The price of garbage: an analysis of the effect of user-pay programs on waste diversion in Ontario municipalities

Christina Chiasson

Supervisor: Nicholas Rivers

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Abstract: As the province of Ontario moves towards its goal of becoming waste free, there remains a substantial uphill battle to curb waste away from landfill and towards more sustainable end-of-life management facilities such as recycling, reusing, and composting plants. Diverting disposed materials into recovery facilities will help Ontario develop its circular economy and will relieve ever-increasing pressures on local landfills. This study analyses the direct effect that waste policies have on residential waste diversion rates, with particular investigation into unit-based pricing mechanisms commonly known as user-pay or pay-as-you-throw programs. This study is intended to help policy-makers decide which policies are most effective at increasing waste separation, and although the main focus is on user-pay schemes, bag limits, frequency of curbside recycling collection, curbside organic/leaf and yard waste collection and the level of promotion and education funding are also investigated for their effects on diversion rates in Ontario. This study uses the extensive database of information of Ontario municipalities' waste programs provided by the Resource Productivity and Recovery Authority, and performs a series of simple and multiple linear regressions to determine the relationships between each waste policy and diversion rates. Between 216-243 municipalities were considered over a nine-year period from 2008-2016. The results of the study indicate a significant relationship between user-pay schemes and increased diversion, and also indicate that the policies may be more effective in urban communities than in rural ones.

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1. Introduction

1.1 The World's waste problem

In many developed countries across the globe, economic prosperity and stability have resulted in a culture of high consumption and disposal. Likewise, developing countries with burgeoning economies are also demonstrating increases in consumption of goods and services, leading to higher rates of disposal in these nations. The challenge of managing increasingly vast amounts of waste produced by developed and developing countries is an increasingly pressing issue as rates of waste generated globally continues to climb at a rapid pace. In 2010, it was estimated in a report from the World Bank[1] that approximately 3.5 million tonnes of waste was produced globally every day and that the world was on track to increase its production of waste by 70% by 2025. The authors of the World Bank report noted above also estimate that under business as usual conditions, waste will be produced at a rate of 11 million tonnes per day by 2100, an increase of approximately three times the rate in 2010[2].

Developed countries that have experienced economic stability and prosperity for some years no longer demonstrate steep increases in consumption that are often witnessed in developing countries, but they have become acclimatized to a high-consumption culture. This has led, in many countries, to the perpetual issue of finding ways to manage the ever-increasing piles of consumptives once they are no longer desirable. Despite Canada's vast geography, the issue of managing waste is an every increasing challenge for Canadian communities as well. In fact, Canada's negligence towards sustainable waste management has contributed to it being one of the worst performers in terms of municipal waste generation among similar developed countries. According to the

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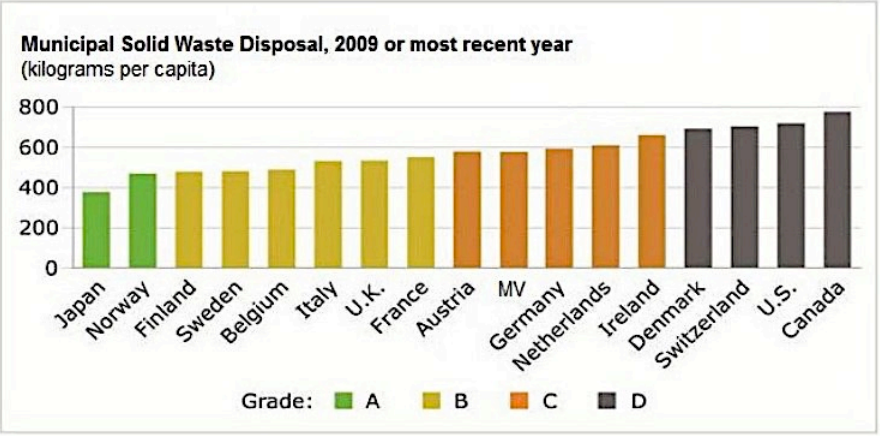
[1] Hoornweg, D. Bhada-Tata, P. (March, 2012). Environment: Waste production must peak this century. *Nature 502*, pp. 615-617.

[2] Hoornweg, D. Bhada-Tata, P. Kennedy, C. (October, 2013). What a waste: a global review of solid waste management. *World Bank Urban Development Series No. 15*.

Conference Board of Canada, out of 17 countries that are part of the Organization for Economic and Cooperative Development, Canada earned the top spot of waste disposed per capita, at 777 kg/capita recorded in 2008[3] (see Figure 1). The rate of waste produced per capita in 2008 resulted in approximately 34 million tonnes of waste produced in a year, of which more than three-quarters ended up in landfills[4].

Figure 1. Comparison of 17 OECD countries on municipal per capita waste disposal. Conference Board of Canada (2013)[5].



1.2 State of waste in Ontario

Although there was once a common perception that there is virtually endless space to dispose of waste in Canada, many municipalities have struggled in recent years to cope with the pressures of disposal on local landfills that are filling up more quickly than expected. According to the Auditor General of Ontario, one in five municipalities are facing the challenge of no longer having space in their landfills to dispose of residential garbage[6]. In some cases, Ontario municipalities have chosen to transport their municipal waste to landfills in the United States as a

[3] Conference Board of Canada (2013). International Ranking, Municipal Waste Generation.
[4] Stats Canada (2008). Waste Management Industry Survey: Business and Government Sectors – Analysis.
[5] Conference Board of Canada, *supra note 3*.
[6] N.A. (October 2011). Ontario landfills are filling up fast. Waterloo Region Record. Retrieved on January 19, 2018 from: https://www.therecord.com/news-story/2589653-ontario-landfills-are-filling-up-fast/

cheaper and quicker option to manage their waste than building a new landfill site[7]. Furthermore, it is becoming increasingly difficult for municipalities to develop new landfill sites, as the approval process can take several years.

Due to the costs and challenges of having new landfill sites approved by the Ontario Ministry of the Environment, many municipalities are looking for methods of reducing pressure on existing landfills by encouraging diversion of residential waste into more sustainable pathways (in this case, sustainable means that products will have longer life-cycles, and that there will be less demand for virgin materials that are energy intensive to extract and/or manufacture). In many cases, alternative methods of waste management such as recycling and composting are not only more sustainable than disposal in landfill, but also produce other benefits as well. Diverting recyclable, reusable, or compostable waste away from landfill and into recovery streams can often produce several benefits to society, the environment, and the economy (discussed further in section 1.4). Although the cost of recycling in many Ontario communities is greater than landfill disposal, the indirect, or external costs of landfilling on communities can often make landfill disposal less economically sustainable in the long run[8]. Despite the apparent benefits of recycling, reuse, and composting programs, many municipalities still struggle to encourage their residents to use these programs to their fullest potential.

Although not all waste is divertible, certain leading municipalities in Ontario have set waste diversion targets as high as 70%[9]. However, despite many Ontario municipalities having recycling

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[7] N.A. (October 19, 2011). With fewer landfills, where will Ontario trash go? *Waterloo Region Record.* Accessed on March 23, 2017. http://www.therecord.com/news-story/2592071-with-fewer-landfills-where-will-ontario-trash-go-/

[8] Lakhan, C. (February 2015). Diversion, but at what cost? The economic challenges of recycling in Ontario. Resources, Conservation & Recycling Vol. 95, pp. 133-142.

[9] City of Guelph (April 2017). Solid Waste Management Master Plan. Accessed on March 28, 2018 from: https://guelph.ca/plans-and-strategies/solid-waste-management-master-plan/

and composting programs in place, in 2015 the average municipal diversion rate was only 31%[10]. The average rate falls far below what has been achievable in leading communities such as Orillia, which had a 64% diversion rate in 2015[11]. The Ontario government, as part of its Waste-Free Ontario Act, has set an ambitious target of achieving a 50% provincial diversion rate target by 2030, and an 80% target by 2050[12], meaning that Ontario municipalities have substantial work to do to improve their diversion rates over the next 10 to 30 years.

Policies that are designed to increase the use of diversion programs among residents have become increasingly popular in Ontario municipalities in recent years as a means of reducing stress on local landfills. Policies such as bag limits, curbside recycling and organics collection, funding for promotion and education of municipal waste programs, and user-pay systems have been implemented in various jurisdictions with the intent that residents will be discouraged from throwing recoverable items into the general waste stream. User-pay (or pay-as-you-throw) schemes that require residents to pay for each container of general waste disposed have become particularly popular in Ontario and other jurisdictions as a means of discouraging residents from placing divertible materials into the waste stream.

1.3 Overview of user-pay mechanisms

User-pay schemes have experienced a notable surge in Ontario over the past decade with over 120 municipalities using some form of the program in 2014[13] (see Figure 2). Although user-pay programs vary in design, the principle is that citizens pay an upfront fee for the collection of each

[10] Resource Productivity & Recovery Authority, (2015). Residential Waste Diversion Rate. Historical records of WDO Municipal Datacall.
[11] *Ibid.*
[12] Province of Ontario. (February, 2017). Strategy for Waste-Free Ontario: Building the Circular Economy. Accessed on February 1, 2018 from: https://www.ontario.ca/page/strategy-waste-free-ontario-building-circular-economy.
[13] Resource Productivity & Recovery Authority, (2014). Program Information. Historical records of WDO Municipal Datacall.

item of garbage they dispose of. A typical fee for a single bag or container of waste in Ontario under a user-pay scheme varies between $1 and $2[14]. This method is contrasted with the common practice for municipalities to fund their waste collection and management services through a fixed fee within property taxes. Unlike through the user-pay method, property taxes are paid once a year and the costs to households of waste collection and management is not always clear. In many cases, the costs of waste management and collection are bundled with a number of other city services in the property tax bill so it can be unclear to residents what they are actually paying for this service. The intention of the user-pay mechanism is to decrease the amount of waste residents dispose in landfill by having them internalize the cost of each item/container they are disposing of. The mechanism also increases the visibility of the cost of waste management, forcing residents to realize how much they pay for the waste management services provided by the municipality, with the intention that it will discourage citizens from over-using the services.

There are various types of user-pay schemes, but they generally can be categorized into full or partial schemes. Full user-pay schemes require citizens to pay a fee for each item of garbage (bag, container, large bulky items, etc.) they wish to have disposed of by the city. Partial user-pay schemes require residents to pay for a limited amount of the cost of collection upfront, while the rest of the cost is imbedded in property taxes (i.e. residents will only have to pay for collection of some of the items put out). Partial user-pay schemes are more common in Ontario than full user-pay programs and can often be used by municipalities as a gradual change for residents in preparation for a shift to a full user-pay program. These programs vary widely in design but typically allow residents to dispose of a certain number of containers of waste before having to pay directly for increased service. For example, in many municipalities, residents are able to set out a single item of waste with

[14] Kelleher Environmental & Robins Environmental. (2009). Household Fees and PAYT Rates. Implementation of a Sustainable Financing System for Solid Waste Management in Ontario. Discussion Paper #3. Prepared for Stewardship Ontario.

no upfront cost, but they must pay a fee for additional service if they wish to set out more than one item. Orillia is an example of a different type of a partial user pay scheme where residents are provided with a set number of collection indicators at the beginning of each year, free of charge, and must ration them throughout the year or else purchase more if required[15]. Although there are various modes of user-pay schemes, the most common form in Ontario is for residents to buy indicators such as stickers or tags that they place on their general waste containers to signal to waste managers or collectors that the municipal service has been paid for. Waste collectors will leave items that have not been indicated as paid for at the curb, and depots will likewise not accept untagged containers.

