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Willingness to pay for kerbside recycling the Brisbane Region

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ABSTRACT

Waste policy in Australia has a strong focus on kerbside recycling. This has a range of costs and benefits to the community, including non-market benefits. However, in Australia, there has been little investigation of household willingness to pay for kerbside recycling. This paper used mixed logit choice modelling to estimate the willingness to pay of households in Brisbane, Australia for kerbside waste collection services including kerbside recycling. It was found that households in Brisbane have a positive and significant willingness to pay of $131.49 per annum for fortnightly kerbside recycling and would be willing to pay an additional $18.30 to increase the frequency of this service to weekly. The utility of respondents was, however, found to decline by $34.18 per year if general waste collection increased from weekly to twice a week. Based on the assumptions used in this study it would appear that the willingness to pay for kerbside recycling exceeds the net financial costs of this service, suggesting that the scheme is economically efficient. However, the reported economic values for recycling may overstate the community's true willingness to pay if household responses to the choice questions were confounded by their underlying perceptions about the environmental and resource sustainability benefits of recycling.

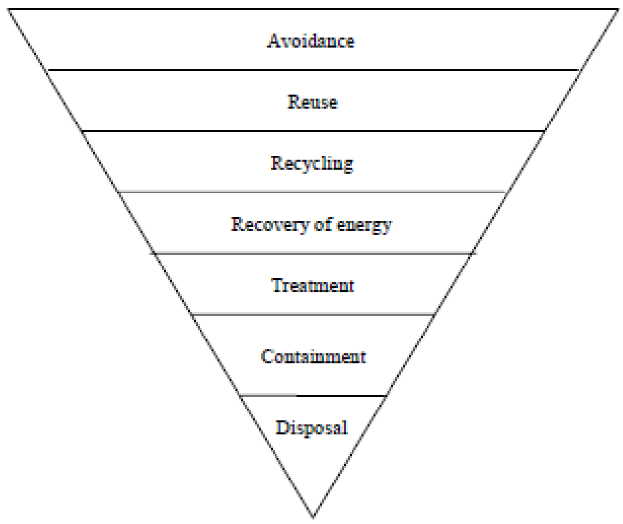
1 INTRODUCTION

Australian domestic waste management was initially focused on the collection and removal of waste from communities and disposal at some remote location with the aim of protecting public health. However, it became apparent that disposal of waste, mainly by landfill, could have a range of off-site impacts including leachate contamination of groundwater and exposure of neighbouring communities to odour, dust, litter and vermin. While in recent years these impacts have been reduced through the development of advanced landfill management techniques, there has been growing concern about the link between waste generation and upstream environmental impacts of virgin resource extraction as well as the sustainability of natural resource use associated with production and consumption (Productivity Commission 2006).

In response to these concerns, an integral component of waste policy in Australia since 1992 has been waste minimisation and recycling. The National Strategy for Ecologically Sustainable Development (ESD) (Commonwealth of Australia 1992) committed Australia to improving the resource use efficiency and reducing the environmental impacts of waste disposal (DEWHA 2009). The National Waste Minimisation and Recycling Strategy (NWMRS) (ANZECC 1992a) included a goal of reducing the amount of waste per capita going to landfill by 50% by 2000 (with 1991 as the reference year). The National Kerbside Recycling Strategy (NKRS) (ANZECC 1992b) was developed to expand on the goals of the NWMRS and included recycling targets for individual materials as well as proposing targets for urban household access to kerbside recycling (Productivity Commission 2006). The National Waste Policy 2009 continued the commitments of the National Strategy for ESD. It aimed, among other things, "to avoid the generation of waste, reduce the amount of waste for disposal and manage waste as a resource" (DEWHA 2009, p.6).

At the State and Territory level, policies and strategies have been developed to pursue the waste minimisation objective of the NWMRS and NKRS. These frequently refer to the concept of a waste hierarchy (Figure 1): waste avoidance is preferred to reuse, reuse to recycling, and so on. Disposal is the least desirable option (Productivity Commission 2006).

Figure 1 **A waste management hierarchy**



Source: Victorian Government (2005).

In response to National and state waste management strategies, local governments have expanded the range of waste management services on offer. This includes moving from a single bin kerbside waste collection system, where all waste goes to landfill, to a two-bin service where mixed putrescibles waste is collect in one bin and goes to landfill and dry recyclables are collected in another bin and goes to a Materials Recovery Facility (MRF). In some areas a third bin is provided for recycling of green waste (Productivity Commission 2006).

Kerbside recycling can have a range of costs and benefits to the community. Consideration of the magnitude of these costs and benefits is useful for policy development (BDA Group and Gillespie Economics 2009). The costs of operating a kerbside recycling scheme can generally be estimated using market data. Some benefits such as the value of recovered materials and avoided costs of landfill can also be estimated using market data. However, other benefits are not marketed and are not so easily defined (Jamelske and Kipperberg 2006).

There is a range of reasons why households may value a recycling service and so enjoy a non-market benefit. These include avoidance of perceived problems associated with the landfill disposal options, concern for the conservation of virgin resources and associated environments, ethical considerations and social obligations (Lake et al 1996). Aadland and Caplan (1999) assume that a loosely defined notion of altruism motivates household demand for kerbside recycling reflecting a concern for the environment and the existence, option and amenity values that the household ascribes to the act of recycling. Whatever the motivations, studies that have aimed to estimate community values for the non-market benefits of kerbside recycling have not attempted to disaggregate the diverse value components. They have however recognised that any willingness to pay (WTP) for the non-market benefits of kerbside recycling represents an amalgam of these motivations (Lake et al 1996).

There are a number of international examples of non-market valuation studies of kerbside recycling. Aadland and Caplan (2005) used contingent valuation (CV) to estimate household WTP for kerbside recycling in 40 western US cities. The average WTP was $5.61 per month and when calibrated for hypothetical bias and sampling error, $2.97 per month. Aadland and Caplan (1999) in a CV study of residents in Ogden Utah found a mean WTP for kerbside recycling of $2.05 per month. Lake *et al* 1996) used CV to estimate mean WTP for a kerbside recycling scheme in the village of Hethersett, South Norfolk, UK at £35.6 per annum. Jamelske and Kipperberg (2006) in a study of single stream kerbside recycling in Madison, Wisconsin found a household WTP of $3 per month. Troske *et al* (2009) estimated mean WTP for kerbside recycling for Lexington, Kentucky residents in the USA at $2.29 per month.

