January 1996

Garbage, Recycling, and Illicit Burning or Dumping

Thomas C. Kinnaman
Bucknell University, kinnaman@bucknell.edu

GARBAGE, RECYCLING, AND ECONOMIC INCENTIVES: THREE RELATED ESSAYS

THOMAS C. KINNAMAN
Bucknell University

INTRODUCTION

Rising land prices and new EPA regulations are largely responsible for the tripling over a six-year period of the average tipping fee paid to a landfill for accepting each ton of garbage from collectors (Steuteville and Goldstein, 1993). Several communities and private firms have responded to these economic pressures by implementing user fees for garbage collection. These towns employ user fees not only to collect additional revenue, but to reduce their direct costs and external costs from using landfills and incinerators. State legislation in Minnesota and Washington require all communities in these states to implement user fees.

User fees require households to pay an incremental amount for each bag of garbage generated. Households must either use specially marked municipal trash bags or purchase special stickers to attach to their own garbage container. In response to these fees, households might recycle more, compost more, and adjust purchasing habits. However, households might also burn paper in fireplaces and carry trash to commercial dumpsters, back woods, and vacant lots. The desirability of unit-pricing depends crucially on the extent of each such method of garbage reduction. The price-per-bag might also induce households to compact their garbage into fewer bags. This practice was noticed when Seattle started one of the first user fee programs. The "Seattle Stomp" is not helpful, since collectors compact the garbage anyway.

This dissertation is comprised of three related essays, all examining issues related to a user fee for residential garbage collection. The first essay solves for the efficient value of a user fee in a model where both legal and illegal garbage disposal emit separate negative externalities. The second essay uses original garbage and recycling data gathered from individual households before and after a user fee was implemented in Charlottesville, Virginia. The third essay develops a utility maximizing model of household choice between disposal methods which is estimated using original data from 200 communities across the nation that have implemented a unit-based pricing program and from 1000 communities without such a program.

ESSAY #1: A THEORETICAL MODEL

Should garbage be taxed to reflect its negative externality, or subsidized to avert illicit dumping? Maybe recycling should be subsidized. If not, could the same effect be achieved by a tax on virgin materials? What is the role for deposits on purchases with refunds on returns?

To address these questions, a simple theoretical general equilibrium model of household choice is developed. Households choose between consumption and leisure, and among three disposal options: garbage, recycling, and illicit burning or dumping. A single consumption good is produced using a single primary factor, recycled input, and virgin materials such as timber or minerals. The model also includes three externalities. First, municipal garbage collection and disposal may impose aesthetic and health costs on those who live near the landfill or incinerator.

Second, improper burning and dumping may impose even higher costs on others. Third, the extraction of virgin materials involves clear-cutting or strip-mining that may adversely affect not only the landowner who sells the timber or mineral rights, but others who enjoy wilderness.[1]

When all tax instruments are available, the first-best solution can be achieved by waste-end taxes on garbage and on illicit dumping. Not surprisingly, these two tax rates just reflect the corresponding externalities. Suppose, however, that a tax on illicit dumping is difficult or impossible to enforce. Does this mean that the first-best can no longer be supported? No. In general equilibrium, only relative prices matter -- and therefore any tax can be set equal to zero as long as taxes on all other relevant activities are adjusted so as to induce first-best relative prices. Several points follow directly from this general equilibrium insight.

First, if illegal dumping is a choice to the consumer, and the tax on illegal dumping is restricted to be zero, then the first-best conditions can still be attained. Consumption must be taxed, recycling must be subsidized, and the optimal tax on garbage can be positive or negative. Garbage is taxed to reflect its own externality, but is subsidized to discourage illegal dumping. The direction of the tax depends on which of these competing forces is greater. In general, the tax depends on the relative ease of burning versus garbage collection. It may also depend on the consumer's willingness to break the law.

Second, if the optimal tax on garbage is negative, and is close to the direct resource cost of collecting garbage, then free garbage collection is quite sensible. Even if the optimal price tax is near zero, then the city or county can save administrative and billing costs involved with implementing a user fee by providing free garbage collection. Combined with a subsidy for recycling, the net effect of free garbage collection is a tax on illicit burning, circumventing the problem that burning could not be taxed directly.

Third, only if we ignore the possibility of illicit burning or dumping is the optimal user fee unambiguously positive. Consumers should pay a user fee on garbage to cover both the resource cost of labor, capital, and landfill, and the negative externality from garbage. The tax increases with the size of the externality and with the number of people adversely affected. No consumption tax or recycling subsidy required for private behavior to yield the social optimum.

