Will Unit-Pricing Reduce Domestic Waste? Lessons from a Contingent Valuation Study.

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Abstract:

This paper estimates the effect of introducing unit-pricing for municipal domestic waste collection and disposal in Christchurch. The price effect is shown in a demand model estimation using data collected in a contingent valuation survey of Christchurch households conducted in 2003. The results show a small but significant price effect. Households on higher incomes exhibit a larger price effect than do those on low incomes. Private service is indicated as the most preferred option for substituting away from municipal service, followed closely by composting, compaction, and recycling. The number of households participating in substitute activities that divert waste from landfill is shown to increase.

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1. Introduction

Collection and disposal of residential solid waste has traditionally been funded by flat fee systems or general tax revenue. Because households face a zero marginal cost for waste, an inefficiently high amount of waste is generated and disposed of. Unit-pricing, where households are charged per unit of waste, is one economic tool that can create an incentive for households to reduce waste. This paper uses the contingent valuation methodology (CVM) to estimate the effect of introducing unit-pricing for domestic waste collection and disposal in Christchurch, New Zealand.

Theoretical effects of unit pricing are well established in the literature (Wertz 1976; Morris and Holthausen, 1994; Fullerton and Kinnaman, 1995; Choe and Fraser, 1999). Charging per unit of waste creates an incentive for households to reduce the amount of waste disposed of at the kerbside. The incentive works at two levels. First, households are encouraged to practise source reduction by purchasing goods that have relatively low waste management costs. Secondly, households will make greater use of diversion options such as recycling and composting. These diversion options typically have a zero direct monetary cost, but incur time and inconvenience costs. The introduction of unit pricing lowers the relative cost of these options. On the other hand, unit pricing can also lead to undesirable diversion such as illegal dumping and burning. When the social costs of illegal disposal are high, unit pricing may no longer be socially beneficial (Fullerton and Kinnaman, 1996).

To achieve economic efficiency, the unit price should be set equal to marginal cost of collection and disposal. Because disposal costs are weight-related, the ideal unit-pricing system would be weight-based. However, administering a weight-based unit price system is costly, and most communities have adopted volume-based systems using either bags or cans. Bags are generally thought to create a greater incentive for waste reduction, because the minimum amount held is less than for a can.

In recent years many communities around the world have adopted unit pricing. However, most evidence comes from the USA where over 4,000 communities now use unit pricing programs for domestic waste service pricing, which serve over 27 million U.S. residents (Gordon, 1999). An exception is Hong (1999) who studies the impact of unit pricing in South Korea. Data is usually collected before and after the implementation of a unit pricing scheme. The empirical evidence is mixed. While there is general agreement that unit pricing reduces the amount of mixed waste collected at the kerbside, there is debate about both the magnitude of this impact, and the diversion options used.

Community-level analysis typically shows a significant reduction in the amount of waste being sent to the landfill following introduction of unit pricing. For example, Miranda *et. al.* (1994) find a range from 10% to 74%, with an average reduction across 21 communities of 40%. However, analysis using household level data has been more equivocal. While van Houtven (1999) found that mixed waste collected at the kerbside fell by 50% following the introduction of a bag programme, most other studies report much smaller reductions (Nestor and Podolsky, 1998; Hong, 1999), with Hong even reporting that increases in the unit price had no significant impact on waste. Fullerton & Kinnaman (1996) suggest that even these relatively low elasticities could be overstated if the reductions are based on volume rather than weight of waste. They found that unit pricing leads to significant levels of compaction, with a 43% increase in bag weight. As a result, while unit pricing was successful in significantly reducing the volume of waste, there was virtually no change in the weight.

The evidence on use of diversion options is also mixed. Most studies report that unit pricing causes an increase in both the rate of recycling and the level of participation (Miranda *et al.*, 1994; Fullerton and Kinnaman, 1996; Hong *et al.*, 1993; Hong, 1999). However a recent United States study by Jenkins (2003) found that the level of unit-price had little if any effect on recycling participation, highlighting that the outcome of unit-pricing programmes can not be taken as given. Illegal disposal is a significant problem for a small number of communities (Miranda *et al*., 1994). Fullerton and Kinnaman (1996) found that 28% of the reduction in waste was accounted for by undesirable diversion. Community characteristics were found by Miranda (2002) to be important predictors of which communities experienced increases in undesirable diversion following implementation of unit pricing. Several studies found that the *total* amount of waste generated may actually increase following the introduction of unit pricing (Nestor and Podolsky, 1998; Hong, 1999). This occurs when the increase in recycling outweighs any reduction in mixed waste, which could occur if households substitute towards bulky products that can more easily be recycled.

