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Household Waste Management in a Swedish Municipality: Determinants of Waste Disposal, Recycling and Composting[1]

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Abstract. This paper analyzes waste disposal, recycling and composting in a municipality in southwest Sweden. In 1994, Varberg introduced a weight-based billing system for household waste charging 1 kr/kg of waste and at the same time recycling centers were set up and a "green shopping" campaign was launched. This led to a significant reduction in waste collected and increased recycling. This study had access to actual measured data on waste disposal at the household level for a residential area called Tvååker, in addition to survey data for the same households. This makes it possible to carry out a more reliable and more detailed analysis than has been previously possible, particularly with respect to attitudinal variables. The most important determinants of each individual household's waste were composting of kitchen waste, living area, age and attitudes concerning the difficulty of recycling various materials. Separate sections look at composting behaviour, at willingness to pay for sound waste management and for the sake of comparison three other municipalities are also studied. The main finding is that economic incentives, although important, are not the only driving force behind the observed reduction in municipal waste: Given the proper infrastructure that facilitates recycling, people are willing to invest more time than can be motivated purely by savings on their waste management bill.

Key words: waste management, recycling, incentives

JEL classification: D12, H31, Q20

1. Introduction

The management of solid waste from households is important for various reasons. One of these is that landfill space is becoming a scarce resource in many countries. More profound is perhaps the concern for ecological damage from hazardous components in the waste collected by the municipality will not automatically alleviate the concern about the spread of hazardous waste into the environment. To the contrary: thoughtless construction of waste handling tariffs might even have the effect of encouraging illicit dumping, burning or other improper disposal: see for instance Fullerton and Kinnaman (1995).

This study focuses on the determinants of total household waste and the effects of unit price payments combined with better access to recycling possibilities. One

of the difficulties encountered by most studies in this field is that they are forced to make do with self-reported data. In Varberg and a number of other Swedish municipalities a new system of waste-handling and rates is being tested that is based on the weight of the garbage. The garbage disposal van weighs the dustbins which have microchips for identification. The weights are used for billing. In this study we have given access to the actual individual weights for the residents of Tvååker, a residential area just outside Varberg, during a year with identification making it possible to send surveys to the same residents and match the answers with the actual amounts of waste delivered.

2. Earlier Research

The number of studies analyzing household waste generation is too large to discuss here. The interested reader can consult Goddard (1995) for an extensive survey. Most of the studies available rely explicitly or implicitly on utility theory of the consumer or household production theory to derive a demand function for solid waste management services. Most empirical studies use models that emphasize socio-demographic factors. Not too many studies have made much use of disposal charge since these have until recently not been very common but there are some exceptions.[2]

In an early study Wertz (1976) estimated the responsiveness of consumers to disposal charges for Solid Waste Services (SWS) by comparing two data points from 1970; the per capita quantity of waste disposed in a city that employed user prices and the per capita quantity of waste in the rest of the cities in the USA (representing non-unit pricing cities). He then calculated a price elasticity of demand equal to –0.15, that is, unit prices seem to have a substantial negative effect on the waste discarded. He also collected cross-sectional data for 10 suburbs of Detroit and estimated a model relating waste collected per capita to annual income per capita. The estimates of income elasticity were about 0.3.

Jenkins (1993) has developed a model where households maximize utility which depends positively on the quantity of goods consumed and negatively on the amount of recycling. Included in the household budget constraint is a disposal charge for SWS. Other variables that affect the demand for SWS are: the household income, the prices of goods consumed, the payment for recycled items, the size and age distribution of the household, weather conditions and the degree of urbanization. She empirically tested the resulting demand equation for data from nine communities in the USA. Five of these had a volume-based fee and the other four had the usual flat fee system.

The model relates the average quantity of household waste discarded per capita per month in an area to the averages of the variables above. Income, high temperature, percentage of population aged 18 to 49 and population density all had a positive effect on quantity of waste discarded. The price for SWS, average household size and the price of recycled paper had negative effects. The price elasticity[3]

of demand for SWS is calculated as –0.12 and the welfare loss of not using unit pricing for an average US community to be about $125 per ton.

Hong et al. (1993) derived a household recycling choice model and a demand function for SWS and estimated these for a sample of households from the Portland, Oregon metropolitan area. Disposal fees are based on a block payment schedule for pickup of a specific volume at a given time interval. The demand for waste collection services is assumed to be a function of the incremental fee associated with contracting an additional bin for waste disposal and the opportunity cost of sorting waste into recyclables and non-recyclables, here equal to the female wage rate. The number of persons per household, education level, race and rent or ownership of their house was also assumed to influence the demand for SWS. The results indicate a positive but small relation between an increased payment difference and the demand for the quantity of waste collected. The effect of income is also positive and significant but the relationship is inelastic. Of the other variables only the value of time and the education level were found significant.

Miranda et al. (1994) examined the changes in household waste production behavior upon implementation of unit-pricing systems. They used data collected from 21 cities through the USA over a 18-month period. The results show that unit-pricing and recycling-programs can have a dramatic effect on solid waste flows.