Fourth, this subsidy for legal garbage disposal tends to subsidize consumption since it lowers the cost of waste disposal. Therefore, to restore the proper relative prices in general equilibrium, a tax on consumption is required. This result addresses a debate in the literature about whether optimal fees would be imposed "upstream" at the point of production, or "downstream" at the point of disposal.[2] In our model, if the downstream tax on illicit dumping cannot be enforced, the same first-best can be achieved using an upstream tax instead. Consumption should be taxed at a rate that reflects not the good's disposal cost, but its possible externality from illicit burning or dumping. This tax is then returned as a subsidy on recycling and on proper disposal of garbage, leaving an implicit tax on burning or dumping. The result is a deposit-refund system, but it applies to all consumption goods rather than just bottles.

ESSAY #2: A COLLECTION OF HOUSEHOLD DATA

This paper employs individual household data to estimate the effect a user fee on the weight of garbage, the volume of garbage, the density of garbage, and the weight of recycling.

The data are based on a natural experiment that provides a unique opportunity to study human behavior in response to a change in price. In Virginia, on July 1, 1992, the City of Charlottesville began charging $.80 per 32-gallon bag of residential garbage collected curbside.[3]

Each household's garbage and recyclable materials were weighed each week over four weeks in late May and early June before the implementation of the unit-pricing program, and again over four weeks in September following its implementation. Garbage was not weighed during the week following Memorial day, to avoid the extra garbage that can be generated over the three-day holiday weekend. We skipped July and August in order to avoid vacation weeks, and to provide a short adjustment period. We also counted the number of cans of garbage presented by each household each week. Measuring volume presents certain difficulties, as households used different-sized plastic bags or boxes as containers. Counting a small plastic kitchen bag or box as one can would not be appropriate. Therefore, we approximated a household's garbage by the number of 32-gallon containers it would have filled. Following the measurement period, each household was sent a questionnaire with a self-addressed stamped envelope. Completed questionnaires reported each household's demographic statistics such as household size, ages, race, income, marital status, education, and other information that could be expected to influence the generation of garbage or recyclable materials

In response to the user fee, the average person living in these households (1) reduced the weight of garbage from 10.89 pounds per week to 9.37 pounds per week, (2) reduced the volume of garbage from 0.73 containers per week to 0.46 containers, (3) increased the density of garbage from 14.79 pounds per container to 19.48 pounds per container, and (4) increased the weight of recyclable material presented for collection from 3.69 pounds per week to 4.27 pounds per week.[4] Also, we estimate that increased illegal disposal accounts for 0.42 pounds per week per person in Charlottesville, or 28 percent of the total reduction in garbage.

Other interesting relationships were uncovered by the data. Owner-occupied households presented 4.41 more pounds per person than renters did, households with individuals who work full-time presented 5.32 fewer pounds of garbage each week, and households with retired persons presented less garbage weight than others. An increase in household size from 2 to 3 is found to reduce weight of garbage by 2.44 pounds per person, while an increase in household size from 5 to 6 is found to reduce garbage weight by only 0.97 pounds per person. The relationship between garbage and income is positive but weak. In terms of density of garbage, households with infants presented garbage that weighed 11.55 more pounds per can than did others. (As those who are parents know, wet disposable diapers are rolled into dense ball, held with tape, before disposal.)

The possibility of increases in illegal forms of garbage disposal have worried policymakers who have considered unit-pricing in their communities. Using two criteria, the amount of illegal dumping that took place in Charlottesville during the period of the experiment is estimated. Illegal dumping is suspected only if (a) the household indicated in the questionnaire that "other" means were used to reduce garbage, and (b) the amount of garbage presented for collection fell to zero for the entire four-week measurement period following implementation of unit-pricing. If the number of bags presented for collection decreased from 3 in May to 2 in September, then the household may have found a legal form of "other" disposal such as the use of an in-sink garbage disposal. However, if the number of bags fell from 3 to 0, then we suspect more strongly that illegal dumping has occurred. If a person goes to the trouble of transporting

trash to a commercial dumpster, he will probably take the entire week's store of trash rather than one bag.