The diversity of these experiences makes it difficult to apply these results to other communities, especially those located in another country. Local characteristics, especially environmental attitudes (Gamba and Oskamp, 1994; Sterner and Bartelings, 1999), will significantly impact the diversion options chosen and ultimately impact on the success of any unit pricing programme. In New Zealand several municipalities use unit-pricing, however there is insufficient data for a detailed analysis. The Wellington City Council has used a pay-per-bag system for around seven years, making it one of New Zealand's longest running programmes. They found that little illegal dumping resulted from the shift to a user pays system. Similarly, the North Shore City Council reports that illegal dumping has remained at a background level and that the contamination of recycling bins with non-recyclable materials remains low at around 2%. Domestic waste diversion in North Shore amounts to around 35-40% (Moore, 2002). The Waitakere City Council estimates that waste going to landfill has declined 28% since the implementation of unit-pricing (Moore, 2002).

These results provide little specific guidance for a community, like Christchurch, seeking to implement a unit pricing scheme. No indication is given of how the unit-price should be chosen. Existing empirical analyses typically use either a dummy variable for the presence of unit pricing or the average unit price for the area. To overcome these problems we use the CVM, which allows us to collect exactly the type of data we need. Responses are collected for several different unit prices. In addition, the survey is tailored to focus on equity issues, as the Christchurch City Council (CCC) is particularly concerned with any regressive impacts of such a policy. This research attempts to incorporate attitudes into the demand model by asking respondents to indicate their level of agreement with several statements indicating various attitudes motivating households to minimise waste. Because the respondents are dealing with a familiar good, some common CVM biases will be reduced. The study shows how CVM can aid in the design of a unit pricing scheme *prior* to implementation. While applications of CVM in relation to domestic waste service are found in developing countries (Altaf and Hughes, 1994; Altaf and Deshazo, 1996; Anaman and Rashidah, 2000), researchers are usually seeking estimates of households' willingness-to-pay (WTP) for improvements in service quality, rather than reactions to price changes.

The rest of the paper is organised as follows. The Christchurch waste problem is described in Section 2. In Section 3, the survey and data collected are described. The method used to estimate a demand function for kerbside waste is discussed in Section 4, while the results are in Section 5. Conclusions and policy implications are summarized in Section 6.

2. Background

Christchurch is a city of approximately 320,000 residents. During 2003, the average resident disposed of 111 kilograms of household waste via kerbside collection. This waste ends up in the city's only landfill at Burwood. The Christchurch City Council (CCC) provides weekly kerbside collection to all households. The service is funded by a flat rate levied on households as part of general annual rates. In order to be collected, waste must be placed in an official council "black bag" that has a 50 litre, 15 kilogram capacity. Until recently each rateable property was supplied with 52 bags per year. This number has now been halved. Residents can buy as many additional bags as they require for $1 a bag. Hazardous waste and liquids are prohibited but anything else can be put in the bag. Approximately 18% of households subscribe to a private waste collection service.

As early as 1995 the CCC City Plan recognised the need for 'sustainable development' in the city (CCC, 1995). In 2002 the CCC adopted the *New Zealand Waste Strategy 2002* as the basis for its own waste management plan. The overarching goal is "towards zero waste and a sustainable New Zealand" (CCC, 2005). As part of achieving this goal, the CCC has adopted a target of an 80% reduction below 1994 levels, in kerbside waste collected by the Council by 2010. Figure 1 shows trends for council collected domestic waste and recycling, and green waste at transfer stations over the past 20 years.

While kerbside recycling has proved popular, with around 85% of households recycling each week, and the average resident recycling 66 kilograms of waste per year, the amount of black bag waste per person has remained virtually unchanged, showing only a slight downward trend in recent years. Separation of green waste at the landfill to be composted has also not reduced kerbside collection, however most green waste would have been taken directly to the landfill rather than placed in a black bag. If this trend continues, the council target will not be achieved. However research shows that much of what is thrown out in black bags has the potential to be diverted if households are given an incentive to do so. Kitchen and garden waste make up nearly half of an average bag (CCC, 2005), even though

Christchurch City Council estimates that approximately 60% of households compost at home or take green waste to transfer stations.

The current flat rate funding however gives households little incentive to reduce waste below their annual allotment of bags. One of the principles in the CCC waste strategy is that of “waster pays”. The recent move to halve the number of bags is a step toward implementing unit pricing for kerbside refuse collection. However households still face a zero marginal cost for the first 26 bags and a relatively low price of only $1 bag for additional bags. Locally there has been opposition to even the halving of the number of bags, with concerns about the potentially regressive nature of the policy.

