A Systematic Comparison of Municipal Solid Waste Management Systems:

Case Studies of Dalian City, China and the Region of Waterloo, Canada

by

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I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

Since the 1990s, Municipal Solid Waste Management (MSWM) has shifted to a more comprehensive approach with an emphasis on managing Municipal Solid Waste (MSW) through the whole process from generation to disposal. Meanwhile, developing countries started to alter their ways of managing wastes and engage in more efforts on waste diversion. Due to their shortage of both resources and expertise, developing countries usually refer to and learn from developed countries' experiences in MSWM to improve their own practices. How and to what extent these experiences are helpful for developing countries remains inconclusive because significant differences are present among MSWM systems in different countries. These differences do not simply reflect the variations in regulations and resource allocation; more importantly, they reflect the variations in the underlying connections between MSWM and other social, economic, demographic, and technological conditions. Therefore, a systematic examination is needed to enhance the understanding of these differences, the reasons for these differences, and the priorities that need to be stressed in order to improve waste diversion in a particular case.

A systematic model, as the framework for the comparison in this thesis, is proposed to illustrate MSMW systems. Based on the model, this thesis compares and contrasts two cases, the Regional Municipality of Waterloo (RMOW) in Canada and Dalian City in China, at multiple levels: overall stage, system components, system structures, and interactions. The results show that Dalian, compared with the RMOW, has less sufficient capacities for waste planning and implementation. Challenges in MSWM are associated with higher density of residences, difficulties in managing informal profit-driven recycling activities, insufficient and unreliable treatment capacity, insufficient multi-agent dialogues and cooperation both within the government and between the public and private sectors, and less specific, program-based public education. The majority of participants in the RMOW are more self-motivated as opposed to the majority in Dalian who are motivated more by compensations.

Based on the comparison, implications and suggestions in several aspects concerning

waste planning are discussed. From the systematic perspective, to improve waste diversion in Dalian requires collaborative efforts of multiple agents. The key aspect is to strengthen the relatively incompetent component in the system to improve the capacities for waste service and treatment, which are contingent on the development of waste industries. In Dalian, waste diversion should begin with limited types of wastes and gradually expand the scope, and new programs should be designed based on the existing system with cooperation of the informal sector. Meanwhile, cooperation among governmental divisions and between public and private sectors need to be promoted by encouraging multi-agent dialogues and improving information transparency. Program promotion also needs to be more specific in instructions and to address both pro-environmental attitudes and service quality and convenience. Finally, scavenging at landfill sites should be discouraged in order to protect scavengers from the detrimental working environment.

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ABBREVIATIONS

BOT	Build, Operation, and Transfer
CBOs	Community Based Organizations
ISWA	International Solid Waste Association
IWM	Integrated Waste Management
MOC	Ministry of Construction (of P. R. China)
MOF	Ministry of Finance (of P. R. China)
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NDPC	National Development Planning Commission (of P. R. China)
NDRC	National Development and Reform Commission (of P. R. China)
NGOs	Non-Governmental Organizations
NIMBY	Not In My Back Yard
RCM	Rational Comprehensive Model
RMOW	Regional Municipality of Waterloo
UNEP	United Nations Environmental Programme
USEPA	United States Environmental Protection Agency
WDA	Waste Diversion Act
WDO	Waste Diversion Ontario

CHAPTER 1 INTRODUCTION

1.1 Background

Linked with both growth of the population and economy is a corresponding increase of Municipal Solid Waste (MSW). Countries with rapid economic growth are also confronted with serious challenges in managing their rapidly increasing wastes. For example, MSW generated in China increased 9% annually from 1979 to 1995, a period associated with rapid economic growth, and the current volume of MSW will double by 2030 (Dan Hoornweg et al., 2005; Zang, 1998). Meanwhile, Municipal Solid Waste Management (MSWM) has also evolved over time: It has been regarded as a public health, engineering, planning, and economic issue (Goddard, 1995; Hostovsky, 2000; Louis, 2004; Zavodska, 2000). Since the 1990s, MSWM in practice has gradually shifted to a more comprehensive, systematic approach with an emphasis on managing MSW through the whole process from generation to disposal. An example of such a systematic approach is Integrated Waste Management (IWM), which has been widely recommended as an effective approach for both developed and developing countries (Dai & Dai, 2004; Daniel Hoornweg & Thomas, 1999; Seadon, 2006).

This whole-process waste management approach in practice pertains closely to waste separation and diversion. Not only developed countries, but also developing countries have started to address waste recycling and recovery. For instance, China in 2000 designated eight cities—Beijing, Shanghai, Xiamen, Guilin, Guangzhou, Nanjing, Shenzhen, and Hangzhou—as localities where pilot programs were to be launched in an attempt to seek more effective systems for diverting MSW. Due to limited participation, none of the eight trials has been successful at the city level. In general, developing countries face various challenges as a result of the shortages of both resources and expertise. Similar to dealing with other environmental problems, developing countries usually refer to and learn from successful experiences from North America, Western Europe, and Japan when developing their own plans to improve MSWM (Chung & Poon, 1998; Yu & Wang, 2004; Zavodska, 2000). Given the increasing comprehensiveness of

MSWM, in what aspects and to what extent these "successful experiences" are helpful to developing countries remains inconclusive and is determined largely by particular conditions of each case.

In order to understand how developing countries can better learn from developed countries' experiences, comparisons should be conducted to carefully examine the differences of MSWM on both sides and, more importantly, to identify why these differences are present and how they shape waste management strategies with respective contexts. Differences of MSWM do not simply reflect the variations in regulations and resource allocation; more importantly, they reflect variations in the underlying connections between MSWM and other social, economic, demographic, and technological conditions (Rushbrook & Finnecy, 1988). MSWM is more than the techniques and facilities for safe treatment and disposal; it requires a "*system*" to integrate program promotion, waste collection, storage and transportation, treatment and disposal, and possibly sales and utilization of recycled materials. Within each of these activities, multiple agents extending from both the public and private sectors must be involved. Each agent has their own interests because of their own needs, constraints, and roles outside of the MSWM system. As a result, MSWM can depend on specific local contexts to such an extent that direct duplications of MSWM systems may not be able to succeed and MSWM still needs rely mainly on the development and implementation of indigenous methods (Sakai et al., 1996). In other words, the milieu in which systems operate will be expected to have significant impacts on the success of what is planned and implemented. Therefore, a systematic comparison of MSWM should be conducted based on a comprehensive framework with regards to both the management system and associated social and economic activities.