In Australia, there has been little investigation of household WTP for kerbside recycling. The authors are unaware of any existing published studies. Non-market valuation studies in relation to waste management have been limited to packaging and beverage container waste management (PWC 2010) and E-Waste Recycling (URS 2009). This paper aims to remedy this deficiency presenting the results of a choice modelling (CM) study of WTP for kerbside recycling by households in Brisbane. The paper is structured as follows. Section 2 introduces the CM method. Section 3 discusses waste management in Brisbane and kerbside recycling services that are provided. Section 4 discusses the survey design and implementation. The econometric results are reported in Section 5. A discussion of the results and their policy implications is given in Section 6. Conclusions are drawn in Section 7.

2 CHOICE MODELLING

In CM, respondents are asked to choose their preferred alternative from a set of choice options (Bennett and Blamey 2001) where the options are described by differing levels of a number of attributes. Based on Lancaster's 'characteristic theory of value' (Lancaster, 1966), it is assumed that respondent utility is derived from the attributes of the alternative (Amaya-Amaya 2008). Using the random utility framework, alternative *i* will be chosen from a choice set if, and only if, the utility derived from that option is greater than the utility derived from any other alternative. Hence, the probability of a respondent choosing a particular option i from a choice set is greater if that option has a higher level of the desirable attributes. Thus the relative utility (U) that a respondent derives from an alternative i, comprises:

- a component (Vi) that is observable and normally specified as a linear, additive function of a vector (Xi) of explanatory variables that can include the attribute levels of the alternative, socio-demographic characteristics of the respondent, information on the decision context and features of the choice task (Hensher and Greene, 2003); and

- a component that is unobservable (εi) which represents variations in choice due to within – and between – individual variance, omitted or unobserved influences (attributes) on individual choice, measurement errors and functional specifications (Batsell and Louviere 1991).

It is generally assumed "that these two components of relative utility are independent and additive" (Hensher et al 2005, p. 75) and that εi is independently and identically distributed (IID) across utilities, with a type I extreme-value (Weibull) distribution. The multi-nomial logit (MNL) specification of the utility function is:

$$U_i = V_i + \varepsilon_i = \beta X_i + \varepsilon_i \quad (1)$$

By including cost as one of the attributes used to describe an alternative it is possible to estimate the marginal rate of substitution between changes in the levels of individual attributes and changes in cost and hence respondents' WTP (implicit price) for changes in the levels of individual attributes (Hanley et al., 1998). Alternative specific constants (*ASC*) can be included in X_i to measure any systematic, but unobserved differences in utilities between alternatives that are not explained by the other parameters in the utility specification.

The mixed logit (ML) specification of the utility function, allows for the relaxation of the IID assumption of the MNL specification as it allows for heterogeneity of preferences across individuals (Hensher et al 2005) and across alternatives (Greene and Hensher 2007). It can also account for correlations in unobserved factors over repeated choices by each individuals (Revelt and Train,1998).

The ML specification is the same as the MNL specification set out in equation 1 except one or more of the parameter estimates are represented as:

$$\beta_{nk} = \beta_k + \eta_k z_{nsjk} \quad (2)$$

where β_k is the mean marginal utility in the sampled population for attribute k and η is the deviation of the mean marginal utility held by respondent *n* for attribute *k* belonging to alternative *j* in choice set *s*. z_{nsjk} represents some underlying distribution such as normal, triangular and lognormal distributions (Rose and Hensher 2010). The model is estimated using simulated maximum likelihood methods (McFadden and Train, 2000).

A ML CM approach that allows for heterogeneity of preferences across individuals including a latent error component term to account for heterogeneity across alternatives and a panel data specification is used in this study.

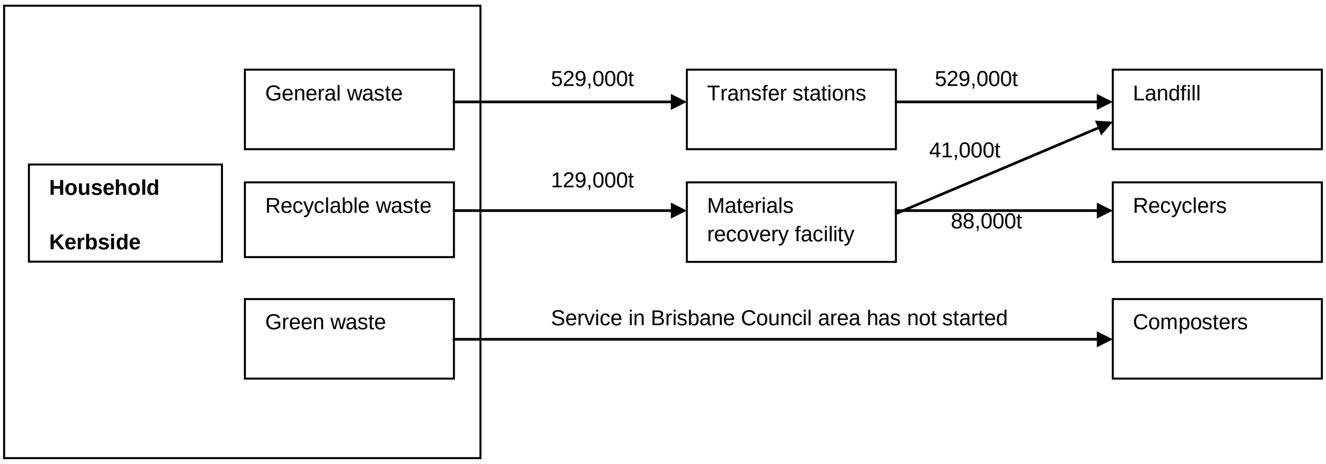
3 KERBSIDE WASTE MANAGEMENT IN BRISBANE

The Brisbane region comprises the local government areas (LGAs) of Brisbane, Logan, Ipswich, Moreton Bay and Redland. Households in the LGAs of Brisbane, Ipswich, Moreton Bay and Redland have a two bin kerbside waste collection system. One bin is for general waste and is collected weekly. This general waste is transported to a transfer station and then to landfill. Another bin is used for recyclables such as cardboard, paper, glass and plastic bottles, and is collected fortnightly. This waste is transported to a material recycling facility (MRF) with recyclable materials sold to processors and unusable materials transported to landfill. Households in the LGA of Logan have a single split bin system collected weekly which separates both general waste and recyclables.