User-pay schemes are mechanisms that discourage residents from disposing divertible materials into the general waste stream, and forces residents to internalize the full or partial cost of waste collection and disposal. In contrast to the conventional use of property taxes to fund municipal waste services, user-pay schemes have the benefit of increasing residents' self-awareness and accountability for the amounts of waste they generate, and the cost to the municipality to manage it. By making the cost of municipal waste management more visible to residents, user-pay schemes theoretically should encourage residents to divert waste through other municipal programs such as recycling and composting programs that do not have similar pay-per-use costs.

Some view user-pay schemes to be an equitable approach to distributing the costs of managing municipal waste, rather than simply having residents pay a fixed (and often unclear) fee in their property taxes. It is supposed that when residents pay in proportion to the amount of waste they produce, rather than paying a fixed fee that the cost of managing waste is distributed more

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[15] Kelleher, M. & Dixie, J. Enviros-RIS (May, 2000). "Here to stay and increasing in popularity and efficiency" *Solid Waste and Recycling Magazine*. Accessed on March 23, 2017 from http://kelleherenvironmental.com/publications/user-pay-in-canada/

equitably among residents[16]. Residents who pay a fixed fee as part of their property taxes are likely paying either too little or too much for the cost of managing their household's specific output. User-pay schemes offer the flexibility to municipalities of setting fees for the disposal of each unit of waste at, or very close to, the actual cost to the municipality to collect and manage each unit. It is unclear, however, how many Ontario municipalities set their user-pay fees equal to the actual cost of waste collection and disposal, as this data is difficult to obtain. Revenue created through user-pay schemes is often put directly towards funding municipal waste collection and disposal[17], rather than being put towards funding a range of municipal services when the costs are bundled with general property taxes.

Certain negative characteristics of user-pay systems include: a higher implementation cost than property tax revenue generation; a common misunderstanding that the fees are a double taxation; and a potential increase of the negative behaviour of illegal dumping. The cost of operating user-pay systems is often higher for municipalities than the property taxation method due to higher administrative, enforcement, and pubic outreach costs[18]. As a result of these increased costs to the municipality, the costs of waste collection and management to residents can also be substantially increased under user-pay schemes. For example, in Toronto, the implementation of user-pay fees for waste had a projected increase from $209 per single-family household, per year, to $271[19]. There is also a danger when implementing user-pay schemes that citizens will view the fees as a double taxation. It is often the case with user-pay schemes that certain costs to the municipality of operating waste management programs continue to be funded through property taxes, meaning

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[16] Kelleher, M., Robins, J., Dixie, J. (July 2005). Taking Out the Trash: How to Allocate the Costs Fairly. *C.D. Howe Institute No. 213*. Toronto, ON.
[17] Kelleher Environmental & Robins Environmental. (2009). Solid Waste Management Fee Structures and Billing Approaches. Implementation of a Sustainable Financing System for Solid Waste Management in Ontario. Discussion Paper #3. Prepared for Stewardship Ontario.
[18] Dewees, D.N. (2002). Pricing Municipal Services: The Economics of User Fees. Canadian Tax Journal, Vol. 50 (2), pp. 586-599.
[19] Kelleher Environmental & Robins Environmental (2009), *Supra note 17*.

that residents will pay for their total waste management service through property tax and user-pay fees. However, the two revenue-generating methods often pay for different services (e.g. property tax might pay for landfill operation costs and waste diversion programs, while user-pay fees pay for the management of additional containers of waste and the operation costs of user-pay programs). Due to this perception of double taxation, implementing user-pay schemes can be politically challenging for municipalities. Another danger is that user-pay schemes can lead to increased occurrences of illegal dumping, particularly when municipalities are unable to enforce by-laws against this type of behaviour. Because of this risk, there are often increased enforcement costs related to user-pay programs to discourage residents from engaging in this negative behaviour. If not adequately controlled, illegal dumping can lead to increased pressure on local landfills, leading to higher negative externalities. Unfortunately, the level of illegal dumping that is a result of user-pay systems is not well understood in Ontario.

1.4 Benefits of achieving higher diversion rates

Diversion rates in Ontario are different from recycling rates as they are calculated by combining the total tonnage of waste diverted into a number of recovery streams, including: blue box recycling, organics collection and composting, and deposit/return programs. Diversion rates are calculated by the RPRA using the following formula:

$$\textbf{Diversion Rate} = \frac{\textbf{Tonnes Diverted}}{\textbf{Tonnes Generated}} \textbf{ x 100\%}$$

where the tonnes generated include all materials collected into all waste streams including general waste going to landfill[20]. User-pay mechanisms encourage waste diversion through recycling, reuse, and composting programs, which all help to reduce the amount of waste disposed of in landfill. The external costs of landfill disposal of municipal solid waste in Ontario are not easily quantifiable in

[20] RPRA (May 2017). 2015 Waste Diversion Rates. Accessed on March 30, 2018 from: https://rpra.ca/wp-content/uploads/2017/10/2015-Waste-Diversion-Rates.pdf

dollar terms, however impacts on the environment and on the quality of life of nearby residents are commonly referenced as examples of external costs. Increasing waste diversion away from landfill disposal can provide a number of social and economic benefits to residents and municipalities, and can provide environmental benefits as well.

There are many environmental benefits to increasing waste diversion that can be experienced on a local scale and beyond. Such benefits include: decreasing the runoff of harmful pollutants into the surrounding environment through ground contamination (which affects soil quality but can also be leached into surrounding water bodies that suffer from the effects of the pollutants and can carry the chemicals elsewhere); decreasing the emission of methane and other greenhouse gases into the surrounding air and atmosphere; reducing dependence on virgin materials that can be energy-intensive to extract and manufacture; and reducing the carbon footprint of transporting recycled materials from other nations. Increasing diversion can also help to achieve a closed-loop waste system, which reduces energy costs (in an ideal closed-loop system, wherein materials are continually recycled into new products without the degradation of their properties, the energy used to create new products using recycled materials would be far less than that needed to produce the same products with virgin materials).

In addition to environmental benefits, increased residential diversion rates can also provide social benefits to communities. Heightened diversion rates provide social benefits as they help to limit stresses on local landfills and the need to create new landfill sites. Landfills have several social costs associated with them such as: reduced property value near landfill sites; loss of opportunity to use the land of a new waste site for public spaces such as parks; and the loss to nearby residents' enjoyment of their surroundings due to the sights and smells of a landfill[21].

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[21] Sustainable Prosperity (February 2016). Supporting Ontario's Circular Economy through the Use of Economic Instruments. Submission to Ontario's Draft Strategy for a Waste-Free Ontario: Building the Circular Economy. Ottawa, ON.

Lastly, increased residential diversion rates can create economic benefits at the community level as well as at the provincial level. Along with the social benefits of not having to develop new landfill sites, there are of course associated financial benefits to not having to locate, gain approval for, build, and operate new landfills. There is also an economic cost to relying on virgin materials or raw materials from other countries that are energy-intensive, rather than using raw materials from Ontario's recycling industry (which is a more energy-efficient source). Finally, increased diversion can lead to an increase in job opportunities in Ontario's recycling and composting industries.

2. Literature review

2.1 Existing research

It has been, and in many cases remains to be the norm in most Canadian municipalities for residents to pay for the cost of waste management through a fixed fee set in their property taxes which are used to deliver a suite of municipal services. Only in the past couple of decades has there been a movement in Canada, and North America more generally, towards modernized methods of taxation to pay for residential waste management. Jurisdictions in Canada and the U.S. are opting to implement more transparent forms of taxation through various styles of user-pay systems designed to alter the waste disposal behaviours of residents. Price signalling mechanisms such as user-pay schemes have gained popularity in recent years in Ontario, particularly as municipalities are facing increasing pressures on waste management systems through growing populations, heightened consumerism, and excessive reliance on disposable goods.

Ontario's first user-pay schemes were implemented between 1991 and 1996 and were initially understood to be appropriate for small municipalities only, due partly to their inapplicability to multi-residential housing common to larger cities. In 1996, only 120 user-pay programs existed in

all of Canada, with about half of them in Ontario[22]. Twenty years later, at the end of this study, there are now about the same amount in Ontario alone (117 at the time of this study), with some programs existing in communities of 2,000 residents and some in communities of 2,000,000.

The proliferation of user-pay schemes in Ontario over the past two decades coincided with an expansion of literature on the topic during the same time period. Studies of the effect of user-pay schemes in various contexts and applications experienced a boom between the late 1970s and 1990s as this type of program gained popularity in various parts of the world. A variety of analyses have been conducted to determine the effects of user-pay schemes on such things as the amount of residential waste generated, residential recycling rates, and municipal revenue generated. Although there have been some studies analysing the effect of user-pay schemes on diversion rates, they are quite rare, likely due to a lack of available data.

Many of the initial studies of user-pay systems attempted to determine the policy's effect on the amount of residential waste generated. An early study by Wertz (1976) attempted to estimate a demand function for the provision of waste services, and theorized that as unit price increases, tonnage of waste produced decreases accordingly[23]. Jenkin's (1993) analysis of panel data of 9 US municipalities in the 1980s demonstrated a reduction in tonnage of waste produced in municipalities with user-pay systems in comparison to those without, theorizing that the consumption of waste-intensive products was reduced by the implementation of the policy[24]. A similar study by Repetto et al. (1992) examined the effect of the implementation of a unit-price of $1.50 in ten American municipalities (across several states) that previously had property tax financing systems over a nine-

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[22] Kelleher, M., Dixie, J. (August 1996) User Pay for Residential Waste Pickup in Ontario. *Solid Waste and Recycling Magazine, 1996 August-September edition.* Accessed on February 15, 2018 from: http://www.toolsofchange.com/en/case-studies/detail/105

[23] Wertz, K. L. (1978). Economic Factors Influencing Households' Production of Refuse. *Journal of Environmental Economics and Management 2(3)*, pp. 263-72.

[24] Jenkins, R. (1993) The Economics of Solid Waste Reduction: The Impact of User Fees; Edward Elgar Publishing: London, UK.

year period. Repetto et al. found an impressive decrease of about 18% in these ten municipalities in comparison to a control group of four municipalities continuing to use property tax financing systems[25]. Studies such as these have been of interest to municipalities searching for ways to reduce stress on local landfills, and have also been of interest for their implications of cost savings for municipalities.