1.2 Research Objectives

The overall objective of this thesis is to conduct a systematic comparison of MSWM in two cases in order to gain a better understanding of the differences between them and to assess the implications on how practices in a developed country can be helpful to a developing country. This objective will be explored by considering:

- Building up a system model that illustrates major agents, structures of, and interactions in MSWM systems for the comparison;
- Identifying the differences of MSWM systems in two cases;
- Exploring and comparing the major features and motivators of participants in waste diversion programs;
- Analyzing the reasons for the differences with regards to local conditions; and
- Providing suggestions to improve waste diversion in Dalian based on the experiences in RMOW.

The two cases studied in this thesis are the Regional Municipality of Waterloo (RMOW) in Ontario, Canada and Dalian City in Liaoning, China. Dalian was chosen for this study because as a "Demonstrational City of Environmental Protection" (*huanjing baohu mofan chengshi*), it is one of the prototypes of environmental management in China. Recently, a city-level recycling pilot program was proposed and launched as a signal of greater efforts on waste diversion. Moreover, the researcher originally comes from Dalian and is acquainted with local conditions and one of the managers in charge of waste management in the local government. As opposed to China, Canada has more experience in waste recycling and recovery, e.g., the Blue Box recycling program. The RMOW was studied because it rolled out a new pilot program, the Green Bin, diverting organic wastes in October 2006. Thus, it is worth examining how a new program is managed and promoted in a municipality (Dalian) where a formal recycling program has just emerged, in comparison with the one (the RMOW) which has a foundation of successful experiences in waste diversion.

1.3 Thesis Structure

Following the introduction in Chapter 1, the literature review is provided in Chapter 2. It begins with a brief historical review of the development of MSWM and the concept of Integrated Waste Management (IWM) and further reviews five planning models, an economic model, and a marketing model to identify relevant components and gaps that need to be addressed. At the end of Chapter 2, a system model is presented as the framework of the comparison to be used in this thesis. Chapter 3 articulates the methodology applied in this study, including research methods and data analysis methods.

In Chapter 4, the backgrounds and summaries of the two case studies are elaborated, including the detail of the MSWM system in each case and results of surveys. Chapter 5 analyzes and discusses the comparison of the two case studies. It compares the MSWM systems at the levels of their overall stage, components, structures, and interactions. Chapter 6 discusses the implications and suggestions reflected from the case studies, and finally a conclusion is presented at the end of this section.

CHAPTER 2 LITERATURE REVIEW

2.1 The Scope and Trends of Municipal Solid Waste Management

One of the major concerns first raised with MSWM practice was the impact on public health. During the middle 19th century, the relationship between disease spread and living environments was gradually realized. Industrialization and growing populations in cities led to excessive accumulation of wastes, which would essentially cause diseases if not properly managed (Zavodska, 2000). During the 1890s, major cities in North America realized the necessity to better manage their sewage and solid wastes. Local governments assumed the responsibility of dealing with urban refuse. Waste services were provided either directly by governments or by private scavenging companies (Louis, 2004). These services gradually replaced the spontaneous approach of dealing with wastes individually such as dumping, animals slopping in the streets, and scavenging, which prevailed during the 18th century (Rathje, 1992).

To mitigate MSW's impacts on public health naturally requires, in addition to collection, safer treatment and disposal. From the 1920s to 1960s, MSWM was strongly characterized as engineering-based management (Louis, 2004). Along with technological progress, sanitary landfilling, incineration, recycling, and other alternative methods emerged, which significantly strengthened the capacity for waste treatment and safe disposal. Not surprisingly, burial and combustion under controlled environments were, and still are, the major methods for disposal. Landfill, the cheapest disposal option, became the most widely adopted method during this period of time (Rathje et al., 1992). Also popular was incineration today. More than 100 communities in the US are in their early stages of planning new incinerators (Pichtel, 2005).

An important shift in attitude emerged in the 1970s at which time the focus gradually shifted to recycling, and material and energy recovery rather than simply burying or burning a community's wastes (Louis, 2004). A major feature of this shift was that waste management and planning became a more systematic and comprehensive process rather than concentrating on a single task such as the design of sanitary landfills. This shift was

also attributed to legislation that encouraged recycling and recovery and set up guidelines for operation and monitoring at the state/provincial or even federal/national level. Since the passage of the Resource Recovery Act in 1970, the material recovery rate in the US has increased rapidly, as illustrated in Table 2.1. Meanwhile, due to the increasing comprehensiveness in waste management and planning, coupled with the emerging application of Environmental Impact Assessment in the US and Canada (Hostovsky, 2003), waste management became a significant planning issue. Planners have played an increasingly important role, cooperating with engineers, in dealing with waste-related projects such as treatment facility siting, public participation and education, and program evaluation.

Table 2.1: The Recovery Rate of MSW in the US

	1960	1970	1980	1990	1997
Generation (thousand tonnes)	88,120	121,060	151,640	205,210	216,970
Recycling (thousand tonnes)	5,610	8,020	14,520	29,040	48,630
Composting (thousand tonnes)	--	--	--	4,200	12,070
Ratio of recovery (%)	6.4	6.6	9.6	16.2	28.0

Source: (USEPA, 1999)

Since the early 1990s, concerns with MSW have been raised from multiple perspectives including health studies, engineering, planning, and economics. As Haight (1991: ix) argued, "owing to the complex and variable nature of municipal solid waste and the various evaluative criteria it can be difficult to identify the optimal option(s) for a particular community." As a result of this complexity, a comprehensive approach has emerged in MSWM, trying to employ an optimal combination of various treatment methods and management tools. Regulatory and financial tools, as both incentives and disincentives, were found to be effective, especially concerning waste diversion. Goddard (1995: 211) argued that "…the [waste management] problem is not primarily one requiring only technical or engineering approaches such as landfill and incineration, but that fundamentally it is economic in nature." In terms of treatment methods, it was suggested that a proper combination of feasible treatment methods was needed for better end uses and the safe disposal of wastes. It is this consideration of integrating multiple treatment methods that was the origin of IWM (Smith, 1990).