Morris and Holthausen (1994)[4] estimated a household production model of solid waste management and implemented a simplified version using data on household expenditures and waste flows in Perkasie in two periods. Period one represents conditions and outcomes of household production choice with a fixed fee. Period two represents conditions and outcomes when the household pays for waste management by volume or weight and receives curbside recycling service at no additional charge. They estimated price elasticities of –0.51 to –0.60 and a Hicks' compensation required by the household to offset benefits of a simultaneous change to unit pricing, curbside recycling and once-a-week collection of $117 per year.

Reading the above we find that not too many studies include many attitudinal variables and not too many have access to detailed individual data on actual waste flows. Outside economics there are however a couple of relevant studies that have looked specifically at attitude and habit formation: Gamba and Oskamp (1994) are psychologists and have concentrated on attitudes, showing that concern for the environment, social pressure and knowledge are important positive determinants of recycling while personal inconvenience is a strong negative determinant. Ronis et al. (1989) find empirical evidence that there are two stages of importance in habit formation with respect to composting and recycling: that of initiation and that of persistence. This finding is corroborated by Åberg et al. (1996) studying composting behaviour in a suburb of Gothenburg.

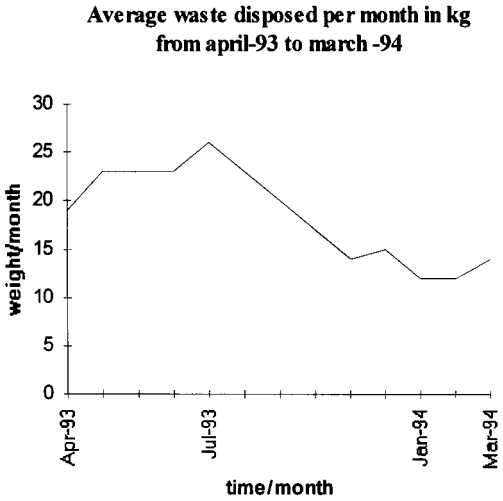

Figure 1. Waste disposal in Tvååker.

3. A Survey in Tvååker

In 1994, Varberg introduced a weight-based billing system for household waste charging 1 kr/kg of waste and at the same time a green shopping campaign was launched in the stores. The fee was actually 1.25 with VAT and has been raised to 1.31 SEK per kg waste, with a minimum yearly fee of 300 SEK As a complement to the disposal fee there is a free curbside collection of recycled paper and glass, and the possibility of leaving other material fractions at a recycling center nearby. The households themselves have now the responsibility of taking the bin to the curbside for the solid waste truck to pick up. If there is no bin outside, the truck just passes by and there is no fee for the households to pay. On average the yearly fee has been reduced by about 230 SEK, and the average waste per household has declined by 35%.

A mail questionnaire was sent (in August 1994) to each of nearly 600 households in Tvååker where all houses are single-family homes. The response rate was approximately 76% after two reminders. The main attraction of carrying out the study in Tvååker was that we had access to the actual quantity of household waste as measured by the weighing and billing system. These data for each household, between April 1993 and March 1994, were provided by the local authorities. We could thus in this study assess the effects of attitudes, income and other variables on actual behaviour as opposed to other questionnaires which are forced to make do with self-reported behaviour.[5]

We did however also include various self-reporting questions concerning recycling and a question on Willingness To Pay for environmentally sound waste management without any work by the respondent. Responses to the mail question-

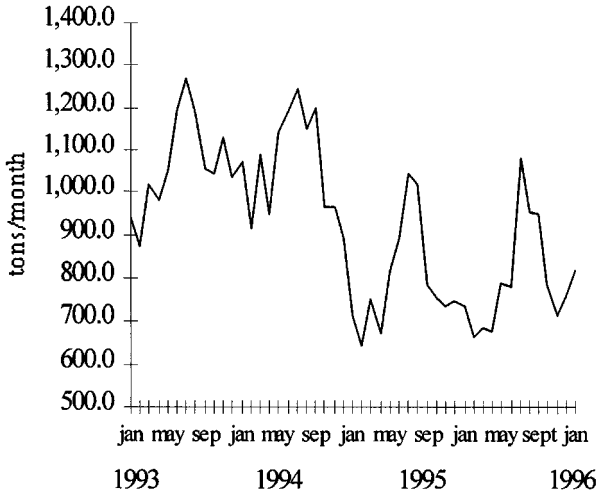

Figure 2. Waste disposal in Varberg.

naire also reflect attitudes concerning recycling, environmental issues and waste handling in general.

Figure 1 shows the average waste disposed of in Tvååker during the year when weight-based charges were introduced (smoothed using a three-month moving average). There is a significant decrease in waste disposed, which is much stronger if one starts comparing from 1992[6] when the average was bout 25% higher but this is masked by seasonal variation.

The data for the whole of Varberg in Figure 2 are more complete and up-to-date. The effect of weight-based payment is clearly visible after January 1995. When seasonal effects are removed we found an effective, once and for all, decrease by 29% or 300 tons/month. In the two years after that there is a discernible but very small (12 tons/month or 1%) increase again; see Ljunge (1997) for more details.

To explain individual behavior we turn to our sample (see Table I) which shows summary statistics; the variables were coded as 1–4, 0–1 or 1–3 depending on the number of alternatives. We see that total waste for the year averaged 242 kg but could actually vary from 6 to 914 kg! Turning to attitudes, 68% thought that environmental problems were very important (value "1"), 28% thought they were important (value "2") and 4% had a "3" for little or no importance, giving a "mean"[7] of 1.36.