More recent studies have examined the effect of user-pay systems on the interaction between waste generation and recycling rates. Community-level studies such as Podolski & Speigel (1998)[26] and Kinnaman & Fullerton (2000)[27] examined how user fees affect the amount of waste produced in US municipalities and whether any changes could be associated with increased recycling rates. Podolski & Speigel used data from 12 New Jersey municipalities with user-pay schemes in place to test their effect on waste generation and recycling rates. They found that an increase of $0.01 per pound of garbage produces a reduction of 40 pounds of waste produced per capita, however they did not find a significant change in recycling rates. Kinnaman & Fullerton's study was similar to that of Podolski & Speigel, although it was the first of its kind to use a large cross-section of US municipalities (114) to determine the effect of user pay schemes on the amount of waste generated and the rate of recycling. They discovered a 44% decrease in waste production in communities with a $1.00 unit price in 1991 compared to municipalities without user-pay schemes but noted only a small increase in recycling rates, raising questions of how the change in waste production was being achieved if not through increased recycling. The results of these studies raise questions on how to account for the substantial reductions in waste generation in the absence of increased recycling rates, with Kinnaman & Fullerton postulating that illegal dumping or burning of waste could be partly

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[25] Repetto, R. Dower, R. C., Jenkins, R., Geoghegan, J. (1992). Green Fees: How a Tax Shift Can Work for the Environment and the Economy. *The World Resources Institute*: Washington, DC.
[26] Podolsky, M.J., Spiegel, M. (August, 2016) Municipal Waste Disposal: Unit Pricing and Recycling Opportunities. *Public Works Management & Policy 3(1)*, pp. 27 – 39.
[27] Kinnaman, T. C., Fullerton, D. (2000). Garbage and Recycling with Endogenous Local Policy. *Journal of Urban Economics, 48(3)*, 419-442. DOI: 10.1006/juec.2000.2174

attributable. Another possibility is that residents are encouraged to divert waste through other programs such as leaf and yard waste collection, composting, and re-use programs. Analysis of overall waste diversion rates alongside that of total tonnage of waste produced could provide further explanation of how the decline in generated waste can be accounted for.

Conversely, a study by Yang & Innes (2007)[28] examining the before-and-after effect of a linear to volume user-pay scheme on the city of Taipei discovered a decrease of between 26-28% in volume of waste generated and an increase of 64% in the volume of recycled materials. Yang & Innes theorize that their results diverge from those of past studies due to the continuous unit pricing used in Taipei, which encouraged residents to limit the costs of disposing waste by eliminating recyclable materials from their output. This interpretation is supported by a study of Dutch municipalities by Allers & Hoeben (2010)[29] that also found that linear to weight user-pay schemes had a greater effect on reducing waste generation (39%) than pay-per-unit schemes (21-29%, based on the type). Allers & Hoeben also found that user-pay schemes had a significant positive effect on quantities recycled, however the increase accounted for only 18% of the reduction in the amount of waste generated.

Household-level studies on the effect of unit-based pricing for waste disposal on recycling rates have produced mixed results. A study by Hong et al. (1993)[30] found that the likeliness of households in Portland, OR to participate frequently in recycling rose in response to a unit increase in the fee for disposal. Conversely, Reschovsky & Stone (1994)[31] found that user-pay programs had no effect on recycling rates on municipalities in Thompson County, NY unless there was a curbside

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[28] Yang, H-L., Innes, R. (2007). Economic Incentives and Residential Waste Management in Taiwan: An Empirical Investigation. *Environmental & Resource Economics,* 37(3), pp. 489-519.
[29] Allers, M.A., Hoeben, C. (2010). Effects of Unit-Based Garbage Pricing: A Differences-in-Differences Approach. *Environmental & Resource Economics*, 45 (3), pp. 405-428.
[30] Hong, S., Adams, R. M., Love, H. A. (1993). An Economic Analysis of Household Recycling of Solid Wastes: The Case of Portland Oregon. *Journal of Environmental Economics and Management, 25*, pp. 136-146.
[31] Reschovsky, J.D., Stone, S. E. (December, 1994). Market incentives to encourage household waste recycling: Paying for what you throw away. *Journal of Policy Analysis and Management, 13(1),* pp. 120-139.

recycling program in place, and even then the effect was found to be quite small. However, they did discover that user-pay schemes had a significant positive effect on participation in composting. Similarly, Jenkins et al. (2003)[32] found that in a comparison of a large sample of US metropolitan cities with marginal-pricing programs to communities without user-pay programs, the recycling rates of the specific materials being studied were not significantly impacted by user-fees. They provide three theories to explain this finding: firstly, that the price of disposal in metropolitan communities may be too low to encourage waste separation (and therefore recycling) due to the high incomes of citizens; secondly, that the unit-based pricing system produces a direct signal to reduce waste but only an indirect signal to increase recycling; and lastly, as suggested by Yang & Innes (2007)[33], discontinuous pricing signals (commonly used by cities in this study) may provide weaker incentives to recycle than continuous signals. The mixed results of these studies demonstrate inconsistencies in how various types of user-pay systems (such as pricing-level and continuous pricing) affect recycling habits, and overall diversion rates. Further analyses of the effects of particular types of user-pay systems are needed.

A topic that requires more research is the disparity between the effects of full user-pay systems in comparison to partial-payment programs, something that will be investigated in the context of Ontario in this study. Ferrara & Missios (2005) found that user-pay programs could have substantially differing effects on waste generation and recycling depending on whether the municipality implemented full or partial user fees[34]. In this study it was found that municipalities that charged a fee for every container of waste collected had a significant positive effect on recycling

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[32] Jenkins, R.R., Martinez, S.A., Palmer, K., Podolsky, M.J., (2003). The determinants of household recycling: a material-specific analysis of recycling program features and unit pricing. *Journal of Environmental Economics and Management 45 (2)*, 294–318.

[33] Yang, H-L., Innes, R., *supra note 28*.

[34] Ferrara, I., Missios, P. (February 2005). Recycling and Waste Diversion Effectiveness: Evidence from Canada. *Environmental and Resource Economics*. DOI: 10.1007/s10640-004-1518-z.

behaviour, while partial-cost systems had a negative effect, as residents weren't encouraged to separate waste streams until a certain container limit was reached.

Research on the effect of unit-based pricing systems for residential waste on municipal diversion rates is scarce in comparison to analyses of the effect on recycling rates. A rare example of such a study is Bauer & Miranda's (1996) analysis of the effect of user-pay schemes on a range of outcome variables, including overall waste diversion rates[35]. The study discovered an increase of 68% in San Jose's diversion rate in the year after a unit pricing scheme was implemented (in 1994). The increased rate was attributed to increased use of the city's curbside recycling program, and increased use of the city's curbside yard waste collection program. Similarly, there is a lack of research analysing the effect of user-pay systems on participation in municipal yard waste collection or composting programs.

There have been a few studies conducted on the effect of a range of policies aimed to reduce waste generation, including user-pay schemes, on recycling rates in Ontario. Mueller (2013)[36] investigated the effect that various policies (such as user-pay schemes, bag limits, single or multi-stream collection, the number of materials that were accepted by recycling programs, and the level of funding for education and promotion of waste programs) had on the recovery of materials out of Ontario's Blue Box program. In this study, it was found that municipalities that had implemented user-pay programs (between 2005-2010) experienced greater recovery rates than those that had not implemented such programs during the same time period. It is noted, however that the significance of the relationship was relatively weak, similar to the findings of Kinnaman & Fullerton (2000)[37].

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[35] Bauer, S., Miranda, M. L. (1996). The urban performance of unit pricing: An analysis of variable rates for residential garbage collection in urban areas. Report prepared for the Office of Policy, Planning, and Evaluation; The U.S. Environmental Protection Agency.

[36] Mueller, W. (2013). The effectiveness of recycling policy options: Waste diversion or just diversions? *Waste Management 33*, pp. 508-518.

[37] Kinnaman, T. C., & Fullerton, D. (2000), *supra note 27*.

Lakhan has also contributed extensive research into the field of user-pay systems in Ontario. In his 2014[38] and 2015[39] studies, Lakhan used community-level and household-level data to determine the effect of user-pay programs on blue box recycling and to determine stakeholder attitudes towards the programs. Like Mueller (2013)[40], Lakhan found that user-pay programs had a positive effect (between 1.95 and 3.01%) on recycling rates. Additionally, Lakhan (2015) found that the majority of Ontario residents were in favour of terminating user-pay programs despite having been exposed to them for a long time. This finding contradicted expectations of attitudes towards user-pay programs over time. In a study of four OECD countries (Canada, Sweden, Switzerland and the Netherlands) by Brown & Johnstone (2014)[41] it was found that overall support for user-pay programs increased the longer communities were exposed to them. The findings of Lakhan[42] and Brown & Johnstone's[43] studies in relation to Canadian, and more specifically Ontarian attitude towards user-pay programs indicate that results of user-pay analyses conducted in other countries are not easily transferrable to Canadian jurisdictions.

2.2 Intent of this study

The aim of this study is to add to the current body of user-pay analysis in Canada, and to examine how such programs affect overall residential waste diversion rates, an area that is lacking a large body of research. Thus far, the research conducted in Ontario has largely focussed on the affect user-pay programs have on recovery derived from Ontario's Blue Box program. Although valuable, studies of the effect user-pay programs have on recycling rates does not provide a

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[38] Lakhan, C. (June 2014). Evaluating the effects of unit based waste disposal schemes on the collection of household recyclables in Ontario, Canada. *Resources, Conservation and Recycling 95,* pp. 38-45.
[39] Lakhan, C. (June, 2015). Stakeholder Perceptions of Unit Based Waste Disposal Schemes in Ontario, Canada. *Resources 4*, pp. 434-456.
[40] Mueller, W. (2013), *supra note 36*.
[41] Brown, Z. & Johnstone, N. (January, 2013). Better the devil you throw: Experience and support for pay-as-you-throw waste charges. *Environmental Science & Policy 38*.
[42] Lakhan, C., (2014) *supra note 38*.
[43] Brown, Z. & Johnstone, N., *supra note 41*.

complete image of how the programs affect total diversion rates. As was pointed out in the RPRA's analysis of Ontario's diversion performance in 2014, organic, compostable material made up the largest portion of divertible material of all waste produced at 40%[44]. Consequently, municipalities that engage in composting programs are likely to have heightened residential diversion rates.

This study will consider how user-fees affect overall diversion rates, which take into account various recovery streams including recycling, organic/leaf and yard waste collection, and re-use programs. It is expected that the implementation of user-pay schemes will have a positive effect on municipal diversion rates when compared to municipalities without such systems in place. As a secondary analysis, this study will determine Ontario user-pay schemes decrease the overall tonnage of waste produced (including all streams), adding to the body of work that has previously explored this topic in other jurisdictions. It will also investigate the differences in effect between municipalities that have implemented full user-pay schemes, and those that have only implemented partial user-pay schemes with the expectation that full user-pay systems will have a greater positive effect on diversion rates. Finally, it will test the prevailing assumption that user-pay schemes are more effective at diverting waste in small municipalities compared to large municipalities.

