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Assessing The Implementation Of Economic Instruments Of Solid Waste Management In A Logit Approach

by

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ABSTRACT

This study applies a binary logit approach to assess the implementation of economic instruments that provide households with incentives to reduce solid waste. The relationship between these instruments and waste diversion programs is analyzed as a secondary objective. The choice of these instruments by local officials in a municipality is explained by: whether or not a municipality provides households with recycling programs (RECY), the level of urbanization (URBAN), per capita private residence (PRVHLD), education (EDUC), Green Peace members (GPEACE), party politics (PC and PQUEB), transfer payments (TRPAYS) and per capita household income (INCOME). Increasing the tipping fees (TPNGFEE) only promotes composting but has no effect on recycling programs or the implementation of economic instruments. The availability of curbside services to single family residents (CSCSF) encourages recycling. Residence in private housing has a positive impact on both composting and recycling but a negative impact on economic instruments. Recycling affects the implementation of economic instruments and not vice versa. Party politics play an important role in the implementation of economic instruments. Right wing political parties have more influence on solid waste management than left wing. They have a negative impact on the use of these instruments.

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DEDICATION

Josephine Köjöö (*my late mama*)

Nelson Wöjia (*my papa*)

Mary Kabaŋ Kamala (*my grand-mama*)

Simona Mödi Löpu (*my grand-papa*)

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1.0 INTRODUCTION

1.1 Background

Waste disposal services are generally becoming more expensive in Canada. For instance, in the Greater Toronto area it is expected that approximately 250 of its 1400 active municipal landfills will close by the year 2003 (Bartkiw, 1992). The dwindling availability of new landfill sites required to replace old ones has caused this rise in disposal expenses. Scarcity for new landfill sites has developed due to fear of potential environmental hazards associated with waste disposal. As a result, this fear has led to strong public resistance[1] and the adoption of expensive environmental safeguards on facilities that are sited (Dinan, 1993). Public resistance and the cost associated with the construction of safer facilities have increased the cost of waste disposal and led to public interest in decreasing the amount of waste that is generated by promoting 'source reduction[2]' or 'waste diversion[3]'.

The interplay of these two forces (public resistance and stringent environmental regulations) has encouraged many municipalities to start using economic instruments, such as a 'variable tipping fee'[4], which provides households with an incentive to reduce the quantity of waste they produce. The

[1]This public resistance is commonly abbreviated as NIMBY which is an acronym for 'Not In My Backyard'. It describes the heart of the popular resistance to new public facilities of any kind. The public appears to be receptive of new truck weighing stations, incinerators, and even landfills as long as it is not in their backyards (Alexander, 1993).
[2] Source reduction describes measures taken to avoid the generation of high levels of waste. At the industry level, these measures may include practices as designing and manufacturing products with minimal packaging. At the household level it includes such practices as selective purchasing habits and reuse of products and materials (Porter, 1989).
[3] The phrase "Waste diversion" in Perspectives on Solid Waste Management in Canada, (1995) refers to the generic sense of targets established by several provincial and municipal governments to reduce solid waste sent for disposal. The practices in these targets may include recycling, composting and incineration.
[4] A marginal fee charged by landfill authorities for disposing waste into a landfill. It varies with

successful implementation of any economic instrument intended to gauge the behaviour of households towards waste generation (as will be discussed in the next chapter) may require the provision of some waste diversion alternatives such as curbside[5] recycling and composting. Otherwise adopting economic instruments alone may force households to engage in illegal dumping, as a better diversion alternative.

The decision to provide a municipality with either an economic or non-economic waste disposal program is mostly a responsibility of the municipal government with a mandate to maximize public welfare. Often however, decisions made by government bureaucracies[6] are ambiguous about weights given to various factors considered in the decision-making process (McFadden, 1975). Such ambiguity is demonstrated in the equation below.

$$Gov't\,Behaviour = f\left(Budget\,Issues, \mathrm{Re}-election\,\mathrm{Pr}\,obability, Philosophy, etc.\right) \qquad (1)$$

Essentially, Equation (1) represents a *Political Economy Model* in which a municipal government decides on what waste management program may be best suited to manage household generated solid waste. Maintaining consistency in the valuation of explanatory variables such as in this case: *the probability of a political party to be re-elected, philosophy of the municipal government, etc.*, may be overly challenging. This exposes a government's final decision to be vulnerable to criticism since it cannot be subjected to a market test of profitability (like decisions of business firms). And evaluating the

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the quantity of waste available for disposal.

[5] The collection of refuse or recyclables (generated by households) from the curb.

[6] These are a group of government officials appointed to make a decision on behalf of the public.

performance of such decisions may be a difficult task. Perhaps, only two approaches can be used to evaluate the performance of such government decisions. The first approach is called the "Carnegie Approach" pioneered by Cyert March.

This approach requires that to evaluate a decision-maker's performance, a decision-maker must be honest and must allow a researcher unlimited access to information. This however, is rarely attainable particularly from outside the bureaucracy. The second approach requires examining outcomes of the bureaucrats' decisions and to pose the *revealed preference* question of whether there exists an implicit choice criterion such that the decision-maker acts as if it is attempting to follow this rule (McFadden, 1975).

Since government bureaucracies are usually complex organizations associated with loss of information and scrambling of directives, McFadden (1975) argues that it is unrealistic to seek a single choice criterion that rationalizes all outcomes. Instead, he asserts that looking for a statistical distribution of decision rules, which can explain an observed pattern of choice, is reasonable. This distribution, he says, provides information on the average weighting of factors in decisions while its dispersion gives a measure of the internal consistency of the bureaucracy's decision structure. This paper provides an econometric framework of decision rules for the revealed preference analysis to evaluate municipal governments' choice of solid waste management programs.

1.2 Study Plan and Objectives

This study examines the impacts of waste reduction programs and other individual municipality specific attributes on the implementation of market-based waste disposal programs. While almost all studies reviewed for this paper proclaim that solving the garbage "crisis" lies in the implementation of market-based programs, most municipalities in Canada do not seem to implement them. In fact only 23.4% of all surveyed municipalities use economic instruments (see Appendix C). This study therefore, investigates the factors behind the adoption of these programs. This serves to achieve the following objectives:

- to understand the key variables affecting the implementation of waste management programs in general and market based programs in particular,
- to verify whether implementing market based programs necessitates the provision of waste reduction programs, by treating recycling and composting as explanatory variables while assessing the implementation of these programs,
- to set a basis for further research in Canadian Municipal Solid Waste (MSW) management; a crucial area with limited literature.

This paper is organized in the following manner: chapter two gives a brief history of solid waste management, showing how the garbage issue is analyzed in an economic framework. The government's position is discussed as far as municipal solid waste is concerned. Discussion on the use of market-based programs is given showing how they relate to recycling and composting. The second chapter closes by giving a brief review of relevant related studies. Chapter three provides a theoretical framework on which choices of programs are assumed to be made. This chapter discusses both choice theory and random utility theory. Chapter four briefly describes the data, defining the variables considered important and used in the data analysis. Hypotheses regarding the impacts of these variables on the implementation of economic instruments and waste reduction programs are made. The last part of this chapter deals with the model specification - showing four different scenarios. Results and discussions constitute chapter five. The paper ends by presenting conclusions transpiring from the analysis of the data. In the conclusions, a brief summary of the findings of the paper is presented. Problems encountered during the study are pointed out and discussed briefly. Policy implications are discussed and chapter six concludes by discussing directions for further research.

2.0 REVIEW OF LITERATURE

2.1 Introduction

This chapter provides a brief history of solid waste management. It shows what attempts have been made to contain the garbage "crisis". This chapter also describes relevant research done in the area of municipal solid waste management. It concludes by explaining how this study is unique from other preceding studies.

2.2 A Brief History of Municipal Solid Waste Management

The problem of garbage dates as far back as the Stone Age period when our ancestors were hunters and lived in caves. When waste began to accumulate on the cave floors, they simply moved to new caves (Alexander, 1993). However with civilization and urbanization came the accumulation of possessions. But codes and ordinances for solid waste control existed for centuries. For instance, cities in India, China, Crete and Israel provided for municipal waste handling two thousand years before the birth of Christ (Alexander, 1993).

With the rise of industrial cities, came the new age of technology where mass production became the norm for demand sustenance. Waste disposal was not a big problem then since oceans were available as dumping grounds for coastal cities. Inland cities had abundant lands for landfills. Later however, increased population growth, rising standards of living and spread of the environmental movement have transformed the previously easily contained problem into an issue that has preoccupied Canadian municipalities and many other developed nations.

Over the past decade, solid waste disposal has become an issue of particular political interest and no more a problem of individual waste generators. In 1988, Canadians produced in total, 30 million tonnes of waste of which 16 million tonnes were produced by the household sector (Canada, 1991). These statistics translate into approximately 2.4 pounds per person per day. Canada along with its neighbour, the United States are at the forefront as leading producers of municipal solid waste in the world. In comparison with Canada in the same year, the United States produced about 12 billion tonnes of solid waste, of which 180 million tonnes were municipal solid waste (Waste Reduction, 1990). Its per capita waste generation rapidly rose from 2.7 pounds per person per day in 1960 to 4 pounds per person per day in 1988 due to fast economic growth and rising standards of living (Miranda et. al, 1994).

Such high levels of waste production gave rise to the "Garbage Crisis" as many landfills approach capacities, and municipalities continued to face the challenge of locating and constructing new ones. The problem was even worsened when new landfills themselves were being depleted at an unprecedented rate in Canada. Hence the *Canadian Council of Ministers of the Environment* (CCME) was established in 1988 in part to help reduce Canadian municipal solid waste. Several provinces across Canada, passed legislation with the aim of locally achieving the CCME objective, which is to reduce Canadian municipal solid waste to fifty percent of the 1988 levels. For instance, in 1993, among other programs, the province of British Columbia developed the *Solid Waste Management Financial Assistance Program* as a consequence of the growing stress on existing landfills and the difficulty of locating new ones (Adamowicz et al., 1996). Alberta, which has been pronounced as the envy of the world by the Minister of Environmental Protection, has been a leader in developing and following an integrated regional approach[7] to solid waste management (ASEAR, 1995).

Following active steps taken by municipal and federal governments to reduce municipal solid waste, some commendable results were achieved. In Alberta for instance, ASEAR (1995) has reported the recycling of 500 million beverage containers and 750,000 pesticide containers in 1993. As of 1994, it reported the diversion of one million scrap tires from the waste stream. Despite some of these tremendous achievements in diverting solid waste from landfills, the solid waste problem is far from being solved.

2.3 The Use of Incentives as a Means to Reduce MSW

Relative to some areas of study, research on waste management is limited, especially in Canada. Of the available literature, most deals with the United States. The available literature on 'demand for solid waste management services' points out that the failure to implement market-based incentives has been a crucial factor causing sub-optimal use of landfills. In Canada for instance, most households pay for waste services through general revenue tax or a flat monthly fee which does not vary with the amount of waste generated (Thivierge, 1992). Economic theory tells us that such a fee implies a marginal cost of zero. Therefore it is bound to discourage households from reducing

[7]Integrated waste management is tailored to include methods of waste disposal plus recycling and composting to suit local needs.

levels of municipal solid waste. Diagrammatically figure 1 and figure 2, as adapted from Miranda et al. (1994), represent this.

In the economic tradition, economic efficiency is only attainable when marginal benefits are equated to marginal costs. In practice however, most Canadian municipalities that have adopted an economic approach (unit pricing) to handle municipal solid waste usually either charge a fee based on average cost pricing or a two-tier pricing system. To arrive at the average total cost the community estimates the total amount of solid waste it will handle in the proceeding year. It also estimates all total costs associated with its disposal. The total cost includes a fixed cost per tonne of waste disposed at landfills and a variable fee associated with solid waste collection. The total expected cost is then divided by total expected quantity of municipal solid waste.

For municipalities implementing a 'tag a bag' system, households are required to purchase tags to place on the bags awaiting collection. The price of the tag is chosen to cover the total costs, which include all variable and fixed costs associated with disposal of the waste. In other words it implies that the price of a tag is the average cost for MSW collection services. If correctly computed, average cost pricing is more efficient than the traditional system (with a marginal cost of zero) but less efficient than marginal cost pricing (see figure 1). In the average cost system of payment, household pays P_{ACP} for CS_{ACP} level of waste disposal services. But in the traditional system where marginal cost is zero ($P_{TSP} = 0$), the household demands CS_{TSP} level of services.

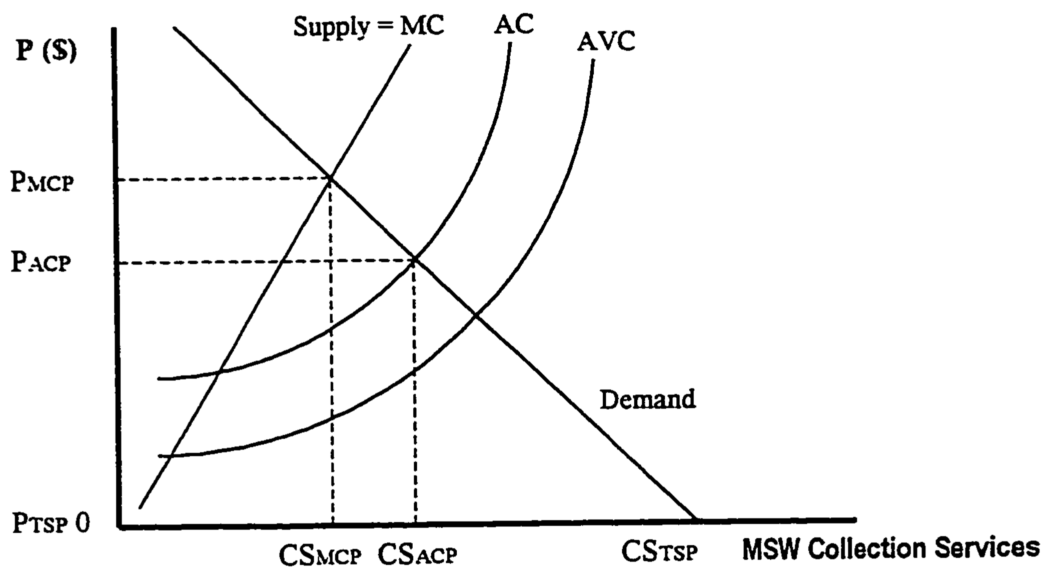

Fig. 1: Comparing the Demand for MSW Collection Services under the Traditional System (CS_{TSP}) and Average Cost System (CS_{ACP}) with Marginal Cost Pricing (CS_{MCP}) [Adapted from Miranda et al. 1994. Journal of Policy Analysis and Mng. Vol (13) 4, p684]

Where a bag limit (which is imposed) or variable tipping fee is the mode of waste disposal, a two-tier pricing mechanism comes into play. This mechanism consists of two components. The first is a fixed price for a minimum level of service for instance three bags per week. The second one is a fee that varies with an incremental demand for extra bags. The variable fee is usually set higher than the fixed price to provide an incentive for households to reduce demand for waste services. This system as shown in figure 2 below, leaves a residual demand for municipal waste disposal services after the minimal demand for solid waste is subtracted from the total. For instance consider the distance AB in figure 2. If the unit price is set to P_{ACP}, then this two-tier pricing system will be as efficient as the average cost system. If however the level of minimal service is decreased then the residual demand increases as the waste generator is left with more undisposed waste. This causes the residual demand curve to shift to the right and intersect with the marginal cost curve at point C. The price charged at this level for CS_{TTP} is P_{TTP} (two tier pricing) and is higher than P_{ACP} therefore being more efficient than average cost pricing but still less efficient than marginal cost pricing. Two-tier pricing will only achieve full efficiency when the minimum level of service payable by average price is reduced to zero, thus shifting the residual demand curve far to the right and overlapping with total demand (D_{TOTAL}). P_{MCP} will be the only price charged. Based on Figure 2 we conclude therefore that the smaller the minimal level of waste disposal services, the more closely unit pricing is based on marginal cost and the more likely two-tier pricing will achieve economic efficiency (Miranda et al, 1994).