2.2 Integrated Waste Management

IWM is an approach that allows managers to systematically manage MSW. In practice, it has been recommended as an effective approach for both developed and developing countries (Dai & Dai, 2004; Daniel Hoornweg & Thomas, 1999; Seadon, 2006). The concept of IWM has also evolved over time and expanded beyond the mere combination of treatment methods. The United Nations Environmental Programme (1996) defined IWM as "a framework of reference for designing and implementing new waste management systems and for analyzing and optimizing existing systems". Seadon (2006) interpreted that the concept of IWM can be categorized into four aspects: the integration of (1) multi-options of treatment for waste into a single medium (atmospheric, aqueous, and solid wastes), (2) treatment for wastes in multi-media, (3) multiple tools, and (4) multiple agents. First, IWM aims to incorporate a proper combination of waste management methods of waste reduction, reuse, recycling, resource recovery, and disposal (Smith, 1990). Second, IWM requires a simultaneous consideration of atmospheric, aqueous, and solid wastes and impacts on atmospheric, aquatic, and terrestrial environments. Although MSW is in a single medium, impacts of its treatment can be felt in multi-media, such as impacts on underground and surface water caused by landfill, and atmospheric pollution caused by incineration. Third, multiple management tools such as regulatory, voluntary, planning, financial, and market-related tools need to be applied. Fourth, multiple agents need to participate in IWM, including various agents from the public, i.e., the government, and from the private sector, e.g., waste pickers, itinerant/stationary waste buyers, small-scale recycling industries, large-scale recycling industries, community based organizations (CBOs), non-governmental organizations (NGOs), and micro-enterprises (Ahmed & Ali, 2004).

2.3 Identifying the Components of Waste Management Systems

2.3.1 Review of Pertinent Planning Models

Waste planning typically deals with the processes of facility siting, selection of appropriate treatment methods, and program evaluation. Hostovsky (2000) summarized five types of planning models applied in waste planning since the 1970s: rational

comprehensive model (RCM), participatory model, advocacy model, incremental model, and adaptive (modeling) model. Each of these models addresses various issues of and major agents in MSWM systems. The remainder of this section identifies these issues and agents by reviewing each of the five models.

2.3.1.1 Rational Comprehensive Model (RCM)

The RCM was a major model employed by planners in waste planning, partly because the model had been the predominant model in land use planning (Hostovsky, 2000). In waste planning, RCM focuses on optimizing facility siting (Albakri et al., 1988; Frantzis, 1993) and treatment methods (Powell, 1996). Evaluation and optimization follow a 'top-down' approach and rely heavily on quantitative methods and rational processes. The criteria for evaluation could be comprehensive, including environmental, social, and economic aspects (Frantzis, 1993; Powell, 1996).

However, the mathematically optimized plans might face barriers in implementation due mainly to the Not-In-My-Back-Yard (NIMBY) syndrome, inadequate public participation, and political interference, which were not or could hardly be simulated by rational models (Hostovsky, 2006). Consequently, new plans are still needed. The environmental assessment of waste-related projects designed by the RCM, such as landfill siting, could be extreme in terms of resources and time required. For example, Guelph spent ten years on three landfill siting plans, but no one succeeded because of extensive public and political controversies; the New Democratic Party disbursed $85 million in the early 90s for planning three landfills in the Greater Toronto Area, but the plans were all abandoned when the Progressive Conservative Party returned to power (Hostovsky, 2006). The relationship between decision makers and other agents had been strictly paternalistic. Discouraging public participation in the waste planning process is even intentional in the conventional RCM. For example, Rushbrook and Finnecy (1988) argued that the general public does not need to be involved in decision making.

2.3.1.2 Participatory Model

According to the participatory model, as opposed to RCM, the public is incorporated into the decision making process, ideally in the early stages, to make plans through dispute

resolution, mediation, and negotiation (Hostovsky, 2000; Rowe, 1992). In the participatory process, information is shared with the public, and, ideally, decisions are made collectively. An example of substantial public participation in waste planning is the "willing host" siting process. Instead of proposing optimal locations, whichever community is willing to be the host of treatment and disposal facilities will become the candidate for the host and will acquire various financial compensations. The plan for a hazardous waste treatment facility in Alberta demonstrated that by the willing-host siting process, "a strong connection was made between the scientific and cultural aspects (McQuaidcook & Simons, 1989: 220)."

The participatory model also faces difficulties in practice. As a result of multiple stakeholders' participation, multiple interests are brought into the waste planning process in which mediation becomes complex and difficult. Participation and communication may not be able to reconcile all conflicts. Petts (1994: 214) argued that "the more people know, in terms of non-technical but issue-relevant information, the more likely they are to exhibit NIMBY attitudes." To obtain buy-in from the public may require more efforts such as improve information transparency and providing more effective education.

2.3.1.3 Advocacy Model

The advocacy model proposes that planning should be congruent with clients' values and goals, and the outcome is the "survival of the fittest" (Hostovsky, 2000). In waste management and planning, a wide range of values and goals of particular agents have been advocated. For example, Lang (1990) argued for social equity; Kovacs (1993: 113), who supported waste industries, suggested that "political leadership is urgently needed to ensure increased disposal capacity, … notwithstanding the objections of the NIMBYists"; Burkart (1994) argued that waste planning should divert attention to public relations, and the NIMBY syndrome could be solved by communication; and Robert (2004) discussed the important role of environmental industries and suggested promoting them by new attitudes and practices, and financial incentives.

Advocates have highlighted several pertinent issues, e.g., social equity, environmental industries, public relations, and taxation. However, a shortcoming of this model is that advocates, while arguing for their clients, may at the same time lose sight for the whole,

which is essential for analyzing a complex system, because advocating for a single agent's interests is likely to be skewed. For instance, it is rather extreme to argue for maintaining industry and disposal capacity regardless of public opposition (Kovacs, 1993).

2.3.1.4 Incremental Model

The incremental model is highly political and focuses on crisis management and responses to fragmented environmental regulations (Hostovsky, 2000). Reviewing the history of municipal solid waste and hazardous waste disposal in the US, Tarr (1985) found that research on contaminations caused by solid waste disposal, as a result of public policy, often only developed after the occurrence of crises. Changes in MSWM also are often correlated with the introduction of environmental regulations. For example, legislation in the 1960s and 1970s inspired state government activities, and resulted in new attitudes towards waste management and increasing waste diversion rates (Tarr, 1985). More recently, the European Union's directive was considered the major impetus in the UK to the shift in waste disposal methods from landfill to alternatives such as incineration and recycling (Davoudi, 2000).

Admittedly, environmental legislation stimulates changes in MSWM, especially at a macro-level. However, the relationship does not make legislation a sufficient condition for the improvement of waste management. Other factors may have an impact on the efficacy of legislation and the extent to which the public is motivated. In the UK, for example, wastes diversion was more successful in communities that faced a shortage of landfill capacity and difficulties in siting new landfills, than the ones that had relatively sufficient landfill capacity (Davoudi, 2000). Therefore, a good strategy can not rely only on legislation and needs to consider local conditions and incorporate other management tools to achieve the best possible result.