On average people claimed that they were composting 75% of their garden waste and 60% of their kitchen waste. 11% did not do any composting at all. The majority of the respondents gave as reason for this: lack of space or that they had not yet bought the necessary equipment, but were planning to do so. The mean figures for recycling are very high. People claim to be recycling about 90% of their glass, paper, batteries and even hazardous waste. At least the latter is surprisingly high and not generally supported by the quantities actually collected.

Table I. Characteristics of sample.

Variable	Mean	Std dev	Min	Max
Dependent variables				
Total waste (kg)	242.4	165.9	6	914
WTP (SEK)	155	292	0	2000
Questions concerning attitudes				
Importance of env. problems	1.36	0.55	1	3
Importance of nature	1.59	0.59	1	3
Importance of waste problem	1.72	0.68	1	
Changing buying habits	2.20	0.96	1	3
Change in attitude toward waste problem	0.52	0.50	0	1
Practical difficulties recycling glass	0.02	0.13	0	1
Practical difficulties recycling paper	0.02	0.12	0	1
Practical difficulties recycling batteries	0.10	0.31	0	1
Practical difficulties for hazardous waste	0.18	0.39	0	1
Importance of diff. waste fees	2.07	0.87	1	4
Questions concerning actual behaviour				
Recycling of paper (%)	89.0	22.7	0	100
Recycling of glass (%)	94.7	15.0	0	100
Recycling of batteries (%)	95.1	15.8	0	100
Recycling hazardous waste (%)	88.8	23.0	0	100
Composting garden waste (%)	74.6	33.8	0	100
Composting kitchen waste (%)	60.4	36.8	0	100
Personal variables				
Gender (1 for female)	0.23	0.42	0	1
Marital status (1 for married)	0.88	0.32	0	1
Education (1 for higher education)	0.37	0.48	0	1
Age	51.1	14.1	24	91
Number of children	1.17	1.24	0	5
Number of people staying at home	0.68	0.77	0	5
Economical variables				
Living area (sq m)	137	39	50	500
Garden area (sq m)	1649	5279	90	94000
Income (thousand SEK/yr)	281	98	22	720
Variables related to waste handling				
Time spent handling waste (min/week)	29.3	33.8	0	420
Distance to recycling center (m)	898	1013	0	10000

The results for self-reported recycling and composting might be biased if the respondents for instance want to give the impression that they are behaving in tune with certain social norms. On the other hand a reduction in waste collection by 35% does indeed suggest a considerable amount of recycling and composting, rather in line with the figures reported.

The average time spent on handling waste within the household was slightly below 30 minutes per week. The average distance to the recycling center was under 1 km. The average living space and garden area were 137 m^2 and 1.649 m^2 respectively. The respondents thought the practical problems of recycling were rather small, perhaps with the exception of hazardous waste. For paper, glass and batteries, more than 50% considered it very easy to recycle.

The average age was about 51 years, which is quite high. This partly explains the low level of formal education; less than 40% had college level or above. The average level of income was about 280.000 Skr. per year. There were on average 3.1 members in the household (and 1.2 children), and of these, on average "0.7 persons" stayed at home for at least part of the day.

About 26% of the respondents claimed that the differentiated fees were very important in their decision regarding waste handling, recycling and composting, and another 41% considered them important. Only 6% said that the new system of fees did not matter at all. The Willingness To Pay question will be discussed in a separate section below.

4. Estimating the Demand for Waste Disposal

The demand for waste disposal can be deduced from an explicit utility maximizing framework or from a household production framework. This is however fairly standard and will not be done formally here; the reader is referred to the references cited earlier, in particular Jenkins (1993). Suffice it to point out that the demand must depend on factors which affect the relative costs of various disposal options. "Ordinary" prices do not generally play such a significant part here, but the generalized "cost" in terms of time for composting, recycling etc. are the main focus of interest. Both the composition of waste produced in the family and the relative availability of time for this type of task depend crucially on the age and gender distribution of the family as well as on their income and other socio-geographical variables. Unfortunately some of these, such as living area, may have several opposing effects on waste disposal and thus the net effect to be expected is not necessarily clear-cut.[8] Various other assets and beliefs, knowledge and opinions within the family may play an important role as well as the ubiquitous formation of habits. The equation to be estimated can be stated as

$$D = F(X_1, \ldots, X_n) + e \tag{1}$$

where D is the demand for waste disposal services measured as the amount of waste left for the solid waste truck to pick up, and $X_1, \ldots, X_n$ are the variables

used to explain the amount of waste disposed. These include variables reflecting a household's demographic, physical and economic situation, the ease or difficulty of recycling and finally attitudes and habits. The price of waste disposal would naturally have been interesting but unfortunately the data we have do not cover the period before the new weight-based billing system was introduced. It is thus impossible to analyze the price effect directly.

Three different functional forms were used: Linear, exponential and loglinear.[9] All three equations can be estimated using ordinary least squares when the appropriate assumptions about the normality of e are made. Table II shows the results of the regressions. The variables which were highly insignificant (t-value lower than 0.50) were omitted from the analysis. Only the variables income and distance were kept in the model irrespectively of their t-value. As economists we have a special reason to be interested in the effects of income and prices and in this case the distance to the recycling center was the closest proxy we could find for a generalised "cost" of solid waste reduction. Considering it is cross-sectional data, there is an acceptable degree of explanation provided by the independent variables: They accounted for 35% to 45% of the variance observed. Most of the categorical variables, like for example attitude toward the waste problem, were used as dummy-variables which take only two values: 1 for very much concern about the waste problem against 0 for slight or no concern.