3. Method

3.1 Choice of study type

In order to determine the effectiveness of a user-pay program in diverting residential municipal waste away from Ontario landfills through recycling, composting and reuse streams, this study will use a before-after/control-treatment comparison of residential waste diversion rates in a treatment group of municipalities that have implemented a user-pay program, to a control group of

[44] RPRA (April 21, 2016). Data Report #5 – 2014 Ontario Residential Waste Diversion Rates. http://www.rpra.ca/Portals/0/Document_Folder/2014%20Residential%20Diversion%20Rates.pdf (accessed March 23, 2017).

municipalities that do not have such a program in place. In order to determine the effect of a user-pay scheme on a municipality's diversion rate independent of regional factors, the treatment group will be compared to itself both before and after program implementation, using panel data. A similar comparison will be conducted in the control group, and the differences in changes to diversion rates in both groups will demonstrate how the treatment affected the outcome variable.

This difference-in-differences method has been performed in analyses of user-pay systems before, such as by Allers & Hoeben (2010)[45]. The advantage of using panel data, as opposed to cross-sectional data, in a community-level study of this size is that it can control for fixed community characteristics that affect diversion rates. Characteristics such as community demographics, attitudinal factors (e.g. heightened public awareness of the issue of rising waste; increased social accountability for the harm created from waste; or public sentiment towards separating waste into streams), or pressure on local government to divert more waste away from local landfills can be difficult to obtain and control for in community-level studies. Without controlling for these factors, bias is likely to occur since unobserved variables would likely be affecting the diversion rate. Such bias can be avoided by using a difference-in-differences approach that compares municipalities to themselves, thereby eliminating the need to control for community characteristics that remain fixed over time. This approach, however, does not control for community characteristics that change over time, which can introduce bias if these factors are not controlled for.

3.2 Choice of variables

The independent variables that are considered in this study were chosen based on previous studies conducted in Ontario on waste-reduction policies by Mueller (2013)[46] and Lakhan (2014)[47].

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[45] Allers & Hoeben (2010), *supra note 29*.
[46] Mueller (2013), *supra note 36*.

They include: user-pay schemes (full and partial), bag limits, weekly curbside recycling collection, bi-weekly curbside collection, the level of per capita funds used to promote and educate residents on the municipality's waste programs, and curbside collection of leaf and yard waste and/or organic waste (such as food scraps). The choice to include curbside collection of organic/leaf and yard waste as an independent variable in this study is new to user-pay analyses in Ontario. The previous studies mentioned above analysed the effect of waste-reduction policies on recycling rates, rather than diversion rates, making the curbside collection of organics irrelevant to their outcome variables. The inclusion of organics collection in this study as a factor affecting diversion rates is an important consideration as organic material contributes a large portion to overall household waste in Ontario.

The choice to examine residential diversion rates as the main outcome variable in this study intends to broaden the research on user-pay systems in Ontario, and globally. Previous studies in Ontario and abroad have generally used recycling rates or total waste generation as main outcome variables. Analysing diversion rates provides a fuller image of where residential waste ends up as it considers reuse and composting programs in addition to recycling. This study will also consider the secondary outcome variable of total tonnage of waste produced per capita (including all waste streams) to build on the existing literature. Such as in past analyses, it is expected in this study that user-pay schemes will have a negative effect on per capita waste generation as residents are expected to reduce their total waste output in an effort to limit their expenditures on waste disposal.

Another interest of this study is to assess how residential diversion rates are affected differently under full and partial user-pay programs. Full and partial user-pay systems differ significantly in the price signal they send to residents. Since partial user-pay systems allow a certain amount of waste to be set at the curb without a fee, it is expected that they will encourage less waste

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[47] Lakhan, C., (2014), *supra note 38*.

diversion than full user-pay systems. Similarly, full user-pay systems are expected to reduce the total amount of waste generated more than partial user-pay systems.

A final consideration of this study is how user-pay systems can vary in effect depending on the size of the municipality that they are implemented in. When user-pay systems were initially introduced in Ontario, it was theorized that they would be less effective in larger communities due to their inapplicability in multi-residential buildings. To determine whether this is the case in Ontario, a multiple linear regression was used to ascertain the combined effect of a user-pay scheme variable and a dummy variable indicating an urban (1) or rural (0) municipality. For ease of categorization, this study will use the municipal groupings 1-5 used in the RPRA data for urban municipalities, and groupings 6-9 for rural municipalities (see Table 1). The RPRA's breakdown of municipal groupings is based on population, density, location, and availability of curbside recycling collection.

Table 1. Description of RPRA municipal groups[48]

Municipal Grouping	Description	
1. Large Urban	Population > 250,000	Density > 4 residents/km^2
2. Urban Regional	Population > 250,000	Density < 4 residents/km^2
3. Medium Urban	Population < 250,000	Density > 3 residents/km^2
4. Rural Regional	Population < 250,000	Density < 3 residents/km^2
5. Small Urban	Population < 50,000	Density > 4 residents/km^2
6. Rural Collection North	Population < 50,000 Density < 4 residents/km^2	Curbside collection service Northern Ontario
7. Rural Collection South	Population < 50,000 Density < 4 residents/km^2	Curbside collection service Southern Ontario
8. Rural Depot North	Population < 50,000 Density < 4 residents/km^2	Depot service Northern Ontario
9. Rural Depot South	Population < 50,000 Density < 4 residents/km^2	Depot service Southern Ontario

[48] Mueller, *supra note 36*.

3.3 Data Source

The data used in this study was gathered from Waste Diversion Ontario's (WDO) municipal datacall, an annual census of Ontario municipal recycling programs that gathers information on waste programs, and waste production and diversion statistics. WDO, which was established under the *Waste Diversion Act (2002),* was dissolved in November 2016 to be replaced by a new organization entitled the Resource Productivity and Recovery Authority (RPRA), which has continued WDO's role of gathering and storing the data from the annual census. The formation of the RPRA was legislated by the *Waste-Free Ontario Act (2016)* to provide greater powers of oversight and enforcement to Ontario's waste authority[49].

All Ontario municipal recycling programs participating in Ontario's Blue Box Program are required to provide a series of information to the RPRA, which it uses to analyse the performance of the waste diversion programs in place. Information such as recycling rates, composting rates, and total tonnage of waste generated are gathered to determine a municipality's overall diversion rate. The census also gathers information on the use of other programs in place in certain municipalities such as user-pay schemes, bag limits, and how often (if at all) blue-bin recycling is picked up at the curb. All data gathered by the RPRA are self-reported by the municipal recycling programs. All census data are gathered and made available through the RPRA's website. At the time of this study, the RPRA had only the past six years of data available online (2011-2016), however upon request, data from earlier years was obtained from the RPRA for the purposes of this study.

This study uses panel data from all Ontario municipal recycling programs that supplied community-level data to the annual RPRA datacall over a nine-year period (2008-2016). Data relating to user-pay schemes is not available earlier than 2008, limiting the range of the study on user-pay schemes to a nine-year period. Each year, over 200 municipal recycling programs

[49] Province of Ontario. (February 2017). Strategy for Waste-Free Ontario: Building the Circular Economy. Accessed on February 1, 2018 from: https://files.ontario.ca/finalstrategywastefreeont_eng_aoda1_final-s.pdf

participate in the datacall representing roughly 90% of the 444 communities in Ontario[50] (some recycling programs provide service to multiple communities). Municipalities that do not participate in the province's Blue Box program, operated by Stewardship Ontario, are not required to participate in the datacall[51]. According to Stewardship Ontario, in 2015, 98% of Ontario households had access to recycling through the province's Blue Box Program[52]. The number of Ontario municipalities that participated in the datacall in the period of study varied from 216 in 2008, and 243 in 2015[53]. To ensure the veracity of the self-reported data, the RPRA works with Stewardship Ontario and the Municipal Industry Program Committee to ensure the proper submission of data, and conduct audits into the accuracy of the reporting[54].

Stewardship Ontario is a not-for-profit organization that is solely funded by industry producers of products and packaging managed through Ontario's Blue Box and Orange Drop (recycling or safe disposal of hazardous and special waste) programs[55]. The organization collects fees from industrial producers that are used to partly fund (approximately 50% of the cost) the collection, transportation, recycling and safe disposal of waste in Ontario municipalities. The municipalities that participate in Ontario's Blue Box program contribute the remainder of the funding for the programs in their own communities.

The main outcome variable of this study, Ontario diversion rates, are calculated by the RPRA, as noted previously, by combining the reported tonnages of waste diverted through the

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[50] Mueller, *Supra note 36*.
[51] RPRA (N.D.) Blue Box Program. Accessed on February 12, 2018 from: https://rpra.ca/blue-box/
[52] Stewardship Ontario. (June 2017). 2016 Annual Report. Accessed on February 12, 2018 from: http://stewardshipontario.ca/wp-content/uploads/2017/06/2016_SO_AnnualReport.pdf
[53] RPRA. (2008-2016) Municipal Datacall. http://208.93.239.103/partners/municipalities/municipal-datacall/ (accessed March 8, 2017).
[54] Stewardship Ontario, (2017) *supra note 52*.
[55] Stewardship Ontario (N.D.). About Us. Accessed on February 12, 2018 from: http://stewardshipontario.ca/about-us/

following recycling, composting, and reuse programs and dividing it by the total tonnage of waste produced. The recovery streams that are included in the diversion calculation are the:

- Municipally operated recycling activities (including the Blue Box program, waste electrical and electronic equipment collection, used tires collection);
- Orange Drop program (including the reuse and recycling of municipal hazardous or special waste);
- Composting programs (including curbside collection of food waste, and leaf & yard waste, and allowances for backyard composting); and
- Reuse, return or deposit programs (including liquor bottle returns).

The secondary outcome variable, total tonnage of waste produced per capita, is derived by adding the total tonnage of waste produced in all collection streams including: the general waste stream, recycling collection, organic/leaf and yard waste collection, and reuse programs. The results of analyses determining the effect on this outcome variable are presented in percentage terms. Although this study predicts that user-pay schemes will increase the use of less costly diversion streams (i.e. recycling, composting, and reuse programs), it is also of interest to determine whether or not user-pay schemes will cause residents to reduce their total waste output as well.

The primary independent variable of interest in this study is user-pay schemes. Since 2008, each municipality that has participated in the RPRA datacall has indicated whether or not their municipality has a user-pay scheme in place. Since 2009, the user-pay schemes are further broken down into the categories of full or partial systems. Unfortunately, the partial user-pay schemes do not provide any indication of the limit of waste that can be disposed before residents must start paying per-use fees. The initial analysis of comparing municipalities with and without user-pay programs will be repeated with the data on partial and full user-pay schemes to determine the difference in effect of the two types of unit-pricing mechanisms.