2.3.1.5 Adaptive (Modeling) Model

The adaptive model is usually anticipatory and relies heavily on mathematic modeling and computerized techniques (Hostovsky, 2000). A variety of decision making and evaluation models are in this category. Widely cited decision-making models include

integer linear programming (Abou Najm et al., 2002a, , 2002b), the artificial intelligence system (Cortes et al., 2000), the multiple mixed integer programming model (Chang & Wang, 1996), geographic information system integrated with multi-objective programming (Chang et al., 1997), and the gray integer-programming (Huang et al., 1997). Some new models were developed based on a combination of multiple models to simulate more complicated situations (Y. P. Li et al., 2007; Nie et al., 2007). Common evaluation models include modified input-out analysis (Huang et al., 1994), economic evaluation models such as cost-benefit analysis and life cycle costing (Reich, 2005), and life cycle analysis (Finnveden, 1999; Thomas & McDougall, 2005).

These models illustrate systematic thinking. A common feature is to assess MSWM systems according to multiple criteria. Moreover, these models simultaneously consider various processes concerning waste management, such as treatment methods, facility siting and construction, transportation, energy recovery, and virgin material substitution.

Criteria for evaluation and assessment can be drawn from an infinite list. However, how and which criteria should be weighed more than others is rather subjective and context-based. The weight of each criterion can vary in different cases. To compare two cases in different contexts by using multiple criteria raises a question of how various criteria should be weighted, to which there is no definitive answers. In addition, most models rely on large amounts of data. Reliability declines when data are not accurate or available. Hence, these models may face difficulties in practice in developing countries where databases are not well developed or not accessible (ISWA, 2002). Another practical challenge to these models is how to obtain buy-in smoothly from practitioners. Some models can be so complicated that the public and politicians can hardly understand how the untraceable model works (Hostovsky, 2000). Presentations of reasoning processes of and final results from a comprehensive model need to be straightforward and pragmatic in order to lead to some substantial improvements in practice.

2.3.2 Review of an Economic Model

The economic model regards waste services as a result of equilibrium between market supply and demand. Waste services, similar to other commodities and services, should be accordingly priced. Porter (2002) argued that excessive waste generation is caused by

under- or un-priced collection and disposal services. In theory, the amount of waste generated, as a by-product of consumption, is determined when the marginal utility (MU) of consuming certain goods is equal to the marginal private cost (MPC) of consuming such goods. The MPC is the sum of the price of both goods and waste services (Choe & Fraser, 1998). If waste services are under- or un-priced, then the MPC decreases and thus the amount of waste generated increases (Figure 2.1). Technically, optimal prices can be estimated by using the general equilibrium model to simultaneously maximize both consumer's and producer's utility with the consideration of consumption, production, waste disposal, recycling, and the usage of recycled materials. This model can be applied to analyze the effects of waste management tools such as virgin material tax, minimum recycled content, and retail disposal charges (Anex, 1995). The general equilibrium model illustrates a market mechanism through which financial tools could affect waste generation and the demand for collection and disposal.

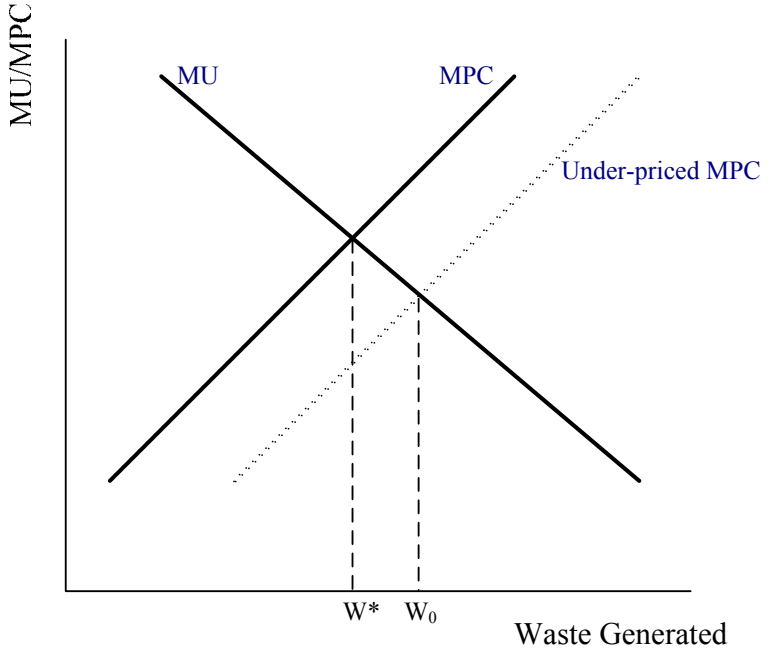

Figure 2.1: Service Price and Waste Generation

Source: by author.

In practice, among the most common financial tools to reduce garbage generation is unit-based pricing of services (by purchasing special bags or stickers for collection, or subscribing to a specific cart volume). Case studies in the US have shown that the

introduction of unit-based pricing reduces waste disposal and increases diversion (Miranda & Aldy, 1998). Various empirical studies have estimated the price elasticity of waste services in a wide range from 0 to 0.77 (summarized in Morris & Holthausen, 1994). These results showed a statistically significant effect of service price on the amount of waste generated, but the wide range also indicated that "the context, including the availability and cost of alternative disposal options, is important to community response to changes in price and the estimation of any welfare effects associated with changing conditions of service and price (Morris & Holthausen, 1994)." Another common tool is taxation such as waste tax or virgin material tax to prevent waste from being generated at early stages (Bruvoll, 1998; Hagelstam, 2001). Similar to taxes are subsidies. For example, the utilization of recycled material can be encouraged by subsidizing products that use such materials during production (Anex, 1995). Other financial tools include user fees, deposit-refunds, and advance disposal fees (Ferrara & Missios, 2005; Palmer et al., 2003; Shinkuma, 2003).

To improve waste diversion exclusively by financial tools is not sufficient. Empirical studies have shown that the effect of service price on the amount of waste generated varies widely; the number of studies is also considered small (Choe & Fraser, 1998). In practice, various social and political conditions also affect the cost and efficacy of these financial tools. For example, in areas where population density is high and waste service is frequent, unit-based pricing that works for weekly curbside pick-up service would not be cost-effective due to the excessive workload of recording and supervision (Liu & Xu, 2004). The policy-economy context with multiple conflicting objectives may also reduce potential benefits and hinder the implementation of some financial tools. Turner et al. (1998) summarized six principles for evaluating an economic tool in society – economic efficiency, environmental effectiveness, fairness, administration cost-effectiveness, institutional concordance, and revenue raising – compliance with all of which, they argued, was a "formidable requirement".