Starting with personal and economic characteristics, the most significant is *age*: Older people seem to be generating significantly less waste, perhaps reflecting a more frugal lifestyle. This coincides with Fullerton and Kinnaman (1994) and Jenkins (1993). *Living area* is positive and highly significant which might be surprising since more space should make it easier to compost and recycle. However, it seems the respondents all have sufficient space in this respect and it could be that the larger the house the more consumption and thus the larger is the production of waste. In principle this should not happen in a regression including income. However, the variable "income" may not actually be a sufficiently good reflection of consumption possibilities since the reporting of income is far from perfect. This suspicion is reinforced by the negative and highly insignificant coefficient for "income" itself. It is worth noting that this area has many old-age pensioners (remember the average age was 52!) for whom official "income" may not be a good description of their consumption possibilities.

The variable *people staying at home* is negative (and significant in the exponential model). If more people are at home at least during part of the day, they will compost more and produce less waste. The variable *time* has a small positive value and is significant in the log-linear model. If recycling takes more time, people are less willing to recycle and produce more waste. The coefficients of the log-linear model give us elasticities directly for the different variables. All the variables are inelastic. This is especially interesting for the variable *household members*, although this variable is not significant. It shows that the amount of waste per person declines as the family size increases. This coincides with the results of

Table II. Regression results explaining the determinants of waste disposal demand.

Variable	Equation (1) Linear model		Equation (2) Exponential model		Equation (3) log linear model	
	Estimate	*t*-value	Estimate	*t*-value	Estimate	*t*-value
Intercept	143.6	1.05	5.29	7.29	7.420	2.67
attitudinal variables						
Importance of the waste problem			–0.13	–0.89		
Composting	–113.2	–1.93	–0.48	–1.62		
Change in buying habits						
Change attitude toward waste problem			0.15	1.54		
Difficulties recycling paper and glass	199.3[a]	2.37	1.22[a]	2.70		
Difficulties recycling batteries	–66.0	–1.48	–0.417	–1.70		
Difficulties recycling hazardous waste	61.0	1.61	0.375	1.77		
Importance different fees	–15.6	–0.73	–0.16	–1.46		
Behavioral variables						
Recycling paper			–0.002	–0.87	–0.218	–0.91
Recycling glass			–0.004	–0.75	0.435	0.90
Recycling batteries					–0.343	–0.90
Recycling hazardous waste			0.003	1.14		
Composting of garden waste	0.560	1.19	0.003	1.14	0.192	1.19
Composting of kitchen waste	–1.13[a]	–3.26	–0.005[a]	–2.78	–0.265[a]	–2.91
Personal characteristics						
Gender (fem = 1)	–29.2	–1.21	–0.187	–1.55		
Marital status	39.3	0.91	0.257	1.20		
Education	–36.1	–1.25	–0.110	–0.77		
Age	–3.11[a]	–3.07	–0.019[a]	–3.75	–1.17[a]	–4.16
Household members	12.2	1.28	0.048	0.93	0.094	0.55
People staying at home	–8.840	–0.68	–0.145[b]	–2.03		
Economical characteristics						
Living area	1.22[a]	4.21	0.005[a]	3.38	0.460[b]	2.07
Garden area			0.000	–0.65		
Income	–9.780	–0.79	–0.060	–1.00	–0.070	–0.50
Variables related to waste management						
Time spent on waste management	0.340	1.25	0.002	1.61	0.239[a]	3.22
Distance to recycling center	2.004	0.22	–0.064	–1.00	–0.015	–0.51
R^2	0.39		0.45		0.35	
R^2-adj	0.34		0.37		0.31	

[a]significant at 99% level; [b]significant at 95% level.

various other authors such as Hong et al. (1993), Gamba and Oskamp (1994) and Jenkins (1993).

Composting of kitchen waste has a strong and significant negative influence on the production of waste. The more people compost, the more potential mixed waste for conventional disposal is diverted and therefore it is logical that these coefficients are negative. It may seem surprising that the coefficient for *composting of garden waste* is positive (albeit small and insignificant) but this is most probably due to the fact that this variable is correlated with the composting of kitchen waste. Furthermore garden waste is probably not to any greater extent thrown into the garbage anyway – it may just be left on the ground.

The variables *recycling paper, glass, batteries and hazardous waste* are found to be very insignificant. This is surprising because one would normally expect these variables to have a significant effect on the amount of waste produced. Note that paper is the main component with respect to weight and that its coefficient is negative. The insignificance may be due to the fact that these variables all have a very high mean value. People are claiming that they recycle almost all their paper, glass, batteries and hazardous waste. It is possible that the correlation between reported and actual behaviour is causing us problems here.