The Brisbane City Council has recently announced the introduction of a voluntarily third bin service for green waste collection in the Brisbane LGA. This bin is mainly intended for lawn clippings and prunings. It will be collected fortnightly and the contents turned into compost. At the time of the study this scheme had not commenced.

Figure 2 summarises how waste from the kerbside bin system is managed and the weights of material handled each year.

Figure 2 – Kerbside Waste Management in the Brisbane Region



The amount paid by residents for general waste collection plus recyclable waste collection varies by LGA within the Brisbane region, from $228 per annum in Moreton Bay to $334 per annum on the islands of Redland LGA. For the Brisbane LGA, which includes the majority of the population of Brisbane region, the charge is $250 per annum.

Nolan-ITU (2004) has collected data on the costs to Councils of waste collection and transport in large Australian cities. The data for Brisbane indicate that the recycling bin contributes around 15% of the total cost of the two bin system. Applying this to the amount paid for the two bin system by Brisbane residents suggests that around $40 of the total fee relates to the provision of the recycling service.

For homeowners, payment for the existing kerbside waste collection system is via their Council rates. For tenants these charges are generally passed on by landlords through rents.

4 QUESTIONNAIRE DESIGN AND IMPLEMENTATION

The questionnaire designed to investigate respondents' WTP for their recycling service included information on the existing household kerbside management in the Brisbane Region and the amount of waste that goes to landfill or is recycled. Households in Brisbane already pay for general waste collection and for kerbside recycling. They are therefore familiar with the service they were being asked to value. However, to elicit their willingness to pay for the existing kerbside recycling service it was necessary to provide respondents with a plausible scenario whereby the existing service would cease unless they expressed a sufficiently high WTP to have it continued.

This scenario involved recycling paper, cardboard, glass, plastic and aluminium not being commercially viable and that even with payments currently made by residents, the recycling scheme is financially questionable. Hence, the prospect of ceasing the current kerbside recycling of paper, cardboard, glass, plastic and aluminium was raised in the questionnaire. With the fortnightly collection of the existing recycling bin ceasing, the scenario outcome was that all recyclable material would be placed in the general waste bin which would continue to be collected weekly.

To add realism to this base case scenario, respondents were advised in the questionnaire that it would involve the waste levy they currently pay annually being reduced from around $250 to $210. Respondents were informed that the recycling scheme would continue if Council could raise sufficient funds from the annual household waste levy to cover the costs of:

- Continuing to provide recycling bins;
- Continuing to manage the separated recyclables; and
- Recycling paper, cardboard, plastics, glass and aluminium.

While some studies have left unspecified what the potential benefits of recycling are, the questionnaire used in this study identified what some of these may be. This was an attempt to address the prospect of exaggerated perceptions of the benefits of recycling. As identified by the Productivity Commission (2006,p xxii), "residual levels of externalities from modern, fully complying landfills appear to be small" and hence the non-market environmental benefits of reducing the waste going to landfill are also likely to be small. There is also sufficient landfill capacity for the medium term to serve the needs of the major population centres (Hyder Consulting 2009). Upstream benefits of recycling such as the conservation of virgin material are also considered highly uncertain (Productivity Commission 2006).

Potential benefits to respondents of recycling were therefore identified narrowly as:

- Reduced use of landfill space;
- Recovery of glass, plastic, cardboard, paper and aluminium for use in creating other products;
- Less wastage.

The attributes used to describe alternative waste collection schemes in the CM choice questions were selected with reference to previous studies, discussions with waste management experts and focus groups. Boyer (2006) found that household WTP for general waste and recycling waste services in Stillwater, Oklahoma, USA, varied with frequency of kerbside pick-up. Attributes used by Boyer (2006) therefore reflected levels of service provision rather than actual environmental benefits. A similar approach was used in this study. Attributes that could be used to represent a base case kerbside bin collection scheme and alternatives bin collection systems were the frequency of general waste bin collection, frequency of recycled bin collection and annual waste levy payment.

Attribute levels represented a realistic range of service frequencies and cost levels. The final attributes and their levels are outlined in Table 1.

Table 1 – Attributes, their measurement units and levels

Attribute	**Unit of measurement**	**Levels***
Cost	Annual waste levy payment ($)	**210;** 230; 280; 380
General waste bin collection	Frequency	**weekly;** twice weekly
Recycling bin collection	Frequency	**nil;** every two weeks; weekly

*The base level of attributes is given in bold.

A Bayesian D-efficient design (Scarpa and Rose 2008) of 18 choice sets was constructed using three attributes, with six choice sets embedded in three blocks of the questionnaire. Priors for the design were obtained from an online pilot test. The design was based on effects coding of the "general waste bin collection" and "recycling bin collection" attributes as follows.

Table 2 – Effects Coding of Attributes

	General waste	Recycling Fortnightly	Recycling Weekly
Level 1 - Weekly	-1		
Level 2- Twice weekly	1		
Level 1 – Nil		-1	-1
Level 2 – Every two weeks		1	0
Level 3 - Weekly		0	1

Effects coding enables non-continuous variables to be represented by n-1 effects coded variables, each of which represents one of the attribute's n-1 levels. This enables non-linearities between attribute levels to be explored. Effects coding was made possible by allowing the base levels for general waste bin collection and recycling bin collection to appear in the alternative bin collection options in the choice sets.