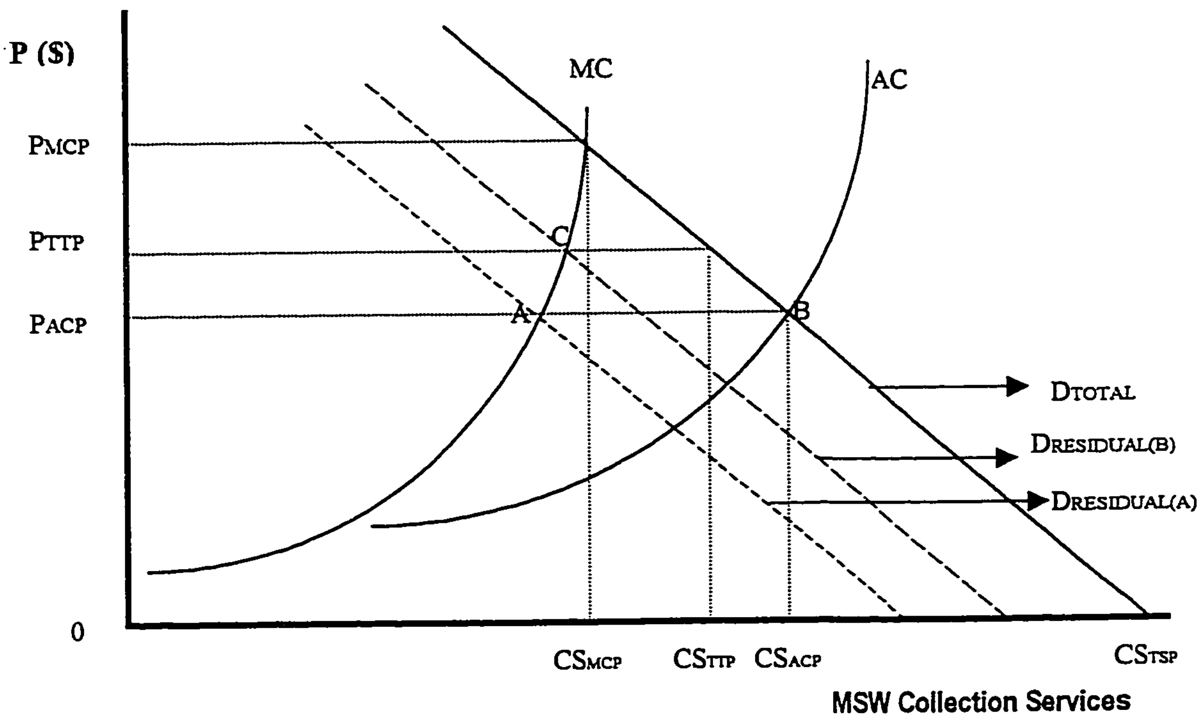

Fig. 2: Demand for MSW Collection – Illustrating the Two-tier Pricing System
[Adapted from Miranda et al. 1994. Journal of Policy Analysis and Mng. Vol(13) 4, p684]

A careful choice of unit pricing creates strong incentives for households to reduce the quantities of waste they generate, whether through changes in their purchasing patterns, reuse of products and containers, or composting of yard wastes. Recycling and composting are two of the activities arising from unit pricing examined in this study.

2.4 Waste Reduction through Recycling

"Instinct tells us that recycling is an excellent answer to waste disposal problems, and many people feel good about their participation. They believe recycling reduces the need for new disposal sites, saves our fast dwindling resources, decreases energy use and cuts pollution" (Alexander, 1993). Still in the hierarchy of integrated waste management (IWM)[8] recycling comes as the first preferred waste reduction option before composting or incineration. Recycling is a widely practiced waste disposal method in Canadian municipalities; 65% of all municipalities surveyed provide recycling programs to households (Appendix C). McClain (1995) attributes the success of recycling to four social, political and economic factors.

First, increased social pressure exists for more environmentally benign activities. With technological breakthroughs, environmental damages can be measured more precisely, and the understanding of such impacts as landfills on groundwater creates social pressure for stricter regulations and more recycling. For instance, increased public awareness of environmental issues in Alberta led

[8] IWM as described by Skumatz (1993) is a combination of all waste management methods designed to work together in a complementary rather than competitive manner. For instance, if both recycling and incineration are thought necessary for a municipality as waste diversion programs, the capacity for incineration must not exceed that for recycling. If it does, it will compete with recycling by consuming some waste material that would have otherwise been recycled. Again, if the recycling capacity is greater, the incineration capacity will be underutilized.

to a recycling incentive program being introduced in 1977 by Alberta Environment (ASEAR).

Second, lifestyle changes occur that lead to increased generation of municipal solid waste. These changes in lifestyles escalate the pressure on local governments to manage waste disposal more effectively. The increase of women in the labor force and the arrival of the microwave have led to greater reliance on prepared foods that usually are more heavily packed for advertising or security purposes (McClain, 1995). Another significant part of the success of recycling stems from nondurable paper, which contributes Canada's single largest municipal solid waste. Nationwide it accounts for 26% of municipal solid waste and in Alberta; it accounts for almost one third (29%) of municipal solid waste (ASEAR). Introduction of copier machines and personal computers into the business world, and the increased use of third class mail for advertising have played a major role in paper disposal and hence its recycling.

Third, the lack of adequate disposal sites and the difficulty associated with locating and constructing new ones affects policy choices. Sites for constructing new landfills may be very difficult to locate due to the stringent regulations of environmental protection agencies such as nearness to groundwater and soil type (McClain, 1995). Even in an event that such sites are located, community opposition to their construction remains formidable because of truck traffic and the landfill's potential negative effects on health. This situation serves as a strong incentive for recycling. For instance in 1990, the city of Edmonton failed to find a new landfill, it then intensified its recycling campaign by providing households with the 'Blue Box' (The City of Edmonton Public

Works, 1996). Consequently, the waste stream flowing into Clover Landfill (its only landfill) declined by 20% creating a further 10 years capacity for the city.

Finally, recycling has become more economically viable. The combined effects of escalating tipping fees, citing costs and new markets for recyclables have raised the economic viability of recycling nationwide. The overall success in recycling is demonstrated by the monotonic decline in total waste disposed of by the household sector. For instance, within a narrow range of four years between 1988 to 1992 total annual waste generated by the household sector declined from 16 million tonnes to 10.5 million tonnes (Environment Canada, 1996). Contrary to the household sector, total waste by the other sectors continues to rise, resulting in a total of 33.2 million tonnes being generated compared to 30 million tonnes in 1988. Despite all this, nearly one third (9.8 million tonnes - 29.7%) of all waste generated was recycled in 1992 of which, only 1.18 million tonnes were from the household sector alone; representing 11.2% of household generated waste (Environment Canada).

Although recycling plays such a major role in waste diversion its provision has shortcomings. A common denominator shared by all processors of recyclable goods is the availability of dependable, long-term supplies of large quantities of clean homogenous materials. The best source for recovered materials meeting these requirements is industrial plants (Alexander, 1993). As can be inferred from the paragraph above, less household waste was recycled in 1992 as compared to waste originating from other sources. This is because individual household waste by contrast is less desirable because it is in small quantities and it is heterogeneous containing a lot of contaminants such as food remains. Recycling household waste (even if in large quantities) may therefore require more labour for separating and decontaminating which translates into uncompetitively higher costs. Another reason that does not favour recycling is the abundance of cheap virgin materials; for instance the abundant pulpwood in Canada serves as a disincentive to using recovered materials which may be relatively costly. With firms wanting to maximize profits, it may be politically unappealing to force large manufacturing companies (with strong lobbying potential) to recycle all or most of their byproducts as would be expected by society. Generally, recycling is costly. McClain (1995) states that although the revenues from the sales of recycled goods could be small or even negligible, as long as the net cost of operating a recycling program is less than the tipping fee, local officials find recycling an attractive alternative to landfill disposal. This infers that from the perspective of local officials, profit maximization may not be the first priority for providing a recycling program but perhaps the maximization of waste diversion from landfills may be overriding, provided the net cost associated with it is less than tipping fees.

2.5 Waste Reduction through Composting

Composting is an aerobic biological process that accelerates the decomposition of organic matter by converting it into mulch and compost. Composting has been part of our global culture since ancient times. Studies have shown that home composting can divert on average 700 pounds of material per household per year. Composting is perceived by many as an excellent way to avoid both, wasting useful natural resources and creating environmental problems while at the same time producing a high quality and inexpensive soil amendment. Compost can also be used to improve soil texture, aeration and augment the soil water holding ability.

Composting represents a potentially important means of reducing municipal solid waste. On average compostable waste accounts for 18% of all waste generated by North American municipalities (Government Institutes, 1987). Specifically in Canada, total organic waste accounted for 23% of municipal solid waste in 1992 (Perspectives on Solid Waste Management in Canada). Taking care of this large portion of municipal solid waste by composting could ease the pressure exerted on landfills which accommodate about 90% of all municipal solid waste generated annually by Canadian municipalities (B.H. Levelton and Associates, 1991). Composting not only prolongs our landfill-lifespans but also avoids environmental hazards like the greenhouse effect that is contributed to by methane slowly escaping from disintegrating organic matter in landfills. The effects of such environmental hazards may last for very many years due to the anaerobic environment under which the organic matter decomposition takes place. For instance, over many years, a single kilogram of putrescible material in a landfill can produce up to 200 liters of methane, an explosive gas twenty five times more harmful than carbondioxide in its potential effect on global warming (Noble, 1989). The instability of landfills containing organic waste also warrants composting. The greater the proportions of biodegradable waste in a landfill, the less stable the landfill. By contrast, landfills exclusively designed for non-degradable materials (the case for China and Germany) are more stable after they have been compacted, and are available for building sites shortly after closure (Hershkowitz and Sarleni, 1987).

Environment Canada in its 1995 'Perspectives on Solid Waste Management' in Canada estimated the total organic fraction of Canada's waste stream to constitute 6.2 million tonnes per year between 1993 and 1995. During this period, composting has increased from 275000 tonnes (4.4%) to 697000 tonnes (11%). That is an increase of 154%. Increased agricultural and horticultural applications of compost particularly in Atlantic and Pacific Canada are significant. For this reason, most composting takes place in the provinces of Ontario, Quebec and New Brunswick in the East and Alberta and British Columbia in the West. The Composting Council of Canada in its 1995 national surveys of composting facilities in Canada, identified a total of 162 facilities, of which 112 were municipal, and 50 private. Ontario alone accounts for 34% (56) while Quebec accounts for 18.5% (30), Alberta accounts for 11.7% (19), New Brunswick accounts for 8.64% (14) and British Columbia accounts for 7.4% (12) of the total.

Although composting may be environmentally or otherwise appealing, odour, NIMBY and market availability for compost pose challenges to its wide acceptability. The public prefers products that are biodegradable but they do not seem to compromise with the smell arising from the decomposing matter. Perhaps that is why only 53% of municipalities surveyed for this study have composting programs as compared to 65% with recycling programs. Professional compost managers are working on sealed systems and indoor facilities to help control odours, but such systems increase composting costs substantially. Another alternative would be to locate composting centers in remote areas far from residential sites. Such locations are difficult to find within reasonable garbage-community distance for the cities from which the waste originates (Alexander, 1993).

Large municipal compost systems require large-volume users, like nurseries, and long growing seasons to be financially viable. Compost produced in the winter practically has no market. Compost is not only low in value, but bulky as well. Composting in general is not a profitable operation. Municipalities only participate in it to avoid cost emanating from exhausting landfill capacity (Alexander, 1993).

2.6 Related Studies on Municipal Solid Waste Management

Most studies in municipal solid waste management focus on how the application of market based instruments influence the behaviour of waste generators and how these instruments ultimately affect landfill-lifespan. In a study to demonstrate the strong potential for unit pricing to improve the efficiency of residential solid waste management, Miranda et al. (1994) used data for 21 American cities. The study revealed a very strong complementary relationship between unit pricing and recycling. One city Nanticoke, Pennsylvania implemented a unit pricing program but without recycling. Residents then quickly turned to private haulers for waste collection services, undercutting the municipality's revenue base which among other sources, is also replenished by waste collection fees. At that time, city managers reported increased illegal dumping incidences. As a result, the city switched back to a flat fee system. The authors asserted that, by implementing recycling or yard waste collection programs alongside market incentives, municipalities make it easier for residents to divert their waste away from landfills - giving them time to alter purchasing and consumption patterns.

In a study by Strathman et al. (1995), the demand elasticity for landfill disposal for the Portland, Oregon metropolitan area was estimated. Waste disposal in this study specifically refers to services provided by landfill authorities, but excluding the services of waste collection provided by haulers. Results of the study showed that demand for disposal services was more price-sensitive than reported by other previous studies. The authors were however uncertain about the specific nature of the response as it relates to source reduction, recycling and illegal dumping. In conclusion, the authors deduced that opportunity cost pricing of landfill disposal services appears to be an important component of an efficient pricing system.

To investigate how households respond to the implementation of pricing by the bag, Fullerton and Kinnaman (1995) conducted a study using a sample comprising of 75 households in Charlottesville, Virginia in 1992. In this study, a fee of $0.80 per bag (with a capacity of 32-gallons) of residential garbage collected at the curb was implemented. The outcome of the study showed that following the implementation of the program, the amount of waste generated declined by 14% and recycling rose by 16%. The study then concluded that unit pricing has more substantial effects on volume, recycling and illegal dumping than weight. The probable implication here is that decline in total waste by recycling was counteracted with illegal dumping, thus causing insignificant net change in weight.

In 1997, Fullerton and Kinnaman estimated the impact of a user fee on curbside recycling and solid waste generation while allowing for the possibility of endogenous policy[9] choices. Correcting for endogeneity in this study was of compelling significance as compared to preceding studies that treat policy variables as exogenous. This makes sense in that, the price charged for waste disposal services is locally determined at the municipal level, not provincial or federal levels although these levels of jurisdiction are closely involved in the management of municipal solid waste.

This study concluded that a user fee has a positive but insignificant effect on aggregate recycling, implying that an increase in user fees may not increase aggregate recycling in communities with curbside recycling programs. They state that additional recycling may not be directly attributed to user fees, but to other unobserved characteristics that jointly affect optimal user fees and the quantity of recycling in opposite directions. More recycling was also found to be undertaken by retired individuals and college-educated households.

In one unpublished study of waste management in a Canadian municipality by Thivierge (1991), the effect of introducing a 'tag a bag[10]' on the amount of household waste generated and the level of recycling was estimated. Faced with the exhaustion crisis of Storrington landfill capacity and a three-fold potential increase in disposable cost, the town of Gananoque, Ontario implemented a 'tag a bag' system along with recycling. The implementation was a great success. Waste generation fell by 45% and recycling rose by 20% while saving $10,000 monthly. Sporadic illegal dumping was reported in the early months following the policy change. All illegally dumped waste was searched for

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[9] The authors designed the model such that local decision-makers may implement these programs only if projected garbage and recycling outcomes provide benefits in excess of costs to the community.

[10] 'Tag a Bag' is one economic instrument used by local officials aimed at reducing household waste levels. Consumers are required to purchase stickers from counters, which they stick on bags containing disposable waste. The price charged for each sticker covers collection and

identifiable materials like letters, addressed envelops, bills, etc. In most cases, this procedure revealed the individuals who had dumped their waste illegally. The waste was then returned to these individuals who were then warned severely but without charges. The practice quickly ended. Although the program was viewed as a success, revenues from the sales of tags covered only 55 - 60% of total disposal cost and the remainder continued to be made up with general tax revenue.

All the relevant studies cited above, in one way or another, investigate the effects of unit pricing on the quantity of waste generated or the effect of such a policy on recycling. None of these studies or any other published empirical work has considered political affiliations as playing a role in the adoption of policy instruments such as unit pricing or economic incentives in general. As this will be done in this study, it makes this study unique. This study is also unique in that it does not only investigate the relationship between economic incentives and recycling but it investigates the relationship between economic incentives and composting.

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disposal costs. Households face no extra charges.

3.0 A THEORETICAL FRAMEWORK

3.1 Introduction

The purpose of this chapter is to present a theoretical framework on which individual municipality choice of a solid waste management program is assumed to be based. Individual choice theory is examined from a random utility perspective. The application of random utility theory to probability of choice is discussed. This discussion is based on Ben-Akiva and Lerman (1985).

3.2 An Individual Choice Theory Framework

As a society is a collection of individuals, we are interested in their aggregate behaviour. For instance, when a firm wants to supply the market with a commodity, the firm is more interested in the aggregate demand for the commodity than individual demand. But modeling individual behaviour in economics is a practice often evoked by economists for simplicity.

In a nutshell, local officials in municipalities face a number of alternatives regarding which solid waste management program is most appropriate for a municipality. Three models are available to assess the decision a municipality is likely to take. These are: *Linear Probability Model*, *Probit Model* and the *Logit Model*. The Logit Model is most preferred in this study since it possesses certain advantages over the Linear Probability Model and the Probit Model. The two latter models are discussed in Appendix D.

Before arriving at a single choice, a local official may go through a decision-making process, outlined by Ben-Akiva and Lerman (1985) to include:

- the decision maker,

- alternatives,
- attributes of the alternatives; and
- choice.

3.2.1 The Decision Maker

The description of a unit representing a decision-maker is not universal. It varies according to circumstances. In general terms, by decision-maker we mean a player in a given circumstance. This player could be a single person, a household, a municipality, a firm or a nation. In this section, the group of local officials who make waste management decisions for the municipality jointly represents the municipality, thus the decision-maker. A municipality thereby becomes the decision-making entity.

At the end of the study we are interested in the aggregate behaviour of these decision-makers which however is an outcome of individual choices. This behaviour is the decision they execute regarding the implementation of market-based programs or provision of recycling and composting programs to households. Due to varying tastes and different choice situations, individual choices are different. Therefore these inherent differences in individual choices dictate an explicit treatment of the differences in decision-making processes.

3.2.2 Alternatives

From the onset, a decision-maker is presumed to exist in an environment that creates a non-empty set of alternatives termed the universal set. From the universal set, a decision-maker has available to him/her a subset of alternatives known as a choice set. We assume that elements in the choice set are both known and feasible to the decision-maker during the decision process.