Turning to the attitudinal questions we find that the expression of *"Practical difficulties with recycling of paper and glass"* has a positive and significant effect on the waste generated as expected. The more difficult the individual's perception of recycling, the less likely he or she is actually to recycle. When it comes to people's perceptions of the difficulties with recycling of hazardous waste we get the same, albeit, not significant result. Surprisingly enough we get the opposite (although again not significant) result for difficulties with batteries which seems illogical. We should note however that these three attitudinal variables are very strongly correlated and if we look at the total effect of all three it is still a strong positive effect. Batteries are normally a very minor share (by weight) of the average household waste and hence the effect of battery recycling is presumably less than that of the other types of recycling.

We also find that a positive attitude to composting has an additional, separate, impact leading to smaller quantities of household waste – over and above the effect of the variables for actual levels of composting. This impact is not significant at the 95% level but at the 90% level and appears to be the variable that best picks up the residual "attitudinal" variation since the variables concerning "the importance of the waste problem" and whether people thought they should change their buying habits had practically no influence at all.

5. The Determinants of Composing

One of the factors which exerts a large physical effect on the demand for solid waste management is the degree to which people actually do compost. The compostable

Table III. Regression results for waste composted[a].

Variable	Composting kitchen waste	
	Estimate	*t*-value
Intercept	12.51	0.56
Attitude		
Importance of the waste problem	6.60	0.99
Change attitude concerning waste	–4.90	–1.15
Importance different fees	8.80	1.86
Composting of garden waste	0.46[b]	6.19
Personal variables		
Gender (fem = 1)	–4.15	–0.81
Education	2.83	0.45
Age	0.21	0.96
Household members	2.45	1.14
People staying at home	2.07	0.75
Economic variables		
Living area	–0.11	–1.77
Garden area	–0.002	–0.99
Income	2.751	1.01
Other		
Time	–0.13[c]	–2.27
R^2	0.23	
R^2-adj	0.18	

[a]The equation for waste composted was estimated using a simple linear form and OLS; [b]significant at 99% level; [c]significant at 95% level.

fraction of household wastes can lie in the range from about 30–50%. We therefore turn now to an explicit analysis of the factors determining composting behaviour.

The dependent variable here was the percentage *composted kitchen waste*. The results re shown in Table III. The explanatory power of the regression is somewhat lower, perhaps reflecting the fact that the data in this case are not actually measured but self-reported estimations. It could be that the answers to these questions are biased because people want to give an estimation that is socially acceptable or because they simply do not know the exact percentage of the amount of waste that they are composting.

The most important variable explaining the composting of household or kitchen waste appears to be the quantity of *garden* waste composted. This is very natural not only from the viewpoint of habit formation but for purely chemical or technical reasons: it is actually a lot easier to compost both types of waste together. Composts consisting only of kitchen waste tend to have an excess of compounds rich in nitrogen but lacking in carbon. This can create a messy and smelly compost but is easily rectified by adding garden compost material such as grass, leaves or twigs which are rich in carbon and also provide a physical structure increasing the penetration of air and acting as a barrier that keeps flies etc. away! People who have access to garden waste are thus not only more likely to start composting kitchen waste since they have the habits and equipment – they are furthermore much more likely to be successful and thus to persist in their composting in the long run!

The variables reflecting personal and economical characteristics were generally supportive of what might be thought of as natural but were not generally significant. This applies to income, number of people in household, age and education. It also concurs with findings from earlier studies by for instance Hong et al. (1993) and Fullerton and Kinnaman (1994) (although the latter did find a negative influence of education). Another rather natural finding is that the number of people staying at home had a positive effect on composting.

Other variables of interest explaining composting behaviour include some attitudinal variables such as the importance of fee structures for waste management and the importance of the waste problem in general. These were however not significant. The variable "time" is an answer to the question whether the respondent considers that recycling and other waste management takes a lot of time. Naturally those who think it takes a long time (be it because they are unaccustomed to it or for other practical reasons), tend to be more reticent about doing it and thus the negative coefficient is rather natural.

6. Willingness to Pay for Environmentally Sound Waste Management

So far we have seen a considerable interest in waste management and related issues among our respondents: not only by their attitudes but more directly through their actual behaviour; most of our respondents have shown that they are interested in a sensible waste management and in fact more interested than would be motivated purely by savings on their bills. However, some people are invariably less interested or less capable of actually getting themselves involved than others. We wanted to study this group and to see if they, too, had an environmental interest. We therefore asked the following question:

> *How much more are you willing to pay in yearly fees so that another organization (such as the county council) would be responsible for taking care of the waste and recycling problem?*

The purpose of this question was to ascertain how much people would be willing to pay – in cash – for an environmentally sound waste management without any effort

Table IV. Regression results for Willingness To Pay.

Variable	Willingness To Pay	
	Estimate	*t*-value
Intercept	604.584	1.78
Importance of the waste problem	74.089	0.91
Change in buying habits	–147.868	–1.23
Composting	–55.315	–1.01
Change attitude toward waste problem	–71.194	–1.32
Difficulties recycling hazardous waste	98.321	1.29
Importance different fees	56.002	0.88
Gender (fem = 1)	128.272[a]	1.81
Martial status	103.439	0.72
Education	–153.467[a]	–1.73
Recycling paper	2.651	2.29
Recycling glass	–1.542	–0.65
Recycling batteries	–2.567	–1.30
Composting of kitchen waste	–0.835	–0.88
Garden area	–0.037	–1.21
Age	–5.415[b]	–2.42
Household members	23.608	0.69
Time	–0.245	–0.37
Distance to recycling center	39.024	1.09
Income	4.153	0.12
R^2	0.256	

[a]significant at 90% level; [b]significant at 95% level.

or work on their behalf. The idea was that there might be some people who have an abstract "interest" or feeling that they want to be "environmentally correct" but who know little about the environment and about waste and may not even want to know or get involved.