3. Data Description

To collect the required information a self-administered questionnaire was sent to 1500 Christchurch households in February and March of 2003. A proportionate-stratified random sample using the electoral roll was conducted, the design variable being household income. This sampling procedure was employed because a secondary objective of the study is to analyse how different income groups react to changes in price. The survey achieved an effective response rate of 32%, with 448 useable responses received.[1] Summary statistics for the independent variables used in the model are reported in Table 1. The survey collected four types of information as described below.[2]

Current Waste Diversion Practises

Households were asked about their current demand for kerbside collection (both bags and recycling bins), as well as their current use of private service and diversion options. This information provides a benchmark for comparison with the results of unit pricing, and a check on the validity of the self-reported values. At the time of the survey, each household

[1] Of the 1500 surveys mailed out, 121 were returned unopened because the respondents had changed address from the one given on the electoral roll.
[2] A copy of the survey is available upon request.

was provided with 52 black bags each year. The average number of bags currently used was reported in the survey as 53 per year, or slightly over two a fortnight. To achieve the CCC goal of an 80% reduction, the average needs to fall to approximately 11 bags per annum or 0.4 per fortnight. Around 90% of respondents reported that they recycle, a very similar figure to council estimates of an 85% participation rate (CCC, 2005). The majority recycle every week, but a significant minority (around 25%) recycle only every second week. The average is 1.5 bins per fortnight, while the mode is 2. Approximately half of the households compost. This figure is very similar to council estimates that 55% of households compost to some extent (CCC, 2005). Very few households indicated that they dispose of waste in other ways such as burning (2%) and illegal dumping (1%). Around 8% of households use a private waste service as a substitute for council kerbside collection. Another 18% use both council and private services. These figures are slightly higher than those reported by the council, which estimates 18% of households use a private service (CCC, 2005). The average size of the subscription is 27 litres per week, although the range is large.[3]

Hypothetical Unit Pricing Scenarios

Respondents were asked to indicate the quantity of bags that they would put out each fortnight for different prices per bag under a hypothetical unit-pricing system. Subjects were asked to imagine that rates would be reduced accordingly. The elicitation method can best be described as iterative bidding. A sample question is shown in Figure 2. Although collection is weekly, a fortnight was used to aid respondents to perceive use below one bag per week. To assist respondents to make meaningful decisions and ease their task, tables were provided that contained the cost of the service to the household per fortnight and per year, under different levels of service (i.e. the number of bags put out for collection).

[3] Additional analysis of the private service figures is provided in the discussion section.

Each respondent was asked about three different unit prices, with respondents randomly allocated to one of two price treatments: either $0.50, $2.00, and $3.00, or $1.00, $2.50 and $4.00. Survey pre-testing, using the cognitive interview method (Dillman, 1998), indicated what respondents might consider to be a realistic range of bag prices. Households indicating a reduction in bags were then asked an open-ended question about how they intended to achieve that reduction.

The legitimacy of these responses depends on the avoidance of common CVM biases (Carson and Mitchell, 1989). Because respondents are already familiar with the subject of the survey (i.e. black bags), hypothetical bias is unlikely to be a problem. In addition, all of those who reduced gave some idea of how they would achieve the reduction. Given local opposition to reducing the number of bags, strategic bias might be more of a problem. This could be evidenced by respondents showing no response, which approximately 45% of the sample did. However there are significant differences between the groups that reduced and did not reduce, which might legitimately account for lack of response. In particular, those not reducing already use a significantly lower number of bags on average, which may indicate that these households are conscientious about minimising waste generation, and are not able to lower further, while those in the higher average group are not so conscientious. Alternatively, because non-reducers use relatively high levels of private service then they will not react to a price increase for the council service.

Environmental Attitudes

The third component of the survey sought to identify attitudinal motivations for household waste minimisation. Respondents were asked what motivated their household to minimize waste. They were presented with six possible motivations and asked to indicate the importance of each using a Likert scale, ranging from one (strongly agree) to five (strongly disagree). The responses were coded into a dummy variable taking on a value one if the respondent either ‘strongly agreed’ or ‘agreed’ with the statement, and zero otherwise. The mean values of these dummy variables are reported in Table 1. The most important motivator was ‘concern for the natural environment,’ with around 85% of respondents indicating it was an important motivating factor.

Waste Generation

The fourth component of the survey collected socio-economic variables such as the number of adults and children in the household, household income, and education. These household characteristics may contribute to the amount of waste generated by the household. Participants were also asked if they “consider the cost of disposing of a product at the end of its lifetime or disposing of its packaging” when making a purchase decision. Only 18% of survey respondents indicated that they practised source reduction of this kind.