Choice sets could have continuous or discrete alternatives. Choice sets with continuous alternatives are natural in events when the decision-maker is dealing with commodity bundles, for example choosing from unlimited proportions of food and clothing - subject to income. Those choice sets with discontinuous alternatives are discrete, for instance a municipality can only decide between providing and not providing households with a solid waste management program. This study focuses on the latter type of choice set.

3.2.3 Attributes of the Alternatives

The choice of an alternative by an individual infers that the choice is preferred to the alternative not selected. Success of the alternative is based on its characteristics. The characteristics, features or qualities of a choice that influence the decision-maker's choice of an alternative are termed attributes.

These attributes may be choice specific (e.g. the cost of tipping service when considering a variable tipping fee as a choice for disposal) or individual specific (e.g. the level of urbanization of the municipality). Whichever they are, attributes are measured either on an ordinal or cardinal scale.

In an event that alternatives are homogenous (e.g. flat fee and variable tipping fee) and described in monetary terms, then they reduce to amounts of money. The case in this study however is not as simple. Here decision-makers are faced with heterogeneous alternatives. With each decision-maker facing different choice sets, they may assign different values to an attribute of the same alternative. For example, a municipality may choose to provide households with a composting program because organic farming is highly practiced in the region while another municipality may not prefer to do so for fear of households being too critical of the odors from decomposing organic matter. Under such situation, it would be convenient to work directly with both alternative specific and individual specific attributes.

3.2.4 Decision Rule

As asserted by McFadden (1975) in the last paragraph of section 1.1, a decision-maker needs a decision rule to make a choice from a choice set. Ben-Akiva and Lerman (1985) enlist four decision rules: dominance, satisfaction, lexicographic rule and utility. An alternative may be considered dominant if it is better for at least one attribute and not worse for all other attributes. For satisfaction, a decision-maker presets an attainable satisfaction criterion for every attribute. Based on the current set of information and expectations, a decision-maker may judge an alternative unsatisfactory if it fails to meet the criterion of at least one attribute. Using lexicographic rules, a decision-maker ranks attributes in their order of importance. The most attractive alternative for the most important attribute is then chosen. In the real world, none of the three decision rules discussed may lead to a unique choice. The fact that these rules do not consider tradeoffs between attributes limits their application in modeling human behaviour.

Utility maximization is one class of decision rule that readily lends itself for application in the field of human behavior. It assumes that the attractiveness of alternatives or utility can be ranked or measured. This ranking or measure defines the decision-maker's objective function expressing the attractiveness of the attributes of the alternative. The choice arrived at is likely to be unique. The cornerstone for the success of this decision rule is that, utility allows for compensatory attributes. For example, the economics of recycling indicate that generally, recycling is costly and unprofitable. But given the fact that it diverts waste from landfills, local officials may find recycling an attractive alternative to landfill disposal as long as its net cost of operation is less than the tipping fee. This means that recycling attributes result in making it an attractive choice to make.

As already mentioned, the utility index can be measured on an ordinal or cardinal scale. The cardinal scale requires assignment of some numeric values thus making it very restrictive in application. More often, this approach is used in the theories of decision making under uncertainty. The ordinal scale, on which the choice theory framework of this study is based, assumes that the level of satisfaction a decision-maker attains can be compared. With the assumption that the decision-maker is rational[11], it is expected that the decision-maker will choose an alternative that yields the highest utility.

3.3 Choice Theory

Presented in the framework of a consumer, choice theory starts off by assuming that consumers are rational and therefore they maximize utility, selecting alternative i over alternative j when

$$U_{in} > U_{jn} \tag{2}$$

[11] This assumption maintains that when given an opportunity to make choices, a consumer will be consistent and transitive in the choices that he/she makes.

where U is utility achievable, and n is the decision-maker.

The utility of this individual is estimated as a function of attributes of the alternatives and/or that of the individual. Equation (3) below shows this.

$$U_{in} = V_i(Z_{in}, S_n) \tag{3}$$

Equation (3) suggests that the utility experienced by individual n is a function of a vector of attributes (Z) of the choice i and a vector of attributes (S) of the individual. In many circumstances, it may be very costly or time consuming to gather both choice-specific and individual-specific attributes. For this reason, many studies only use individual-specific attributes that are relatively easy to obtain in the data collection process. This then transforms equation (3) into,

$$U_{in} = V_i(S_n). \tag{4}$$

This utility function will be the form applied in this study.

The equal signs in equation (3) and (4) assume perfect certainty and no error. This situation is not realistic. Observational errors may occur as a result of unobservable attributes or lack of accuracy on the part of the researcher in judging observable attributes. In this kind of study, these errors are captured as an error term and then utilized in random utility model to predict choice behaviour.

3.4 Random Utility Theory

Since unobservable attributes are an important component of a choice to be made, utility may be redefined as a function of both observable and unobservable attributes, expressed as:

$$U_{in} = V_i(Z_{in}, S_n) + \varepsilon_{in}. \qquad (5)$$

Equation (5) is composed of two parts; $V_i(Z_{in}\ ,\ S_n)$ which represents observable attributes (the deterministic component) while ε represents attributes unobserved by the researcher (the stochastic component). The latter has a characteristic of varying randomly across observations. This means that not everyone will pick the same choice from a given choice set even if they face the same attributes and have the same preference parameters.

Considering a binary choice scenario, the probability function representing a municipality's preference of choice i over j will be represented as:

$$P_{in} = \Pr ob(U_{in} > U_{jn}, \quad \forall\ j \in C_n, \quad j \neq i) \qquad (6)$$

which by substituting (5) transforms into:

$$P_{in} = \Pr ob(\varepsilon_{jn} - \varepsilon_{in} < V_{in} - V_{jn}, \quad \forall\ j \in C_n, \quad j \neq i). \qquad (7)$$

The error terms being random, their difference will also be random, namely,

$$\varepsilon^{*} = \varepsilon_{jn} - \varepsilon_{in}. \tag{8}$$

In addition to the random distribution, if ε_j and ε_i are Gumbel[12] distributed, and also identically and independently distributed (IID)[13], then equation (7) will be logistically distributed and represented as:

$$F(\varepsilon_n) = \frac{1}{1+e^{-\mu\varepsilon_n}}, \mu > 0, -\infty < \varepsilon_n < \infty,$$
$$F(\varepsilon_n) = \frac{\mu e^{-\mu\varepsilon_n}}{\left(1+e^{-\mu\varepsilon_n}\right)^2}, \tag{9}$$

where μ is a positive scale parameter, e is a natural number (≈ 2.71828) and 2 represents a binomial scenario.

Under the assumption that ε_n is logistically distributed, the choice probability for an alternative i can be represented as:

$$P_{in} = \frac{e^{\mu\beta' X_{in}}}{\sum_{j \in C_n} e^{\mu\beta' X_{jn}}}. \tag{10}$$

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[12] A detailed explanation of the properties that describe Gumbel distribution e.g. mode (η), mean $\eta + \frac{\gamma}{\mu}$ (where γ is a Euler constant $\approx$ 0.577 and μ is an arbitrary number) and variance $(\frac{\pi^2}{6\mu^2})$, is given in Ben-Akiva and Lerman (1985).

[13] It was Arrow (1951) who first proposed IID. The basis of the theory is 'how social choices should be made given individuals' choice structures. IID imposes the rule of transivity in a choice, which requires that the probability of choosing a particular alternative be unaltered given a change within the choice set. That is independence across alternatives.

The utility functions used here are assumed to be linear in parameters. With this assumption, μ cannot be distinguished from the overall scale of the βs. Therefore for convenience, we arbitrarily assign $\mu = 1$ (Ben-Akiva and Lerman, 1985), thus transforming (10) into

$$P_{in} = \frac{e^{\beta X_{in}}}{\sum_{j \in C_n} e^{\beta X_{jn}}}. \tag{11}$$

The product of individual probability functions is a likelihood function (see equation (12)) which can be maximized with respect to each $\hat{\beta}$.

$$L^{*}(\beta_1, \ldots\ldots \beta_k) = \prod_{n=1}^{N} \prod_{i \in C_n} P_n(i)^{Y_{in}}. \tag{12}$$

From Ben-Akiva and Lerman's description, N denotes sample size (n=1,………,N), L^{*} represents the likelihood function, $\prod$ is the "product" operator analogous to the summation operator, $\sum$ and Y is an indicator defined as:

$$Y_{in} = \begin{cases} 1 & \textit{if individual } n \textit{ chooses alternative } i \\ 0 & \textit{if individual } n \textit{ chooses alternative } j \end{cases} \tag{13}$$

representing the municipality's choice of alternative i or j. Under relatively weak conditions, McFadden (1974) shows that L^{*} is globally concave so if maximized, the solution arrived at is unique hence making the estimator of β consistent and asymptotically efficient.

4.0 DATA DESCRIPTION, MODEL SPECIFICATION AND ESTIMATION

4.1 Introduction

Chapter four is composed of three parts. Part one presents a brief description of the data used in the study. The method of collection is discussed and some limitations encountered are pointed out. This part also defines the variables considered important and used in the analysis of the data. Part two of this chapter deals with the model specification showing four different scenarios. Part three of this chapter briefly shows the different estimators that are used to compare the predictive abilities of different estimated models.

4.2.1 The Data - A Brief Description

Two sets of data were collected. In the first one, a list of municipalities across Canada with populations greater than 2500 and thought to be using economic instruments was compiled, then 105 communities were chosen for survey by phone. Phone calls were made between May 01 and August 01 1995 to Anglophone communities and between January 01 and March 01 1996 to Francophone communities (Appendix A). Out of the 105 communities, eighty-seven responded. For the second set of data a list of municipalities with populations greater than 2500 was compiled by *randomly* selecting from a list of communities from Statistics Canada (1995). The resulting data set composed of ninety-four communities. Apart from the methods employed to collect the data, the first set of data (Economic Instrument Sample - EIS) and the second set of data (Random Sample - RS) significantly differed from each other. The EIS communities were located in only four provinces and one territory and they had a mean population size which was twice that of the RS communities. In total 181 surveys were completed, of which 87 were from the EIS and 94 from the RS.

Information was also collected from other sources, particularly demographic information for these communities. Sources include Census 1991 data and Green Peace International from the worldwide web. Data on several socioeconomic variables of each community representing an average household was collected. Data on different economic instruments was also collected. However, data on the attributes of these instruments (choice-specific attributes) was limited or missing in most cases. In both sets of data, some variables had missing[14] observations. For those variables thought to be very important in this study, all observations with missing information were rejected in the analysis, leaving only 55 or 56 observations.

Finally, this study is carried out only using the random sample data set for three basic reasons. First, the EIS sample is not a random sample thereby failing to meet an important statistical requirement of random selection. Second, the economic instrument sample data set is smaller yet it contained more missing observations than the RS data set. Lastly, using the EIS data would be more appropriate for case studies than representing solid waste management in Canadian municipalities because it was composed of data from only four provinces and one territory.

4.2.2 Variables Chosen

All variables defined below are individual municipality specific attributes (independent variables) unless otherwise mentioned.

[14] All missing information was coded as –999.

MBUDGET	Is a continuous variable representing the proportion of municipal budget (in percentage) allocated to run municipal solid waste management programs.
PFNDNG	Is a dummy variable representing whether or not the municipality receives any provincial funds for its solid waste management programs.
TWASTE	Is a continuous variable representing the level of per capita waste produced and disposed of in municipal landfills [(total waste)/popn[15]].
INCOME	Is a continuous variable representing the level of per capita household income in Canadian dollars [income/popn].
TRPAYS	Is a continuous variable representing transfer payments to households (as extra income) from the government. It is measured in percentage terms.
URBAN	Is the population density (popn/area) but it is used as a proxy for urbanization.
PRVHLD	Is a continuous variable, per capita private residence [(private households)/popn]. It measures the extent of residence in private housing as opposed to public or apartment housing.
GPEACE	Is a continuous variable measuring the per capita level of Green Peace members in a municipality.
EDUC	Is a continuous variable [(university degree holders)/popn] used as an education index that measures the general level of education in the municipality.

[15] POPN represents the population size of the municipality – this is found in Appendix C.

CSCSF	Is a dummy variable representing whether or not there is a curbside collection service for single family dwellers.
CSCMF	Is a dummy variable representing whether or not there is a curbside collection for multi-family dwellers.
ECON	Is a dummy variable representing whether or not the municipality implements economic instruments to manage its household solid waste. In scenario 2, ECON is used as the dependent variable but as an independent variable in scenario 3 and scenario 4.
RECY	Is a dummy variable representing whether or not the municipality provides a recycling program to households. In scenario 3, RECY is used as the dependent variable but in scenario 2 and scenario 4, it is used as an independent variable.
COMP	Is a dummy variable representing whether or not the municipality provides a composting program to households. In scenario 4, COMP is used as the dependent variable but as an independent variable in scenario 2.
TPNGFEE	Is a continuous variable representing the level of tipping fees in Canadian dollars per tonne paid to landfill authorities as disposal fees.
PC	Is a dummy variable representing whether or not the representative of the municipality at the federal level belongs to the Progressive Conservative Party.
NDP	Is a dummy variable representing whether or not the representative of the municipality at the federal level belongs to the New Democratic Party.

LIB	Is a dummy variable representing whether or not the representative of the municipality at the federal level belongs to the Liberal Party.
PQUEB	Is a dummy variable representing whether or not the representative of the municipality at the federal level belongs to Party Quebecois.
LINCOME	Is the natural logarithm of per capita household income, log(per capita household income).
EDUC1	Is an interacted variable; per capita university degree holders times per capita household income, (EDUC x INCOME).
URBAN1	Is an interacted variable; urbanization times per capita household income, (URBAN x INCOME).
TPNGFEE1	Is an interacted variable; tipping fees times per capita private residence, (TPNGFEE x PRVHLD).
GPEACE1	Is an interacted variable; per capita Green Peace members times per capita waste (GPEACE x TWASTE).

4.3 Hypotheses

This section provides *a priori* expectations of the impacts of municipality specific attributes on the choice of economic instruments (ECON), recycling (RECY) and composting (COMP). At the end of this section, a table (Table 4.1) that summarizes the hypothesized signs of each explanatory variable is provided for quick reference purposes. Actual signs of these variables can be read directly from the estimated models in the next chapter (i.e. Models 1 to 9).

When defining the problem of this study, we pointed out that the cost of disposal services is becoming more expensive, that is because tipping fees charged by landfill authorities is rising. The rise in tipping fees explains the high demand for landfill space required to accommodate municipal solid waste. Often municipalities do not recover all waste disposal expenses from waste generators; therefore, they use general tax revenues to cover the extra disposal costs. This suggests that with increasing tipping fees and fixed general tax revenues available for municipal solid waste disposal, municipalities may implement economic instruments to discourage households from producing high levels of solid waste. Other variables that were thought to have an influence on the implementation of market instruments include the following: per capita level of household waste (TWASTE) generated; the extent of per capita private residence (PRVHLD) in the municipality; per capita household income (INCOME); the general level of education (EDUC) in the municipality; the level of urbanization (URBAN) of the municipality; the proportion of municipal budget (MBUDGET) allocated for solid waste management; whether or not the municipality receives provincial funds (PFNDNG) to finance these services; the per capita level of Green Peace members (GPEACE); whether or not single and multi-family residents are provided with curbside collection services (CSCSF/CSCMF); whether or not the municipality provides households with recycling (RECY) and/or composting (COMP) programs, the landfill life and party politics.

Information on landfill life or space was inadequate; therefore both variables were left out in the analysis of the data. Per capita private residence (PRVHLD) is expected to have a positive impact on the choice of ECON. Private residents probably have more waste per capita especially organic waste. But most importantly, the positive impact is based on the grounds that residence in private housing may be associated with lower transaction costs than residence in apartment buildings. The reason being that residents in private housing pay for their waste disposal services as separate bills, providing the opportunity for incentives to reduce waste. To the contrary, apartment dwellers pay for their waste disposal services through rents therefore they may have no incentive to reduce waste. An effort to deter such behaviour would be uneconomical. Given such mechanics, local officials may implement economic instruments with increasing PRVHLD.

Before implementation of any policy, policy makers are often concerned about the policy's feasibility. Based on this background, policy makers may want to understand the circumstances under which households may have a positive impact on the policies to be implemented. For instance, the provision of curbside collection services to single families (CSCSF) would allow them to get rid of their household waste without having to deliver it to the landfill. Also, the provision of recycling (RECY) and composting (COMP) centres would provide the convenience of diversity in choices. With these programs providing convenience, CSCSF, RECY and COMP may have positive impacts on the municipality's adoption of economic instruments. As for multi-family residents, since they often use a common container to dump almost all their household waste, a curbside collection service would fail to provide any incentive. CSCMF may therefore be expected to have a negative impact on the implementation of economic instruments.