Secondarily, this study will analyse the effects of other independent variables, including: bag limits, curbside organic/leaf and yard waste collection, weekly or bi-weekly curbside recycling collection, and level of funding for promotion and education of waste programs. The RPRA's reporting of bag limits is qualified simply as "yes" or "no", leaving no opportunity to assess the varied effect of different levels of limits. Curbside recycling collection is reported as 0, 28, or 52 collections per year in the RPRA data. The level of funding per capita each municipality uses for public outreach and education relating to its waste programs is recorded in dollar amounts. All of the data on the above variables are available in all years of the study period. Data on curbside organic/leaf and yard waste collection is only available from 2011 to 2016. This data is provided through the RPRA in terms of total tonnes collected from each municipality, but for this analysis the data will be categorized as either having or not having access to the service for simplicity.

3.4 Equations

3.4.1 Regression analysis

Once data on independent variables and the main outcome variable are gathered from the treatment and control groups, a multiple linear regression analysis will be performed using the following equation:

$$Y_{mt} = \beta_0 + (\beta_1 * X_{mt}) + \alpha_m + \gamma_t + (\beta_2 * Z_{mt}) + \mu_{mt}$$

The diversion rate, Y_{mt} of municipality *m* in year *t* is dependent on the effect of a user-pay program on diversion rate β_1 multiplied by a binary indicator X_{mt} signaling the presence (1) or absence (0) of a user pay system. β_0 is the benchmark diversion rate (intercept); Z represents observable characteristics of the municipality *m* in year *t* under (i.e. presence of a bag limit, weekly curbside collection, bi-weekly curbside collection, funds spent on promotion an education, and curbside organics and/or leaf and yard waste collection) multiplied by the effect, β_2, of each characteristic on

the diversion rate; α_m is a dummy variable for each municipality; γ_t is a dummy variable for each year; and μ_{mt} is the error value.

Before the multiple linear regression using all independent variables were performed, regressions of each independent variable considered in this study were performed to determine their independent effect on the outcome variable. These regressions were performed using the following equation:

$$Y_{mt} = \beta_0 + (\beta_1 * X_{mt}) + \alpha_m + \gamma_t + \mu_{mt}$$

where, Y_{mt} is the outcome variable (either diversion rate or total waste produced per capita) in municipality *m*, in year *t* ; β_0 is the intercept; X_{mt} is the exploratory variable, and β_1 is the effect of this variable on the outcome variable; α_m is a dummy variable for each municipality; γ_t is a dummy variable for each year; and μ_{mt} is the error value. This exploratory analysis was performed to determine the independent effect of each exploratory variable on diversion rates.

3.4.2 Promotion and education

The RPRA's annual municipal datacall provides the total amount of money each municipality spends on promotion and education for their waste programs. For the purpose of this study, the amount of funds spent per capita by each municipality is the value of interest. This study initially considered the total amount of funds spent by each municipality, instead of funds/capita, however the results indicated that the variable had no effect on the outcome variables. This is likely because of the vast differences in funding spent on municipalities based on their population sizes (e.g. Toronto had a population of 2.7 million in 2016 and spent $2.3 million on promotion and education, whereas Dysart had a population of 8,000 in 2016 and spent $168 on promotion and education). Therefore, to determine the funds spent on promotion and education per capita, the following equation was used:

$$F_{mt} \div P_{mt}$$

where F_{mt} are the total funds spent on promotion and education in municipality m at time t, and P_{mt} is the population in municipality m at time t.

3.5 Assumptions and limitations

An important limitation of this study involves the data source used for the regression analyses. The RPRA is the only source of detailed information on individual municipal waste programs in Ontario, leaving no opportunity to cross-reference the data used in this study with data from other sources. The RPRA endeavours to publish accurate information by verifying the data submitted under the datacall and conducting audits with the help of Stewardship Ontario (approximately 10% of municipalities that participate in the datacall are audited each year), however the correctness of the data remains the responsibility of the municipality[56]. Despite the efforts of Stewardship Ontario and the RPRA, it is impossible to assume that all data gathered in the datacall are perfectly accurate. The danger of self-reported data is that it has the potential to be either intentionally or unintentionally misreported. Furthermore, the RPRA is not capable of fact-checking all of the data reported by municipalities, leaving significant opportunity for municipal program data to be misrepresented.

Another limitation of this study is its inability to assess the extent to which illegal dumping occurs in each municipality. This data is not collected by the RPRA or any other source in Ontario. As Lakhan found in his 2015[57] study, which included a survey of Ontario households the occurrence of illegal dumping is likely to increase in the presence of user-pay programs. Out of survey respondents (47), 39.5% of respondents reported witnessing illegal dumping in their communities,

[56] RPRA. (February 2018). 2017 Datacall User Guide. Accessed on March 4, 2018 from: https://rpra.ca/wp-content/uploads/2018/02/Datacall-Guide.pdf
[57] Lakhan, C. (2015) *supra note 39*.

and 50.3% of respondents either agree or strongly agree with the statement: "Pay-as-you-throw policy results in households illegally dumping garbage". This is an important consideration, as illegal dumping may cause inaccuracies in reported diversion rates and tonnage of waste generated in the residential sector.

A final limitation of this study is that it does not provide detail into the price signal set in user-pay programs in each municipality. Rather than providing the unit price in user-pay municipalities, the data only indicate whether user-pay fees apply to each unit of garbage (full) or only units after a certain limit is reached (partial). The RPRA data do not contain detailed information on the program design of user-pay systems (such as the special case of Orillia described above) nor does it provide information on the limit of units that can be set to the curb without fees under partial user-pay systems. The lack of this information in the data limits this study's ability to analyse the variation in effect of different unit prices on the outcome variables.

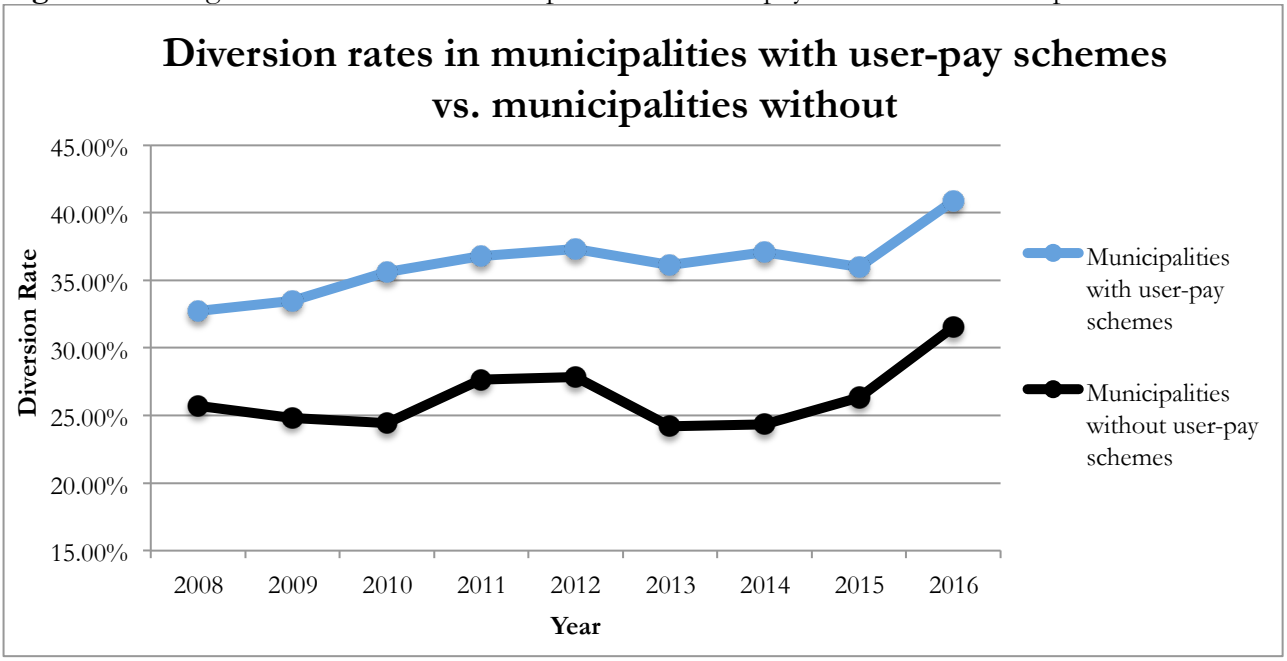
4. Results

4.1 Observed trends in the data

Initial observation of the data prior to any statistical analysis reveals that municipalities with user-pay schemes in place have a significantly higher mean diversion rate than municipalities without user pay schemes (see Figure 2). On average, municipalities with a user-pay scheme had a 10% higher diversion rate than municipalities without one. The blue line in Figure 2, which has a consistently higher diversion rate in all years (2008-2016), represents municipalities with user-pay schemes, while the black line represents municipalities without user-pay schemes. It can be seen in Figure 2 that there are similar trends in the variation in diversion rates from year to year in both treatment and control groups such as moderate decreases in 2013, and sharp increases in 2016. The

similarities in diversion rate trends over time in Figure 2 demonstrate normative shifts that cannot be accounted for by the presence or absence of user-pay schemes.

Figure 2. Average diversion rates in municipalities with user-pay schemes vs. municipalities without



By graphing individual municipalities that implemented user-pay schemes at some point during the study period, it can be seen that unit-pricing policies have hugely varying effects in each municipality. Some municipalities experience the expected effect of increased diversion rates that coincide with the implementation of a user-pay scheme. Examples of user-pay schemes having positive effects on diversion rates can be seen in municipalities such as the City of Guelph (Figure 4), North Frontenac (Figure 5). However there are also examples of user-pay schemes having the opposite of the expected effect on diversion rates. Some municipalities experienced no increase in diversion rates after the implementation of a user-pay scheme, such as in the combined municipality of Head, Clara and Maria (Figure 6), while others experienced a negative effect on diversion rates after implementation, such as in the Town of Arnprior (Figure 7).