A chi-squared test was used to test the null hypothesis that there is no association between the distribution of the sample and 2001 census data. The null was rejected at better than 95% significance level for all demographic variables (income, size of household, gender, labour force status, education, ethnicity), except for age. The distribution of age is skewed upwards because respondents were taken from the electoral roll, which naturally omits those 17 and under, however these individuals would seldom be responsible for decisions on household waste management. These results confirm both the representativeness of the sample and the success of stratified sampling by income. This together with the 32% response rate and the similarity of the figures to council ones serves to further strengthen the validity of the study.

The limitations of this research stem from the inability to form a quantitative estimate of respondent’s use of diversion options such as recycling post-implementation of a unit-pricing programme. This research is able to present only a qualitative measure. Some limitations also stem from the data collection process. The number of bags put out provides the measure of the level of waste disposed of via council service. However the volume and weight of a council rubbish bag varies across households, but is treated as constant, that is, one bag.

4. Model Specification

To evaluate the effectiveness of unit pricing, the following demand function is estimated:

Q = f (waste diversion practises, unit price, environmental attitudes, waste generation)

where Q = the number of CCC black bags put out every fortnight, and the independent variables are detailed in Table 1.

Two econometric issues need to be accounted for. First, because the dependent variable takes on predominately integer values the count data model is the appropriate one to use. Second, the decision about number of bags and recycling participation is made jointly by households. In order to control for the simultaneous nature of these decisions, instrumental variables is used.

Poisson Count Data Model

Figure 3 shows the distribution of the dependent variable, the number of bags that a household puts out each fortnight over all values of the price per bag given. The majority (97 percent) of the values reported by households are integers. The appropriate econometric model to use in this circumstance is the Poisson count data model (Cameron and Trivedi, (1998)). To apply the count data model, non-integer values were rounded down to the nearest whole number. This adjustment had no impact on the mean or standard deviation of the dependent variable.

The Poisson parameterisation exploits the discrete characteristic of the dependent variable. For a discrete random variable, y_i, with observed frequencies, y_i, $i = 1,..., N$, where $y_i \geq 0$, the Poisson regression model specifies that y_i given x_i is Poisson distributed with density

$$f\left(y_i \middle| x_i\right) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i}, \; y_i = 1, 2, 3...$$

The distribution is determined by the single parameter μ, the mean. This parameter is given by the conditional mean function

$$\mathrm{E}\left(y_i \middle| x_i\right) = \mu_i = e^{x_i'\beta}$$

which is determined by the regression equation. This study specifies an exponential conditional mean function, as is common practice. This mimics the nonnegative nature of the dependent variable, ensuring that none of the fitted values of the model will be negative.

For empirical estimation one of the most important restrictions of the Poisson assumption is the equality of the (conditional) mean and variance. The raw data shown in Figure 3 suggest that there is under-dispersion present, that is, the variance is less than the mean.[4] In settings of under-dispersion an alternative is to use Poisson quasi-maximum likelihood (PQML), involving use of Huber-White robust standard errors (Huber (1967) and White (1982)). Provided the conditional mean function is correctly specified and the conditional distribution of y is Poisson, the PQML $\hat{\beta}$ is consistent, efficient, and asymptotically normally distributed.

The non-linear nature of the model complicates interpretation of the results. The estimated coefficients (β) only indicate the direction and significance. The impact of a unit change in a regressor on the expected value of the dependent variable is found by calculating the marginal effect, where the marginal effect of the jth regressor is given by:

[4] This restriction, referred to as equi-dispersion, is formally tested using a regression based test proposed by Cameron and Trivedi (1990). The test is based on an auxiliary regression of $e_{oi}^2 - y_i$ on $\hat{y}_i^2$ where the errors and fitted values are obtained from an initial estimation of the Poisson model. The test statistic is highly significant leading to rejection of the equi-dispersion assumption.

$$\frac{\partial E(y_i|x_i)}{\partial x_{ji}} = \beta_j e^{x_i'\beta} = \beta_j E(y_i|x_i)$$

The value of the marginal effect depends on the value of the explanatory variables for which it is computed. It is common to evaluate these at the mean values of the regressors.

Instrumental Variable Estimation for Recycling

To control for the simultaneity between bags and recycling bins, an instrumental variables regression is used for recycling, and then the fitted values for recycling are used in the bags equation. The recycling equation is estimated with the best regressors: number of adults, number of children and household income. Because the recycling variable is also integer and suffers from under-dispersion the PQML is appropriate here also. As with number of bags all non-integer values are rounded down, but this does not change the mean and variance significantly. These results are summarized in Table 2.[5] The variables collectively and individually are highly significant. The fitted values for the dependent variable from this model are used as the instrument in the original equation.