Education (EDUC) and per capita household income (INCOME) and transfer payments to households (TRPAYS - defined in section 4.2.2 as extra income to households) are socioeconomic variables and therefore their estimated coefficients could either be positive or negative. While implementing and enforcing economic and non-economic waste management programs, substantial amounts of funds may be involved. This suggests that municipal budget (MBUDGET) and provincial funding (PFNDNG) allocated for municipal solid waste management may have positive impacts on the implementation of economic instruments as well as waste reduction programs. But even with low funds municipalities have the incentive to adopt economic instruments as long as waste disposal continues to be a serious municipal problem. Similar to socioeconomic variables, these variables may bear either positive or negative impacts on the choice of ECON. Although Green Peace members do not trust in markets, they may have a positive impact on the choice of ECON since it is generally believed that market-based waste management programs provide waste generators with incentives to reduce household solid waste.

Intuitively, urbanization (URBAN) is positively correlated with total municipal solid waste. There is often a drift of the rural population to urban centres because urban centres have better job opportunities, educational and health facilities, among others. With higher population densities, it would therefore be logical to expect urban dwellers to generate more waste than their rural counterparts. Assuming this holds, and urban centres run out of landfill space faster than rural areas, municipalities may be likely to implement economic instruments to reduce the rate at which landfill capacities are depleted and also to maintain acceptable sanitary levels. Therefore, URBAN and TWASTE may be expected to have positive impacts on the implementation of economic instruments.

Since recycling and composting are both waste reduction programs, their hypotheses will be offered jointly. Generally the same variables affecting the choice of ECON are believed to affect the choice of RECY and COMP because the literature on solid waste management stresses that economic instruments and waste reduction programs are positively related.

Similar to the case of adopting economic instruments, per capita household income (INCOME), transfer payments (TRPAYS) and education (EDUC) all of which are socioeconomic variables, may either have positive or negative impacts on the choice of RECY and/or COMP. Urbanization (URBAN) and per capita household waste (TWASTE) are two variables expected to have positive impacts on recycling and composting. As has already been argued earlier in the choice of ECON, urbanization is associated with the generation of higher levels of household waste per unit area. Local officials are therefore likely to provide recycling and/or composting programs to suppress the amount of waste that may be destined for landfilling. Since total organic waste constitutes up to 23% of Canadian municipal waste (Perspectives on Solid Waste Management in Canada, 1995), TWASTE may not only have a positive impact on recycling but on composting as well.

Increasing tipping fee (TPNGFEE) if felt by households, is likely to indirectly incite residents in private housing (PRVHLD) to get involved in recycling and composting in order to minimize waste disposal expenses. Since households do not directly pay landfill disposal fees, when a municipality's total cost of waste management increases due to rising disposal fees, a municipality may be likely to charge residents in private housing a higher waste collection fee, thus inciting waste reduction. This suggests that TPNGFEE and PRVHLD are likely to have positive impacts on the choice of RECY or COMP. With Green Peace (GPEACE) members propagating the sustenance of a cleaner and safer environment, GPEACE is expected to have a positive impact on the choice of RECY or COMP. Curbside collection service for single family (CSCSF) residents is expected to have a positive impact on recycling. A positive coefficient on CSCSF would suggest that the availability of a curbside collection service in single family residence provides convenience to the household. Households would no longer have to spend time and energy delivering recyclable materials to recycling depots. Thus, CSCSF encourages residents to recycle. But CSCMF is expected to have a negative impact on recycling due to free-riding and the public-good syndrome of multi-family residents. Multi-family residents know that participation in recycling does not reduce any waste disposal costs because they would have already paid for waste disposal through rents. Second, since there is no rivalry or excludability of individuals who had not participated in recycling from enjoying a cleaner environment, multi-family residents would free-ride on each other thus making recycling impracticable.

The availability of curbside collection services to both single and multi-family households may have negative impacts on composting. Negative signs on the coefficients of CSCSF and CSCMF imply that with curbside collection services, a considerable amount of household waste that would have otherwise been composted in backyards or in the vicinity of the multi-family residences might be channeled out for recycling or landfilling.

Platforms for the four political parties used in this study are crucial in developing hypotheses of how political affiliation may influence the choice of solid waste management programs. "While the Liberal Party (LIB) in the United States is 'left extremist'[16], in Canada it is a centre party appearing at one time as

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[16] Judging a party to be 'left or right wing' is based on the degree to which big businesses dominate social life (Thornburn G.Hugh, 1996). While the Liberal Party in the United States is

a left wing and sometimes as a right wing. Unlike other political parties which are based on class, the Liberal view is that true political progress is marked by the reconciliation of classes and promotion of general interest above all particular interests" (Thornburn, 1996). The neutral position of the Liberal Party makes it very difficult to hypothesize its impact on the choice of any waste management program. With reference to the Liberals, the New Democrats (NDP) are left wing. Since the vast majority of wealthier individuals in Canada are more likely to vote for the conservatives, it suggests the party's right wing position (Pickergill, 1992). If 'right wing' party politics are positively correlated with big businesses and environmental pollution as is the case in the United States, then 'right wing' parties would favour the use of market instruments while they may be less inclined toward environmental protection.

Party Quebecois (PQUEB) is based on three ideologies with the third[17] (development and participation ideology), overriding the other two. The Liberals through their dynamism, influenced PQUEB during its reform from the 'conservation ideology' through the 'recoupment ideology' to the radical 'development and participation' ideology. This influence made PQUEB more of a right wing than a left wing political party.

The effects of political affiliation on waste management programs is hypothesized based on the grounds that politics display class lineage, for instance rich people voting for the PC political party. This however is not always

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'left wing', which implies minimal influence of social life by big businesses, in Canada, it is a neutral party. It claims to reconcile between the 'left wing' and 'right wing' political parties.

[17] First is the ideology of conservation which considers Quebecois group as a cultural minority within Canada that must be preserved and transmitted as intact as possible over the generations. Second is the ideology of recoupment, which also considers French-Canadians as a minority group spread across Canada who must modernize their culture throughout the nation.
Third is the development and participation ideology, which seems the most radical. It defines the Quebecois Francophone as a modern industrialized society dominated economically and politically by the rest of Canada; and Quebec must be saved and liberated. This information on

true; therefore political affiliation on waste management may have positive or negative impacts on waste management policy instruments.

Table 4.1: Hypothesized Signs of Explanatory Variables

Variable	Hypothesis $_{(ECON)}$	Hypothesis $_{(RECY)}$	Hypothesis $_{(COMP)}$
TWASTE	+	+	+
TPNGFEE	+	+	+
PRVHLD	+	+	+
URBAN	+	+	+
EDUC	-/+	-/+	-/+
EDUC 1	-/+	—	-/+
INCOME	-/+	-/+	-/+
TRPAYS	-/+	-/+	-/+
MBUDGET	-/+	-/+	-/+
PFNDNG	-/+	-/+	-/+
GPEACE	+	+	+
GPEACE 1	+	—	+
CSCSF	+	+	-
CSCMF	-	-	-
ECON	—	+	+
RECY	+	—	+
COMP	+	+	—
NDP	-/+	-/+	-/+
LIB	-/+	-/+	-/+
PQUEB	-/+	-/+	-/+
PC	-/+	-/+	-/+

party politics has been adapted from Thornburn G.Hugh (1996).

4.4 Model Specification

The model outlined in the theoretical framework in chapter two is used to analyze the data described in part one of this chapter. Probabilities by which a municipality provides solid waste management programs to households are estimated. The two key objectives of this study as outlined in the introduction in chapter one are: 1) to assess the implementation of waste disposal programs in general and economic instruments in particular, and 2) to assess the relationship between economic instruments and waste diversion methods. Given the permissiveness or quality of the data, these research questions can be modeled as in figure 3 and analyzed by a multinomial logit approach. In this scenario if a municipality has a solid waste management program (SWMP), it is faced with a situation to make choices that can be made at one level. Once the municipality has a solid waste management program in place, it may choose to use economic instruments only (ECON), recycling programs only (RECY), composting programs only (COMP) or a combination of more than one programs (COMB).

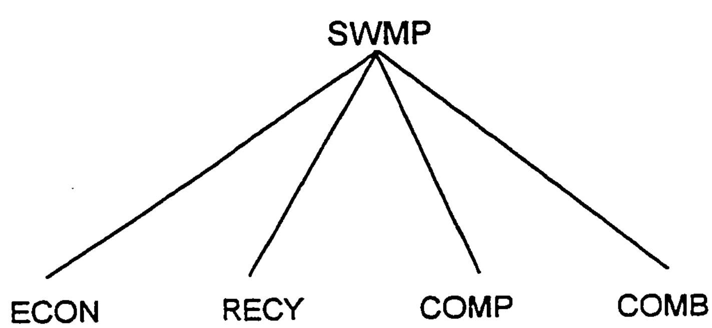

Fig. 3: An Ideal Scenario Representing the Research Questions under Investigation

As pointed out in chapter two, municipalities maximize utility by choosing an alternative that yields the highest utility level; based on the attributes under consideration. The decision process represented in figure 3 results in four utility functions, which can be represented as:

$$
\begin{aligned}
V_{i(ECON)} &= \gamma'_{EC} Z_{in} + \beta'_{EC} S_n \\
V_{i(RECY)} &= \gamma'_{RE} Z_{in} + \beta'_{RE} S_n \\
V_{i(COMP)} &= \gamma'_{CP} Z_{in} + \beta'_{CP} S_n \\
V_{i(COMB)} &= \gamma'_{CB} Z_{in} + \beta'_{CB} S_n
\end{aligned}
\qquad (14)
$$

where the subscripted[18] βs and γs are estimates to be made and Z and S are choice-specific and individual municipality specific attributes, respectively. In all scenarios however, Z=0 since we have no choice-specific attributes, thus reducing equation (14) to:

$$
\begin{aligned}
V_{i(ECON)} &= \beta'_{EC} S_n \\
V_{i(RECY)} &= \beta'_{RE} S_n \\
V_{i(COMP)} &= \beta'_{CP} S_n \\
V_{i(COMB)} &= \beta'_{CB} S_n
\end{aligned}
\qquad (15)
$$

The individual municipality specific attributes remain constant regardless of the choice made. For example, as in (15) above, whatever waste management option the municipality chooses, its level of urbanization or number of Green Peace members does not change.

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[18] Subscripted parameters represent estimators associated with the utility function of a specific choice. *EC* = ECON is chosen and the municipality uses economic instruments as the only waste management method, *RE* = RECY is chosen and recycling is the only waste management program offered to households, *CP* = COMP is chosen and the municipality provides households with composting as the only waste management program, *CB* = COMB is chosen and the municipality provides households with a combination of waste management programs.

The above model-structure allows us to assess the implementation of economic instruments and the provision of waste management programs. If RECY and COMP are included in the utility function of ECON as municipality specific attributes, it allows us to investigate the relationship between market-based programs and waste reduction programs (recycling and composting). However in an event that the data set is very small or the number of missing observations is too large to permit the use of a multinomial logit analysis (as is the case in this study), these research questions can still be investigated but by binary logit analysis. A binary logit approach simplifies the model-structure in figure 3 by breaking it down into three model structures as shown in figure 4, figure 5 and figure 6 below.

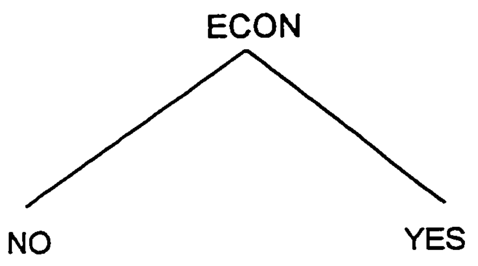

Fig. 4: A Municipality Decides on Whether or not to Implement a Market-Based Program

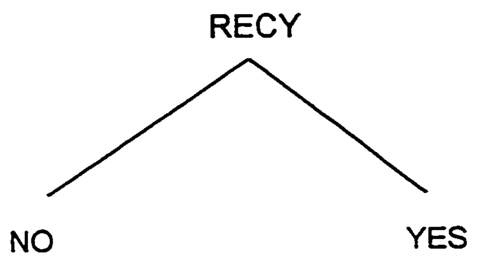

Fig. 5: A Municipality Decides on Whether or not to Provide a Recycling Program

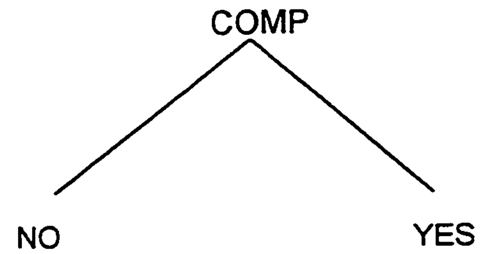

Fig. 6: A Municipality Decides on Whether or not to Provide a Composting Program

In figure 4, the municipality is faced with a choice between implementing and not implementing a market-based program. This choice is made at one level with two utility functions as:

$$V_{j(no\ ECON)} = \beta'_{nEC} S_n$$
$$V_{i(ECON)} = \beta'_{EC} S_n \tag{16}$$

To analyze this model, RECY and COMP are included as regressors so that their relationship with the choice of ECON is investigated.

In a similar manner, the decision to provide or not to provide a recycling program can be modeled as shown in figure 5. With only two alternatives to choose from, the municipality will have two utility functions as:

$$V_{j(no\ RECY)} = \beta'_{nRE} S_n$$
$$V_{i(RECY)} = \beta'_{RE} S_n. \tag{17}$$

Similarly the decision on composting (see figure 6) is made at one level with only two alternatives available to the municipality. The two resulting utility functions required for estimation can be represented as in equation (18) below.

The estimators in equation (16), equation (17) and equation (18) are subscripted[19] in a similar fashion as those in equation (14).

$$V_{j(no\,COMP)} = \beta'_{nCP} S_n$$
$$V_{i(COMP)} = \beta'_{CP} S_n. \tag{18}$$

Dictated by the limited size of data we have for this study, a binary logit approach will be used to estimate the model structures represented by scenarios 2, 3 and 4. In order to econometrically estimate values for $\beta_1,\ldots\ldots\ldots,\beta_k$ from a sample of N observations, we will need to substitute (11) into the likelihood function (12) to arrive at,

$$L^*(\beta'_1,\ldots\ldots\beta'_k) = \prod_{n=1}^{N} \prod_{i \in C_n} \left(\frac{1}{1 + e^{(\beta_i - \beta_j)x_n}} \right). \tag{19}$$

where X_n represents the individual municipality specific attributes. Equation (19) can then be maximized using LIMDEP Version 7.0 (Green, 1995) to estimate these coefficients.

4.5 Estimation

A statistic that frequently appears in econometrics is the coefficient of determination, R^2. It represents the proportion of the variation in the dependent variable explained by variations in the independent variables (Kennedy, 1985).

[19] Here, EC = ECON is chosen, nEC = no ECON is chosen, RE = RECY is chosen, nRE = no RECY is chosen, CP = COMP is chosen and nCP = no COMP is chosen. In this case there is no estimator subscripted with COMB since each waste management program is analyzed

This coefficient is viewed as a measure of the predictive ability of a model stating how well the estimated regression fits the data (Griffiths et al., 1993). It is relevant in general linear regression models. It however cannot be used in nonlinear estimations. The accuracy by which nonlinear discrete choice models approximate observed data can be measured by how well the model forecasts observed behaviour (Akabua, 1996). Another statistic, which does a similar job like the coefficient of determination except that it is usable in nonlinear estimations, is the 'Percent Correct Predictions - PCP'. PCP states the percentage of all predictions correctly made by the model. This statistic is reported in the models estimated in this study.

Among others, the McFadden and Cragg and Uhler's ρ^2 are two versions of the coefficient of determination analogous to the R^2 of the ordinary least squares regression analysis (Maddala, 1983). The measure attributed to McFadden's ρ^2 is defined as:

$$\rho^2 = 1 - \frac{\ell^*(\hat{\beta})}{\ell^*(0)} \tag{20}$$

where $\ell^*(\hat{\beta})$ is the value of the log likelihood function maximized with respect to all parameters including the constant term, $\beta_i \neq 0 \quad \forall\, i = 0,\ 1, 2, \ldots\ldots\ldots, k$ and $\ell^*(0)$ is the value of the log likelihood function evaluated at a point when all parameters except the constant are equal to zero, $\beta_i = 0 \quad \forall\, i = 1, 2, \ldots\ldots\ldots\ldots, k$ – that is restricted log likelihood function. Similarly, the measure of ρ^2 attributed to Cragg and Uhler is defined as:

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separately. *i* is associated with a YES choice while *j* is associated with a NO choice.

$$\rho^2 = \frac{\ell_{\Omega}^{2/n} - \ell_{w}^{2/n}}{1 - \ell_{w}^{2/n}} \tag{21}$$

where n is the sample size, ℓ_{Ω} is the value of the log likelihood function maximized with respect to all parameters including the constant term; $\beta_i \neq 0 \quad \forall\, i = 0,\ 1,\ 2, \ldots\ldots\ldots, k$. ℓ_{w} is the value of the log likelihood function maximized with respect to the constant term alone; $\beta_i = 0 \quad \forall\, i = 1, 2, \ldots\ldots\ldots\ldots, k$. Both the McFadden and Crag Uhler's ρ^2 are reported in this study.

