To our knowledge, such a response has not previously been estimated in the literature, since no prior study has decomposed the effect of unit price on disposal demand. Perhaps other researchers can replicate this approach in other contexts to determine if similar findings are obtained.

In addition to investigating price sensitivity, we also find that a community's decision to offer curbside services has a significant influence on disposal and recycling demand. The empirical results provide evidence that the expected incentives do in fact operate. More curbside disposal services discourage recycling, and more curbside recycling services discourage disposal, validating the expected influence of opportunity costs on household MSW decisions. Again, this is practical information for local officials responsible for setting MSW policy and realizing MSW targets.

We further determine that the state's provision of community-based recycling grants provides an added incentive for residents to increase recycling activity. In Massachusetts, these monetary incentives operate through the funding of educational materials or investment in recycling equipment. Evidence of the effectiveness of these grant awards has a practical value to public officials in designing or reforming MSW grant programs. In fact, all the policy-related findings of this research provide support for implementing certain MSW initiatives, and the associated elasticities can help officials forecast expected results.

Beyond the policy implications of this analysis, the findings about density also are of interest and may even influence MSW program design in certain communities. Specifically, the results suggest that urban and rural communities are those in which lower levels of both disposal and recycling activities are observed. One argument is that these communities might be those where illegal dumping is more prevalent. This possibility has been suggested by other researchers but often has not been supported empirically. Alternative explanations are also possible. For example, rural areas might dispose and recycle less because their residents substitute composting for disposal more than those in others communities. In any case, officials in such communities might be motivated by the density findings to investigate the extent of such behavior as well as the potential for illegal dumping.

In sum, we hope that future research will replicate our approach and our specification to determine if these findings are observed in other contexts. In so doing, the accumulation of empirical evidence can help build consensus, which in turn should aid public officials in designing and implementing effective MSW policy.

NOTES

1. The 1998 Solid Waste Survey was funded by the Solid Waste Association of North America and the American Plastics Council. The findings corroborate those of a Duke University estimate of over 3,800 communities using unit pricing in 1998.
2. The Commonwealth of Massachusetts provides a relevant context for the empirical estimation because of its aggressive solid waste plan launched in 1990 [Commonwealth of Massachusetts, June 1990]. This plan defined waste management objectives for the subsequent ten-year period and outlined policies and strategies to achieve those goals. Recently, the state announced its new plan, *Beyond 2000 Solid Waste Master Plan – A New Framework,* to continue these efforts through the next decade [Commonwealth of Massachusetts, December 20, 2000]. Among the policies promoted by the state are "pay-as-you-throw" disposal programs, recycling grants, and education to improve recycling participation rates.
3. In a similar analysis, Hong and Adams [1999] investigate households' responses to unit pricing based on sample data from Portland, Oregon. Their results suggest that for a given container size, household MSW disposal and recycling demands respond predictably to unit price changes.
4. Unfortunately, Hong provides neither methodology nor standard errors for these reduced form estimates, so it is not known if these elasticities are statistically significant.
5. This result is much larger than the cross price elasticity of 0.073 reported in Fullerton and Kinnaman [1996] and lower than the 0.457 value reported by Hong [1999].
6. Regarding the conventional community characteristics such as income, education, and household size, Kinnaman and Fullerton [2000] obtain results that generally conform to the existing literature. However, the majority of the community variables they specify are not statistically significant in explaining either demand function.
7. Interestingly, Podolsky and Spiegel [1998] initially specified a system of simultaneous equations for disposal demand and recycling demand for their study. However, the results of the Hausman [1978] test did not support the assumed endogeneity of recycling in their model. The authors suggest that the structure of recycling programs in New Jersey may have contributed to this outcome. Specifically, the state had imposed mandatory recycling since 1987, and most communities in New Jersey offer curbside recycling services.
8. *Grant* is not specified as an endogenous variable, since grant monies are awarded based on a town's recycling performance in *prior* periods.
9. Kinnaman and Fullerton [2000] argue this point, suggesting that low-density communities, or more rural areas, have remote locations where illegal dumping may occur and that high-density towns, or urban communities, are those with greater access to commercial dumpsters, which would facilitate illegal dumping.
10. Hong [1999] uses a similar approach in estimating generation and recycling to allow for a determination of what he calls feedback effects across equations.
11. We attempted to include both frequency measures in both equations, but doing so made most of the corresponding parameters insignificant. This is likely due to the fact that $Freq_{REC}$ and $Freq_{DISP}$ are highly correlated.
12. See Podolsky and Spiegel [1998, 30] for a graphical depiction of these two effects.
13. We wish to express our appreciation to John Crisley and John Fischer at the Massachusetts DEP for their assistance in making these data available and for explaining the state's data collection methods and variable definitions. Specific data sources for the model are U.S. Department of Commerce [1990], Horner [1994], and Commonwealth of Massachusetts [1994; 1996; 1997; 1998; 1999; July 2000].
14. Though the parameter estimates from forming the instrumental variables, P_{DISP}, $Freq_{REC}$, and $Freq_{DISP}$, are not of particular interest, it is relevant to report that the overall fit of the equations is

acceptable. Adjusted R^2 statistics for the instrumental variables estimation of these variables are 0.488, 0.233, and 0.292, respectively. Specific parameter estimates are available from the authors upon request.

15. We apply the Hausman specification test to our use of 3SLS relative to OLS [Hausman, 1978]. The estimated test statistic, which is distributed as a χ^2 with 18 degrees of freedom, is 26.81 and is significant at the 10 percent level. Therefore, we reject the null hypothesis and conclude that there is significant contemporaneous cross-equation correlation in the simultaneous system. In such a case, ordinary least squares estimation of this model would be inefficient, and hence the use of 3SLS is warranted.
16. This same relationship obtains even if recycling is not held constant, though the resulting coefficients on *PersonH* and *PersonH*^{2} are smaller. This decrease in their values occurs because in determining $\partial Q_{DISP} / \partial PersonH$, the *PersonH* and *PersonH*^{2} parameters in the recycling equation are multiplied by α_{10}, which logically is negative.
17. For the indirect effect of education, i.e., $\alpha_{10}(\beta_4 + 2\beta_5 Educ)$, we find a standard error of 0.178, and for the combined effect of education, i.e., $\alpha_4 + \alpha_{10}(\beta_4 + 2\beta_5 Educ)$, the standard error is 0.192. These standard errors are calculated using the approximation formula suggested by Kmenta [1971].
18. We thank an anonymous referee for suggesting this latter possibility.
19. This calculation and other comparable standard errors subsequently given in this paper are based on the approximation formula suggested by Kmenta [1971]. Selected estimates of the price elasticity of disposal demand in the literature are as follows: Skumatz [1990], –0.14; Podolsky and Spiegel [1998], –0.39; and Kinnaman and Fullerton [2000], –0.28.
20. Although the results indicate that recycling triggers this disposal decline, we cannot identify the exact disposition of the MSW no longer being disposed due to the indirect effect. If generation is unchanged or increased by a feedback effect as suggested by Hong [1999], then the indirect effect would give rise to an increased amount of illegal disposal. If generation declines sufficiently, it is possible that illegal disposal is unchanged. However, because data on this elusive activity are not available, only inferences such as these are possible.
21. *Den, Freq*$_{DISP}$, and *Grant* are statistically significant using a one-tailed test. Note that their algebraic signs validate our hypothesis about the influence of each.
22. It should be noted that the quadratic relationship is significant only at the 10 percent level. At lower levels of significance, the estimated relationship between education and recycling becomes linear.
23. We thank an anonymous referee for suggesting the influence of this possibility.

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