5. Results

Table 3 reports the results for the estimation of the demand function for CCC bags. Overall the model fits well, with the chi-squared test indicating that the explanatory variables as a whole are significant in explaining the dependent variable. The value of RsqD, the sum of the squared deviance residuals, considered by Cameron and Trivedi (1998) to be the most appropriate measure of fit for this model, could be considered low, however cross-sectional data often suffer from this result.

While not all the individual variables are individually significant, those that are have the correct sign. Particularly important, the unit price charged has a significant negative impact on the demand for bags. Greater use of waste diversion options (recycling, private

[5] All empirical model estimation is carried out using LIMDEP econometric software.

service, and composting) also significantly reduces demand for bags. Looking specifically at the marginal effects, each litre of private service that the household uses decreases the expected number of bags by 0.0085 bags. Each bin of recycling put out by the household reduces the expected number of bags by 2.8 per fortnight.

If the household uses composting to dispose of food waste then the expected number of bags put out per fortnight falls by 0.83 bags. If the household purchases products with relatively less packaging or otherwise relatively low disposal costs, behaviour referred to as source reduction, then this reduces the expected number of bags by 0.78 bags per fortnight.

None of the attitudinal variables are individually statistically significant although concern for the natural environment, other peoples views of oneself, and price of waste service all have the envisaged signs.

For the average household, each additional adult results in an additional bag every fortnight, while each child contributes approximately half as much waste as each adult, with each extra child resulting in half a bag extra per fortnight. The marginal effect of household income on the number of bags put out as presented in Table 3 is estimated as 0.09. As the income variable is measured in census categories, the coefficient estimate is interpreted as an increase in income from one category to the next, calculated at the average value.

In the next three subsections more detailed discussion is included on three particular issues of interest: the potential for unit pricing to achieve waste reductions, diversion options, and equity considerations.

5.1 Unit Pricing

The marginal effect of price in Table 3 is -0.21. This is calculated at the average of all prices (all other variables are at their averages also), which is $1.64. This is interpreted as a one unit increase in price (i.e. $1.00), from the average price, leading to a decrease in the expected number of bags by 0.21 bags per fortnight. To investigate how the marginal effect of price changes across price levels, we can change the value at which the marginal effect of price is computed, all other variables remain at their mean values. These effects are summarised in Table 4. We can see that the magnitude of the marginal effect of price is decreasing as price increases. This illustrates how important it is to factor in the status quo policy when considering any change. Households respond more strongly to initial increases in price than they do to increases once the price is set.

To calculate the effect of increasing price from $0.00 to a price greater than a one unit increase (*i.e.* $1.00), we need to compute an accumulative or total effect. For example, consider an increase from $0.00 to $3.00 per bag. Using the conditional means provided in Table 4 the cumulative effect is a decrease in the expected number of bags of 0.61 per fortnight.

Even though the absolute magnitudes are small, cumulatively quite large impacts occur when they are multiplied over the entire city. For example, if a unit-price of $1.00 per bag was introduced the model predicts a reduction of 0.23 bags for the average household per fortnight compared with the status-quo of $0. In Christchurch with approximately 123,000 households this equates to a reduction of 735,540 bags per year going to the landfill. However, even a price of $4.00 per bag would only reduce the number of bags by 40%, halfway to meeting the council's target.

5.2 Reduction Achievement

How households achieve any reduction is crucial to the success of the waste management program. Respondents who indicated reductions under unit-pricing were asked an open-ended question about how they would achieve any reduction in the number of bags put out. The responses are categorised in Table 5, where the percentages given are of the number of households actually reducing the number of bags put out, where n = 247. The sum of the percentages is more than 100 because some households indicated several options. All households that would reduce number of bags indicated at least one option.

Subscription to a private service is the most popular option, with almost 25 percent of households choosing this option to help obtain reductions in the number of council bags used. This is perhaps the most serious threat to achieving waste targets in a unit-pricing programme as it results in no reduction in the amount of waste going to the landfill.

Composting, compaction, and recycling are also major reduction options for households. Compaction reduces the volume but not the mass of waste, and so does not contribute to a waste reduction goal. Some households considered that they would decrease the number of bags that their household put out but did not know how they would achieve this. This group is measured by ‘can not do any more’. This group of households may be doing all they can to minimise waste.