Based on the above criteria, it is estimated that 5.33 percent of households disposed of garbage in some illegal fashion. To estimate the amount of illegal dumping, the increase in recycling plus the estimated increase in composting is subtracted from the weight of garbage before implementation of the user fee. It is estimated that households dumped an average of 13.38 pounds per person per week. Given the sample size, the implication is that unit-pricing induced an additional 0.42 pounds per person per week of illegal dumping in Charlottesville. Furthermore, this estimate constitutes 28 percent of the total reduction in garbage at the curb. For comparison, additional recycling constitutes 38 percent of the total reduction in garbage. Thus households may have increased dumping by almost as much as they increased recycling! The remaining 34 percent of the total reduction in garbage could be explained by additional composting, less packaging demanded at stores, additional recycling at drop-off locations, or even additional illegal dumping.

The social costs can vary over methods of illegal dumping. For example, if a person takes the weekly garbage to a commercial dumpster where he is employed, and has permission from his employer, the social costs could be quite low. However, if this individual throws his garbage along a rural route or burns it in his back yard, the social cost could be quite large. Unfortunately, the data do not identify what kind of "other" methods were used by households in the study.

ESSAY #3: A NATIONAL STUDY OF GARBAGE USER FEES

This paper uses original data gathered from a cross-section of communities across the country that have and have not implemented user fees for garbage collection to estimate the impact a user fee has on the aggregate quantity of data. A local government's choice about whether to implement a user fee is assumed to be endogenous. Previous studies may have provided a biased estimate of the reduction in garbage and increase in recycling attributable to a user fee by using a self-selected sample of only communities that have experienced large reductions in garbage. The selection bias is corrected for by applying the Heckman Two-Step procedure. First, the probability that a local government implements a user fee for garbage collection is estimated. Second, aggregate garbage and recycling quantities are separately regressed on the on the user fee, a set of exogenous variables, and the inverse-Mills ratio generated from the first stage.

Kinnaman and Fullerton (1995a) find that the quantity of garbage and recycling produced by a community are functions of (1) the communities taste for the environment, (2) the availability of dumping grounds, (3) the distribution of income in the community, (4) the market price of recyclable materials, and (5) the presence of a curbside recycling program. Local laws requiring all households to recycle, state laws prohibiting yardwaste from entering landfills, and mandatory deposit-refund system for certain types of drink containers may also affect a community's garbage and recycling quantities.

The probability that a local government implements a user fee is assumed to increase with the social benefits of a user fee and decrease with the social costs. The primary social benefit is

the value of less garbage. Social costs arise from additional dumping and the value of resources used to administer the user fee. Specifically, the likelihood that a community implements a user fee for garbage collection is assumed to be a function of the tipping fee (the price of disposing garbage), the market price of recyclable material, the communities taste for the environment, per-capita income, the population density (very high or very low densities could provide many places for illegal dumping), and the administrative costs of implementing and operating a user fee. Administrative costs are proxied in the data by a dummy variable which indicates whether garbage collection is conducted by the municipality or a private but regulated firm. Private firms may be more efficient at administering the program and may therefore face lower administrative costs.

The legal environment can also play a role. Some states, California for example, require all communities within their jurisdiction to recycle a certain fraction of their waste. Communities located within these states may be more likely to implement a user fee in order to meet the state recycling quota. Other states restrict a communities ability to increase property taxes. Communities in these state that face budgetary pressures may be more likely to turn to user fees instead of property taxes to finance operations.

Data is gathered from four different sources. The first and most important source is an original data set collected from almost 200 communities that have implemented user fees. Solid waste officials from each of these communities were contacted personally, and information was gathered from each through a telephone interview. The second source of data was provided by the International City Managers Association (ICMA). This organization sent a questionnaire to over 4,000 communities across the United States and over 1,000 of these communities responded. Third, demographic characteristics and per-capita income for each community through the 1990 U.S. Census report. Fourth, the local tipping fee for each community and all other state regulations expected to affect local government choice were obtained from *Biocycle Magazine's* annual survey (Steuteville and Goldstein, 1993).

The results of the regressions are as follows.[5] The probability that a community in our sample implements a user fee is estimated to increase with the percentage of owner occupied homes, to increase with the population density up to 5,497 persons per square mile (and then decreases), and decreases with income. One explanation for the negative coefficient on income is that communities that use property taxes to pay for garbage collection enable their residents to deduct those local taxes against federal income tax. User fees are not deductible. Communities with high per-capita incomes have more residents that face high marginal tax rates. A switch to a user fee would be more costly to high per-capita income communities in terms of lost deductions.

The probability of a community employing user fees is also estimated to increase with the price received for removal of recyclable materials, to increase with the probability that a community has implemented a curbside recycling program, and to decrease with the tipping fee. Casual observation and much of the previous literature attribute the recent popularity of user fees to higher tipping fees. These data do not support such claims.