Each choice set comprised three alternative waste management options:

- option 1 – recycling ceases – return to a single bin. This option would result in weekly collection of the general waste bin and an annual waste levy of $210.
- option 2 and option 3 – alternative bin collection systems. These options would result in different frequencies of collection of the general waste bin and a recycling bin but a higher annual waste levy payment.

An example choice set is provided in Figure 3.

Figure 3 – Choice Set Example

Question 6

Carefully consider each of the following three options for managing kerbside waste. Suppose options 1, 2 and 3 in the table below are the **ONLY ones available**. Which one would you choose?

Option	**Your annual waste levy payment**	**General waste bin collection**	**Recycling bin collection**	**Which option would you choose? (Please tick)**
Option 1 –Recycling Ceases – Return to a Single Bin	$210	Weekly	Nil	Option 1 ☐
Option 2 - *Recycling continues*	$280	Weekly	Weekly	Option 2 ☐
Option 3 - *Recycling continues*	$380	Twice a week	Every two weeks	Option 3 ☐
				Not Sure ☐

The provision rule included in the questionnaire was:

> *Kerbside recycling would only continue to be provided if more than 50% of households across Brisbane region are willing to pay for it. If a decision is made to continue providing kerbside recycling it would be compulsory for all households.*

A provision rule can improve the incentive compatibility of non-market valuation studies as it provides a connection between respondent choices and actual outcome (Hoen and Randall 1987) and removes ambiguity about how respondent choices will impact policy. It provides an incentive to respond truthfully. The majority decision rule combined with the nature of the good (it is able to be provided to each individual household separately) results in there being no incentive for respondents to provide a "yes" response if they do not want the scheme: If there are enough votes then the good will be provided to each household at a cost to all respondents. Similarly, there is no incentive for respondents to provide a "no" response if they do want the scheme as insufficient votes will lead to the service not being provided.

Follow-up questions were designed to detect problems that respondents may have experienced in answering the questionnaire, specifically protest responses, the adequacy and bias of the information provided, the level of the payment, and the difficulty of the WTP question. The final section of the questionnaire sought attitudinal and socio-economic data.

The questionnaire was administered between 11 November 2010 and 6 December 2010 using a web-based survey, with a sample drawn from an existing panel of pre-stratified and registered respondents. The sampling strategy was aimed at obtaining 200 completed questionnaires per block with respondents for each block stratified by age and gender to reflect the Brisbane region population aged between18 and 85 years of age[1].

5 RESULTS

5.1 Biases and Protests

To test for problems that respondents had in answering the questionnaire, specifically in relation to the adequacy of and bias in the information provided, the level of the payment, and the difficulty of the choice questions, a Likert scale was used.

Table 3 summarises the mean response to a sequence of statements. On average respondents understood all the information provided, did not need additional information, did not consider the information biased and did not have difficulties answering the choice questions.

Table 3 – Questionnaire issues

	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree
I understood all the information provided (4.0)	1	2	3	4	5
I need more information than was provided (2.8)	1	2	3	4	5
I thought the information was biased towards recycling (2.6)	1	2	3	4	5
I thought the information was biased against recycling (3.1)	1	2	3	4	5
I found answering the choice questions confusing (2.5)	1	2	3	4	5

Less than three per cent of respondents indicated a protest by choosing the status quo in all choice sets because they objected to a payment of any amount for a recycling bin collection system.

[1] Logan LGA was excluded from the study because its existing bin collection system was different from other LGAs within the Brisbane region.

5.2 Data Analysis

Mixed Logit Results[2]

The variables included in the choice models are shown in Table 4.

Table 4 – Variables Considered in Models

Variable code	Description
ASC	Alternative Specific Constant (1 = status quo alternative)
Cost	Cost of choice alternative ($ pa)
Gwaste	Frequency of collection of general waste bin – effects coded
Recycweekly	Frequency of collection of recycling bin – effects coded
Recycfortnightly	Frequency of collection of recycling bin – effects coded
Age	Age as continuous variable
Gender	Respondent gender (1 = female)
Locat	Respondent LGA of residence (1=Brisbane)
Recyc	Respondent recycling (1= household recycles)
Comp	Respondent composting (1=composts food waste)
Int	Respondent interest in waste management and recycling (1=interested)
Child	Respondent has children (1 = children)
HHsize	Number of people living in the respondents household
Nukids	Number of people living in the respondents household who are under 18 years of age
Houseown	Respondent house ownership (1 = owned outright or paying off)
Housetype	Respondent house type (1 = house)
Educ	Respondent education level (1 = post school qualification)
Income	Annual household income before taxes ($000)
Envdev	Respondent attitude to development and the environment (-1= favour development, 0=favour neither, 1=favour protection of the environment more frequently)
Envorg	Respondent or close family a member or contribute to an environmental organisation (1= yes)
Fishorg	Respondent or close family associated with waste management industry (1= yes)

In the preferred ML model reported in Table 5, the three effects coded choice attributes (Gwaste, Recycweekly and Recycfortnightly) were defined as random variables. A number of distributional assumptions were tested (normal, lognormal, uniform and triangular), of which the normal distribution performed best statistically. A range of socio-demographic variables was initially included in the model. Variables that were insignificant were not included in the final model specification. The model was estimated by simulated maximum likelihood using Halton draws with 1,000 replications (Train, 2003).