Respondents who indicate that they are willing to dump waste illegally may pose a problem. Almost 5% of those households reducing the number of bags put out in response to the introduction of unit-pricing state they will dispose of waste illegally, for example dumping on the roadside, to help achieve that reduction. This might be considered an emotive reaction. When the costs of actually doing it are realised, this may not be cost minimising behaviour. Miranda and Bynum (2002) report that while illegal dumping may increase initially this reduces when long-run adjustments occur. The option to substitute towards private service could also be overstated. As opposed to other diversion options, households face a significant positive marginal cost for private service. Households who currently use only the council provided service, (74% of the sample) may react differently when they look to substitute towards private service as alternatives with lower relative cost, such as recycling and source reduction behaviour will be more attractive.

As part of question three of the survey, respondents currently using private service were asked to state the cost of the service as well as billing and collection periods. This data was used to calculate a cost per litre of service.[6] Eleven percent of private service users are achieving costs per litre of $0.02 or less. At this rate an equivalent cost for the fifty litre council bag would be $1.00. However the average per litre cost is $0.05, indicating an equivalent cost per council bag of $2.50.

In addition, some households used private service exclusively even though they were aware that they had already paid (in their rates) to use the council service. This highlights that there are characteristics of the private service that attract consumers other than the price. The convenience of having a waste receptacle that does not rip easily, either accidentally or by animals; is easy to put at kerbside because it has wheels; is weather proof; can store waste easily; and is monitored by service people; is demanded by many households.

While unit pricing may achieve reductions in black bag waste, if households shift to private service then there will be no reduction in the total amount of waste being landfilled. The CCC may need to consider other positive incentives in addition to unit pricing. One possibility is a council provided composting services, a trial of which is currently under way.

5.3 Do different income groups react differently to changes in price?

Income distribution concerns can be investigated as part of an effort to recognise social sustainability as a requirement for domestic waste management policy. We might expect the marginal effect of price to be greater for lower income groups who face a relatively tighter budget constraint. Analysing this effect could highlight which income groups might reduce their demand more than others. The expected number of bags demanded at varying price levels is computed for three different household income groups.

[6] Households fill their containers to 94 percent on average.

The results are shown in Figure 4, where the slope gives the marginal effect of price changes.[7]

As Figure 4 shows, the price effect is greatest when moving from a price of zero to $1.00, and that the effect of price is diminishing as the price per bag increases. This is the same for all income groups. A more interesting observation is the higher income groups react more strongly to the price, and the price effect is converging between income groups as price increases. The marginal effect at price equal to zero is -0.22, -0.27 and -0.33 for the low income, medium and high income groups respectively. This gives a range of 0.11. When the marginal effect is evaluated at a price of $4.00 then the effects are -0.13, -0.16 and -0.20, giving a range of 0.07. This suggests that as an autonomous level is reached the ability of a household to reduce waste further is limited. Figure 4 also reminds us that, holding all else constant, higher income groups have a higher conditional mean relative to low income households. That is, holding all else constant, a wealthy household will produce more waste than a relatively low income household. At each price level the high income groups have a relatively greater opportunity to decrease the amount of bags used because the magnitude of their waste is greater. The lower income groups are closer to the autonomous level of waste generation and disposal. They do not generate or dispose of a lot to start with and therefore they do not have as much opportunity to decrease the use of bags. This result is consistent with Fullerton & Kinnaman (1996) who found that those with higher incomes achieved greater reductions in weight of garbage following introduction of unit- pricing.

6. Conclusions and Policy Implications

This paper demonstrates that the use of the CVM before the implementation of a unit pricing scheme can provide valuable information to communities. The demand estimation

[7] Marginal effects are calculated with all variables other than price and income set at their mean values.

shows that initial responses to unit pricing are the strongest, with reductions becoming progressively smaller for higher increases in prices. In the Christchurch context, the results suggest that a price of at least $8 would be needed to achieve the CCC goal of 80% reduction. This price is likely to be an understatement, because a price so high is likely to cause even more local opposition and use of diversion options (especially illegal disposal) than that reported in the survey where the highest price scenario was $4 per bag.

While unit pricing may lower the number of black bags collected at the kerbside, this does not necessarily translate into a lower weight of waste being sent to the landfill. The main diversion options used are substitution towards private service and compaction. With compaction, while the number of bags may lessen, the weight will not. Private service provides attributes to consumers that the council provided service does not, so that some households use the private service even though it costs more than the council service. If households simply substitute towards private service then no reduction waste will be achieved. Use of private service seems more attractive as the unit price increases.

In summary, the introduction of unit pricing in isolation seems unlikely to achieve the goal of reduced waste. To avoid mass substitution to private service, the council service may need to change to being bin or can based, providing some of the non-price attributes that household's value. Additional positive incentives are also required, such as kerbside collection of organic waste, currently being trialled by the CCC.