In some cases, decisions and policies concerning waste diversion are driven by non-economic interests. Because of these interests, waste diversion programs are often not economically optimal. Kinnaman (2002) showed the recycling program in Lewisburg

is not economically beneficial where the cost of the program exceeded the sum of revenues from selling recycled materials and saving landfill space. He further argued that the reason for running the costly program was chiefly the residents' demand, the same as other demands for parks and recreational facilities, which governments would devote resources to satisfy.

Charging waste collection services would also increase the probability of improper or illegal behaviour in waste disposal. The impact of these behaviours can be significant. For example, unit-based pricing might cause 'Seattle Stomp' – compacting garbage into smaller volumes – and illegal dumping that would account for up to 40% of the perceived reduction of waste collection (Fullerton & Kinnaman, 2002). However, these improper and illegal behaviours have not been profoundly considered in economic models, while only a few studies, such as Shinkuma (2003), considered some of them.

2.3.3 The Marketing of Waste Diversion Programs

If waste diversion programs are regarded as services, then promoting such programs is to market the services to the customers, i.e., residents. Shrum et al (1994) proposed a framework to analyze recycling services as a marketing problem and explored four aspects for research: consumer, pricing, distribution, and promotion and communication. These four aspects are consistent with the four Cs (consumer, cost, channel, and communication) (Lauterborn, 1990) or the four Ps (product, price, place, and promotion) in the marketing mix applied for general products and services marketing (McCarthy & Shapiro, 1983).

First, consumer research focuses on socio-demographics and psychographics. Equivocal evidence made demographics a poor predictor for waste separation behaviours (Barr, 2004; Shrum et al., 1994). Attitudes towards the environment or environmental values is widely stated as a major factor influencing the participation in recycling programs (Barr, 2004; Qu, 2007; Shrum et al., 1994; Taylor & Todd, 1995). Some motives are intrinsic, e.g., ecological self realization and selfish environmental value (Meneses et al., 2005; Qu, 2007). Other motives are extrinsic. Taylor and Todd (1995) and Chan (1998) demonstrated both perceived behaviour control and subject norms also exerted influences on the participation in recycling programs. Social norm is also an important factor:

Recycling behaviour could be encouraged by friends' and neighbours' recycling behaviours (Hopper & Nielsen, 1991; Oskamp et al., 1991). Other factors include environmental knowledge and involvement (Gamba & Oskamp, 1994; Meneses et al., 2005; Qu et al., 2007; Vining & Ebreo, 1990) and environmental citizenship (Selman, 1996 in Barr, 2004).

Second, the major cost of participation in waste diversion programs is economic disincentives or taxes that are, as discussed previously, directly related to economic tools. In addition to monetary costs, learning costs associated with behavioural changes may be required for the adaptation to new programs. This process could take a long time and require a large information campaign (ISWA, 2002).

Third, distribution research touches upon the channel and the entities of service delivery and the distance and frequency of service access (Goldsby, 1998). It examines the convenience of waste diversion programs. Pieters (1991 in Goldsby, 1998) proposed three "convenience strategies": closer proximity, higher availability, and minimal complexity in sorting and storage for consumers.

Finally, better communication and promotion are also crucial for improving the participation in waste diversion programs. Publicity was identified as an influencing factor for household waste management behaviour (Qu et al., 2007). A communication campaign in the UK, *recycling2go*, was found to contribute to the increase in the curbside recycling rate from 9.7% to nearly 50% in two years (Mee et al., 2004). These authors also found marketing and communication activities had encouraged about 75% of the residents to recycle more. Another study in the UK revealed that a useful tool for promoting recycling programs was door-to-door communication which, compared with flyers and news paper advertisements, could increase public concern in a shorter period of time (Read, 1999). The role of public education can be essential in program promotion. An experiment in New Zealand showed that neither verbal nor financial commitment had a significant impact on the participation rate in a recycling program; whereas educational efforts may suffice as long as the convenience of services remains (Bryce et al., 1997).

Each of these four aspects of the marketing model does not work independently. Similar

to the concept of IWM, efforts need to be made on all aspects in order to attain a high participation rate. Goldsby (1998) argued that appeal promotions, low participation costs, and convenience are key tools to promote curbside recycling. In the Netherlands, for example, the promotion of a small electronic products recycling program included local taxes on household wastes that contained electronics, convenient collection points located in supermarkets, special carrier bags, and rewards for promotional campaigns and direct feedbacks (Melissen, 2006).

However, research on the motivators to recycling behaviour in MSWM is not conclusive. Staunch relationships between various factors and recycling behaviour can not be guaranteed when research methods or locations of cases vary. Conclusions in certain cases face uncertainties in generalization. First, most studies have focused heavily on curbside recycling. Little attention was paid to other forms, such as services for apartment buildings for which Curbside recycling is not suitable. Second, most cases studied are in developed countries. Whether these marketing strategies would be equally effective in developing countries remains inclusive. The socio-economic and psychological features of consumers may be different due to the different social, cultural, and economic conditions in developing countries. Moreover, informal agents, such as scavengers and junk buyers, divert a considerable amount of MSW in developing countries (Dan Hoornweg et al., 2005). How would these agents influence the promotion of "formal" diversion programs is not clearly understood.

2.4 Synthesis: A Systematic Framework

2.4.1 A Summary of Major Agents and Relationships

The planning, economic, and marketing models reviewed in Section 2.3 have covered a variety of aspects of MSWM. The major issues, agents, and the features of each model are summarized in Table 2.2. Various issues discussed in these models pertain to waste management, from planning to implementation, from facility siting to service delivery, and from programmatic factors to socioeconomic and psychological factors. In terms of agents concerning MSWM, five major groups can be identified: residents, the government, professionals (engineers and planners), the formal private sector including

enterprises and interest groups, and the informal sector.

Table 2.2: Reviewed Models and Identified Agents, Factors, and Relationships

Model	Major Issues Concerned	Major Agents	Features
Planning			
a) Rational-Comprehensive	Land use planning, scientific process	Government, planner	Paternalistic, based on 'top-down' approach
b) Participatory	Public participation, 'willing host'	Government, planner, the public	Participatory, collective decision making
c) Advocacy	Social equity, tax policy, public relation, environmental industry	Government, planner, industry, resident	Congruent with concerned clients
d) Incremental	Legislation, public policy	Government, planner	Response to crises, policy-driven
e) Adaptive (Modeling)	Treatment method, virgin material substitution, energy recovery, transportation, construction, uncertainty	Government, producer, the public, engineer, professional consultant	Optimized by mathematical and computer based model,
Economical	Service fee, waste tax, virgin material tax, subsidy, waste diversion, disposal	Government, waste manager, enterprise, resident	Aiming to internalize externalities associate with waste and encouraging waste reduction and diversion by economic incentives
Marketing	Social norm, knowledge, experience, cost, convenience, education, communication, promotion	Consumer, service provider (public/ private sector)	Waste diversion and reduction programs as services marketed to consumers

Source: by author.