5.0 RESULTS AND DISCUSSIONS

5.1 Introduction

Chapter five presents the results transpiring from the analysis of the data. The signs on the parameters provide information about whether a particular choice is more likely or less likely to be made as influenced by the associated individual municipality specific attribute. Results for three scenarios: the implementation of market-based (ECON) policies in solid waste management by municipalities; the provision of recycling (RECY) programs by municipalities; and the provision of composting (COMP) programs by municipalities, are presented sequentially. Discussion of these results is also presented in this chapter.

5.2 Estimation Results

Three separate specifications of binary logit models for each scenario (ECON, RECY and COMP) as modeled in chapter four were estimated. Table 5.1, Table 5.2 and Table 5.3 present estimated parameters for scenario two. Table 5.4, Table 5.5 and Table 5.6 present estimated parameters for scenario three and estimated parameters for scenario four are presented in Table 5.7, Table 5.8 and Table 5.9. Using this procedure to estimate coefficients $\beta_i \; \forall \; i = 1, 2, \ldots\ldots\ldots, k$ allows the examination of how the different levels of municipality specific attributes vary across alternatives while a likelihood function is maximized. On the other hand, estimation of the constant terms, $\beta_0 s$, allows the examination of how the different levels of attributes undefined by the model vary across alternatives while all $\beta_i = 0 \; \forall \; i = 1, 2, \ldots\ldots\ldots k$. The maximum likelihood model is consistent with the Random Utility Model on which the individual municipality choices are based.

Table 5.1

Model 1 Market-Based Policy Models (Scenario 2)

Discrete Choice Logit Model
Number of observations 55

Dependent variable	ECON
Log likelihood function	-12.25694
Restricted log likelihood	-28.85284
Chi-squared	33.19181
Significance level	0.0015946

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	41.5860**	19.020	2.186	0.02878
PFNDNG	-4.5922*	2.7357	-1.679	0.09322
TPNGFEE	-0.0398	0.0312	-1.276	0.20208
TWASTE	-7.1186**	3.5791	-1.989	0.04671
PRVHLD	-85.642**	38.513	-2.224	0.02617
GPEACE1	410.770**	193.03	2.128	0.03333
RECY	3.15110	2.3789	1.325	0.18531
COMP	-2.2816	2.2322	-1.022	0.30671
URBAN	17.958**	8.2238	2.184	0.02899
TRPAYS	-0.40824*	0.2261	-1.806	0.07097
INCOME	-0.6892*	0.3560	-1.936	0.05285
LIB	-19.306	170.88	-0.113	0.91005
NDP	7.7064	5.2220	1.476	0.14001
PQUEB	-4.2888*	2.3840	-1.799	0.07202

McFadden's ρ^2 = 0.572
Cragg and Uhler's ρ^2 = 0.264
Percent Correct Predictions = 89.1%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

Table 5.2

Model 2 Market-Based Policy Models (Scenario 2)

Discrete Choice Logit Model
Number of observations 55

Dependent variable	ECON
Log likelihood function	-9.906167
Restricted log likelihood	-28.85284
Chi-squared	37.89335
Significance level	0.0001598

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	49.198**	23.668	2.079	0.03765
PFNDNG	-8.6290**	4.0847	-2.112	0.03464
TPNGFEE	-0.0546	0.0373	-1.463	0.14345
TWASTE	-7.1348*	3.7791	-1.888	0.05903
PRVHLD	-69.213**	35.307	-1.960	0.04996
GPEACE1	357.170*	183.25	1.949	0.05128
RECY	10.0940*	5.1941	1.943	0.05197
COMP	-1.1244	2.0110	-0.559	0.57607
EDUC1	-16.345**	8.3270	-1.963	0.04966
INCOME	0.45981	0.3255	1.413	0.15771
CSCSF	-12.512*	7.1051	-1.761	0.07824
NDP	8.8295	6.1867	1.427	0.15353
LIB	-21.738	203.95	-0.107	0.91512
PQUEB	-9.1105**	4.1853	-2.177	0.02950

McFadden's ρ^2 = 0.573
Cragg and Uhler's ρ^2 = 0.278
Percent Correct Predictions = 90.1%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

Table 5.3

Model 3 Market-Based Policy Models (Scenario 2)

Discrete Choice Logit Model
Number of observations 56

Dependent variable	ECON
Log likelihood function	-14.41631
Restricted log likelihood	-29.09647
Chi-squared	29.36032
Significance level	0.0058172

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	35.257**	15.765	2.236	0.02533
MBUDGET	0.0283	0.1243	0.227	0.82014
TPNGFEE	-0.0315	0.0240	-1.313	0.18930
TWASTE	-4.7508**	2.4011	-1.979	0.04786
PRVHLD	-57.147**	27.263	-2.096	0.03607
GPEACE1	267.32**	132.29	2.021	0.04331
RECY	0.71097	1.5071	0.472	0.63711
COMP	-0.6158	1.4851	-0.415	0.67841
URBAN	13.067**	6.4779	2.017	0.04368
INCOME	-0.3186**	0.1569	-2.030	0.04235
TRPAYS	-0.1672	0.1530	-1.092	0.27467
PC	-8.0698*	4.2158	-1.914	0.05560
LIB	-22.691	183.55	-0.124	0.90161
PQUEB	-9.5618**	4.4434	-2.152	0.03140

McFadden's ρ^2 = 0.505
Cragg and Uhler's ρ^2 = 0.218
Percent Correct Predictions = 91.1%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

5.2.1 Market-Based Policy Models

The estimated coefficient on composting (COMP) is statistically insignificant in all three models, which implies that composting program presence does not influence the choice of ECON. However the estimated coefficient on recycling (RECY) is statistically significant at the 10% level in Model 2 and bears the expected positive sign. This result partially answers the secondary objective of this paper, which is to investigate if the adoption of market-based programs may need the provision of waste reduction programs. From the analysis of this scenario, results weakly indicate that the implementation of market-based programs may be likely when households are provided with recycling programs. Market-based programs certainly constrain waste generators as to the amount of waste they can generate, but recycling relaxes this constraint by allowing them to maintain the same level of waste while reducing waste collection expenses through recycling. The compatibility of recycling programs with economic instruments makes them appealing for policy consideration. A recycling program has a marginal effect[20] of 0.87% on the choice of ECON.

Urbanization (URBAN) is positive in Model 1 and Model 3 bearing the expected positive coefficient and statistically significant at the 5% level. This implies that as a residential centre or urban area becomes more and more crowded, waste disposal becomes a menace that may require the use of economic instruments to deal with the situation. URBAN has a marginal effect of 0.26% on the choice of ECON. The impact of Green Peace members as expected, is positive. The interacted variable GPEACE1 (GPEACE x TWASTE)

[20] A marginal effect in the context of this paper defines the change in the probability of making a choice given a unit change in the municipality specific attribute under observation.

is statistically significant at the 5% level in Model 1 and Model 3 and 10% in Model 2. This might imply that although Green Peace members generally do not trust the market, as long as economic instruments reduce household solid waste and sustain a cleaner and safer environment, Green Peace members may pressure the municipality to implement these instruments.

Per capita household income (INCOME) and transfer payments (TRPAYS) affect the choice of ECON. INCOME is statistically significant in Model 1 at the 10% level and at 5% in Model 3. TRPAYS is also statistically significant at the 10% level in Model 1. Both variables bear negative signs. Alexander (1993) and Jenkins (1991) arrived at the same results in their separate studies and both authors argued that, high-income individuals produce less disposal waste compared to their low-income counterparts. This, they said, is because high-income individuals can buy food and other consumable materials in bulk since storage space may not be a constraint. In the process, they minimize the amount of package material, which in many cases is the major source of household solid waste. With less waste being produced as a result of increasing INCOME and TRPAYS, municipalities may be less likely to choose ECON. In fact this study shows that a $1.00 increase in per capita household income decreases the municipality's probability of choosing ECON by 0.52% and a 1% increase in transfer payments to households decreases the municipality's probability of choosing ECON by 0.37%. Education (EDUC1 = EDUC x INCOME) affects the choice of ECON. It is statistically significant at the 5% level in Model 2. Similar to INCOME and TRPAYS, EDUC1 has a negative impact on the choice of ECON. Since individuals with more education are likely to be employed in better paying jobs than those with less education, the arguments on how INCOME affects the choice of ECON can be applied to EDUC1. A marginal increase in EDUC1 decreases a municipality's probability of adopting economic instruments of waste management by almost 1%.

The estimated coefficient on per capita private residence (PRVHLD) is negative across all three models and statistically significant at the 5% level. This contradicts the intuition that residence in private housing makes it easier to administer incentives in solid waste management. The negative sign might suggest that with increasing PRVHLD, there is more voting power against taxes. Property tax paid by property owners in many municipalities covers sewage and solid waste management services. The vast majority of residents in private housing however seem to pay additional charges for solid waste management. If this majority is aware that some private residents enjoy benefits while all of them pay the same property tax rate, increasing PRVHLD is likely to cause a tax revolt which has a negative impact on the choice of ECON. A unit increase in per capita private residence has a marginal effect of –0.80% on the choice of ECON.

Curbside collection service for single family residents (CSCSF) is statistically significant at the 10% level in Model 2 but with a negative unexpected sign. About 87% of all surveyed municipalities have a curbside collection service in place. The negative unexpected sign on this coefficient may be as a result of correlation between CSCSF with other regressors in the model such as PRVHLD. Availing this service to single family residents reduces the probability that a municipality chooses ECON by 0.4%. TPNGFEE that was hypothesized to have an indirect positive impact on the choice of ECON is statistically insignificant. Lack of sufficient variation due to the small data size and its indirect relationship with ECON may have contributed to its statistical insignificance. PFNDNG is statistically significant at the 10% level in Model 1 and 5% in Model 2. In both models, the estimated coefficients have a negative impact on the choice of ECON implying that, with increasing municipal funding, a municipality may be less likely to adopt economic instruments of waste management. Literature limitations have rendered it difficult to explain why we observe this outcome. Further research may be necessary to provide an explanation.

Per capita household waste (TWASTE) has a sign contrary to expectations. By intuition it is expected that the higher the level of per capita household waste, the more likely local officials would implement market-based programs. Correlation effect between TWASTE and INCOME could be the cause for the unexpected sign.

Party politics seem to have some effect on the choice of ECON. In this scenario, the right wing Progressive Conservative Party was arbitrarily chosen and treated as a base case for Model 1 and Model 2. But in Model 3 the left wing New Democratic Party was instead arbitrarily chosen for a base case, just to see if the choice of a base case has any effect on the estimation. Estimated models in this scenario indicate that left wing party politics have no effect on the municipality's decision to adopt market instruments, but right wing party politics have a negative impact on the adoption of these instruments. Right wing voters as reported by Thornburn (1996) may mostly be composed of wealthier social class. If that is true and PC and PQUEB have a low inclination toward environmental protection which requires reduction in pollution, thus, economic activity, then owners of corporations and the majority of wealthier members of society who have higher bargaining power, may negatively influence the municipality's decision to choose ECON. Based on Model 3, shifting the municipality's leadership from the New Democratic Party to the Progressive Conservative Party, decreases the probability that a municipality chooses ECON by 0.78%. But if the leadership is shifted from the New Democratic Party to Party Quebecois, the probability decreases by 0.55%.

Model 1 and Model 2 have similar predictive abilities. Model 1 has a McFadden ρ^2 value of 0.572 and Model 2 has McFadden ρ^2 value of 0.573. Model 3 has the least predictive ability of 50.5%.

Table 5.4

Model 4 Recycling Program Models (Scenario 3)

Discrete Choice Logit Model
Number of observations 55

Dependent variable	RECY
Log likelihood function	-16.74479
Restricted log likelihood	-33.16300
Chi-squared	32.83642
Significance level	0.0010266

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	-11.226*	6.3969	-1.755	0.07928
PFNDNG	1.2914	1.5699	0.823	0.41073
TRPAYS	-0.1247	0.0863	-1.445	0.14850
TPNGFEE	0.0056	0.0295	0.188	0.85077
TWASTE	0.0328	0.1646	0.200	0.84187
PRVHLD	22.202*	12.669	1.753	0.07968
URBAN	1.5171	4.4932	0.338	0.73564
INCOME	-0.1585*	0.0897	-1.768	0.07708
CSCSF	6.0990**	2.5183	2.422	0.01544
CSCMF	-5.0139**	2.5125	-1.996	0.04598
PC	4.2969**	1.8873	2.277	0.02280
NDP	13.109	185.65	0.071	0.94371
PQUEB	3.8734*	2.0409	1.898	0.05771

McFadden's $\rho^2 = 0.495$
Cragg and Uhler's $\rho^2 = 0.205$
Percent Correct Predictions = 85.5%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

Table 5.5

Model 5 Recycling Program Models (Scenario 3)

Discrete Choice Logit Model
Number of observations 55

Dependent variable	RECY
Log likelihood function	-16.66749
Restricted log likelihood	-33.16300
Chi-squared	32.99103
Significance level	0.0009711

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	-11.584*	6.4079	-1.808	0.07064
ECON	0.66623	1.5692	0.425	0.67115
PFNDNG	1.5363	1.5607	0.984	0.32493
TRPAYS	-0.1218	0.0850	-1.433	0.15185
TWASTE	0.0317	0.1708	0.185	0.85294
PRVHLD	22.440*	12.557	1.787	0.07393
URBAN	1.0752	4.8944	0.220	0.82612
INCOME	-0.1507*	0.0897	-1.679	0.09320
CSCSF	6.3490**	2.6306	2.413	0.01580
CSCMF	-5.0963**	2.5128	-2.028	0.04255
PC	4.1567**	1.9194	2.166	0.03033
NDP	13.074	188.15	0.069	0.94460
PQUEB	3.9095*	2.0180	1.937	0.05271

McFadden's $\rho^2 = 0.497$
Cragg and Uhler's $\rho^2 = 0.207$
Percent Correct Predictions = 85.5%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

Table 5.6

Model 6 Recycling Program Models (Scenario 3)

Discrete Choice Logit Model
Number of observations 55

Dependent variable	RECY
Log likelihood function	-16.80797
Restricted log likelihood	-33.16300
Chi-squared	32.71006
Significance level	0.000586

Variable	Coefficient	Standard Error	t-ratio	Prob $\mid t \mid \geq X$
Constant	-11.673*	6.2800	-1.859	0.06306
PFNDNG	1.1847	1.5252	0.777	0.43730
TPNGFEE	0.0076	0.0290	0.261	0.79447
TWASTE	0.0316	0.1702	0.185	0.85288
PRVHLD	23.310*	12.260	1.901	0.05727
TRPAYS	-0.128	0.0857	-1.493	0.13542
INCOME	-0.1538*	0.0892	-1.725	0.08458
CSCSF	6.2234**	2.4968	2.493	0.01268
CSCMF	-5.0927**	2.5029	-2.035	0.04188
PC	4.2289**	1.8719	2.259	0.02387
NDP	13.040	190.02	0.069	0.94529
PQUEB	3.8182*	2.0276	1.883	0.05968

McFadden's ρ^2 = 0.493
Cragg and Uhler's ρ^2 = 0.204
Percent Correct Predictions = 85.5%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

5.2.2 Recycling Program Models

Per capita private residence (PRVHLD), per capita household income (INCOME), curbside collection services for both single and multi-family residences (CSCSF/CSCMF) and party politics are associated with the municipality's decision to provide households with recycling programs. The coefficient on residence in private housing is positive as expected and statistically significant at the 10% level in Model 5 and Model 6. While recycling in apartment buildings would require a collective commitment, which is difficult to achieve and maintain, the positive sign on PRVHLD seems to suggest that provision of this program to residents in private housing requires relatively lesser administrative cost. A unit increase in per capita private residence increases the municipality's probability of choosing RECY by 0.65%.

CSCSF has a positive impact on the provision of recycling programs as expected and CSCMF has a negative impact as expected. This suggests that single family residents receive and enjoy the convenience provided by curbside collection services as hypothesized earlier. These services alleviate the burden of delivering recyclable waste to depots, which might be a considerable distance from many residences. Conversely, the negative sign on CSCMF seems to suggest that the availability of this service to multi-family households does not provide multi-family residents with any incentive to engage in recycling due to the public-good syndrome, especially after already having paid for their waste disposal through rents. Second, the lack of rivalry and excludability of those residents who did not participate in recycling from enjoying a cleaner environment, provide no incentive in the first place for multi-family residents to engage in recycling even if a curbside collection service were made available. From the analysis of this data therefore, a curbside collection service to multi-family residents would decrease the municipality's probability of choosing RECY by 0.21% but this service if provided to single family residents, increases the probability by 0.4%.

Per capita household income (INCOME) is statistically significant at the 10% level and has a negative impact on the provision of recycling programs. A positive sign would have meant that high-income individuals demand better environmental amenities, thus supporting recycling. The negative sign however might suggest that the opportunity cost for one hour of high-income individuals is so high that they would prefer to spend it where benefits are higher than in recycling. Monetary return, which may be the primary incentive for most individuals participating in recycling, is usually low. Second, recycling may be time consuming because it involves the sorting of waste and delivering the recyclables to recycling depots.