This study has focused on the application of a market-based instrument at the household level. Instruments applied at the industry level, aimed at producers, also play an important role in minimizing waste generation (Choe and Fraser, 1999). Research into the interaction of instruments at this, and the household level in New Zealand, is an essential part of the waste minimization debate. Analysis of the incentive structures surrounding source reduction must also form an important part of further research in waste management.

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Figure 1: Per person domestic waste, recycling and green waste

Source: C.C.C. (2005)

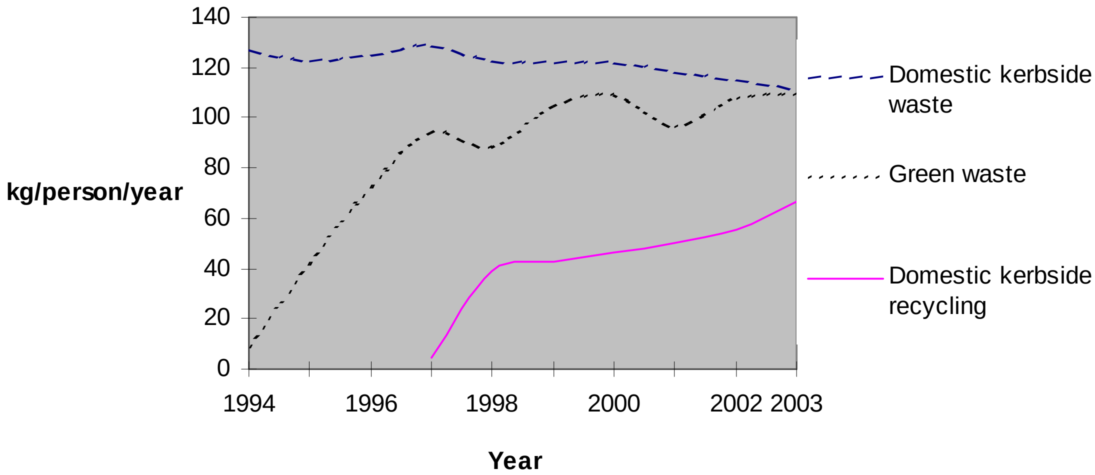

Figure 2: WTP elicitation

If rubbish bags were to cost **$2.00** each, how much would your households rubbish collection cost? *(get figures from table below)*

$2.00 per bag	**1 bag per fortnight**	**2 bags per fortnight**	**3 bags per fortnight**	**4 bags per fortnight**	**6 bags per fortnight**
Cost per fortnight	$2.00	$4.00	$6.00	$8.00	$12.00
Cost per year	$52.00	$104.00	$156.00	$208.00	$312.00

Would this cost mean that your household would change the number of bags put out?