[2] A variety of models were estimated using NLOGIT4.0 (Econometric Software, 2007

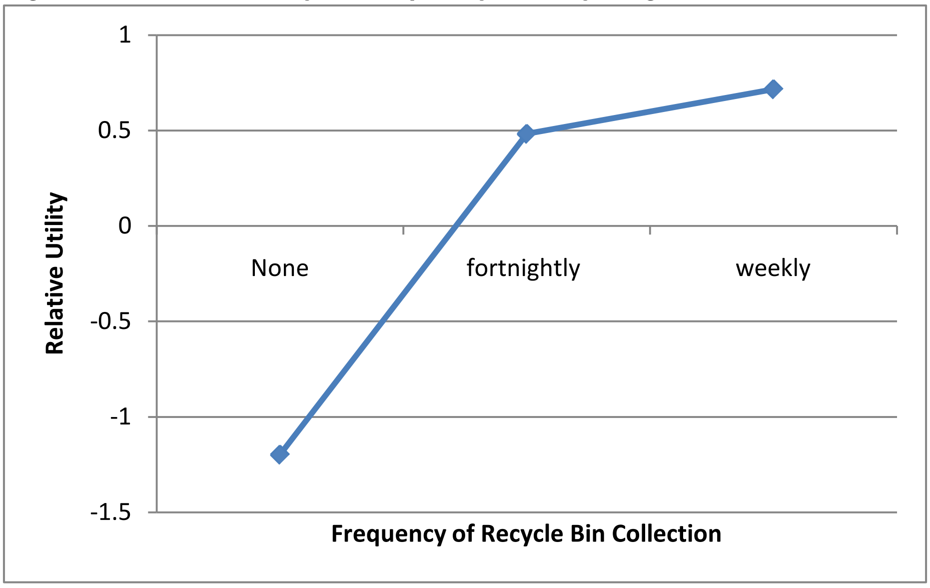
Table 5 – Mixed Logit model results

Variable	Coefficient Mean	Standard Deviations of Random Parameters
Random Parameters		
Gwaste	-0.2185***	0.4225***
Recycweekly	0.7163***	0.9218***
Recycfortnightly	0.4824***	0.5220***
Non-random Parameters		
Cost	-0.0128***	
Gender	0.6654**	
Recyc	2.0240***	
Int	1.9643***	
Income	0.0173***	
Envdev	0.5718***	
Envorg	1.5075**	
ASC	-5.2577***	
Standard Deviation of Latent Random Effects	2.7508***	
Log likelihood	-2923	
McFadden Pseudo $R^{2\,(a)}$	0.29	

Significance levels: *p = 0.1, **p = 0.05, ***p = 0.01; [(a)] Compared to a constants only base model

The estimated attribute parameters are all significant at the one per cent level. The negative sign on the Gwaste attribute indicates that when the collection of the general waste bin increases from weekly to twice a week the utility of respondents declines. The positive signs on the Recycweekly and Recycfortnightly attributes indicate that respondent's utility increases with the introduction of a recycling bin that is collected weekly or fortnightly. The relative utility of respondents is greater for a weekly collection of the recycling bin. However, graphical representation of the effects coded recycle bin attribute indicates that the majority of the utility gain from a recycle bin is associated with fortnightly collection (Figure 4). An increase in the frequency of collection of the recycle bin from fortnightly to weekly appears to result in additional but declining marginal utility. Whether this is significant can be determined using a Wald Test of Linear Restrictions. This test rejects the equality of parameters and hence it is concluded that the parameters are not equal and that the non-linear specification is better.

Figure 4 – Relative Utility of Frequency of Recycling Bin Collection



The significant standard deviations on the random parameters reflect the heterogeneity in preferences towards all attributes.

Being female, living in a household that undertakes some recycling, having an interest in recycling, having a higher household income, favouring the environment over development and being a member of or contributing to an environmental organisation are all factors that increase the probability of respondents choosing one of the 'alternative bin collection systems'. The ASC is negative and significant at the one per cent level, indicating a systematic preference for Option 1 – recycling ceases, return to a single bin system. However, the significance of the latent error component indicates individual heterogeneity in the way respondents evaluate the base case option, compared to the alternative bin collection system options.

Estimates of Willingness to Pay

The parameter estimates reported above were used to estimate implicit prices (in 2010 A$) for each of the non-market attributes levels (Table 5).

Table 5 – Mean estimated implicit prices (A$/household/year)

Attribute	Mean	95% Confidence Interval#
Gwaste	-$34.18	(-$13.83 - -$57.07)
Recycfortnightly	$131.49	($105.23 - $160.29)
Recycweekly	$18.30	($15.02 - $19.42)

The 95% confidence intervals are in brackets and were calculated using the Krinsky & Robb procedure (Krinsky and Robb, 1986) with 1,000 draws.

The results show that, on average, respondent's utility declines by $34.18 per year if general waste collection increases from weekly to twice a week. Respondents are, however, on average willing to pay $131.49 per year for a fortnightly recycling service and an extra $18.30 to increase the frequency of this service to weekly.

6 DISCUSSION

While recycling is a fundamental component of waste policy in Australia and households are required to pay extra for the provision of a kerbside recycling service in most LGAs, the communities' WTP for this service (and the implied benefits it provides) has rarely been estimated. Benefit cost analyses of recycling services in Australia has been limited and, where undertaken, has been reliant on benefit transfer rather than primary non-market valuation studies (Nolan-ITU 2001). In terms of recouping the financial costs of recycling it has also generally been implicitly assumed that households on average value the recycling service (and the implied benefits it provides) by at least the financial cost that is imposed on them.

While a full benefit cost analysis of recycling in Brisbane is beyond the scope of this paper, consideration of the general costs and benefits of recycling provides some context for the WTP figure estimated here. In the absence of kerbside recycling, household domestic waste would be collected and transported to landfill for disposal. The incremental costs and benefits of kerbside recycling therefore need to be considered relative to this base case. Table 6 summarises these potential incremental costs and benefits.

Table 6 – Potential Incremental Benefits and Costs of Kerbside Recycling Compared to Landfill

	Costs	Benefits
Non-financial / Private	Household time and effort of separating waste	
Financial / Private	Increased collection and transport	Decreased landfill costs
	MRF operation costs	Revenue from sale of recyclables
Non-market	Amenity, congestion, pollution and accident risk associated with increased truck movements.	Decreased landfill externality costs
	Amenity effects of MRFs	Reduced resource depletion (marginal user cost)
		Avoided externalities associated with reduced resource depletion)

*Shaded area net values are likely to be negligible according to the Productivity Commission

Kerbside recycling requires households to expend time and effort separating their waste into a number of bins. This is a non-financial cost to society that is borne by households. There is also an increase in the costs associated with collecting waste from multiple bins and transporting general and recycling waste to different destinations. The operation of MRFs, where recyclable materials are sorted for further processing, is another financial cost of recycling which is offset to some extent by the value of the recyclable material (Productivity Commission 2006). Because less waste ultimately ends up in landfill there is a cost saving in the operation and management of landfills. The net financial costs of waste collection, transportation and disposal are passed on to households via the waste levy in their council rates.