Party politics seem to be a high profile issue in solid waste recycling. In this scenario the Liberal Party which is a neutral political party was arbitrarily chosen as a base case. Both right wing political parties (PC and PQUEB) which had negative impacts on the choice of ECON, do have positive impacts on the municipality's decision to choose RECY. Although right wing political parties have a low inclination toward environmental protection, their positive impact on the choice of RECY seems to suggest that subsidies which are often offered alongside such programs as recycling and composting, make these programs attractive. While recycling program aims at pollution reduction just like a market instrument, it does not necessarily hamper the economic base of the wealthy social class. Since subsidies are appealing, right wing political parties may have a positive impact on the municipality's provision of these programs. This seems to explain why the provision of recycling programs to households is attractive to right wing voters. Shifting the municipal leadership from the Liberal Party to the Progressive Conservative Party increases the probability that a municipality chooses RECY by 0.53% and shifting to PQUEB increases the probability by 0.23%.

Although recycling (RECY) has a direct effect on the implementation of economic instruments, economic instruments do not have any influence on choice of a recycling program.

Tipping fee (TPNGFEE) bears the expected positive sign but similar to scenario 2, it is statistically insignificant. The interpretation offered in scenario 2 of indirect effect and inadequate variability (arising from small data size) may be applicable in this scenario. Provincial funding (PFNDNG), transfer payments (TRPAYS), per capita household waste (TWASTE) and urbanization (URBAN) are other variables that do not affect the municipality's decision to choose RECY. Lack of adequate variability in these attributes may also be a likely cause for insignificance.

All models in this scenario used a common attribute, LIB (Liberal Party) as a base case and therefore can be compared. All three models have fairly similar predictive abilities. Model 5 has a McFadden's ρ^2 value of 0.497 compared to 0.495 in Model 4 and 0.493 in Model 6. Cragg and Uhler's correlation coefficients are consistent with McFadden's ρ^2 values.

Table 5.7

Model 7 Composting Program Model (Scenario 4)

Discrete Choice Logit Model
Number of observations 56

Dependent variable	COMP
Log likelihood function	-19.78958
Restricted log likelihood	-38.49420
Chi-squared	37.40924
Significance level	0.000357

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	-17.992**	8.3511	-2.154	0.03120
ECON	0.73609	1.4284	0.515	0.60632
MBUDGET	0.46952**	0.2320	2.024	0.04297
TPNGFEE	0.02924	0.0193	1.517	0.12918
TWASTE	0.25271*	0.1300	1.944	0.05192
URBAN	-4.3002	5.3946	-0.797	0.42537
PRVHLD	26.908*	14.370	1.872	0.06114
GPEACE1	-115.95*	61.958	-1.871	0.06128
RECY	2.9554**	1.3994	2.112	0.03470
EDUC1	3.1637**	1.3673	2.314	0.02067
INCOME	-0.4519**	0.1979	-2.283	0.02240
PC	5.7807**	2.4676	2.343	0.01915
LIB	4.9680*	2.6950	1.843	0.06527
PQUEB	1.1386	1.7095	0.666	0.50539

McFadden's ρ^2 = 0.486
Cragg and Uhler's ρ^2 = 0.192
Percent Correct Predictions = 83.9%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

Table 5.8

Model 8 Composting Program Model (Scenario 4)

Discrete Choice Logit Model
Number of observations 55

Dependent variable	COMP
Log likelihood function	-23.37506
Restricted log likelihood	-37.67643
Chi-squared	28.60273
Significance level	0.004514

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	-8.7429*	5.1646	-1.693	0.09049
ECON	0.2899	1.2277	0.236	0.81334
PFNDNG	1.4945	1.2627	1.184	0.23658
TPNGFEE	0.0320*	0.0186	1.723	0.08483
TWASTE	0.2063*	0.1139	1.811	0.07016
PRVHLD	21.292*	10.951	1.944	0.05187
GPEACE1	-93.007**	46.667	-1.993	0.04626
RECY	2.0756*	1.1618	1.786	0.07402
EDUC1	2.2665**	0.9625	2.355	0.01853
INCOME	-0.3198**	0.1310	-2.442	0.01459
NDP	-4.6199**	2.0174	-2.290	0.02202
LIB	-1.0406	1.0968	-0.949	0.34273
PQUEB	-3.4550**	1.3891	-2.487	0.01288

McFadden's ρ^2 = 0.380
Cragg and Uhler's ρ^2 = 0.139
Percent Correct Predictions = 87.3%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

Table 5.9

Model 9 Composting Program Models (Scenario 4)

Discrete Choice Logit Model
Number of observations 55

Dependent variable	COMP
Log likelihood function	-24.97226
Restricted log likelihood	-37.67643
Chi-squared	25.40833
Significance level	0.007941

Variable	Coefficient	Standard Error	t-ratio	Prob | t | ≥ X
Constant	-10.022**	4.6176	-2.170	0.02997
ECON	0.4768	1.0966	0.435	0.66372
PFNDNG	1.0410	1.0777	0.966	0.33406
TPNGFEE	0.0272	0.0180	1.510	0.13099
TWASTE	0.1940*	0.1113	1.743	0.08135
PRVHLD	18.258*	9.6421	1.894	0.05829
GPEACE1	-95.974**	42.956	-2.234	0.02547
RECY	1.7368*	1.0200	1.703	0.08862
EDUC	20.040**	9.2049	2.177	0.02947
NDP	-3.7193**	1.8621	-1.997	0.04578
LIB	-0.9848	1.0790	-0.913	0.36139
PQUEB	-2.8686**	1.2146	-2.362	0.01819

McFadden's ρ^2 = 0.352
Cragg and Uhler's ρ^2 = 0.127
Percent Correct Predictions = 76.4%

*** Statistically Significant at the 1% level.
** Statistically Significant at the 5% level.
* Statistically Significant at the 10% level.

5.2.3 Composting Program Models

Municipal budget (MBUDGET), per capita household waste (TWASTE) and tipping fee (TPNGFEE) have positive impacts on the provision of composting programs. The positive sign on MBUDGET is based on the grounds that waste management programs require financial support. MBUDGET is statistically significant at the 5% level. A 1% increase in municipal budget allocated to household solid waste management increases the probability that a municipality provides a composting program by 0.54%. The positive coefficient on per capita household waste suggests that since 'almost one quarter of municipal solid waste in Canada is compostable' as documented in the *Perspectives on Solid Waste Management in Canada* (1995), municipalities may provide households with composting programs as per capita household solid waste increases. A unit increase in per capita household waste raises the municipality's probability of choosing COMP by 0.05%. TPNGFEE and PRVHLD have the expected positive impacts on composting. This suggests that when landfill authorities raise tipping fees in response to higher demand for landfill services, municipalities may be likely to provide residents in private housing with composting facilities usable in their backyards. An explanation as to why TPNGFEE has no effect on both the choice of ECON and RECY but COMP is beyond the scope of this study. Marginal effects indicate that a $1.00 increase in tipping fees increases a municipality's probability to choose COMP by 0.19% and a unit increase in per capita private residence raises the municipality's probability of choosing COMP by 0.36%.

Per capita household income has a negative impact on composting. Model 7 and Model 8 show that INCOME is statistically significant at the 5%

level. This contradicts Jenkins (1991) findings in his Ph.D. dissertation on "Municipal Demand for Solid Waste Disposal Services: *The Impact of User Fees*" that municipalities with high-income households dispose of more compostable waste than municipalities with low-income households. He argues that high income allows purchases of food and other consumable materials in bulk that sooner or later end up as compostable waste. This argument therefore would suggest that per capita household income has a positive impact on the choice of COMP. The negative sign however might suggest that high-income is indirectly associated with high opportunity cost which may not be compatible with composting that requires a lot of time and attention. In fact a $1.00 increase in per capita household income decreases the municipality's probability to provide a composting program by 0.54%.

It was mentioned in the hypotheses section (section 4.3) that EDUC and INCOME are socioeconomic variables and therefore, their impacts on waste management programs could not be hypothesized. However, we can say with some confidence that we expect the two variables to have the same impact on COMP because according to many studies income and education are positively correlated. To the contrary, they have opposing impacts. While INCOME has a negative impact on the choice of COMP, the general level of education (EDUC) has a positive impact. A unit increase in the measure of the general level of education increases the probability that a municipality chooses COMP by 0.32%. If higher education teaches waste generators the importance of environmental quality and how composting can be an excellent way to avoid wasting useful natural resources while producing a high quality and inexpensive soil amendment, then the positive impact of EDUC on COMP is consistent with expectations.

As it has been argued in the literature that waste reduction programs are necessary for the viability of economic instruments, it implies that if there is any relationship among these waste reduction programs, it must be a positive one. The positive and statistically significant coefficient on RECY confirms this to be true. The presence of a recycling program increases the municipality's probability of choosing COMP by 0.32%.

GPEACE is statistically significant in Model 7 at the 10% level and 5% in Model 8 and Model 9 respectively. It has an unexpected negative impact on composting. A per capita increase in Green Peace members has a marginal effect of -0.25% on the probability that the municipality chooses COMP. Further research may be required to provide an explanation to this observation.

In this scenario, the estimated models indicate that party politics play an important role in a municipality's decision to provide composting programs. When investigating the effects of party politics on its decision to provide composting programs, the left wing political party (NDP) was arbitrarily chosen as a base case in the analysis of Model 7. But when analyzing Model 8 and Model 9, the right wing political party (PC) was arbitrarily chosen as a base case. The estimated coefficient on the Progressive Conservative Party (PC) is positive and statistically significant at the 5% level in Model 7. Similar to recycling, the Progressive Conservative Party has a positive impact on composting which does not have adverse effects on the economic activity of corporations and manufacturing companies. The fact that recycling and composting are compatible with right wing party politics, this makes it appealing to policy-makers. PQUEB in this scenario had a different impact on COMP from PC. Given the established relationship between right wing party politics and waste reduction, it would be expected that both PQUEB and PC have the same sign. Since PQUEB is uniquely a political party limited to municipalities in Quebec, a correlation effect could be a likely reason for the unexpected impact. Shifting the municipal leadership from NDP to PC increases the municipality's probability of choosing COMP by 0.80% but shifting the leadership from PC to PQUEB, decreases the probability by 0.30%. NDP party politics have a negative impact on the provision of composting programs. Since 'left wing' party politics do not have any impact on the choice of ECON and RECY except for a negative impact on the choice of COMP, this may perhaps imply that municipal decision-makers feel that other programs are more important. A shift in the leadership from PC to NDP decreases the municipality's probability of choosing COMP by 0.31%. The coefficient on the neutral political party (LIB) is positive when a 'left wing' political party is used as a base case in Model 7 and negative when a 'right wing' political party is used as a base case in Model 8 and Model 9. However LIB is only statistically significant in Model 7 which has the highest predictive ability. Being a neutral party, an interpretation of the sign on LIB is difficult. Based on this analysis, a shift in the municipal leadership from NDP to LIB increases the probability of choosing COMP by 0.49%.

Provincial funding (PFNDNG) has no effect on composting. This might suggest that provision of composting programs is cheaper since municipalities can afford to supply households with composting facilities that can be used in backyards. This therefore makes composting a municipal responsibility, unlike recycling which requires costly infrastructure of industrial proportion therefore requiring provincial or even federal aid. Economic instruments (ECON) have no effect on the provision of a composting program by municipalities.

Of the three models estimated in this scenario, Model 7 fits the data best explaining 48.6% (McFadden's ρ^2) of the variation in COMP resulting from variations in the explanatory variables. Model 8 explains 38% (McFadden's ρ^2) of the variations in COMP while Model 9 explains only 35.2% (McFadden's ρ^2) of the variations in COMP. As in the two preceding scenarios, the Cragg and Uhler's ρ^2 values in these models are consistent with the McFadden's ρ^2 values (see Table 5.7, Table 5.8 and Table 5.9).

6.0 CONCLUSIONS

6.1 A Brief Summary of the Study

Table 6.1 concisely presents results transpiring from the analysis of the three scenarios modeled in chapter four. It is a summary in a tabular form serving as a guide to policy design.

The key objective of this study is to assess the implementation of economic instruments of waste management. The relationship between these instruments and waste diversion methods becomes a secondary objective. From the three formulated scenarios, we were able to understand the key attributes affecting the implementation of these instruments and waste diversion programs although some of these attributes revealed results that were contrary to expectations (see Table 6.1).

The results revealed that; availability of recycling programs, level of urbanization, private residence, education, Green Peace members, party politics, transfer payments and per capita household income are the major determinants for the implementation of economic instruments. The analysis also shows that increasing a tipping fee has no direct effect on either recycling or adoption of economic instruments. Instead, increasing a tipping fee seems to promote composting. In this regard, it may be implied that decision-makers are more likely to provide households with composting programs when landfill disposal services become more expensive due to increasing tipping fee. The availability of curbside collection services to single family residents seems to encourage recycling. Residence in private housing has a positive impact on recycling and composting but a negative impact on the adoption of economic instruments. Perhaps this signifies a "tax revolt" issue. Property owners are often charged a property tax, which in many cases covers both sewage and solid waste management services. The study also shows that recycling affects the implementation of economic instruments but composting does not. Although recycling seems to influence the implementation of economic instruments, the implementation of economic instruments does not influence the provision of recycling programs. This implies that a recycling program may be offered to encourage the use of economic instruments but not vice versa.

Municipal politics do seem to play a role in both the implementation of economic instruments and provision of waste reduction programs. Generally, 'right wing' political parties are likely to have a positive influence on waste reduction programs but negative influence against the implementation of economic instruments. On the other hand, 'left wing' political parties have a limited impact on waste management programs. They only have a negative impact on composting.

6.2 Problems Encountered in the Study

The ideal scenario representing the research questions in this study is represented by figure 3 (section 4.4). This scenario would appropriately be analyzed by a multinomial logit approach. However the available size of data set hampered its application. Out of 94 observations (see Appendix C), rejection of missing values during model estimation reduced the overall observations to 55 or 56 depending on what attribute is included or excluded. Reducing the data set to this number of observations rendered minimal variation in some of the municipality specific attributes, making them to be statistically insignificant at the end of the analysis. It also hampered the production of better results.

Data quality was the second major problem encountered in this study. Most of the information on municipality specific attributes was for average households across each municipality. This allows minimal variation. Increasing the data set considerably would alleviate the problem.

6.3 Policy Implications

To achieve the policy goal of reducing municipal solid waste through implementing economic instruments, this study suggests that, the provision of curbside collection services to single families might be necessary to encourage recycling which itself appears to be a factor affecting implementation of economic instruments. Where the proportion of private residence is high in a municipality, this study reveals that, providing both recycling and composting programs appears to be an effective waste reduction strategy. Although the results show that raising tipping fees may only seem to encourage households to compost, it might have a far-reaching implication on the management and utilization of municipal landfills. Compostable waste which accounts for about 23% of Canadian municipal solid waste if composted, diverts a significant proportion of municipal solid waste from landfills. If done, the result is safer and more stable landfills, which are suitable for construction needs soon after closure.

Overall, party politics seem to have more effect on the selection of solid waste management programs than other variables. But 'right wing' political parties are more influential than the 'left wing'. RECY, URBAN and GPEACE1 are three variables which directly lead to the adoption of economic instruments while CSCSF indirectly leads to the adoption of the same instruments through its positive impact on the choice of recycling programs.

Table 6.1: Policy Implications Options

ECONOMIC INSTRUMENTS					
Impact (+)	marg effect (%)	Sig. Level	Impact (-)	marg effect (%)	Sig. Level
RECY	0.87	1.94	TWASTE	0.99	1.89
URBAN	0.26	2.02	PFNDNG	0.53	2.11
GPEACE1	0.95	1.95	PRVHLDS	0.80	2.22
			INCOME	0.52	2.03
			TRPAYS	0.37	1.81
			EDUC1	0.97	1.96
			CSCSF	0.40	1.76
			PC	0.78	1.91
			PQUEB	0.55	2.18
RECYCLING PROGRAMS					
Impacts (+)	marg effect (%)	Sig. Level	Impacts (-)	marg effect (%)	Sig. Level
PRVHLD	0.65	1.90	INCOME	0.30	1.77
CSCSF	0.40	2.49	CSCMF	0.21	2.04
PC	0.53	2.28			
PQUEB	0.23	1.94			
COMPOSTING PROGRAMS					
Impacts (+)	marg effect (%)	Sig. Level	Impacts (-)	marg effect (%)	Sig. Level
MBUDGET	0.54	2.02	INCOME	0.54	2.44
TWASTE	0.48	1.94	GPEACE1	0.25	2.23
TPNGFEE	0.19	1.72	NDP	0.31	2.29
RECY	0.32	2.11	PQUEB	0.30	2.49
PRVHLD	0.36	1.94			
EDUC	0.32	2.18			
PC	0.80	2.34			
LIB	0.49	1.84			

* The statistical significance reported for each variable is the highest among three estimated models in each scenario.

* marg effect = marginal effect; Sig. Level = statistical significance level (t-ratio).