As predicted, communities that do not franchise or contract the collection service to a single private firm are less likely to implement a user fee for garbage collection. The administrative costs of operating a user fee may be lower for private firms than for a less efficient government agency, making a user fee program more attractive to these communities. Also as

predicted, (1) communities that face such state recycling quotas are more likely to implement user fees for garbage collection, and (2) communities with household recycling laws are less likely to implement user fees. Our results do not, however, substantiate this hypothesis that communities facing a legal constraint on raising property taxes will be more likely to implement a user fee. These data suggests the opposite. Perhaps these communities are located in states with low preferences for any taxes or government functions.

The quantity of garbage is estimated to decrease with the user fee. In addition, the coefficient on the Inverse Mills ratio is negative which would support the theory that communities expecting a greater reduction in garbage are more likely to implement a user fee. However, this coefficient is not significant. Either local governments are not concerned with the expected reduction in garbage resulting from a user fee or they are bad at estimating it.

POLICY ISSUES

A community may be interested in the amount of revenue it could earn with a unit-pricing program. These revenues could be used to finance recycling collection programs and to pay tipping fees. Based on our results, at mean values for Charlottesville, the additional revenue would be $0.86 per single-family household per week. Several economic arguments favor unit-charges for garbage as a source of revenue. First, such charges can help reduce the city's garbage and thus its expenditures on disposal. Second, garbage collection and disposal is not a "public good". Each bag incurs additional cost (rival), and collection can be limited to those with paid stickers (excludable). Third, the "benefit principle" suggests that such charges are "fair", since each household pays only according to its use of this service. Fourth, we find that the demand for garbage is inelastic. Established optimal tax theories suggest that the total dead-weight loss to an economy can be reduced by taxing goods with inelastic demand.

Other arguments can be made against this type of taxation. First, administrative and enforcement costs may be higher than for other sources of revenue. Second, the social cost of non-compliance can be large. Illegal dumping could require costly cleanups of backwoods dump sites. Third, our results suggest the tax on garbage is regressive. With unit-pricing, the volume of garbage varies from 0.55 containers per person for the lowest income group to 0.46 containers per person for the highest income group. Thus high-income households would pay a lower fraction of their income in garbage fees. Fourth, communities that use property taxes to pay for garbage collection enable their residents to deduct those local taxes against their federal income tax. Depending on the number who itemize, and their marginal tax rates, this deduction can pass to the federal government up to 30 percent of the cost of this local public service. If the community switches to unit-pricing, it loses a federal subsidy on this portion of revenue.

A program of user fees imposes both costs and benefits to a community. What are the social benefits to Charlottesville of a unit-pricing program? Repetto et al (1992) find that the social marginal cost of an additional cost of garbage for a town like Charlottesville is $1.03 per bag. Thus a price of zero generates too much garbage, and the Charlottesville price of $.80/bag is estimated to provide a welfare gain of $3.14 per person per year.[6]

Unit-pricing also imposes several types of costs, mostly administrative and enforcement costs. The municipality must (1) pay to print and distribute the stickers to area merchants, (2)

pay to enforce laws against illegal dumpers, (3) pay to clean up illegal dump sites, and (4) pay to promote the program. Additional costs to the household arise from (5) traveling to outlets that sell the garbage stickers, (6) spending time and effort to compact more garbage into each container, and (7) spending time and effort to dump their garbage. Further costs to private business include (8) locking dumpsters and (9) paying to remove garbage that has been dumped on their property. These costs are difficult to quantify, but must not exceed $0.13 per bag ($3.14 per person per year/52 weeks per year/0.46 bags presented per week) if a user fee program is to be beneficial to a community. The City of Charlottesville twice purchased stickers from the printer at a cost of at least 13 cents per sticker and pays for two part time positions in order to administer the user fee program. It is not evident that a user fee is beneficial to Charlottesville.

CONCLUSION

User fees for garbage collection have become a popular method for local governments to finance garbage collection and disposal costs. Because user fees affect the quantities of garbage and litter produced by a community, and because garbage and litter impose social costs on society, user fees are worthy of economic attention. The economic literature has emphasized the many benefits of these programs and have been nearly unanimous in their recommendation of user fees for all communities in the United States. The major contribution of this dissertation was to draw attention to an important cost of user fees programs: illegal dumping. The first essay provides a better policy alternative for a community that fears illegal dumping. The second essay estimates the quantity of illegal dumping experienced in Charlottesville following the implementation of a user fee. Another contribution of this dissertation was the collection and presentation of new sources of data. The second essay was based on the first ever set of garbage and recycling data collected from individual households. The data set collected for the third essay was the largest and most comprehensive of its kind. A third contribution of this dissertation was to treat the decision over whether to implement a user fee to as endogenous to the empirical model. Previous estimates of the effect of a user fee on aggregate garbage and recycling totals could be biased.