In addition to these financial and non-financial private benefits and costs, there may be a range of non-market values of kerbside recycling. The operation of landfills may involve a number of external costs including greenhouse and non-greenhouse gas emissions, leachate and loss of amenity to adjoining areas as a result of litter, dust, odour, vermin and visual impacts (Productivity Commission 2006). Therefore any reduction in waste going to landfill may potentially reduce these externalities. However, for landfills with best practice controls external costs have been estimated at less than 4% of the total costs of operating landfills (BDA Group 2009). Furthermore, because most recyclable materials are inert, the external benefits of not sending them to landfill are likely to be small.

There may also be non-marketed external costs of kerbside recycling associated with increased truck movements collecting and transporting dual waste streams and from the operation of MRFs. Externalities from increased truck movements can include amenity affects from truck noise, increased congestion and risk of accidents as well as pollution and greenhouse gases. The operation of MRFs can result in amenity impacts on nearby landholders (Productivity Commission 2006). However, on balance, the Productivity Commission (2006) considered that the net external costs of recycling (benefits from reduced landfill and costs from truck movements and MRF operation) are not likely to be significant.

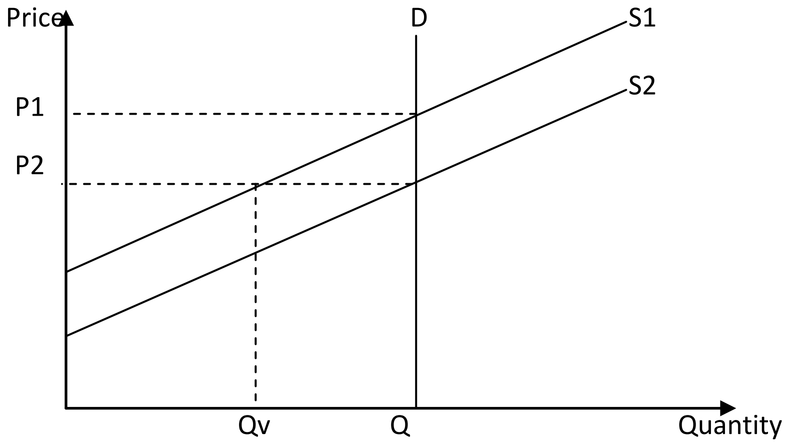
Two additional non-market benefits of recycling are reduced resource depletion leaving a greater stock available for future extraction and the avoided environmental externalities associated with this reduced resource depletion. The former benefit is an avoided marginal user cost. Both depend on an assumption that recycling leads to a reduction of in the use of virgin materials. Each of these issues is addressed below.

A marginal user cost occurs where, because of scarcity, greater current use of a resource diminishes future opportunities. The marginal user cost is the present value of these foregone opportunities at the margin (Tietenberg 1992). Conversely, where actions taken today, such as recycling, increase the resources available in the future this marginal user cost may be avoided, and becomes a benefit of current day actions. However, where there is sufficient supply of mineral and other resources for many decades or centuries, which is the case for aluminium, steel, glass and plastic, any future scarcity from current day consumption is a considerable distance in the future and the present value of foregone future extraction net benefits is likely to be negligible under realistic discount rates. So even if actions, such as current day recycling, do reduce current day extraction of virgin material the avoided marginal user cost is likely to be negligible.

Notwithstanding this, it is far from clear that recycling will actually lead to a reduction in the current day resource depletion. Some studies of recycling in Australia (Nolan-ITU 2001) assume that recycled material replaces virgin material on a one to one basis.

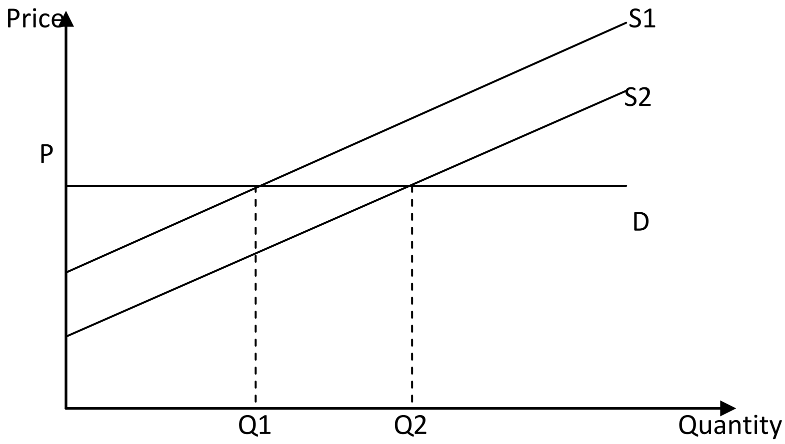
From an economic perspective, this assumption is equivalent to assuming, firstly that recycled product is homogenous with the virgin product (which is not the case for some recycled material such as paper) and secondly that the market demand curve is perfectly inelastic for each of the products. Hence, an extra quantity of recycled material simply substitutes (crowds-out) production from an alternative virgin source.

Figure 5 – Demand and Supply When Demand is Perfectly Inelastic



Hence, as the market supply of say aluminium increases from S1 to S2, in Figure 5, as a result of increased recycling, the same fixed quantity is demanded by the market and hence the recycled aluminium production displaces production from virgin material and price decreases from P1 to P2. The quantity supplied from virgin material decreases from Q to Qv. However, for many resources demand is relatively elastic. Any theoretical crowding out of virgin production will therefore be negligible. The additional (recycled) supply merely increases the volume consumed with the quantity supplied from virgin material remaining unchanged at Q1 in Figure 6.