Obviously there is a considerable risk of misunderstanding associated with a question such as this one. The people who are concerned with waste management and environmental questions will generally realize that the most sensible solution to waste management policies *is* source separation and necessarily does involve the individual in sorting, recycling and composting. In fact the whole information concerning waste management in the last few years has emphasized precisely these aspects. Many who are interested and motivated could be expected to reject this question as illegitimate and either answer 0 or not answer at all.

This is, in fact, exactly what happened! Only 57% of the respondents answered this question. Of this 57% approximately 60% gave a WTP of zero. It is quite

understandable that all these respondents rejected as *unreasonable the suggestion that they should pay someone else to sort their waste*. Thus the fact that many respondents gave a WTP of zero is not because they do not care about waste collection, but because they feel it is better to take care of he recycling and composting themselves. We, however, wanted to reach the others – those who do not compost or recycle but may have a less articulate and consistent analysis of the waste problem but still some vague desire to be environmental. For the 23% of the respondents who did give a positive reply this may still be an indication that some of them have a willingness to pay specifically with cash (420 SEK on average) rather than time and effort in order to contribute to a sound waste management.

Bearing this in mind the regression does seem to give some reasonable information; see Table IV. Most of the variables had expected signs although only three were significant even at the 90% significance level: *gender, education* and *age*. The variable *gender* has a positive sign, which implies that women are willing to pay more than men. *Education* and *age* both have negative signs. People with less education seem to be willing to pay more. In Table III we found that people with less education produce more waste so it might be logical that they would be willing to pay more for waste collection. Also more education might make it obvious that the suggested waste management is rather unreasonable. Younger people were also found to produce more waste and be more willing to pay with money than time to take care of it.

It is also worth nothing that there is a negative (although not significant) relationship between willingness to pay and time actually spent on waste management. This would seem to strengthen the hypothesis that the payment is being seen as an alternative to physical involvement and not as an abstract measure of interest.

Another measure of Willingness To Pay is precisely this estimated time spent on waste management. On average the respondents reported that they spent just under half an hour per week or roughly 25 hours per year. The average income in this area would correspond very roughly to an after tax income of 100 SEK/hr. This suggests that the average "willingness to actually get involved" in waste management 25 hours per year is much more valuable (corresponding to roughly 2500 SEK) than the average 400 SEK/yr that the respondents to the Willingness To Pay question reported. The question of course arises which value is most reasonable. Perhaps the answer is in some sense between the two. On the one hand people's valuation of their free time spent on waste management may very well, at the margin, be lower than the market wage. They may derive some satisfaction from this activity. On the other hand the WTP question had a number of weaknesses already mentioned and probably the 25 hours does give a better indication of interest for this issue even if it is hard to translate the time spent exactly into monetary terms.

7. Waste Management in Eda, Mark and Åmål

A special study of attitudes and habits concerning recycling and waste was carried out, by way of comparison, in three communities using a questionnaire based on the one used in Tvååker.[10] The three municipalities were chosen to give as much variation as possible with respect to fee structures and changes in fee structure during the period studied (1994). Eda in Värmland has in 1993 introduced a weight based fee system much like the one used in Tvååker. They started with a fee of 1 kr/kg of unsorted household waste which has then been raised to 1.25 and now 1.40 kr/kg. Mark in Västergötland introduced during 1994–1995 a waste sorting scheme with a differentiation in fee depending on the frequency of collection and Åmål had no change in fee or waste collection system during the period at all. Their system was similar to the one introduced in Mark.

For 1994 Eda reports a drastic reduction in waste collection from a level of 553 kg/household to 284. This is a reduction by 48% but it should be noted that the figure for 1993 was estimated (from average number of bags times estimated average weight) while the figure for 1994 was actually weighed which could imply some bias. Mark had a reduction by about 12% from 600 to 526 kg/household. In Åmål the amount of waste was constant between 1990–1993 at about 628 kg/household but decreased during 1994, by 11% (and without any apparent reason at least as far as the fee structure goes) to 559 kg/household in 1994.

In all three municipalities there has been an increase in recycling of glass, paper and various other types of material an waste during 1994. This was particularly noticeable in Eda where sorted waste of various kinds (including household machines, metal, electronic gear etc.) can be left at recycling stations free of charge.

The figure for Eda is now exceptionally low and while part of this may be explained by composting and recycling (see below) one might have suspected some illegal dumping. This has not been observed by the local authorities (Rydström 1996). The waste disposal figures for Eda have actually continued to decline and by 1996 they have fallen by another 18% compared to 1994! If this decrease can be attributed to a rise in tariff from 1 to 1.25 kr/kg then we can calculate a crude price elasticity which turns out quite high at around –0.7! Eda is now down to 1100 tons (233 kgs/household or 118 kgs/cap) which is very low indeed. It should however be pointed out that the low level is to some extent explained by the fact that this is a very rural community with a low population density of 11 persons/sq km compared to 28 and 36 for Åmål and Mark respectively. The low population density may make composting (and other local disposal?) easier.

