Sustainable Cities and Society 30 (2017) 139–149

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Comparison between Canadian and Nova Scotian waste management and diversion models—A Canadian case study

Amy Richter, Nathan Bruce, Kelvin T.W. Ng*, Asma Chowdhury, Hoang Lan Vu

Environmental Systems Engineering, University of Regina, Saskatchewan, S4S 0A2, Canada

ARTICLE INFO

Article history:
Received 16 December 2016
Received in revised form 18 January 2017
Accepted 24 January 2017
Available online 29 January 2017

Keywords:
Capital and operating expenditures
GDP
Waste policy
Business size
Recycling

ABSTRACT

Canadians disposed 965 kg of solid waste per capita in 2010, while in Nova Scotia, a Canadian province, the average disposal was only 390 kg/cap. Using aggregate data from national surveys, regression analysis was conducted to examine disposal and diversion trends, and their relationships with economy (GDP, employment) and waste business characteristics (expenditure, business size, and employee number) in Nova Scotia, Québec, Ontario, and nationally. Waste diversion increased by 35% in Nova Scotia, compared to a 1.5% increase nationally over the study period (1996–2010). There was a statistically significant negative relationship ($R^2 = 0.846$, $p = 0.0012$) between non-residential diversion and per capita GDP. An analysis of capital and operating expenditure found that, using a simple linear model, Nova Scotia would only have to spend $455/t of waste managed to achieve a diversion rate of 60%, while Ontario would have to spend $2200/t to achieve the same result. Unlike other provinces considered, Nova Scotia diversion rate was found sensitive to waste business size ($R^2 = 0.630$, $p = 0.0186$). Nova Scotia has more waste management businesses per capita, and the average number of employees increased more than in other provinces, revealing some important aspects of waste business characteristics on diversion.

1. Introduction

In 2010, Canadians generated 965 kg of solid waste per capita (Statistics Canada, 2010), compared to 735 kg/capita generated in the United States, and 500 kg/capita generated by European OECD countries (OECD, 2015). Urbanization rates, consumption patterns, household revenues, lifestyle, income level, and household size are commonly reported factors on increased waste generation (Bandara, Hettiaratchi, Wirasinghe, & Pilapiiya, 2007; Bonam, 2009; Senzige, Makinde, Njau, & Nkansah-Gyeke, 2014). In Canada, residential waste generation is related to increased family income and gross domestic product (GDP), population growth, lack of producer responsibility, and declining average household size (Bonam, 2009; Wang, Ng, & Asha, 2016). The rate of increase in Canadian solid waste disposed over the study period (1996–2010) is appalling, increasing by more than 20%. Meanwhile, waste diversion only increased by 1.5% in Canada. However, Nova Scotia, a maritime province, has performed well by reducing waste disposed by 34% from 1996 to 2010.

Because of the high availability of non-developed land, landfilling is a logical choice for many Canadian communities (Assamoi and Lawryshyn, 2012; Bonam, 2009; Statistics Canada, 2012; Wagner and Arnold, 2008). In 1989, the Canadian Council of Ministers of the Environment (CCME) adopted a goal to divert 50% of municipal solid waste (MSW) by the year 2000 (Wagner and Arnold, 2008), a goal which was not met as of 2010. ON, QC, and NS are all provinces located in eastern Canada. Combined, ON and QC make up just under 30% of Canada's land area, while NS, located on the eastern seaboard, makes up less than 1%. Waste management in western Canada has already been reported by others (Bruce, Asha, & Ng, 2016; Wang et al., 2016) and was excluded from the present study.

The Ontario Minister of Environment set a provincial recycling target of 60% for all residential recycling material in 2011. Mueller (2013) used program characteristics, such as bag limits and user pay programs, to evaluate the effectiveness of ON policies on recovery rates through a combination of *t*-tests and regression techniques. He found that (i) a system focused on more convenience to the user is more important for increased diversion rates than penalizing users for non-compliance, and (ii) only the number of materials collected and the presence of a garbage limit were significantly related to better recovery (Mueller, 2013). Lakhan (2014) modeled municipal recycling rates against a number of variables, and found that promotion and education did not increase recycling rates in

* Corresponding author.
E-mail address: kelvin.ng@uregina.ca (K.T.W. Ng).

http://dx.doi.org/10.1016/j.scs.2017.01.013
2210-6707/

ON. He concluded that unless there is an acceptable infrastructure system for accepting and handling other types of recycling, promotion and education will not help to increase recycling rates. According to Lakhan (2016), declining resource stocks, increased waste generation, and a scarcity of available landfill space have drastically changed recycling practices in ON, requiring more comprehensive and cost effective waste diversion programs. Diversion rates have stalled in ON over the past three years, and for the first time since the inception of the Blue Box program, there appears to be a decreasing trend in recycling (Lakhan, 2016).

Metson and Bennett's (2015) recent case study on phosphorus recycling and organic diversion strategies detailed common diversion barriers observed in Montréal, the largest city in QC (24% of the population). The three identified barriers were: (i) facility locations and siting issues; (ii) difficulties in cost estimation due to impurities and compost quality; and (iii) the level of support and involvement of participating neighbourhoods. According to Metson and Bennett (2015), the city was likely going to fail to meet the provincial government mandate for 60% organic waste diversion by 2015.