Figure 6 – Demand and Supply When Demand is Perfectly Elastic



If recycling has little impact on extraction of virgin resources there will also be little benefit by way of avoided externalities associated with the extraction of virgin materials – such as loss of biodiversity from harvesting forests for paper production or clearing forests to mine bauxite. Even if some crowding out does occur the environmental externalities avoided may be minimal given the internalisation of upstream externalities through environmental regulations (Productivity Commission 2006).

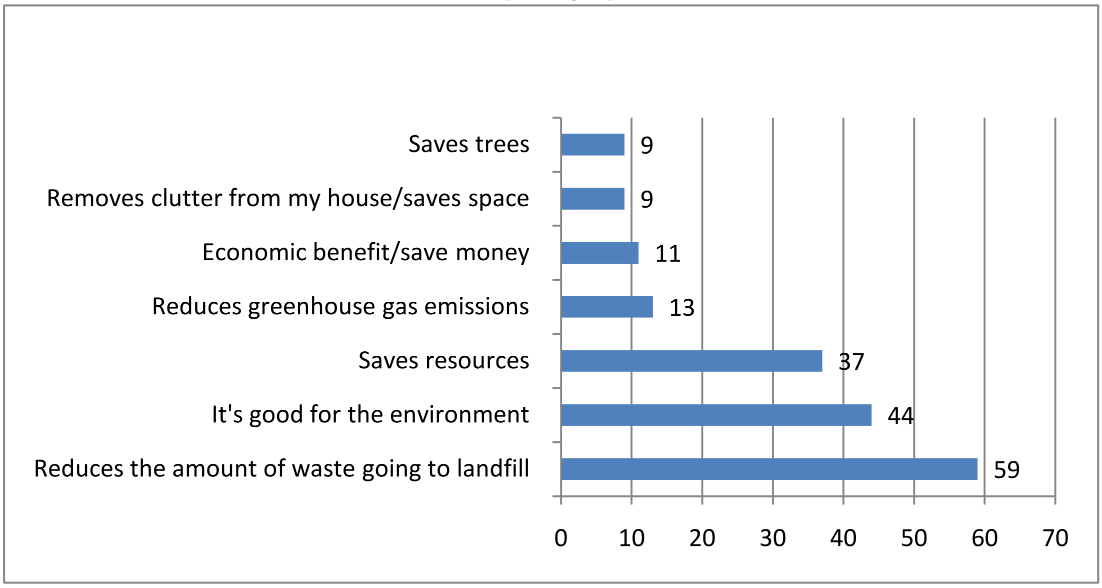
Nevertheless, households may value the provision of recycling services for a wide range of reasons including avoiding some of the perceived problems of landfills, concern for conservation of virgin materials or ethical considerations. Ultimately it is difficult to disaggregate the diverse value components of respondents and so no attempt has been made here to do so.

However, demand by households for recycling services is dependent on the information that respondents have available to them and in this study we sought to provide factually correct information in the questionnaire. The reasons provided in the questionnaire for why respondents may think kerbside recycling is a good idea were limited. Reference was made in the questionnaire to reduced use of landfill space, recovery of materials and less wastage. Care was taken in the questionnaire, not to refer to any environmental costs or benefits of recycling or saving of virgin resources. With the information that was provided, it was found that household WTP for kerbside recycling was positive and significant. This respondent WTP is from current and potential users of the recycling service and is therefore likely to be net of the non-financial costs to them of recycling.

Ultimately, households bear the net financial costs of recycling schemes. Given that external costs and benefits of kerbside recycling in Brisbane may be negligible, provided household WTP for kerbside recycling (net of non-financial costs) exceeds these net financial costs then kerbside recycling may be considered to be economically efficient. The net financial costs of fortnightly kerbside recycling were estimated to be in the order of $40 per household per year while the WTP for this service was estimated at around $131 per household per year. This comparison suggests that the scheme is economically efficient. However, more specific estimation of the net financial costs of kerbside recycling is required by councils in the Brisbane region to confirm this conclusion.

One potential concern with the estimation of the WTP for kerbside recycling reported in this study is the extent to which respondent WTP may be confounded by their underlying perceptions about the environmental and resource sustainability benefits of recycling. For instance, a study by Synovate (2007) looking at recycling behaviour in Western Australia, found that 44 per cent of respondents believed recycling was good for the environment and 37 per cent believed that recycling would save resources.

Table 7 – The Perceived Benefits of Recycling by Western Australian Households



Source: Synovate (2007)

It is therefore possible that even though the CM questionnaire specifically refrained from identifying these types of outcomes as a benefit of recycling, the expression of respondent preferences in the study may have incorporated them. If this is the case, then household WTP for recycling may be overstated.

With regard to general waste collection, the results of this study show that there is disutility associated with increasing the frequency of bin collection from once per week to twice per week. This is consistent with the findings of Boyer (2006) who found that the second garbage pick-up per week imposes a negative externality on residents of Stillwater, Oklahoma, USA. The disutility associated with increased frequency of general waste collection may be related to the time and effort associated with putting the bin out and bringing it back in, and perhaps that households generate insufficient general waste to warrant an additional collection each week.

7 CONCLUSION

While kerbside recycling is a fundamental component of waste management policy in Australia the community's willingness to pay for it has never been examined. This study shows that households in Brisbane have a positive and significant WTP of $131.49 per annum for fortnightly kerbside recycling and would be WTP an additional $18.30 to increase the frequency of this service to weekly. The utility of respondents was, however, found to decline by $34.18 per year if general waste collection increased from weekly to twice a week

Whether kerbside recycling in Brisbane is economically efficient requires a consideration of all the potential costs and benefits. Based on the findings of the Productivity Commission, the external costs and benefits of kerbside recycling would appear to be negligible. Therefore, provided household WTP for kerbside recycling exceeds the net financial costs that they actually pay it may be considered to be economically efficient. Based on the assumptions used in this study it would appear that the WTP for kerbside recycling exceeds the net financial costs of this service, suggesting that the scheme is economically efficient. However, more specific estimation of the net financial costs of kerbside recycling is required by Councils in the Brisbane region to confirm this conclusion.

One potential concern with any study that examines the estimation of respondents' WTP for kerbside recycling is the extent to which respondent WTP is confounded by their underlying perceptions about the environmental and resource sustainability benefits of recycling. To the extent that this has occurred in this study, the results may overstate the community's true WTP for kerbside recycling.