ENDNOTES

[1] See Fullerton and Kinnaman (1995a) for a detailed description of the model and its conclusions.

[2] Wertz (1976) finds that a (downstream) per-unit garbage fee raises the effective purchase price of goods with high disposal content. Menell (1990) suggests retail disposal-content charges that reflect the subsequent disposal cost of each item. Sigman (1991) finds that a tax on virgin lead is equivalent to a deposit-refund system, when virgin lead and recycled lead are perfect substitutes in production. The pros and cons of alternative policies are nicely described in some of these papers, as well as in Miedema (1983) and Project 88 -- Round II (1991).

[3] See Fullerton and Kinnaman (1995b) for a careful description of the data gathering process and a more thorough description of the results.

[4] The implied arc-price elasticity of demand is -0.076 at mean levels of price and weight. Using aggregate data, others have estimated the price-elasticity to be -0.12 (Jenkins, 1991), -0.15 (Wertz, 1976), -0.26 and -0.22 (Morris and Byrd, 1990), and -0.14 (Skumatz and Breckinridge, 1990). The cross-price elasticity of recycling with respect to a change in the price is estimated to be 0.073 at mean levels.

[5] See Kinnaman and Fullerton (1995b) for specific estimation results and standard errors.

[6] We ignore the benefits of additional recycling and composting. The price of recyclables is near zero or less than zero for most types of material. See Baumol (1977) for a good discussion of the possible costs and benefits to recycling.

REFERENCES

Baumol, William J. "On Recycling as a Moot Environmental Issue." *Journal of Environmental Economics and Management* 4 (1977): 83-87.

Fullerton, Don and Kinnaman, Thomas C. "Garbage, Recycling, and Illicit Burning or Dumping." *Journal of Environmental Economics and Management* 29 (1995a): 78-91.

Fullerton, Don and Kinnaman, Thomas C. "Household Responses to Pricing Garbage by the Bag." mimeo, Bucknell University Department of Economics, 1995b.

Jenkins, Robin "Municipal Demand for Solid Waste Disposal Services: The Impact of User Fees." mimeo, University of Maryland (1991).

Kinnaman, Thomas C. and Fullerton, Don. "How a Fee Per-Unit Garbage Affects Aggregate Recycling In a Model with Heterogeneous Households." In Public Economics and the Environment in an Imperfect World. Boston: Kluwer Publishers, 1995a.

Kinnaman, Thomas C. and Fullerton, Don. "Garbage and Recycling in Cities with Unit-Based Pricing." mimeo, Bucknell University Department of Economics, 1995b.

Menell, Peter S. "Beyond the Throwaway Society: An incentive approach to Regulating Municipal Solid Waste." *Ecology Law Quarterly* 17 (1990): 655-739.

Miedema, Allen K. "Fundamental Economic Comparisons of Solid Waste Policy Options." *Resource Energy* 5 (1983): 21-43.

Morris Glenn E. and Byrd, Denise "The Effects of Weight or Volume-Based Pricing on Solid Waste Management." prepared for the U.S. EPA (1990).

Project 88--Round II. *A Public Policy Study Sponsored by Senator Timothy E. Wirth and Senator John Heinz.* Directed by Robert N. Stavins, Washington D.C., 1991.

Repetto, Robert, Dower, Roger C., Jenkins, Robin, and Geoghegan, Jacqueline. "Green Fees: How a Tax Shift Can Work for the Environment and the Economy". Washington DC: World Resource Institute (1992).

Sigman, Hillary "A Comparison of Public Policies for Lead Recycling." mimeo, UCLA Department of Economics, 1991.

Skumatz, Lisa and Breckinridge, Cabell "Variable Rates In Solid Waste." In Handbook for Solid Waste Officials, Volume 2, EPA 530-SW-90-084B, Washington D.C., 1990.

Steuteville, Robert and Goldstein, Nora "State of Garbage in America, 1993 Nationwide Survey." *Biocycle* 34, No. 5 (1993): 42-50.

Wertz, Kenneth L. "Economic Factors Influencing Households' Production of Refuse." *Journal of Environmental Economics and Management* 2 (1976): 263-272.