For a systematic comparison of MSWM systems, it is important to stress the synergy of various components rather than focusing exclusively on one management tool or one agent because no single tool or agent alone is sufficient to solve the MSW crisis. An example of the synergy of various aspects discussed in the planning, economic, and marketing models is IWM as Seadon (2006) summarized, which has highlighted four categories of integration in practice. First, IWM represents an integration of treatment methods. Adaptive models are widely used in optimizing various combinations of these

methods. Second, IWM simultaneously considers the treatment and impacts of atmospheric, aqueous, and solid wastes. Although MSW is a single medium, the impact of its treatment could be of multi-media. These multi-media impacts are often analyzed in studies pertaining to the life-cycle analysis of waste management. Third, multiple management tools including regulatory, financial, planning, and market-related tools are mainly discussed in incremental, economical, and marketing models. Finally, in terms of multi-agent integration, all planning, economical, and marketing models touch upon various agents but focus on different aspects of the interactions among the public and private sectors, and the public.

However, the four aspects focused exclusively on the integration of multiple components of a system, but do not specifically reflect the differences in particular components (e.g., differences concerning residents, governments, or the private sector), reasons for the existence of the differences, and the implications to MSWM. These aspects are also important for the analysis and comparison of MSWM systems. Taking a systematic perspective, this thesis proposes a system framework, as a synthesis of summarized issues and agents, for the comparative comparison of waste management systems so as to better understand the differences among them.

2.4.2 The Framework for Comparison: A Systematic Model

> *A system is a group of parts that are interacting according to some kind of process, and systems are often visualized as component blocks with some kind of connections drawn between them…As often stated, the whole becomes more than the sum of the parts when there are interactions. Such wholes that have emergent properties from the interaction of the parts we call systems.*
>
> ---- *(Odum, 1994: 4)*

Typical systematic approaches are widely employed in studies on ecosystems. Some concepts have also been directly applied in the research on waste management: The concept of "emergy" – all energy of one form required to provide a given flow or storage of energy and matter – has been adopted to assess the impacts of MSWM systems in various scenarios (Brown & Buranakarn, 2003; Marchettini et al., 2007). More generally, as demonstrated by some waste planning and economic models reviewed in this Chapter, the systematic perspective is illustrated by simultaneously considering multiple relevant economical, social, and environmental criteria (e.g., integer linear programming and

life-cycle analysis). In this section, a conceptual model based on the systematic approach is presented as the framework for the comparison of waste management systems.

According to the definition of the general system given by Odum (1994), three aspects concerning a system are crucial: components (the parts involved), structure (the way they are connected), and processes (their interactions). In order to understand a system, its components, structure, and processes should be thus studied. Particularly in MSWM systems, components refer to the agents who directly deal with MSW in anywhere from its generation to final disposal. Agents, as summarized in Table 2.2, include residents, governments, professionals, the formal private sector (e.g., formal enterprises and interest groups), and the informal sector (e.g., junk-buyers and scavengers). The system structure represents how components are connected. These components usually interact through transactions and thus are primarily connected by the flows of waste and money. The waste flow is the primary connection that indicates who is directly involved in a waste management system. Yet, as financial and market-related tools are widely applied in waste management and planning processes (e.g., unit service fees, waste taxes, and the "willing host"), the financial flow also makes up an important feature of MSWM systems. The interactions are illustrated by cooperation and partnerships between the public and private sectors, and among agents within each sector.

As a synthesis and a reflection of the three aspects (i.e., component, structure, and processes), a systematic model is proposed as illustrated in Figure 2.2. The main thread of this model is lying in the actions concerning the waste flow (illustrated in grey circles), including consumption, source separation, associated education, collection, transportation, storage, treatment, and final disposal. Concerned agents (illustrated in rectangles) perform or are related to some of these actions. All components and their connections are enclosed within the system's boundary.