According to our enquiry the decrease in waste can be explained by large increases in composting, changes in buying habits and increased recycling. Eda has the highest reported percentages of recycling for paper (85%) and glass (95%).

A number of regressions were run explaining the amount of reported recycling; see Table V. Only for glass was there a significant difference between the

Table V. The determinants of recycling

	Glass	Paper	Refundables	Batteries	Hazardous waste	Household machines	Textiles
Constant	58.42	29.14	65.78	67.12	47.95	32.94	11.92
	(8.55)	(2.94)	(16.02)	(11.58)	(4.52)	(3.71)	(1.36)
Previous	0.21	0.42	0.30	0.22	0.54	0.56	0.91
Experience	(6.79)	(8.66)	(9.87)	(6.94)	(10.33)	(11.04)	(19.67)
Information	1.91	9.03	1.30	–0.41	–1.09	–1.10	5.20
on waste problems	(0.71)	(2.27)	(1.17)	(–0.19)	(–0.21)	(–0.26)	(1.17)
Change in buying	–0.88	7.60	0.42	–1.77	6.03	5.83	–2.46
behavior	(–0.35)	(2.06)	(0.41)	(0.86)	(1.33)	(1.51)	(–0.61)
Nr of persons	1.00	3.59	0.07	–0.11	1.06	1.29	–4.43
in household	(0.78)	(1.94)	(0.13)	(–0.11)	(0.47)	(0.66)	(–2.44)
Ease of recycling	9.67	11.17	0.26	6.55	0.66	–1.40	–0.29
	(2.32)	(1.68)	(0.13)	(2.13)	(0.14)	(–0.36)	(–0.07)
Average age of	0.01	–0.23	0.08	0.06	–0.23	–0.01	0.04
adults in family	(0.06)	(–1.44)	(1.81)	(0.78)	(–1.20)	(–0.06)	(0.23)
Attitude about	2.76	4.34	–0.77	3.70	–1.44	3.74	9.08
importance of waste	(0.97)	(1.02)	(–0.65)	(1.64)	(–0.29)	(0.87)	(2.11)
Dummy 1,	6.81	0.75	–0.71	0.86	4.57	1.00	–2.03
Eda	(2.27)	(0.17)	(–0.57)	(0.36)	(0.86)	(0.21)	(–0.39)
Dummy 2,	8.50	4.87	0.26	1.08	8.88	4.11	1.66
Mark	(2.56)	(0.97)	(0.19)	(0.41)	(1.49)	(0.83)	(0.32)
R^2	0.26	0.37	0.35	0.26	0.48	0.51	0.83

t-statistics in brackets.

municipalities (Eda and Mark and higher percentages than Åmål). Other significant variables were the degree to which the respondent had been accustomed to recycling in the past (this variable naturally picks up a large share of the relevant individual characteristics), information and number of persons in the household. The latter was positive for recycling of newspaper and various other types of bulky waste but negative for textiles – presumably because families with many children "recycle" clothes internally and thus have less waste textiles per family! Another variable that had different effects on different types of waste was age: older people were better at recycling refundables but not as good as younger people at newspaper and hazardous waste which is not entirely surprising considering differences in economy, information and lifestyle. The last variable which had some explanatory

power was how difficult respondents judged the recycling to be, i.e. the distance etc. to recycling centers. This was particularly important for glass, batteries and newspapers.

8. Conclusions

The experience in Tvååker shows a significant reduction in waste collected and increased recycling after a weight-based billing system was introduced. The most important determinants were composting of kitchen waste, living area, age and the perceived difficulties with recycling of various materials. The effect of age on the amount of waste produced is quite strong. The elasticity of age is –0.9. Other slightly less significant determinants were the number of people staying at home during some part of the day and the time it took to recycle.

It is clear that most people are willing to spend a considerable amount of time on recycling and composting and while economic incentives are an important element in encouraging this process they are not its only determinant. The amount of effort and time invested are greater than would be purely motivated by savings on their waste management bill.

The surveys from Eda, Mark and Åmål broadly speaking confirm these results. There is an increased interest across the country in recycling and composting but it does obviously help a lot if the local municipality provides correct economic incentives and good physical infrastructure that facilitates environmentally sound waste management. Price sensitivity to tariffs appears to be a significant factor.

One of the contributions of this paper is that it has used actual (measured) household data on waste delivered, together with survey data on attitudes and other variables. An important result is that perceptions about the difficulties related to recycling and composting are important determinants of the effort people are prepared to make.

Notes

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2. See also Derksen and Gartell (1993), Gamba and Oskamp (1994), Fullerton and Kinnaman (1994), Menell (1990), Miedema (1983), Neal and Schubel (1994), Pearce and Kerry (1992) and US EPA (1990).

3. Two other studies are worth mention here: McFarland et al. (1972) reports –0.46 and Skumatz (1990) –0.14. Both used revenues for the waste collection firms as proxies for the disposal price variable.
4. See also Richardson (1978), Duggal et al. (1991) or Lackman (1976).
5. Unfortunately the figures are all for the period after the weight-based billing system is introduced (billing is the reason why the trash is weighed in the first place). We can thus not, at the household level, compare with conditions prior to the reform and therefore we cannot calculate price elasticities.
6. Report (RVF 94:2). For 1992 we only have an aggregate level of waste collection for comparison.
7. Clearly this type of "mean" is not legitimate and we do not use them in the regressions, rather we use dummies for more or less interest.
8. More space may facilitate recycling but may also reflect a tendency to have more objects around!
9. Variables which can take on the value zero (such as dummies for gender) were always used in linear form. Tests between the functional forms were inconclusive and we felt it was most instructive to keep all three for the sake of comparison.
10. See Hällerdahl and Fagerling (1995). 600 questionnaires were sent to 200 house-owners (individual homes only) in each of the three municipalities. The reply frequency was 61%.