Figure 4. City of Guelph diversion rates in years with user-pay schemes (blue indicator) and years without user-pay schemes (black indicator)

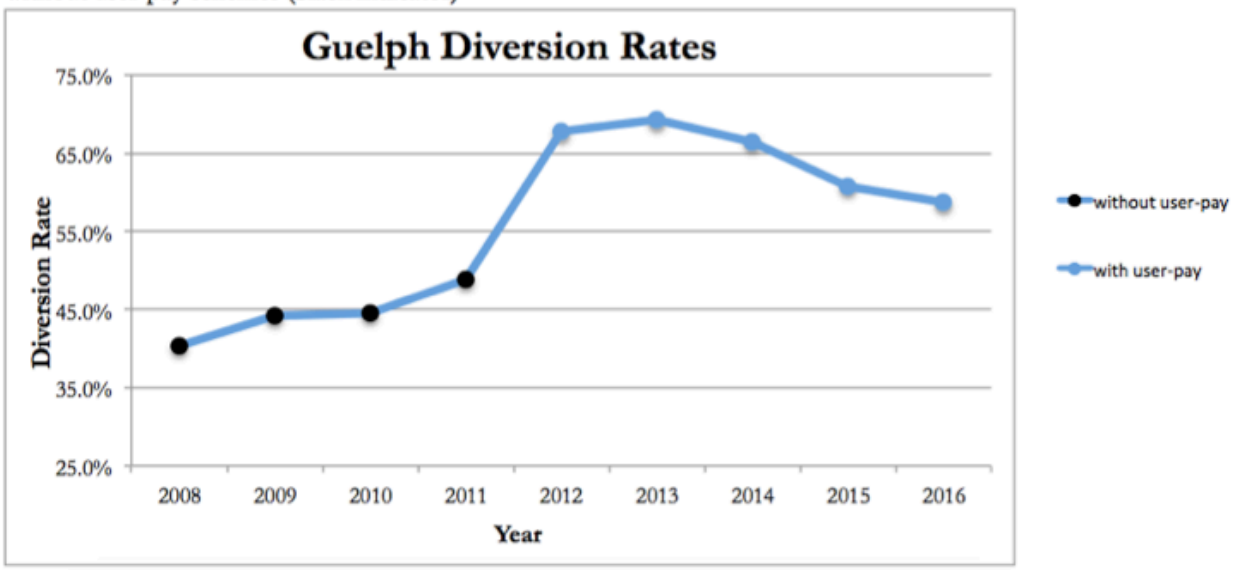
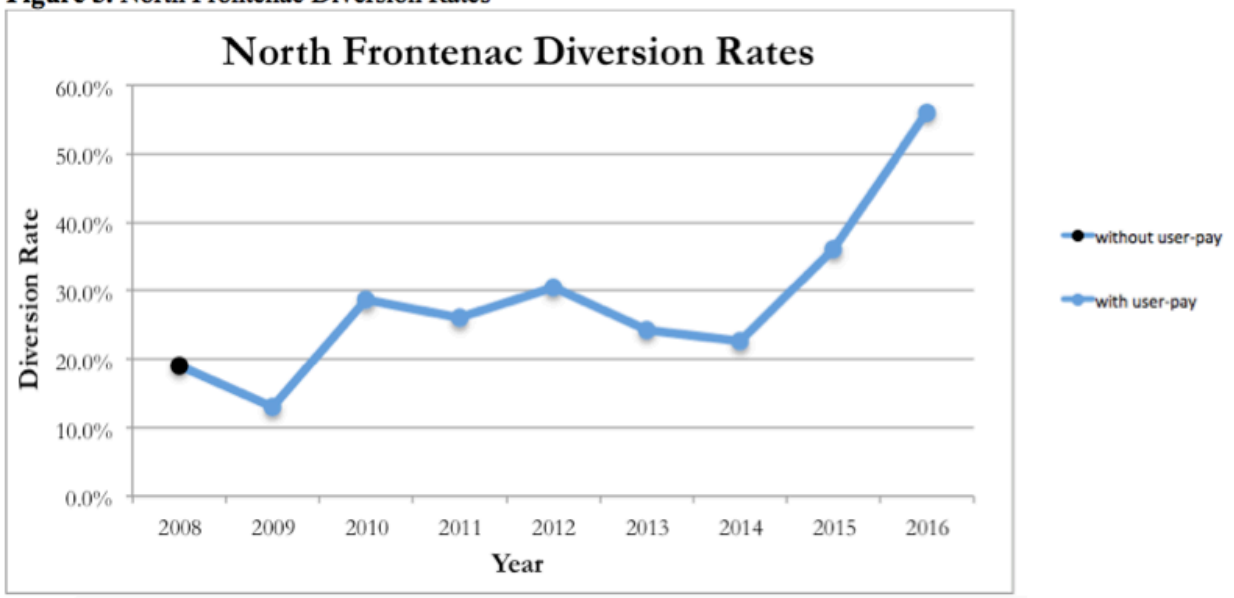


Figure 5. North Frontenac Diversion Rates



There is substantial variation in the effects that user-pay schemes have on the diversion rates of individual municipalities. Simple visualizations of municipal diversion rate responses to the implementation of user-pay systems in individual communities do not present convincing support for the expected results of introducing unit-pricing mechanisms. However, the following sections

report the findings of the statistical analysis, which provide a more detailed account of how the unit-pricing mechanisms affect municipal diversion rates across the board.

Figure 6. Townships of Head, Clara, and Maria Diversion Rates

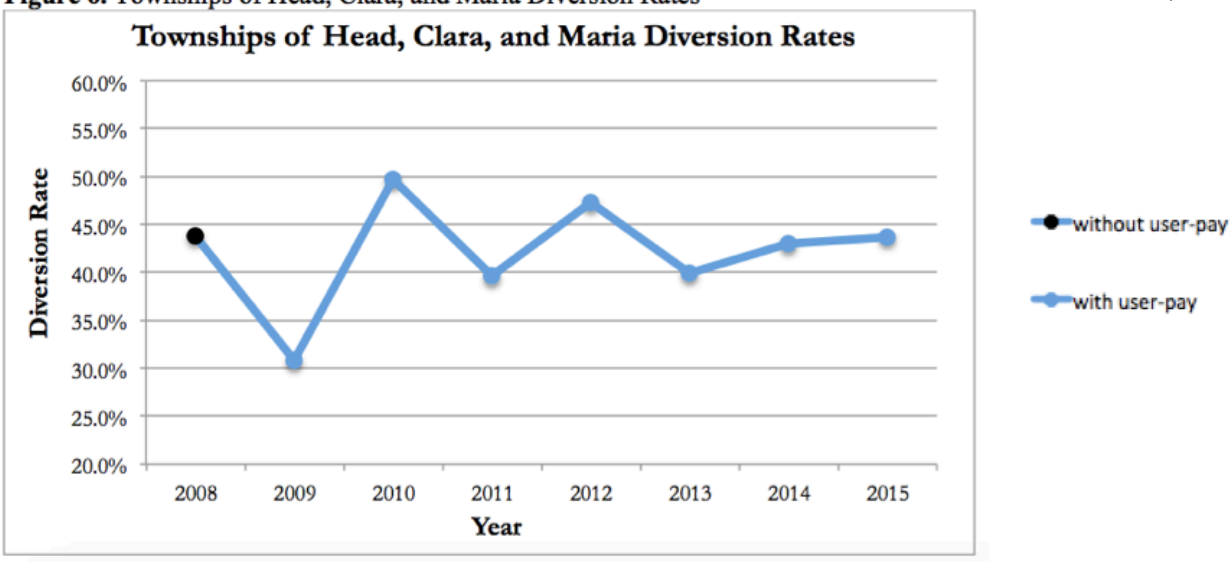
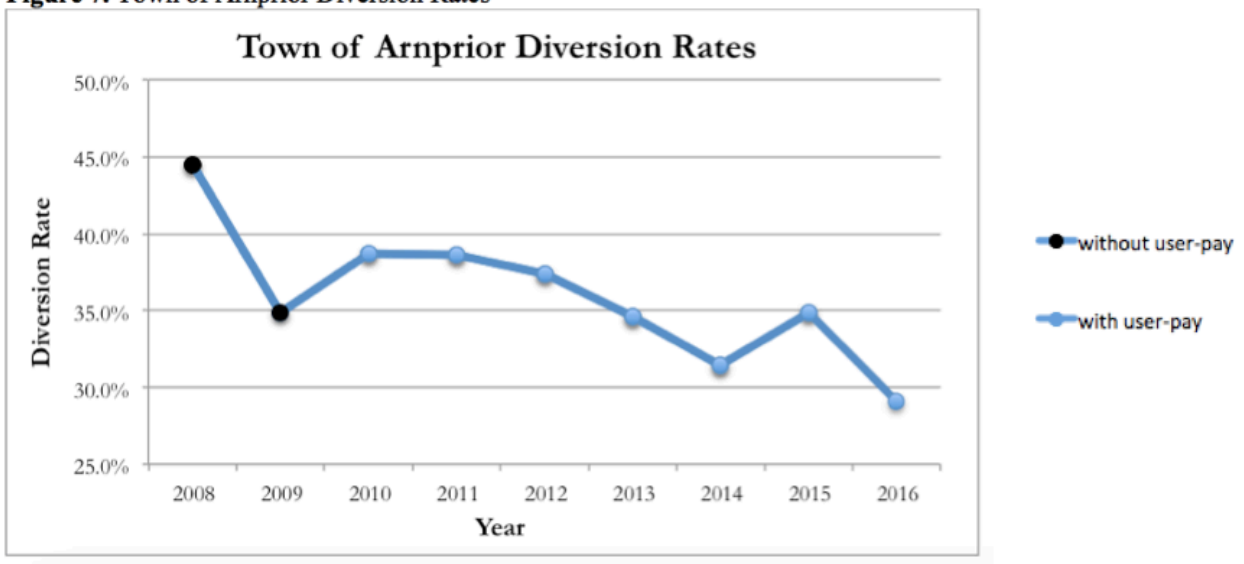


Figure 7. Town of Arnprior Diversion Rates



4.2 Single-variable multiple linear regressions

As described above, a single-variable linear regression was performed on each of the independent variables considered for their relationship with both diversion rate and tonnage of

waste generated per capita. This initial analysis was performed to determine the individual effect of each independent variable on the outcome variables.

Table 2. Definition of variables used in the regression analyses.

Definition of Variables
DR = Residential diversion rates (%)
TO = Tonnage of waste produced per capita (kg/capita)
UP = Dummy variable indicating presence (1) or absence (0) of a user-pay scheme
UPP = Dummy variable indicating presence (1) or absence (0) of a partial user-pay scheme
UPF = Dummy variable indicating presence (1) or absence (0) of a full user-pay scheme
BL = Dummy variable indicating presence (1) or absence (0) of a bag limit
WBB = Dummy variable indicating presence (1) or absence (0) of weekly curbside Blue Box (recycling) collection
BBB = Dummy variable indicating presence (1) or absence (0) of Bi-weekly curbside Blue Box (recycling) collection
FUNDS = Municipal funds spent on promotion and education per capita ($/capita)
OR = Dummy variable indicating presence (1) or absence (0) of curbside collection of organic/leaf and yard waste
MG = Dummy variable indicating whether the municipality is urban (1) or rural (0)

4.2.1 Diversion rate

Single-variable regressions on all independent variables in respect to their relationship with diversion rates were performed for all years (2008-2016) and for curbside collection of organics, in years 2011-2016. It was found that only user-pay schemes had a significant effect on diversion rates with a 1.6% increase ($p=0.008$) (see Table 3). All other independent variables were found to be non-significant ($p>0.05$).