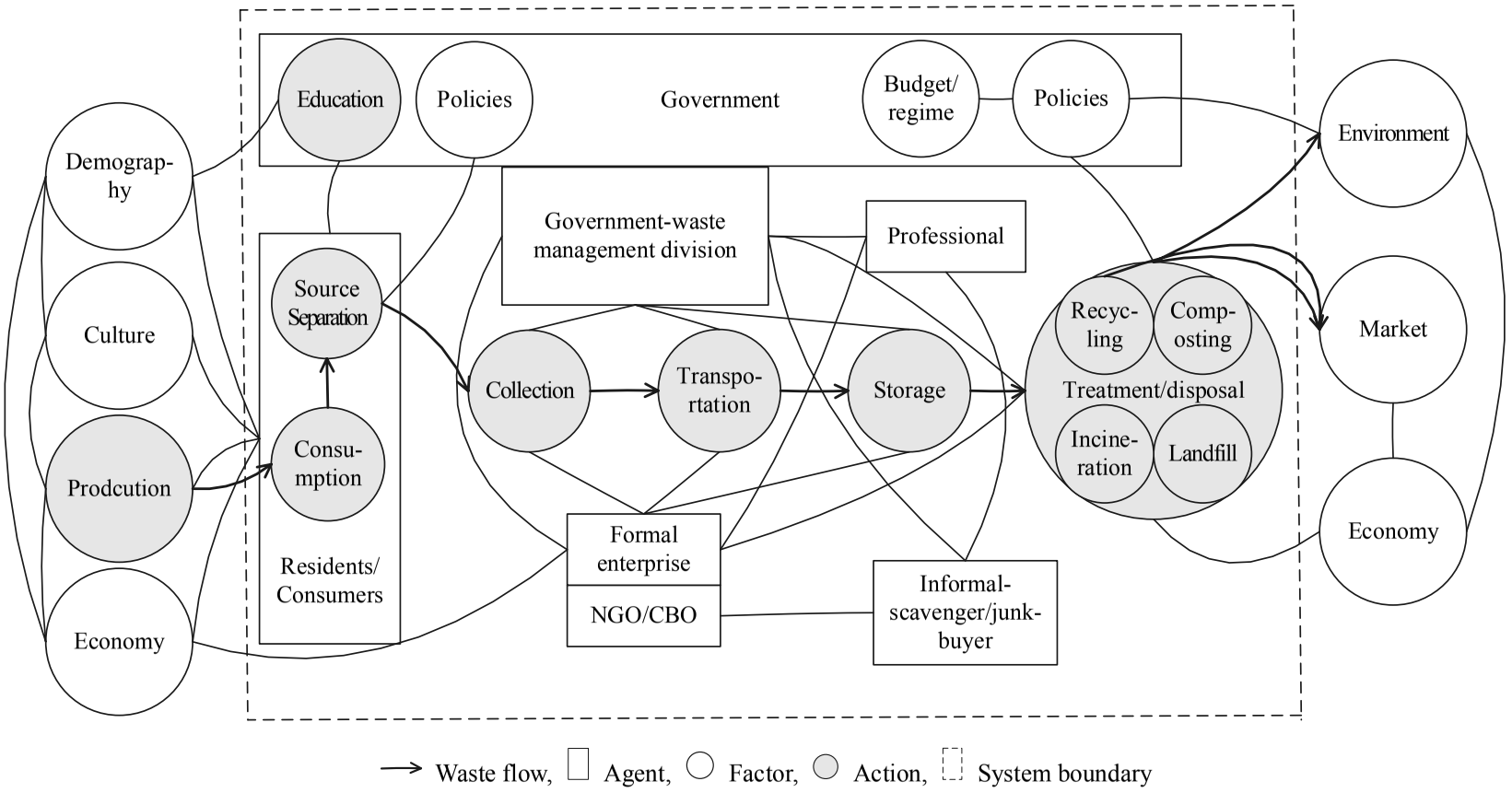

Figure 2.2: The System Model

Source: by author

The performance of MSWM systems is also connected to a number of contingent factors (illustrated in white circles) in the surrounding environment of the systems, such as demography, economy, and culture (Figure 2.2). The analysis of system components, structures, and interactions should correspondingly reflect these contingent factors. For example, the effectiveness of public education and the consumption of commodities are influenced by a combination of demographical, cultural, and economical factors; and appropriate treatment methods are impacted by relevant policies, and economic and environmental factors. This model provides a template and a framework for analyzing and comparing the MSWM systems in the two case studies (see Sections 4.1.2 and 4.2.2 and Chapter 5).

CHAPTER 3 METHODOLOGY

3.1 An Overview of Research Approach

The research methodology employed in this thesis is the embedded case study. According to Yin (1989: 23), a case study is defined as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used." Embedded case study, as opposed to a holistic case study, is a case study that involves more than one unit or object for analysis (Scholz & Tietje, 2002). In this thesis, each component of the MSWM system, as a unit of the case, is studied and compared. In comparison with other research methods, a case study has the advantage when a "how" or "why" question is inquired about contemporary events that are complex and contextualized and the researcher has little or no control over (Scholz & Tietje, 2002; Yin, 1989). This thesis examines two new waste diversion programs as examples and is particularly concerned with why differences between MSWM systems are present and how waste management in Dalian will be possibly improved. Furthermore, a case study and other research methods are not mutually exclusive: Multiple case studies can be applied for the purpose of comparison (Yin, 1989), which is the major purpose of this thesis. Therefore, the embedded case study is a proper method for such a subject and research objectives involved in this thesis.

In order to perform a thorough, objective investigation of the cases, data should consist of both first- and second-hand materials and be collected from multiple sources (Yin, 1989). In this thesis, literature on planning and economical models concerning waste management and documents obtained from governments were reviewed. Following the literature review, semi-structured interviews were conducted to collect information and data from governments and private companies. In addition, surveys were conducted to the residents in the two cases to collect information about the factors that influence the participation in diversion programs. On-site observation was also performed to collect first-hand information concerning the living and working environments in communities

and waste treatment sites. Details of these methods are introduced in Section 3.2.

According to the features and properties of various data sets, different analytical methods are required to obtain valuable and reliable results. Qualitative methods as well as quantitative methods can be effective analytical tools in case studies, especially in embedded case studies (Scholz & Tietje, 2002). A systematic model was proposed as a framework for the multi-level comparative analysis. In light of specific local conditions in each case, minor variations of the systematic model were applied in order to enhance the model's applicability (e.g., the informal sector is absent in the RMOW). Based on this model, this thesis organized and analyzed both first-hand materials and data collected from interviews and on-site observations, and second-hand information extracted from statistical data, legislative documents, and relevant reports. The data collected from surveys were analyzed by quantitative methods and further compared. These data analysis methods are elaborated in Section 3.3.

3.2 Research Methods

3.2.1 Literature and Document Review

The major content of the literature review provides the base for the system model and data analyses. In addition to the review of relevant literature, statistical data and documents concerning waste management in each of the study areas were also reviewed. In the case of the RMOW, materials included the Waste Management Master Plan (updated in April 2006), council reports concerning the Green Bin pilot program, newsletters related to MSWM, and the promotion package of the Green Bin pilot program. In Dalian, materials consisted of an introductory document to the waste management authority – the Municipal Environmental and Sanitary Department, regulations and policies concerning waste management, and the project proposal and plan for a recycling program proposed by Shengda Holding, Inc.

In addition, the Solid Waste Management Master Plan, Annual Reports (2005, 2006), waste management news letters, and the promotion package of the Green Cart program in the City of Hamilton were also reviewed as a reference for organic waste diversion

program organization in Southern Ontario.

3.2.2 Interviews

Semi-structured interviews were conducted to collect further background information about waste management, concerns in decision making, and program initiatives and organization, and participation. Major interviewees came from the municipal government and the enterprise that processed or proposed to process separated wastes. Five informants in Canada and eight in China were interviewed. Informants in Canada included waste managers in municipal governments in the RMOW, the City of Hamilton, and the Township of Orangeville in the County of Dufferin; and a facility manager in the private company that processes the Green Bin organics. In Dalian, major informants included managers and employers from the local government, Shengda Holding Inc., the property management company in Dayou Tianyuan, and a Ph.D. student at Dalian University of Technology who conducted research on waste management in Dalian. A public servant working at the State Environmental Protection Administration was also interviewed for general information on the administration of solid wastes in China (see Appendix I). Interviewees from both cases were anonymous in this thesis. The ones that were interviewed in Canada seemed more open and easier to access. All interviewees in Canada granted the request for audio recording during the interview, as opposed only two did in China.

3.2.3 Survey

The survey in the RMOW was conducted in two communities where the pilot program was operating: Hazel/Cardill area in the City of Waterloo (H/C Waterloo) and Downtown Kitchener (DT Kitchener). The two areas were selected because, according to the weekly audit and the survey conducted by the regional municipal government, H/C Waterloo had the lowest participation rate whereas DT Kitchener held the highest participation rate in the pilot program. Moreover, in H/C Waterloo, a large proportion of dwellers are students who are relatively young and transitory, whereas DT Kitchener is a community with relatively stable residents. These two areas could be rather representative and distinct in their features. In Dalian, the survey was also conducted in two residential communities

located at Jiefang Square and Heishijiao Street where redemption centres for the proposed recycling program would be eventually set up. The community at Jiefang Square is a relatively old community close to a major commercial district, Xi'an Road, whereas the one at Heishijiao is a newer enclosed community with property management.