If yes, then how many bags would be put out per fortnight? ____________________

Figure 3: Distribution of CCC Black Bags

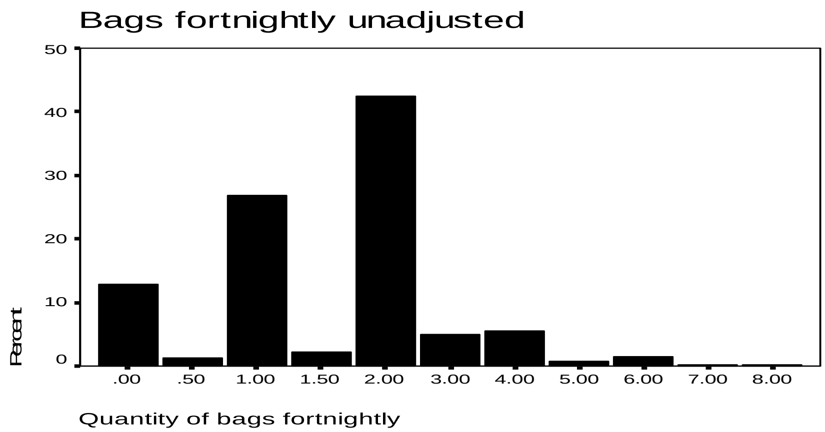

Figure 4: Marginal Price Effect Across Income Groups

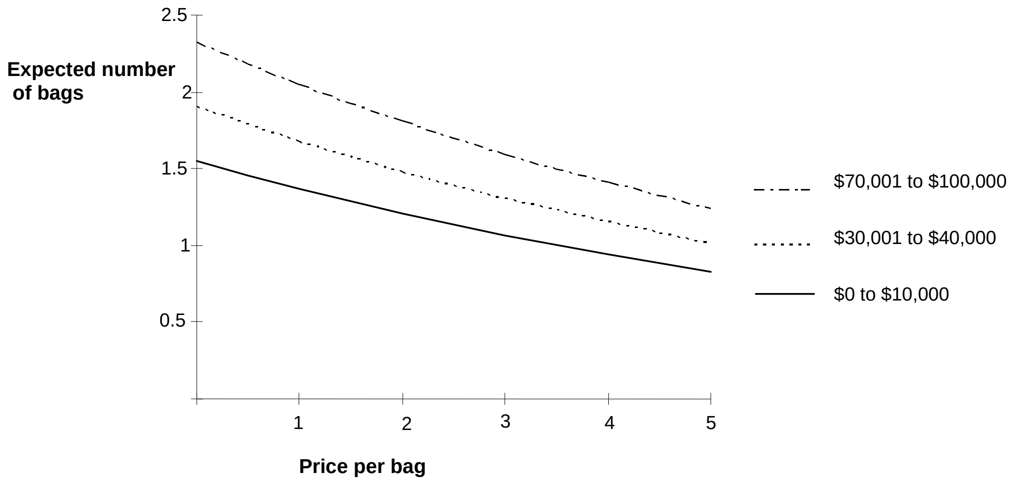

Table 1: Summary Statistics for Independent Variables

Variable	Mean Value	Standard Deviation
Current Waste Diversion Practises		
Recycling bins (per fortnight)	1.54	0.78
Private service subscriptions (litres per week)	27.08	54.45
Indicator variable for composting	0.50	0.50
Indicator variable for burning	0.02	0.12
Indicator variable for illegal disposal	0.01	0.09
Unit Pricing		
Price per bag	1.64	1.40
Environmental Attitudes		
Indicator variable for motivated by 'concern for natural environment'	0.85	0.35
Indicator variable for motivated by 'other peoples views of oneself'	0.13	0.34
Indicator variable for motivated by 'price of waste service'	0.55	0.50
Indicator variable for motivated by 'time and effort managing waste'	0.42	0.49
Indicator variable for motivated by 'negative attributes of waste'	0.60	0.49
Indicator variable for motivated by 'desire for efficiency'	0.70	0.46
Indicator variable for member of environmental organisation	0.07	0.26
Waste Generation Influences		
Number of adults (aged 16 and over)	2.11	0.73
Number of children (aged less than 16)	0.54	0.92
Household income census category	5.80	2.03
Indicator variable for source reduction	0.18	0.39

Table 2: Instrumental variable estimation for recycling

Variable	Marginal Effects[a]	Standard Error[b]
Adults	0.24**	0.04
Children	0.10**	0.03
Income	0.03*	0.01
RsqD	0.10	
Chi-squared	68.00**	

* significant at 95% level of confidence
** significant at 99% level of confidence
a = computed at mean values of the independent variables.
b = Huber-White robust standard errors

Table 3: Model Estimation for Number of Bags.

Variable	Marginal Effects[a]	Standard Error[b]
Constant	3.09**	1.040
Current Waste Diversion Practises		
Recycling (fitted values)	-2.79*	1.205
Private service	-0.01**	0.001
Composting[c]	-0.83**	0.070
Burning[c]	-0.81	0.273
Illegal[c]	-1.38	0.400
Unit Pricing		
Price	-0.21**	0.030
Environmental Attitudes[c]		
Concern	-0.90	0.104
Other peoples	-0.93	0.105
Price of waste service	-0.97	0.070
Time and effort	1.05	0.076
Negative attributes of waste	1.08	0.078
Desire for efficiency	1.01	0.082
Member	1.00	0.000
Waste Generation Influences		
Adult	0.99**	0.327
Children	0.50**	0.132
Income	0.09**	0.032
Source reduction[c]	-0.78**	0.089
RsqD	0.20	
Chi squared statistic	329.59**	

* significant at 95% level of confidence
** significant at 99% level of confidence
a = computed at mean values of all the independent variables.
b = Huber-White robust standard errors
c = Values given for indicator variables are actual marginal effects

Table 4 Marginal price effects

Price	Conditional mean (bags)	Marginal effect of price
\$0.00	1.96	-0.25
\$1.00	1.73	-0.22
\$2.00	1.53	-0.19
\$3.00	1.35	-0.17
\$4.00	1.19	-0.15

Table 5 Waste Reduction Options (n = 247)

Variable description	Percentage
Private	24.3
Compost	19.8
Compaction	19.4
Recycle	18.2
Burn	12.1
Source reduction	10.1
Can not do any more	5.7
Illegal	4.9
Insinkerator	2.0