Table 3. Single variable regressions (SVR) of effects of independent variables on diversion rates

Independent variable	**Coefficient**	**p-value**	**R-squared**
UP	0.016	0.008	0.815
BL	-0.004	0.424	0.814
WBB	-0.004	0.429	0.814
BBB	0.0002	0.976	0.814
FUNDS	0.000	0.447	0.814
OR (2011-2016)	-0.003	0.768	0.836

Observations for 2008-2016 (1,926); observations for 2011-2016 (1,271)

4.2.2 Tonnage of waste generated per capita

Single-variable regressions were also performed on all independent variables to determine their effects on the total tonnage of waste produced per capita. This analysis determined that none of the variables had an effect on the outcome variable at the significant level ($p<0.05$), however user-pay schemes and weekly recycling collection approached significance (see Table 4). User-pay schemes were found to have a 2.7% reduction of waste production compared to municipalities without user-pay schemes in place ($p<0.1$). Weekly recycling collection was found to have a 2.3% increase in total waste generation per capita ($p=0.105$). Funding for promotion and education also approached significance, however the effect on the outcome variable was minimal.

Table 4. SVR of effects of independent variables on kg/capita of waste produced

Independent Variable	Coefficient	p-value	R-squared
UP	-0.027	0.097	0.642
BL	0.004	0.795	0.641
WBB	0.023	0.105	0.642
BBB	0.006	0.707	0.641
FUNDS	0.000	0.118	0.642
OR	0.020	0.527	0.688

Observations for 2008-2016 (1,926); observations for 2011-2016 (1,271)

4.3 Multiple linear regressions

4.3.1 Diversion rate

Following the single-variable multiple linear regressions, a multiple linear regression was performed which included all independent variables to determine their effects on diversion rates for all years. In this analysis, it was found that only user-pay schemes and the level of funding for promotion and education were found to have a significant effect on diversion rates (see Table 5). User-pay schemes were found to have a 1.6% increase in diversion with a high level of significance ($p=0.010$). Increased funding for promotion and education was found to have a 0.3% increase on

diversion rates (p=0.04). All other independent variables were not significant in determining diversion rates.

Table 5. Multiple linear regression (MLR) of effects of independent variables on diversion rate

Independent Variable	Coefficient	p-value	R-squared
UP	0.016	0.010	0.816
BL	-0.002	0.699	
WBB	-0.005	0.396	
BBB	-0.003	0.681	
FUNDS	0.003	0.040	
OR (2011-2016)	-0.004	0.718	0.837

Observations for 2008-2016 (1,926); observations for 2011-2016 (1,271)

4.3.2 Tonnage of waste produced per capita

A multiple linear regression including all independent variables was also performed to determine the effect of all waste policies on tonnage of waste produced per capita. Only weekly curbside recycling collection was found to have a significant effect on the outcome variable with a 3.5% increase on tonnage of waste produced per capita ($p<0.05$) (see Table 6). The effects of user-pay schemes, bi-weekly recycling collection, and funding for promotion and education approached significance. User-pay schemes were associated with a 2.7% decrease in waste generation (p=0.105); bi-weekly recycling collection was associated with a 2.7% increase in waste generation (p=0.154); and increased funding for promotion and education was associated with a 0.6% reduction in waste production (p=0.104).

Table 6. MLR of effect of all independent variables on kg/capita of waste produced

Independent Variable	Coefficient	p-value	R-squared
UP	-0.027	0.105	0.644
BL	-0.001	0.930	
WBB	0.035	0.037	
BBB	0.027	0.154	
FUNDS	-0.006	0.104	
OR (2011-2016)	0.011	0.730	0.704

Observations for 2008-2016 (1,926); observations for 2011-2016 (1,271)

4.4 Rural vs. Urban

In order to test the difference in effects of user-pay schemes on diversion rates in urban and rural municipalities, a dummy variable (1 indicating urban, and 0 indicating rural) was created to indicate whether a municipality was classified as urban (municipal groups 1-5) or rural (municipal groups 6-9). A multiple linear regression was then performed using this additional variable, which was combined with the dummy variable indicating the presence of a user pay scheme. The other independent variables considered in other sections of this study (i.e. bag limits, curbside recycling and organics collection, and funding for promotion and education) were not considered in this analysis. The combination of the user-pay scheme variable and urban municipality variable resulted in a non-significant change to diversion rates. It was found that user-pay schemes in urban municipalities resulted in a 1.2% increase in diversion rates ($p=0.319$) relative to user-pay schemes in rural municipalities (see Table 7). The analysis also found that the dummy variable indicating urban municipalities, when tested independently of user-pay schemes, was associated with a 7.9% increase in waste diversion ($p<0.05$).

Table 7. MLR of effect of user-pay schemes on diversion rates in urban municipalities

Independent Variable	Coefficient	p-value	R-squared
MG	0.079	0.019	0.816
UP*MG	0.012	0.319	
Constant	0.239	0.000	
Observations (1,926)			

A similar analysis was performed to determine the combined effect of user-pay schemes in urban municipalities on tonnage of waste produced per capita. It was determined that relative to rural municipalities, user-pay schemes in urban municipalities resulted in a non-significant, 3.3% decrease on tonnes of waste produced per capita ($p=0.338$) (see Table 8). When tested on its own, the variable indicating an urban municipality was found to have a non-significant increase ($p=0.815$) on waste generation per capita.

Table 8. MLR of effect of user-pay schemes on waste generation (kg)/capita in urban municipalities

Independent Variable	Coefficient	p-value	R-squared
MG	0.022	0.815	0.642
UP*MG	-0.033	0.338	
Constant	5.871	0.000	

Observations (1,926)

4.5 Partial vs. Full

In order to determine the differences in effect of full and partial user-pay schemes on diversion rates and on tonnage of waste generated per capita for years 2009-2016, multiple linear regressions were performed, wherein dummy variables were created to indicate full user-pay schemes (0: no system in place; 1: system in place), and partial user-pay schemes (0: no system in place; 1: system in place). The results of the regressions demonstrate the effects of both full and partial user-pay schemes on the outcome variables relative to municipalities without any type of user-pay system in place. Through this analysis, it was determined that neither user-pay scheme had a significant effect on diversion rates below the 5% confidence level, however they both approached significance (see Table 9). Although not significant, partial user-pay schemes were found to have a 1.3% increase on diversion rates and full user-pay schemes were found to have a 1.4% increase on diversion rates.

Table 9. MLR of the effect of full and partial user-pay schemes on diversion rates

Independent Variable	Coefficient	p-value	R-squared
UPF	0.014	0.105	0.830
UPP	0.013	0.085	
Constant	0.232	0.000	

Observations (1,711)

A similar regression was performed to determine the effect of full and partial user-pay schemes on tonnes of waste produced per capita. In this analysis, it was determined that partial user-pay schemes had a 2.5% decrease on waste generation per capita and that full user-pay schemes

had a 3.3% increase on waste generation, however neither of the results were found to be significant (see Table 10).

Table 10. MLR of the effect of full and partial user-pay schemes on waste generation (kg)/capita

Independent Variable	Coefficient	p-value	R-squared
UPP	-0.025	0.205	0.672
UPF	0.033	0.167	
Constant	5.856	0.000	
Observations (1,711)			

5. Discussion

5.1 Single-variable multiple linear regressions

The single-variable multiple linear regressions performed on each of the independent variables considered for their relationship with diversion rates revealed that only user-pay schemes were found to have a significant association with the outcome variable. User-pay schemes were associated with a 1.6% increase in diversion rates. This result was in line with this study's prediction, however the non-significant results of the other waste policies were not expected. None of the other independent variables had results approaching significance, which was surprising as each policy was thought to incentivize residents to divert waste into recovery streams, either through penalties for producing excess general waste (bag limits), convenience for using recovery streams (curbside collection of organic/leaf & yard waste, weekly and bi-weekly curbside recycling collection), or encouragement to participate in waste recovery efforts (funding for waste program promotion and education).

Testing the relationship between the independent variables and the secondary outcome variable, total tonnage of waste produced per capita (which includes all waste streams), revealed mixed results. None of the independent variables were found to be significantly associated with a change in waste generation, however three of the variables approached significance. User-pay

schemes were found to have an association with a 2.7% decrease in waste generation ($p<0.1$); and weekly recycling collection was associated with a 2.3% increase in waste generation ($p=0.105$). Increased funding for promotion and education also approached significance, however it was found to have no effect on waste generation. The decrease in waste generation associated with user-pay schemes could be explained by a reduction in consumption of disposable materials in user-pay municipalities, perhaps as the cost of waste, both to residents and the municipality become more apparent to citizens. The increase in total waste generation in municipalities with weekly curbside recycling collection might be explained by the added convenience to residents who can dispose of recyclable materials more easily and frequently than bi-weekly curbside collection or through a depot service. The added convenience of weekly recycling collection might actually allow residents to produce greater amounts of waste, as recyclable waste doesn't become an inconvenience by building up in homes.

5.2 Multiple regression analysis

The main interest of this study was to determine the direct effect that user-pay schemes (and, secondarily, other waste program policies) have on residential diversion rates and total tonnage of waste generated per capita. After individual regressions were performed on each independent variable, two regressions were performed to determine the combined effect of all independent variables on diversion rates, and on total tonnage of waste produced per capita. In certain cases, independent variables had different effects on the outcome variables when they were combined with other policies.

5.2.1 User-pay schemes

Of the six policies considered for their effects on diversion rates, user-pay schemes were found to have the greatest significant positive increase (1.6%) on the outcome variable, and it is one

of only two policies that were found to have a significantly positive effect on increased diversion rates. This finding is supported by the results of a previous study of waste policies in Ontario by Lakhan (2014)[58], which found that user-pay schemes had an effect of a 1.95-3.01% increase on residential recycling rates. Although Lakhan's study examined a different outcome variable, the results still provide a benchmark to compare the findings of this study to, as the recycling rate contributes substantially to a municipality's diversion rate.

The results of the multiple linear regression demonstrated that user-pay schemes are having their intended effect in Ontario municipalities, i.e. to discourage residents from using the general waste stream to dispose of their divertible materials. By implementing fees on each unit of waste disposed through the general waste stream (or each unit after a limit is reached), residents will use less costly methods to dispose of their waste via recycling, composting, and reuse programs that do not carry per-use charges. It is also likely that when residents are presented with an opportunity to save their money from paying for the garbage they produce, they will be incentivized to reduce their general waste production (i.e. the indivertible material that is sent to landfill).

The results of the effect of user-pay schemes on waste generation were found in both analyses to only be approaching significance, and associated with a 2.7% decrease in waste generation. These findings are somewhat in line with results produced in previous studies by Jenkins (1993)[59] and Repetto et al. (1992)[60], which both found that user-pay schemes had significant negative relationships with waste generation. The lack of a significant effect of user-pay schemes on waste generation is not altogether surprising, particularly when there are accessible and convenient diversion programs in place (such as compost and recycling collection), which can help residents

[58] Lakhan (2014), *supra note 38*.
[59] Jenkins (1993), *supra note 24*.
[60] Repetto et al. (1992), *supra note 25*.

reduce their general waste output without having to reduce their consumption of disposable materials.