6.4 Directions for Further Research

For further research in solid waste management, the importance of data quality and sample size does not need to be overemphasized. Correctly sampling a set of data is necessary but may not be sufficient if variability is limited especially in the case of aggregated data. Municipality specific attributes used in this study have limited variability because each attribute essentially represents its average level in an entire municipality. To circumvent this problem, the size of the data set must be reasonably large to make greater variability in the municipality specific attributes.

To extend this study a step further, requires information on specific economic instruments. This permits the assessment of the implementation of specific economic instruments and how they relate to waste diversion programs. The dependent variable, ECON used in this study, lumped together all economic instruments including; 'tag a bag', 'bag limit' and 'variable tipping fees'. Lack of adequate information on these specific instruments prohibited the assessment of the implementation of each of them. It is probable that a single municipality specific attribute could have different impacts on the implementation of specific economic instruments, therefore lumping all instruments together gives room to question the credibility of the impacts of the attributes analyzed. Other important missing data that might be useful in extending this study is information on proximity to substitute landfill. Information on environmental impact assessment might also be of importance in improving this study.

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APPENDIX

CANADIAN MUNICIPALITIES

SOLID WASTE MANAGEMENT STUDY

Sponsored by the University of Alberta

Department of Rural Economy

Appendix A: S W M - Survey Questionnaire 1995

Date:______________________Time:__________________________________
Municipality:____
Population:____
Department, Person Contacted, Title:___________________________________
Phone # and questions answered:_______________________________________
____

Hello, my name is ____________________. I am a research assistant at the University of Alberta. This summer we are doing a study on residential solid waste management funded by Canada's Greenplan which involves surveying municipalities across Canada about their residential solid waste management practices. I was wondering if you might have the time to help us out by answering some questions.

PART A - GARBAGE COLLECTION

1.0) Does your municipality operate a solid waste collection program for single family residents (e.g. houses)? Circle the appropriate answer. **YES** or **NO.**

If the answer is **NO**, proceed to question # 7.

If the is **YES**, go to #2.

2.0) Is this service contracted out to private companies? Circle the appropriate answer. **YES** or **NO.**

If the answer is **YES,**

What proportion of this service is contracted out?________________________

What is the fee structure?____

If the answer is **NO,** proceed to #3.

3.0) Do you charge a separate identifiable fee for this service? **YES** or **NO**

If the answer is **NO**_____Go to question #3.1

If the answer is **YES**_____Go to question #3.2

3.1) How do you charge for charge for solid waste collection family residents?

a) Flat fee that does **not** show as a line item on the utility bill etc.

b) Taxation assessment (based on the value of property).

c) Other Systems.

Describe.____

____.

3.2) How do you charge for solid waste collection from family residents?

a) Flat fee that shows as a line item on the utility bill. How much is the flat fee?________

b) Residents pay according to the number of bags/cans the put out for collection. If this is the case, what is the rate?____________________________________

c) Taxation assessment (based on property values)

d) Other system.

Describe.____

____

4.0) Is the limit as to the number of bags/cans that can be put out at the curb? Circle the appropriate answer. **YES** or **NO.**

If the answer is **YES,** what is the limit?_________________________________

If the answer is **NO,** proceed to #6.

5.0) If a resident wishes to exceed the limit of garbage for collection, what will happen to this garbage?

a) It will be left at the curb and residents have the option to haul the extra garbage out to the landfill. Is there a charge? Yes or No? How much?________

b) It will be left at the curb and residents will have to wait until the following week to dispose of the garbage.

c) It will be picked up only if residents pay an additional price for each extra unit. How much?____

d) Other. Explain.____

6.0) At the time of pickup from the curb, is the **weight** or **volume** of the bag/cans considered. Circle one.

Details.____

*****Answer only if the municipality DOES NOT operate a solid waste collection program for Single Families. Otherwise proceed to #8.***

7.0) If the municipality does not operate a municipal solid waste collection program, how do single family residents dispose of their solid waste?

a) They are able to haul it out to the landfill. Is there a charge for dumping?

b) How much?________________ Is there a bag limit? What is it?_______________ when was this implemented?__________________

c) Other. Explain.____

____.

8.0) Does the municipality operate a waste collection program for multi-family residences (e.g. apartment buildings)? Circle the appropriate answer. **YES** or **NO**

If the answer is **NO,** proceed to question #12

If the answer is **YES,** proceed to #9

9.0) What kind?____

When was it implemented?____

10.0) Is this service contracted out to private companies? **YES** or **NO.**

If the answer is **YES,** what is the proportion (%)?_______Fee structure ________________.

Is there a bag limit?____

If the answer is **NO,** proceed to #11.0

11.0) Do you charge a separate identifiable fee for solid waste collection for multi-family residences?

If the answer is **NO,** proceed to #11.1

If the answer is **YES,** proceed to #11.2

11.1) How do you charge for this service?

a) Flat fee that does not show as a line item on the utility bill for each **household.**

b) Flat fee that is charged to the **property owner**. How much?_____________

c) Taxation Assessment

d) Other. Explain.____

11.2) How do you charge for this service?

a) Flat fee that shows as a line on the utility bill for each household. How much?_______

b) Flat fee that is charged to the property owner. How much?______________

c) Other. Explain.____

*****Answer only if the municipality DOES NOT provide a solid waste collection program for multi-family residents.***

12.0) If a solid waste collection program is not provided by the municipality, how do multi-family residents dispose of their waste?

a) This service is provided by private haulers. What proportion of the garbage collection system for multi-family residences is contracted out? ________

What type?____________________

Bag Limit ____________________ Fee Structure __________________________

b) Residents in multi-family residences must haul their waste out to the landfill themselves. If so, is there a charge for dumping? How much?_______________

c) Other. Explain.____

____.

****Answer #13 only if municipality DOES NOT have any sort of economic instruments scheme.***

13.0) Has your municipality ever considered charging residents on the basis of how much waste is discard (a user pay system)?__________________________

If so, when was this proposed?____

Has this idea been rejected? When?_____________________________________

Why?

a) Not politically feasible

b) Costly to implement

a) Low participation predicted

b) No public support

c) Too costly for certain groups to participate

d) Other.

Explain.____

Answer #14 only if your municipality HAS an economic instruments scheme.

14.0) When was this system implemented?________________________________

Why?

a) Politically acceptable

b) Public pressure

e) Cost-effective

f) Maximize landfill capacity

g) Other.

Discuss.____

____.

PART B - REDUCTION EFFORTS

1.0) Does your municipality have a recycling program for single family residents?

Circle one. **YES** or **NO**.

If the answer is **NO,** proceed directly to #2

If the answer is **YES,** proceed directly to #1.1

1.1)What kind?

a) Curbside program. When was it implemented?________________________

b) Recyclable drop-off depots. When were they implemented?______________

Of these, what proportion are staffed?_________________________________

c) Other.

Explain.____

____.

2.0) Are the recycling services contracted out to private? **YES** or **NO**.

If the answer is **YES,**

Proportion (%)____

If the answer is **NO,** proceed to #3.

3.0) Does your municipality provide a recycling program to multi-family residences? Circle answer. **YES** or **NO.**

If the answer **NO,** proceed to #5

If the answer is **YES,** proceed to #3.1

3.1) What kind?

a) Recyclable drop-off depots (at malls, city centers, etc.) Of there, what proportion are staffed (%).____________________________________

b) Recyclable materials drop-offs or 'tooters' located at the apartment. When was this program implemented?____________________________________

c) Same as that for single family residents

d) Other.

Describe.____

4.0) Is this service contracted out to private collectors?

If the answer is **YES,**

What is the proportion (%)________________Fee Structure____________________

If the answer is **NO,** proceed to #5.1

5.0) Are there any recycling programs available to the residents of your municipality by private companies? **YES** or **NO.**

If the answer is **NO,** proceed to #6

If the answer is **YES,** proceed to #5.1.

5.1) What kind?

a) Recyclable drop-off depots (at mall, city centers, etc.). Of these, what proportions are staffed (%).

When was this program implemented?____________________________________

b) Recyclable materials drop-off bins or 'tooters' located at apartments. When was this program implemented?______________________________

c) Other.

Describe.____

____

****Answer question #6 only if RECYCLING PROGRAMS ARE AVAILABLE to residents.***

6.0) Approximately what percentage of your **total** waste stream is diverted from landfills as a result of recycling programs

a) provided by the municipality?

Program	Diversion Rate (%)

b) provided by private companies?

Program	Diversion Rate (%)

c) in total (%)______________________________________

8.0) Does your municipality operate a composting program for single family residents? **YES** or **NO.**

If the answer is **NO,** proceed directly to #9

If the answer is **YES,** proceed to #8.1.

8.1) What kind?

a) Distribution of backyard composters? What is the charge?_______________

When was this program implemented?______________________________

b) Other.

Explain____

9.0) Is a composting program provided to single family residents by a private company?

If the answer is **NO,** proceed to #10

If the answer is **YES,** proceed to #9.1

9.1) What kind?

a) Distribute of backyard composters? What is the charge?_______________

When was this program implemented?______________________________

b) Other. Explain______________________Implementation date:__________

10.0) Does your municipality have a composting program for multi-family residences? **YES** or **NO.**

If the answer is **NO,** proceed to #11

If the answer is **YES,** proceed to #10.1

10.1) what kind?

a) Same as that for single-family residents

b) Curbside collection. Implementation date:______________________

c) Other.

Explain____

____

When was it Implemented?_________________________________

11.0) Are there composting programs provided to multi-family residents by private companies? **YES** or **NO.**

If the answer is **NO**, proceed to #12

If the answer is **YES,** proceed to #11.1

11.1) What kind?____

____

When was it implemented?_________________________________

****Answer question #12 only if composting programs are available to residents.***

12.0) Approximately what percentage of the waste stream is diverted as a result of participation in:

a) municipally operated composting programs

Program	Diversion (%)

b) privately operated composting programs

Program	Diversion (%)

b) composting in total (%)?____

PART C - DISPERSAL

1.0) At what landfill(s) is the municipal solid waste from municipality disposed?

a) What percentage of residential solid waste goes to each?

b) What year did this landfill begin operation?

c) Given it's current capacity, how many years before expect this landfill to close?

Landfill Name & Loctn	% of MSW to Each	Operating Date	Expected Closing Date

2.0) What is the tipping structure for municipal solid waste at each of these landfills?

Landfill Name	Tipping Fee Structure

3.0) Are there facilities other than landfills available to handle residential solid waste? Check the appropriate boxes. What percentage of the residential solid waste stream is handled by each of these?

Facility	Yes	No	Diversion (%)
a) Incinerators			
b) Waste-to-energy facilities			
c) Resource recovery plants			
d) Transfer stations			
e) Centralized composting centers			
f) Other			

4.0) Approximately what is the **total** waste flow from your municipality (metric tones/year)?

5.0) Approximately what portion what portion of the **total** waste stream is made up of residential solid waste (%)______________________________

6.0) Does your solid waste management plan receive

a) Federal funding. Yes or No. What percentage?____________________

b) Provincial funding. Yes or No What percentage?____________________

c) Other.____

Comments:____

____

7.0) What percentage of the municipal budget is spent on residential solid waste management (%)?____

8.0) When was the last municipal election?__________________________

When is the next municipal election?______________________________

Additional Comments:____

____

____

____

____

____

____

____

____

____

Thank you very much for taking the time to help us out with this survey. Good bye.

If you have any information to send to us, our address is:

University of Alberta

Department of Rural Economy

Faculty of Agriculture and Forestry

515 General Services Building

Edmonton, Alberta

T6G 2H1

Phone: (403) 492-4225 *Fax: (403) 492-0268*

Appendix B: Descriptive Statistics (unscaled)

Variable	Mean	Std. Dev.	Skew.	Kurt.	Minimum	Maximum	Cases
MBUDGET	5.031	5.825	3.8	19.7	0.000	37.50	56
TWASTE	17761	35601	3.0	10.7	260.0	151840	56
URBAN	522.2	640.9	1.4	4.20	1.100	2589.6	56
PRVHLD	8629	20219	4.2	22.0	815.0	125200	56
INCOME	44394	10575	1.2	4.2	27650	75295	56
EDUC	1877	4337	3.2	12.8	65.00	22390	56
TPNGFEE	28.4	27.25	1.8	8.2	0.000	150.00	56
PFNDNG	0.273	0.450	1.0	2.0	0.000	1.0000	55
RECY	0.696	0.464	-0.8	1.7	0.000	1.0000	56
COMP	0.554	0.502	-0.2	1.0	0.000	1.0000	56
PC	0.375	0.489	0.5	1.2	0.000	1.0000	56
NDP	0.089	0.288	2.9	9.1	0.000	1.0000	56
LIB	0.268	0.447	1.0	2.1	0.000	1.0000	56
PQUEB	0.268	0.447	1.0	2.1	0.000	1.0000	56
GPEACE	244.0	669.2	4.2	21	0.000	3987.0	56

Appendix C: Cleaned Raw Data Used for the Study

Serial #	Econ	method	mbudgt	Q-waste	popn	urban	Prvhlds	incm	trpays	edu
1	1	2	4	11465	7795	801.4	3980	37138	15.1	730
2	1	3	1.5	6500	15210	4.9	6260	75295	4.7	2655
3	1	4	-999	-999	6890	596.6	6400	43172	9.3	480
4	1	1	4	6135	8455	2008	4450	40891	18.2	660
5	1	1	11.8	-999	7800	7.2	3650	43594	13.7	470
6	1	2	12.02	3500	10450	107	4520	63885	7.9	1555
7	1	2	-999	3140.4	7515	50	3075	54601	9.2	355
8	1	4	5.7	-999	2120	64.2	935	51891	10.9	130
9	1	1	2.6	1955	4190	17.1	1940	47288	13.8	390
10	1	3	24	120000	68935	1280.2	32410	49707	9.7	11820
11	1	4	3	830.32	2605	18.6	1100	52689	11.4	185
12	1	3	-999	2902.5	3370	53	1445	49228	12.4	170
13	1	2	4	10500	23225	1361	11535	41501	14.5	1235
14	1	2	-999	1235	4620	17.3	1990	66428	7.6	595
15	1	3	5	3148.9	2300	854.7	1190	34716	16.5	150
16	1	1	5	5132	5985	644.3	3180	38047	20.1	290
17	1	2	2.4	285	6595	57.4	3285	37801	15.7	345
18	0	0	-999	20000	7260	456.2	3585	45767	8.6	660
19	0	0	3	151840	31470	1796	62755	47394	10.1	15755
20	0	0	-999	4300	3210	3	1520	64776	3	185
21	0	0	-999	3125	17185	13	8275	42020	13.4	1430
22	0	0	10.5	6969.6	3155	13.2	1510	40644	16.1	170
23	0	0	0.05	3123	4300	23.4	1745	74433	5.8	580
24	0	0	4.96	137379	256080	2589.6	125200	41232	14.3	22390
25	0	0	3	50000	36615	742.4	18360	38209	16.4	2160
26	0	0	4.5	1169.9	2735	19.8	1185	49329	11.1	180
27	0	0	6	36000	130530	1245.1	62255	47115	9.9	13710
28	0	0	5	4753	5180	1158.3	2460	52189	8.3	680
29	0	0	-999	4218	6515	30.9	2860	52363	8.3	335
30	0	0	9.01	1240.4	2585	30.3	1115	50819	10.9	115
31	0	0	10	10000	7645	638.1	3875	44572	12.8	675
32	0	0	3	-999	2535	12.5	1110	47263	13	140
33	0	0	5	2893	5740	25.7	2375	69842	5.5	685
34	0	0	-999	245000	27335	102	11305	53327	7.1	3235
35	0	0	2	6949.5	7380	8.48	3190	40869	18.5	370
36	0	0	1	3046.8	3185	534.1	1520	35464	20.4	280
37	0	0	-999	-999	2620	314	1190	40281	13.8	140
38	0	0	23	12000	5805	21.6	2600	51769	1.7	560
39	0	0	4.7	3000	10585	157.1	4910	54490	7.1	870
40	0	0	2.5	17000	29605	460.3	13555	45672	9.9	1835
41	0	0	2	29600	60160	1564.1	28860	42562	13	10440
42	0	0	5	17000	37345	2032.2	16925	54393	7.1	3920
43	0	0	8	8300	5610	205.8	2520	56643	6.8	1100
44	0	0	5	1500	2490	673.4	1245	36614	17.9	205
45	0	0	1.14	6000	10540	18.6	5110	44502	13.2	685
46	0	0	37.5	1456	3820	16.6	1615	38668	19.3	200
47	0	0	8	18000	6255	13.7	2650	42933	15	325