Unlike ON and QC, NS has taken a more active approach with solid waste management issues. In 1995, NS approved their first Solid Waste Resource Management Strategy (SWRMS), adopting a goal of 50% diversion set out by the CCME (Wagner, 2007). After the implementation of the SWRMS, a number of studies aimed to evaluate and analyze the components of NS's strategy for: waste management policies (Wagner, 2007; Wagner and Arnold, 2008); economics (Walker et al., 2004; Wendt, 2001) and environmental improvements (Goodick, 2002). Greene (2001), Wagner (2007), and Wagner and Arnold (2008) discuss the various regulations and bans that were part of the Environment Act, passed in 1995, as a major player in the success of the SWRMS. In addition, various stewardship programs were introduced, and include: recycling beverage containers, used tires, leftover paint, electronics, household hazardous waste, and unwanted clothing & textiles. According to Greene (2001), approximately 1000 jobs were created, and the province has approximately 3000 jobs in the solid waste management sector as a result of the SWRMS. The strong link between the SWRMS and the economy has helped to make the program a success (Wagner and Arnold, 2008).

Other studies have examined the costs and benefits of NS's SWRM. Wendt (2001) compared a theoretical minimal diversion scenario to the SWRMS. Looking specifically at the Halifax Regional Municipality, the waste management strategy has a total annual cost of approximately $253/person; however, Wendt (2001) reported that the strategy has an annual benefit of at least $363/person using cost benefit analysis. Goodick (2002) comes to a similar conclusion about the success of the SWRMS, in that it provides positive environmental impacts. Prior to the introduction of the SWRMS, NS had more than 100 active dumps, many of which used open burning, and did not have proper attenuation for leachate (Goodick, 2002). The environmental burdens relieved between 1995 and 2001 due to the implementation of the strategy were equivalent to the emissions from 40,000 cars for one year (Goodick, 2002). Walker et al. (2004) estimated a cost savings between $33 and $178 per person in NS from the 1996–1997 fiscal year to 2000–2001 fiscal year, implying that the strategy had paid for itself, without considering the positive effects of new job creation and a cleaner environment.

Table 1 shows some key findings with respect to waste management and GDP, business size, employment, and expenditure around the world. Some studies (Bruce et al., 2016; Conference Board of Canada, 2014; Liu and Wu, 2010; Wang et al., 2016) have discussed how GDP is related to waste generation. Other studies (Folz, 1999; Giroux, 2014) examined the relationships between increasing diversion rates and increased expenditure on solid waste management. Goldman and Ogishi (2001) studied the employment and economic value of diversion and disposal rates in the US. They estimated that 2.5 new employees would be required to manage 1000 US tons in disposal operations annually, while 4.7 new employees would be required for diversion under similar conditions.

Limited papers have been published on Canadian solid waste management (Asase, Yanful, Mensha, Stanford, & Amponsah, 2009; Asha and Ng, 2015; Bruce, Wang, & Ng, 2015; Bruce et al., 2016; Sawell, Hetherington, & Chandler, 1996; Wagner and Arnold, 2008). The objectives of the present paper are thus: (i) compare and contrast disposal and diversion trends in Nova Scotia (NS), Québec (QC), Ontario (ON) and in Canada (CA) as a whole from 1996 to 2010, (ii) determine the relationships between waste diversion, expenditure, and GDP in each study area, and (iii) examine financial and employment features over the study period with respect to diversion rates. A comprehensive literature review was conducted on waste management and diversion in Canada and the US. Waste management and demographic data for the study period were collected, verified, and processed. Descriptive statistical analyses were performed to compare diversion rates with the selected financial characteristics of the waste industry.

2. Materials and methods

Statistics Canada is a federal agency commissioned with producing statistics to understand Canadian trends in population, resources, economy, society, and culture. Waste management data during the study period (1996–2010) was collected, verified and processed from 8 Waste Management Industry Survey reports (Statistics Canada, 1996, 1998, 2000, 2002, 2004, 2006, 2008, 2010).

Waste data are collected via survey by Statistics Canada every two years. These surveys gather information on financial characteristics and waste management activities undertaken by public and private waste management bodies. The data are based on information gathered for one fiscal year. For example, for the 2010 report, data were gathered between April 1, 2010 and March 31, 2011. For the 2010 report, 1353 businesses and local governments were surveyed, and 1054 were fully or partially completed, and another 231 were considered in-scope (Statistics Canada, 2010). This equates to a response rate of about 95%. Only waste and recyclable materials that have been collected, processed, and disposed by either private waste management firms or local government are included in this study. All waste or recyclables managed directly by the generator are excluded from this study.

In order to ensure reliability and accuracy, the collected data were verified by comparing the values reported by Statistics Canada to government agencies in each province (i.e. Government of Nova Scotia, 1995; Government of Québec, 2009; Waste Diversion Ontario, 2008). Differences with the data from these three sources were generally under 10%. For example, Ontario residential waste diversion in 2008 was reported at 1,878,899 t by Statistics Canada, while this value was reported at 1,803,038 t by WDO (4.1% difference). In 2006, per capita annual waste disposal in NS was reported as 430 kg by Statistics Canada, while this value was reported as 477 kg by NS Environment (10.4% difference). Per capita waste disposal in QC was reported as 794 kg in 2008, while this value was reported as 810 kg in QC's residual materials management policy document (2.0% difference). This discrepancy between the data sources can be explained by differences in waste definitions due to lack of a national standardized system of classification and measurement (Statistics Canada, 2008), as well as differing start and end points. For example, the use of calendar or fiscal years varied depending on the organization. Given the nature of the materials, the ranges of uncertainties are acceptable. Bruce et al. (2016)