5.2.2 Bag limits

In both types of regression, bag limits were found to have non-significant effects on diversion rates. These finding conflict somewhat with those of Mueller (2011)[61], which found that bag limits of three or less had a significant effect on increasing recycling recovery rates. The non-significant results in this study in comparison to Mueller's findings could be explained by two main differences in the data. Firstly, this study evaluates the effectiveness of bag limits as a broad policy encompassing all levels of limits, whereas Mueller distinguishes between stringent bag limits (three or fewer) and lenient limits (more than three). Secondly, Mueller only uses data from 2010 to determine the effectiveness of the policy rather than the large time span examined in this study.

It is not surprising that bag limits were not found to have a significant effect on diversion rates in this study, particularly as the policies vary so widely in set limits across the province (ranging from less than three to more than seven)[62]. Although the policy is designed to discourage residents from overusing the general waste stream by penalizing them for exceeding the limit of containers for disposal, the policy becomes ineffective at encouraging waste diversion when the limit is set too high. Furthermore, the policy is ineffective at encouraging waste diversion no matter what the limit is set to if the household's waste production doesn't approach the limit (i.e. residents will still put recyclable materials into the general waste stream if they can do so without reaching the bag limit).

As a secondary analysis, bag limits were tested for their effect on waste generation and were found to have no significant impact. Intuitively, it is expected that bag limits would naturally reduce waste by discouraging (via a financial penalty) residents to exceed the limit, however if the bag limits

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[61] Mueller, *supra note 36*.
[62] *Ibid.*

are set too high, the policy loses its effectiveness. It is likely that on average, bag limits are set too high in Ontario municipalities for residents to have to make behavioural changes to stay within the bag limit, making the policies inefficient at reducing waste generation. Additionally, if bag limits are not properly enforced by the municipality, then the policy becomes altogether ineffective as residents will be aware that there is no consequence to exceeding the limit.

This study finds that on a whole, bag limits are neither an effective way to increase diversion rates, nor to reduce waste generation. Unfortunately, this study does not provide analysis of the varying effects of differing levels of the policy (i.e. stringent vs. lenient limits).

5.2.3 Frequency of curbside recycling collection

In both regression analyses, weekly and bi-weekly curbside recycling collection were found to have no significant effect on changes in diversion rates. The results of these initial analyses were somewhat expected, although with one caveat. These results contradicted the prediction that weekly curbside collection would have a stronger association with increased diversion than bi-weekly collection due to the added convenience to residents of using the recycling stream twice as often, and therefore not being tempted to dispose of recyclable waste in the general waste stream to reduce the build-up of waste in the home. These results are in line with the findings of Mueller (2011)[63], but are contrary to the findings of Lakhan (2014)[64], which determined curbside recycling collection to have between a 4.4-6.6% increase on recycling rates. It was predicted in this study that the policy would encourage residents to divert waste through the recycling stream by providing them the convenience of weekly curbside service. The results, however, indicate that convenience is not enough to persuade residents to separate waste into the various streams available.

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[63] *Ibid.*
[64] Lakhan (2014), *supra note 38*.

Weekly and bi-weekly curbside recycling collection was also tested for its effect on waste generation per capita (all streams, including recycling) with the expectation that it would not significantly change waste generation rates. The results of the multiple linear regression of all independent variables contradict this prediction, as weekly recycling collection was found to have a 3.5% increase on waste produced per capita. As noted above, this might be explained by the added convenience of the frequency and ease of disposing of recyclable materials, which doesn't encourage residents to limit their consumption of recyclable materials.

5.2.4 Level of promotion & education funding

The multiple linear regression of all independent variables revealed that increased funding for promotion and education had a significant, slight increase (0.3%) on diversion rates. This finding was in line with the study's prediction and is somewhat supported by the previous findings of Lakhan (2014)[65], which, although not significant, determined the level of effect to be similar (i.e. between -0.6-2.5% on increased recycling rates). The results of the regression supported the prediction that increased funding for promotion and education of municipal waste programs would have a positive effect on waste diversion, as it would educate and encourage residents to partake in the municipality's waste diversion programs. Increased funding for promotion and education was found to have a significant positive effect on diversion rates, the only other policy than user-pay schemes that was found to have a significant relationship with the main outcome variable.

Although not significant (p=0.104), increased funding for promotion and education for municipal waste programs was found to have 0.6% decrease on waste generated per capita. This result supports the expectations of this study, as waste program promotion and education is likely to encourage residents to rethink their waste disposal and generation habits, and potentially encourages residents to limit the amount of waste they produce.

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[65] *Ibid.*

5.2.5 Curbside organic/leaf & yard waste collection

Against expectations, the multiple linear regression which included all independent variables revealed that the presence of curbside organics collection had no significant effect on diversion rates. This result heavily contradicted the expectations of this study, which predicted that the presence of curbside organics collection would encourage residents to divert their kitchen and yard waste (which contributes a large portion to the general waste stream without diversion programs in place).

The weak significance in the effect of organics collection on diversion rates might be explained by the generality of the policy examined in this study (i.e. any municipality which collected over 30 tonnes of organic or leaf and yard waste was considered as having a curbside organic/leaf and yard waste collection policy in place). Perhaps if this study had only considered municipalities that had kitchen waste diversion programs such as green bins in place, the results would have revealed a stronger effect on diversion rates. It is also possible that curbside organic/leaf and yard waste collection programs are less effective at diverting compostable waste than intended, resulting in an unperceivable difference in overall diversion rates.

It was also found that organics collection had no significant effect on the tonnage of waste generated per capita. This result was not surprising as kitchen and yard waste still contribute to the total amount of waste generated even if it is properly diverted into a waste-composting stream.

5.2.6 Community size

One of the intentions of this study was to determine whether user-pay schemes were more effective in rural communities than urban communities in Ontario. It was once believed that user-pay schemes were not effective policies for reducing waste or increasing diversion in large communities, as they are not easily applied to multi-residential buildings. However, urban Ontario municipalities have a much higher proportion of user-pay systems in place than rural municipalities.

Over the time period of this study, an average of 71% of communities in municipal groups 1 to 5 (urban) had a user-pay system in place, compared to only 41% of communities in groups 6 to 9 (rural). Regression analysis produced non-significant results when user-pay schemes were used in urban municipalities relative to rural ones. User-pay schemes were found to have a 1.2% increase on diversion rates in urban municipalities but with a low level of significance ($p=0.319$), making it difficult to determine whether or not the policy is indeed more effective in urban municipalities.

User-pay schemes in urban municipalities also resulted in a non-significant reduction in waste production per capita. It was found that, relative to in rural municipalities, user-pay schemes had a 3.3% reduction in diversion rates in urban municipalities ($p=0.338$). Again, with such low levels of significance, it is difficult to ascertain whether or not the predictions of this study are supported.

5.2.7 Type of user-pay policy

It was found through the multiple linear regression that neither partial or full user-pay schemes had a significant effect on diversion rates below the 5% confidence level, although both approached significance ($p\leq0.105$). Full user-pay schemes were associated with a 1.4% increase in waste diversion ($p=0.105$) and partial user-pay schemes were associated with a 1.3% increase in waste diversion ($p=0.085$).

Although the findings of the multiple linear regression are not significant, they are very close. The results support the expectation of the study, which was that full user-pay programs would be more effective at increasing diversion rates than partial user-pay programs. It was predicted that by charging residents for each unit of waste disposed, they would be discouraged from using the general waste stream to dispose of divertible materials. Furthermore, it was expected that partial user-pay schemes would only encourage waste separation once the limit of "free" units of waste was

reached. The findings of this study are supported by the findings of Ferrara & Missios (2005)[66], wherein full user-pay schemes were found to have a stronger effect on waste diversion than partial user-pay schemes.

The results also revealed a non-significant effect of both types of user-pay schemes on total tonnage of waste produced per capita. It was found that partial user-pay schemes decreased waste generation by 2.5% and that full user-pay schemes increased waste by 3.3% although neither of these results approached significance.

The lack of significance in the results might be explained by the potential for the data used in this study to be inaccurate, particularly in its reporting of partial or full user-pay programs. The data collected by the RPRA, although verified to some extent, is self-reported by each Ontario municipality, leaving inherent possibilities of inaccuracies in the data (either intentional or unintentional) that perhaps go unchecked. Certain information reported by municipalities to the RPRA is of greater interest to the role of the Authority than others (e.g. diversion rates, tonnage of waste produced/capita) and this is likely the information that is most heavily scrutinized and audited by the Authority. Information such as the presence and types of user-pay schemes in place are likely not inspected to the same degree as other information provided by municipalities.

6. Conclusion

The primary interest of this study was to determine whether or not user-pay schemes were an effective policy to increase waste diversion rates in Ontario municipalities. It also measured the effect of user-pay schemes against other common waste programs including bag limits, weekly or bi-weekly curbside recycling collection, curbside organic/leaf and yard waste collection, and funding put towards promoting and educating residents about the municipality's waste programs. This study

[66] Ferrara and Missios (2005), *supra note 34*.

determined that user-pay schemes were the most effective of the policies analysed to increase waste separation, while funding for promotion and education also had a slight positive effect on diversion as well. Previous studies of user-pay schemes have revealed mixed results when testing their relationship with increased recycling rates, but this study provides evidence in support of the effectiveness of the policy at increasing waste separation. Unlike previous studies, this study did not find that user-pay schemes had a significant effect on reducing the total tonnage of waste (all streams) produced per capita, however this is likely because previous studies have attempted to determine whether user-pay schemes reduce the amount of waste in the general waste stream only.

It was not determined with certainty in this study whether or not user-pay schemes were more effective in increasing waste diversion in urban communities than in rural communities, and therefore does not support or reject the prediction that the policy is less effective in large municipalities.

It was also discovered that although not significant, full user-pay schemes were found to be more effective at increasing diversion rates than partial user-pay schemes, although neither were found to be significant beneath the $p<0.05$ level. These findings, although not significant, supported the prediction that full user-pay schemes would be more effective at diverting waste than partial user-pay schemes.

The results of this study provide further evidence for municipal decision-makers to base their policies on, however there remains uncertainty of how these findings can be applied to other jurisdictions. Ontario has highly developed recycling programs, and other waste diversions in place, and is a mature system. Therefore the successfulness of the user-pay schemes in the context of Ontario can't necessarily be applied to other provinces or countries without similar mature diversion programs in place.

Further analysis of user-pay schemes in Ontario could benefit from exploration of the effect that various levels of user-pay fees in place, and of various levels of partial user-pay schemes (i.e. the limit of free units of waste) have on waste diversion. It would also be of interest to analyse how user-pay schemes in Ontario affect total non-divertible waste produced per capita to add to the body of work that has examined this effect previously in other jurisdictions.

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