48	0	0	2.9	150000	4315	327.9	1715	42985	13.2	250
49	0	0	2.5	3400	2310	62.4	1200	48947	11.1	405
50	0	0	-999	-999	2055	43.7	805	33216	35.7	80
51	1	1	3.5	7250	3928	1.1	2037	37223	14.9	343
52	1	2	4	2400	3145	1781.6	1485	40659	13	95
53	0	0	0	5500	4770	316.8	2310	51042	7.7	485
54	0	0	3	7000	6730	708	3675	32265	20.7	460
55	0	0	3	8891	4220	383.9	2255	33597	19.4	325
56	0	0	6	10863	2240	8.95	1130	35101	20.3	105
57	0	0	0	2743.2	2122	-999	989	37469	14.4	216
58	0	0	0.65	10000	2175	402	1370	38353	16	270
59	0	0	1	739	2400	455.6	1060	33823	23.7	110
60	0	0	5	10400	3995	445.3	1630	33758	23	240
61	0	0	3.3	7100	4350	350.2	2255	32338	20.2	70
62	0	0	5.6	5525	5655	822.4	2525	41516	14.1	170
63	0	0	3.4	-999	2145	970	1140	24803	28.9	55
64	0	0	6.7	8300	3350	26.7	1715	28977	27.8	75
65	0	0	6	8500	4480	-999	2510	29965	17.7	220
66	0	0	3.6	3000	6240	1655.9	3085	42914	9	495
67	0	0	5	5000	6555	134	2915	65907	5.4	850
68	0	0	5	300	3325	421.7	1570	43048	11	140
69	1	3	1.2	7500	8535	3	3620	62411	5.5	1265
70	1	1	-999	14000	6050	379.4	3045	40078	14.5	375
71	1	2	-999	2099.3	1895	374	885	57502	5.7	125
72	0	0	2.36	-999	6135	2.8	2785	39778	12.3	275
73	0	0	1.6	3600	8605	0.17	3805	36032	15.5	395
74	0	0	2	-999	6825	3.4	2980	43630	8.9	445
75	0	0	0.9	-999	2290	15.9	965	63255	9.4	120
76	0	0	2.5	-999	1680	351.2	780	41451	-999	155
77	0	0	-999	11500	10620	888.8	4925	53712	5.9	825
78	0	0	1	-999	2034	2.9	865	39366	11.6	74
79	0	0	1	-999	2085	4.6	850	37386	14.4	110
80	0	0	1	640	2070	364.1	935	35957	25.4	220
81	0	0	6	4402	5230	7.7	2225	42159	15.6	690
82	0	0	4	2000	2980	507.1	1305	43999	11.6	340
83	0	0	3	8000	3045	3.8	1310	37171	21	225
84	0	0	0.67	36500	9675	306.7	5060	36980	17.2	1390
85	0	0	2	5525	6065	698.5	3085	32687	21.1	405
86	0	0	9.25	7000	2055	159.2	815	51950	14.5	165
87	0	0	0.5	8000	2825	329.5	1175	48152	13.7	165
88	0	0	5.4	260	2285	5.3	1100	27650	29.9	65
89	0	0	7	11000	2715	878.4	1190	33230	25.1	175
90	0	0	7.5	4600	3030	20.1	1405	33634	19.6	55
91	0	0	5.3	4600	2550	66.9	1175	44764	13.1	70
92	0	0	4	-999	1890	492.8	840	39784	16.4	115
93	0	0	-999	-999	2885	312.9	1035	44575	9.9	230
94	0	0	5	-999	2885	50.3	1315	36904	12.6	105

Serial #	Pc	ndp	lib	pqueb	gp	Tpngfe	pfndng	Cscsf	cscmf	recy	comp
1	1	0	0	0	95	15	0	1	1	1	1
2	1	0	0	0	177	30	0	0	0	1	1
3	1	0	0	0	84	0	-999	1	1	1	1
4	0	1	0	0	150	75	0	1	1	1	1
5	0	1	0	0	150	50	1	1	1	1	1
6	1	0	0	0	168	48	0	1	1	1	1
7	1	0	0	0	122	70	-999	1	1	1	1
8	1	0	0	0	35	2.5	1	1	1	1	1
9	1	0	0	0	66	10.17	0	1	1	1	1
10	1	0	0	0	1101	7	1	1	1	1	1
11	1	0	0	0	44	-999	0	1	0	1	1
12	1	0	0	0	54	107	0	0	0	1	1
13	1	0	0	0	375	0	1	1	1	1	1
14	1	0	0	0	74	45	0	1	1	1	1
15	1	0	0	0	32	-999	0	1	1	1	1
16	0	1	0	0	109	60	0	1	1	1	1
17	0	0	0	1	29	32	0	1	1	1	1
18	1	0	0	0	89	-999	1	1	0	1	1
19	0	1	0	0	2360	69	0	1	1	1	1
20	0	1	0	0	69	-999	0	1	1	1	1
21	0	1	0	0	330	30	0	0	0	1	1
22	1	0	0	0	48	1.5	1	1	1	1	1
23	1	0	0	0	68	0	0	0	0	1	1
24	1	0	0	0	3987	70	1	1	1	1	1
25	1	0	0	0	590	42	1	1	1	1	1
26	1	0	0	0	52	75	1	1	1	1	1
27	1	0	0	0	2107	75	1	1	0	1	1
28	1	0	0	0	86	-999	0	1	1	1	1
29	1	0	0	0	112	-999	1	1	1	1	1
30	1	0	0	0	42	50	1	1	0	1	1
31	1	0	0	0	122	25	0	1	1	1	1
32	1	0	0	0	41	0	0	0	0	1	1
33	1	0	0	0	95	7	0	1	1	1	1
34	0	0	1	0	414	80	0	1	0	1	1
35	0	0	1	0	106	25	0	1	0	1	1
36	0	0	1	0	46	25	0	1	0	1	1
37	0	0	1	0	17	75	0	1	1	1	1
38	1	0	0	0	96	-999	1	1	0	1	1
39	0	0	0	1	51	-999	0	1	1	1	1
40	0	0	0	1	116	28.8	0	1	1	1	1
41	0	0	0	1	249	29.26	0	1	1	1	1
42	0	0	0	1	171	29	0	1	1	1	1
43	0	0	0	1	26	34.8	0	1	1	1	1
44	1	0	0	0	41	45	0	1	1	0	1
45	1	0	0	0	176	0	0	1	1	0	1
46	0	0	1	0	1	42	1	1	1	0	1
47	0	0	1	0	1	42	1	1	1	0	1
48	0	0	1	0	3	12	0	1	1	0	1

49	0	0	0	1	9	26.5	0	1	1	0	1
50	0	0	0	1	87	0	0	1	1	0	1
51	0	1	0	0	74	150	0	1	1	1	0
52	0	0	0	1	15	29.36	0	1	1	1	0
53	1	0	0	0	60	18.84	0	1	1	1	0
54	1	0	0	0	87	0	1	1	1	1	0
55	0	1	0	0	8	7	0	1	1	1	0
56	1	0	0	0	28	0	1	1	1	1	0
57	0	0	1	0	90	0	0	1	1	1	0
58	0	0	1	0	40	0	0	1	1	1	0
59	0	0	1	0	33	25	0	1	0	1	0
60	0	0	1	0	2	-999	0	1	0	1	0
61	0	0	0	1	19	25.2	0	1	1	1	0
62	0	0	0	1	26	26.5	0	1	0	1	0
63	0	0	0	1	9	0	0	1	1	1	0
64	0	0	0	1	14	28	0	1	1	1	0
65	0	0	0	1	19	27	0	1	1	1	0
66	0	0	0	1	28	27.03	0	1	1	1	0
67	0	0	0	1	31	30	0	1	1	1	0
68	0	0	0	1	14	24	0	1	0	1	0
69	1	0	0	0	97	29	0	0	0	0	0
70	0	1	0	0	122	0	1	1	1	0	0
71	0	1	0	0	39	0	0	1	1	0	0
72	1	0	0	0	72	0	0	1	1	0	0
73	1	0	0	0	109	-999	0	0	0	0	0
74	1	0	0	0	83	0	0	0	0	0	0
75	1	0	0	0	37	0	-999	0	0	0	0
76	0	1	0	0	15	0	0	1	1	0	0
77	1	0	0	0	154	-999	0	1	1	0	0
78	1	0	0	0	28	0	0	0	0	0	0
79	1	0	0	0	31	0	1	1	0	0	0
80	0	0	1	0	0	58	-999	1	0	0	0
81	0	0	1	0	80	0	0	1	1	0	0
82	0	0	1	0	44	0	0	1	0	0	0
83	0	0	1	0	43	0	1	1	1	0	0
84	0	0	1	0	130	30	1	0	0	0	0
85	0	0	1	0	87	0	0	0	0	0	0
86	0	0	1	0	1	10.75	0	1	0	0	0
87	0	0	1	0	2	10.75	1	1	1	0	0
88	0	0	0	1	10	31.8	0	1	1	0	0
89	0	0	0	1	13	-999	0	1	0	0	0
90	0	0	0	1	14	-999	0	1	1	0	0
91	0	0	0	1	12	0	0	1	1	0	0
92	0	0	0	1	9	-999	1	1	1	0	0
93	0	0	0	1	10	42	0	1	1	0	0
94	0	0	0	1	13	-999	0	1	1	0	0

Variable Names:

econ	- whether or not econometric instruments are used.
method	- different types of economic instruments.
mbudgt	- amount of municipal budget allocated to municipal waste disposal.
Q-waste	- annual average household waste landfilled.
popn	- population size of the municipality
urban	- population density of the municipality.
prvhlds	- number of private housings.
incm	- mean annual household income.
trpays	- transfer payments to households.
edu	- number of degree holders in the municipality.
pc	- municipal leader belongs to the Progressive Conservative Party.
ndp	- municipal leader belongs to the New Democratic Party.
lib	- municipal leader belongs to the Liberal Party.
pqueb	- municipal leader belongs to Party Quebecois.
tpngfee	- tipping fee charged by landfill authorities.
pfndng	- whether or not a municipality receives provincial funds for SWM.
cscsf	- whether or not a curbside collection for single families is available.
cscmf	- whether or not a curbside collection for multi-families is available.
recy	- whether or not a municipality provides a recycling program.
comp	- whether or not a municipality provides a composting program.

Data Summary:

Municipalities Using Economic Instruments	22/94	(23.4%)
Municipalities Providing Recycling Programs	61/94	(64.9%)
Municipalities Providing Composting Programs	50/94	(53.2%)
Municipalities Receiving Provincial Funds	23/94	(24.5%)
Municipalities with Curbside Collection for Single Families	82/94	(87.2%)
Municipalities with Curbside Collection for Multi-Families	65/94	(69.1%)
Municipalities Headed by Leader Belonging to PC	40/94	(42.6%)
Municipalities Headed by Leader Belonging to NDP	11/94	(11.7%)
Municipalities Headed by Leader Belonging to LIB	19/94	(20.2%)
Municipalities Headed by Leader Belonging to PQUEB	24/94	(25.5%)

-999 represents a missing entry
0 represents the answer NO
1 represents the answer YES
For variable names see section 4.3 (Chapter Four)

Appendix D: Other Discrete Choice Models[21]

Linear Probability Model

This model treats the task of modeling the variation of the random variable Y_i as a regression problem.

$$Y_i = E[Y_i] + e_i \quad \text{(i)}$$

with a systematic component $E[Y_i] = P_i$ and $E[e_i] = 0$. Assuming that P_i is linear in parameters,

$$E[Y_i] = P_i = \beta_1 + \beta_2 X_{i2} + \ldots\ldots + \beta_k X_{ik} \quad \text{(ii)}$$

or

$$Y_i = \beta_1 + \beta_2 X_{i2} + \ldots\ldots + \beta_k X_{ik} + e_i \quad \text{(iii)}$$

which is our linear statistical model for the discrete random variable Y_i. From (iii) above, since Y_i is discrete, the errors $e_i = Y_i - P_i$ are discrete as well and therefore cannot be assumed as normal. The variance of these errors is also not constant therefore; any attempted analysis would face heteroskedasticity problems.

The third problem associated with this model is that, expressing the probability function, P_i as a linear function of X_{ik}, does not confine P_i in the [0,1] interval as explanatory variables X_{ik} vary. A probability measure greater

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[21] Review of the Linear Probability Model and the Probit Model were taken from 'Learning and Practicing Econometrics' by Griffiths et. al pp 736 – 747.

than one is clearly not satisfactory. This particular weakness totally disqualifies the *Linear probability Model* from use.

Probit Model

The *Probit Model* is a nonlinear discrete choice model that relates P_i to X_{ik} while confining the probability in the [0,1] interval. This model uses a utility index I_i for the *i*th individual as;

$$I_i = X_i{}'\beta = \beta_1 + \beta_2 X_{i2} + ...+ \beta_k X_{ik}. \qquad \text{(iv)}$$

In equation (iv) above, when the explanatory variable X_{ik} increases, the value of I_i also increases over the real number line. The larger the value of I_i, the greater will be P_i, the probability that individual *i* chooses the option where Y_i=1. This type of relationship between I_i and P_i can be depicted by a cumulative distribution function where P_i varies between zero and one as I_i varies between $-\infty$ and $+\infty$, namely:

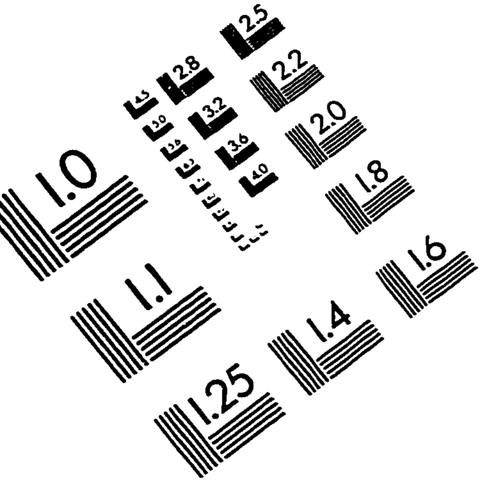
$$P_i = F_i(I_i) = F\left(X_i{}'\beta\right) = P[Z \le I_i] = \int_{-\infty}^{I_i} (2\pi)^{-1/2} e^{-Z^2/2} dZ \qquad \text{(v)}$$

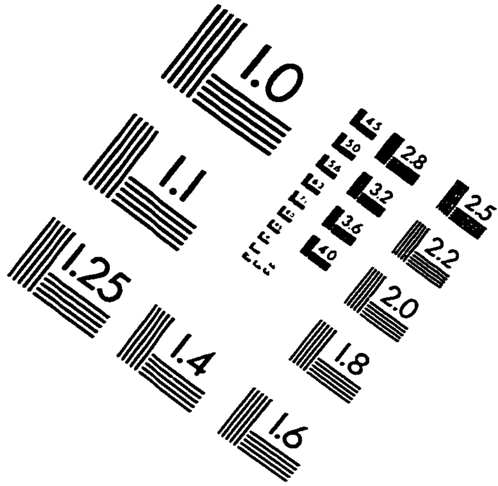
where Z is a standard normal random variable. The fact that this model involves the use of integrals makes it unappealing to use. Using integrals is cumbersome.

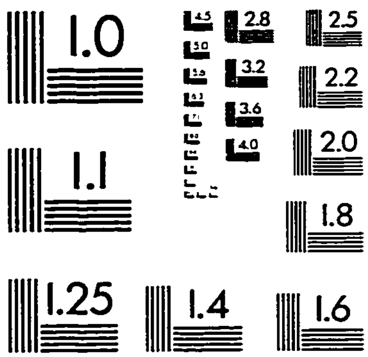
The *Logit Model* however has advantages over both models. It is linear in parameters just like the *Linear Probability Model* but uses a nonlinear function (maximum likelihood function) to estimate the linear parameters. Unlike the

Linear Probability Model, it confines the probability in the [0,1] interval as in the *Probit Model*. The *Logit Model* also assumes the error term to be normal and identically and independently distributed. This means no heteroskedasticity problems and without any integral functions, the *Logit Model* is simpler to use than the *Probit Model*.

IMAGE EVALUATION TEST TARGET (QA-3)

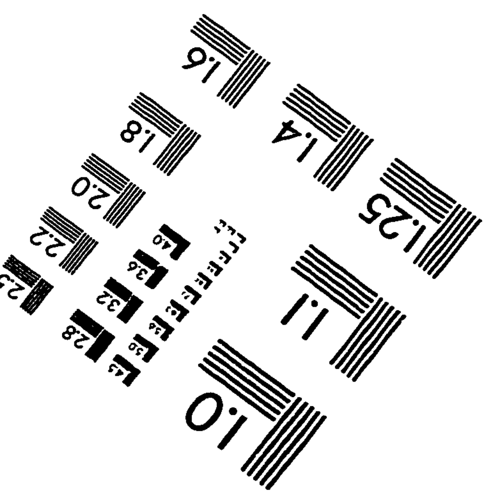


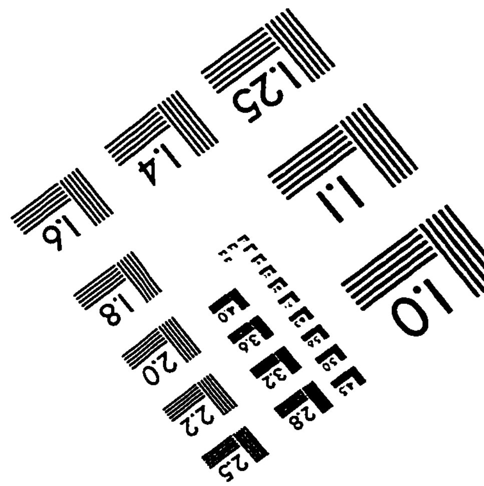




150mm

6″





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