References

Bruvoll, A. (1998), 'The Costs of Alternative Policies for Paper and Plastic waste', *Rapporter* 98/2, Statistisk Sentralbyrå, Oslo.

Derksen, L. and J. Gartrell (1993), 'The Social Context of Recycling', *American Sociological Review* **58**, June.

Duggal V. G., C. Saltzman and M. L. Williams (1991), 'Recycling: An Economic Analysis', *Eastern Economic Journal* **17**(3), July–Sept.

'The Effects of Weight- or Volume-based Pricing on Solid Waste Management'. EPA/530–SW–90–047. Sept. 1990.

Fullerton, D. and T. C. Kinnaman (1994), 'Household Demand for Garbage and Recycling Collection With the Start of a Price per Bag', *NBER* WP 4670.

Fullerton, D. and T. C. Kinnaman (1995), 'Garbage, Recycling and Illicit Burning or Dumping', *Journal of Environmental Economics and Management* **29**(1).

Gamba, R. J. and S. Oskamp (1994), 'Factors Influencing Community Residents' Participation in Commingled Curbside Recycling Programs', *Environment and Behaviour* **26**(5).

Goddard, H. G. (1995), 'The Benefits of Costs of Alternative Solid Waste Management Policies', *Resources, Conservation and Recycling* **13**, 183–213.

Hong, S., R. M. Adams and H. A. Love (1993), 'An Economic Analysis of Household Recycling of Solid Wastes: The Case of Portland, Oregon', *Journal of Environmental Economics and Management* **25**, 136–146.

Hällerdahl, A. and M. Fagerling (1995), *Kompostering och Återvinningsvanor*. Project paper for the B Sc Degree 5:7, Unit for Environmental Economics, University of Göteborg.

Jenkins, R. R. (1993), *The Economics of Solid Waste Reduction. The Impact of User Fees*. Edward Elgar.

Lackman, C. L. (1976), 'Consumption of Solid Waste', *Journal of Economic Theory* **13**, 478–483.

Ljunge, M. (1997), *Economic Instruments in Local environmental Policy*. Project paper for the M Sc Degree: 5, Unit for Environmental Economics, University of Göteborg.

McFarland J. L. et al. (1972), 'Comprehensive Studies of Solid Waste Management', *Report to the US EPA*. Berkeley, May: The University of California.

Miedema, A. K. (1983), 'Fundamental Economic Comparison of Solid Waste Policy Options', *Resources and Energy* **5**, 21–43.

Miranda, M. L., J. W. Everett, D. Blume and B. A. Roy (1994), 'Market-Based Incentives and Residential Municipal Solid Waste', *Journal of Policy Analysis and Management* **13**(4), 681–698.

Morris, G. E. and D. Holthausen (1994), 'The Economics of Household Solid Waste Generation and Disposal', *Journal of Environmental Economics and Management*, 215–234.

Neal, H. A. and J. R. Schubel (1994), *Solid Waste Management and the Environment: The mounting Garbage and Trash Crisis*, Englewood Cliffs: Prentice Hall Inc.

Pearce, D. and K. T. Kerry (1992), *Market-Based Approaches to Solid Waste Management*, CSERGE. Working Paper WM 92–102.

Richardson, R. A. (1978), 'Economic Analysis of the Composition of Household Solid Wastes', *Journal of Environmental Economics and Management* (5), 103–111.

Ronis, D. L., J. F. Yates and J. P. Kirscht (1989), 'Attitudes, Decisions and Habits as Determinants of Repeated Behaviour', in A. R. Pratkanis, S. J. Becker and A. J. Greenwald, eds., *Attitude Structure and Function*. Hillsdale: NJ Erlbaum, 213–239.

RVF. Rapport (1994:2), *Tvåker-projektet. Försök med vägning av avfall i kärl.*

RVF. Rapport (1991:16), *Differentierade taxor. Förstudie*.

Rydström (1996), Telephone Interview with Mates Rydström, Miljö och hälskoskyddsinspektör, Eda Kommun, 951127 and 961227.

Skumatz, L. (1990), 'Volume-Based Rates in Solid Waste: Seattle's Experience', Report for the Seattle Solid Waste Utility, mimeo.

US Environmental Protection Agency (1990), 'Charging Household for Waste Collection and Disposal: The Effects of Weight- or Volume-based Pricing on Solid Waste Management', EPA/530–SW–90–047. Sept.

Wertz, K. L. (1967), 'Economic Factors Influencing Households' Production of Refuse', *Journal of Environmental Economics and Management* April, 263–272.

Åberg, H., S. Dahlman, H. Shanahan and R Säljö (1996), 'Towards Sound Environmental Behaviour: Exploring Household Participation in Waste Management', *Journal of Consumer Policy* **19**, 45–67.