8 REFERENCES

Aadland, David, M. and Caplan, Arthur J.(1999) Household Valuation of Curbside Recycling, *Journal of Environmental Planning and Management*, 42: 6, 781 - 799

Amaya-Amaya (2008) Discrete Choice Experiments in a Nutshell, IN, Eds Ryan, M., Gerard, K. and Amaya-Amaya, M. *Using Discrete Choice Experiments to Value Health and Health Care*, Springer, Netherlands.

ANZECC (Australia and New Zealand Environment and Conservation Council) (1992a), *National Waste Minimisation and Recycling Strategy.*

ANZECC (Australia and New Zealand Environment and Conservation Council) (1992b), *Report on the Establishment and Implementation of the National Kerbside Recycling Strategy*.

Batsell, R. and Louviere, J. (1991) Experimental Analysis of Choice, *Marketing Letters*, 2:3, 199-214.

Bennett, J. and R. Blamey **(2001)**, *The choice modelling approach to environmental valuation*. Edward Elgar Publishing, Cheltenham, England. BDA Group (2009) *The full cost of landfill disposal in Australia*, prepared for Department of the Environment, Water, Heritage and the Arts

BDA Group and Gillespie Economics (2009) *Analysis of social and environmental valuation methodologies for waste managemen*t, prepared for DEWHA.

Boyer, T. (2006) Talking *Trash: Valuing Household Preferences for Garbage and Recycling Services Bundles Using a Discrete Choice Experiment*, Paper presented at the American Agricultural Economics Associate Annual Meeting, Long Beach, California, July 23-26, 2006.

Commonwealth of Australia (1992), *National Strategy for Ecologically Sustainable Development*, Canberra.

DEWHA (2009) *National Waste Policy: Less Waste, More Resources*, Fact Sheet, Commonwealth Government, Canberra.

Econometric Software, (2007). LIMDEP 9.0. Econometric Software Inc.: Castle Hill.

Green, W.H. and Hensher, D.A. (2007) Heteroscedastic control for random coefficients and error components in mixed logit, *Transportation Research Part E: Logistics and Transportation Revie*w, 43, 610-623.

Hanley, N., Wright, R., Adamowicz, V., (1998) Using Choice Experiments to Value the Environment. *Environmental and Resource Economics* 11, 413-428.

Hensher, D.A., Greene, W.H., (2003) The Mixed Logit model: The state of practice. *Transportation* 30, 133-176.

Hensher, D.A., Rose, J.M., Greene, W.H., (2005) Applied Choice Analysis: A Primer. Cambridge University Press, Cambridge.

Hoehn, J. P. & Randall, A. (1987) A Satisfactory Benefit-Cost Indicator from Contingent Valuation. *Journal of Environmental Economics and Management,* 14**,** 226-246.

Hyder Consulting (2009), *Waste and Recycling in Australia*, for Department of the Environment Water Heritage and the Arts.

Jemelske, E. and Kipperberg, G. (2006) A Contingent Valuation Study and Benefit/Cost Analysis of the Switch to Automated Collection of Solid Waste with Single Stream Recycling in Madison, Wisconsin, *Public Works Management & Policy*, v.11, n.2, pp. 89-103.

Krinsky, I., Robb, A.L. (1986) On Approximating the Statistical Properties of Elasticities. *The Review of Economics and Statistics* 68, 715-719.

Lake, I., Bateman, I., and Parfitt, J. (1996) Assessing a Kerbside Recycling Scheme: A Quantitative and Willingness to Pay Case Study, *Journal of Environmental Management,* 46, 239–254.

Lancaster, K.J., (1966) A new approach to consumer theory. *Journal of Political Economy* 74, 132-157.

McFadden, D., Train, K., (2000) Mixed MNL Models for Discrete Response. *Journal of Applied Econometrics* 15, 447-470.

Nolan-ITU (2004), *Global Renewables: National Benefits of Implementation of UR-3R Process: A Triple Bottom Line Assessment,* Nolan-ITU, Sydney.

Nolan-ITU (2001) *Independent Assessment of Kerbside Recycling in Australia*, prepared for the National Packaging Covenant Council.

PWC (Pricewaterhouse Coopers) (2010) *Estimating consumers' willingness to pay for improvements to packaging and beverage container waste management*, prepared for Environment Protection and Heritage Council.

Productivity Commission (2006) *Waste Management*, Draft Report, Canberra

Revelt, D., Train, K., (1998) Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. *Review of Economics and Statistics* 80, 647-657.

Rose, J. and Hensher, D. (2010) *Mixed Multinomial Logit (MMNL) Model*, Executive Course February 2010

Scarpa, R., Willis, K.G., Acutt, M.,(2007). Valuing Externalities from Water Supply: Status Quo, Choice Complexity and Individual Random Effects in Panel Kernel Logit Analysis of Choice Experiments. *Journal of Environmental Planning and Management* 50, 449-466.

Scarpa, R. and Rose, J. (2008) Design Efficiency for Non-Market Valuation with Choice Modelling: How to Measure It, What to Report and Why. *Australian Journal of Agricultural and Resource Economics*, 52(3): 253-282.

Synovate (2007) *A Profile of Recycling Behaviour*, prepared for the Department of Environment and Conservation, Western Australia, www.zerowastewa.com.au/documents/presentations/synovate_survey_hholdatt

Tietenberg, T. (1992) *Environmental and Natural Resource Economics*, Harper Collins Inc., New York.

Train, K.E., 2003. *Discrete Choice Methods with Simulation*. Cambridge University Press.

Troske, K., Blomquist, G., Hardesty, D., Koford, B., and Hughes, M. (2009) *Estimating Willingness of Citizens to Pay for Recycling*, Industry Studies Association 2009 Annual Conference, Chicago, USA.

URS (2009) *Willingness to Pay for E-waste Recycling*, prepared for the Environment Protection and Heritage Council.

Victorian Government (2005) *Towards Zero Waste Strategy*, Melbourne.