The survey aimed to explore and contrast the major factors influencing their behaviours concerning waste separation and the characteristics of the waste service market segments. With the same aim, Surveys distributed in the RMOW and Dalian shared a similar format and content. The survey consisted of three main parts (Table 3.1). The first part (questions one to three) pertained to the participation in the local waste diversion program and the methods dealing with particular types of wastes. The second part was designed to explore the factors influencing residents' waste separation behaviour. Most questions linked to the factors discussed in the literature on the marketing model (section 2.3.3). In addition, the survey also included a programmatic factor, mandate/request for participation, which was found pertinent to the performance of recycling programs (Peretz et al., 2005). Questions in this part were measured by a five-category rating scale based on the Likert Scales (Anderson et al., 1983). Each question was a statement followed by rating scale from 1 to 5, with 1 indicating "not important at all" or "strongly disagree" and 5 indicating "very important" or "strongly agree". The third part of the survey contained open questions requesting participants to state any perceived shortcomings of and suggestions to the current waste management system. The survey in the RMOW took the Green Bin pilot program as an example, where the one in Dalian focused mainly on the current management system including informal agents. Before delivery, the survey (English version) was reviewed by the Office of Research Ethics at University of Waterloo for ethical clearance and by the researcher's advisor, Dr. Murray Haight, for comments on the content. Correspondingly, the survey conducted in Dalian, after translation into Mandarin, was further reviewed for local-context-based suggestions by a senior project manager in Dalian Economic and Technological Development Zone Environmental

Protection Bureau and the employee in charge of program promotions at Shengda Holding Inc., the private company proposing a waste recycling program in Dalian. The complete versions of survey in the RMOW and Dalian are included in Appendix II and III.

Table 3.1: Summary of Survey Questions

Category	Questions in the survey	
	RMOW	Dalian
Activity in participation	Participation frequency in Blue Box and Green Bin; Methods dealing with organics before.	Understanding and practice of waste separation; Methods dealing with separate wastes.
Consumer	Attitude to environment: benefiting the natural environment; Self-realization: feeling of contribution to environmental protection; Right and responsibility: sense of citizenship; Social norm: neighbours' behaviour; Knowledge: aware of the treatment site and procedure; Experience: important for better managing wastes; Benefit: reducing the volume of garbage; Programmatic factor: requested to participate.	
Costs/ Compensation	The price of liner bags; The accessibility of liner bags.	The price of recyclables redemption; The revenue of selling recyclables; Reasonable service fee.
Service delivery/ Convenience	Service frequency and accessibility; Easy to follow instructions of operation.	Service accessibility of garbage collection; Service quality of garbage collection; Service accessibility of recycling.
Promotion	Major Channels acquiring information waste programs and environmental protection.	
Open question	Major shortcomings of the current service; Suggestions for improvement.	

In terms of collection methods, the survey delivered in the RMOW asked participants to mail it back to the researcher. The density of residents is relatively low, and the major building type is townhouses to which the survey is easy to drop off. The survey was enclosed in an envelope accompanied with a recruitment letter and a mail-back envelope

with address and stamp affixed. In Dalian, a face-to-face interview-based survey was conducted. Experiences from empirical research have shown that mail-back surveys often do not attain a satisfactory response rate. Alternative collection methods need to be considered. As opposed to the RMOW, the population density in Dalian is high, and the building type is apartment. Residents usually go out for a walk and chat at public spaces within or near their communities after dinner if the weather condition is comfortable. A sample of such people in the public spaces was surveyed.

3.2.4 On-Site Observation

On-site observations can provide direct perceptions of the program operation, facilities, and operational environments. In the RMOW, the researcher helped audit the Green Bin setout rates in the two communities where the survey was delivered. The researcher also visited the landfill site and recycling centre in the RMOW, and the composting facility in Thorold at which the organic waste collected by the Green Bin was processed. In Dalian, the researcher observed the garbage collection points and redemption centres in residential communities where the survey was conducted, visited Dayou Tianyuan and its processing centre, and toured the landfill site at Maoyingzi, Dalian.

3.3 Data Analysis Methods

3.3.1 Qualitative Methods

The main body of the analysis is a comparison of two waste management systems. In the RMOW, the current waste collection and diversion systems were illustrated, and the Green Bin pilot program as an example of new programs was studied in detail; in Dalian, the current waste collection and recycling system and an in-progress recycling program proposed by Shengda Holding Inc. were studied as examples.

The comparative analysis based on a system model resulted in Section 2.4.2. was conducted at four levels. First, the stage of management and the capacity and resources for planning and administration were compared to provide an overview of the differences in the background of each case's management system.

Second, comparisons in the three essential aspects of systems were conducted. The MSWM system was first segregated into subunits, allowing for a comparison of each system component and the analysis of reasons for the differences. At this level, each component is a sub-unit that, as a part of the embedded case study, is worth in-depth scrutiny. As one of the thesis's objectives, the feature and motives for residents to participate in waste diversion programs received a special consideration. A quantitative exploratory approach based on the data collected from surveys (see Section 3.3.2) was incorporated for the comparison of the residents as customers of waste services, in terms of the major factors influencing their behaviours concerning waste separation and the characteristics of the waste service market segments.

After the analysis of components, differences and characteristics of system structures—illustrated by the waste and financial flows—were discussed. Lastly, the interactions and cooperation among various agents were then compared and discussed. Specific local contexts were regarded. That is, relevant local economical, demographical, and historical conditions were referred to along the way of the analysis.

3.3.2 Quantitative Methods

This research was not designed as a rigorous data-based quantitative study because of limited resource and time for collecting a large amount of first-hand data. Quantitative methods were only applied to explore and compare the major motivators for waste separation and the features of the participants in waste diversion programs. The researcher employed a computer-based statistical software package, SPSS 15.0 for Windows®, to manage data sets and conduct the following quantitative analyses. These analyses would enhance the understanding of the differences in effective promotion strategies between the two study areas.

A descriptive analysis was first conducted to summarize data sets and illustrate participation rates and approaches taken by residents for dealing with different types of wastes. Next, an exploratory approach was adopted to compare and contrast the major motivators for waste separation. This exploratory approach focused only on those who actively participate in waste separation. A *factor analysis* was employed to explore the

major motivators for waste separation behaviours. The aim of the factor analysis was to reduce the number of variables and to synthesize key factors that could better explain the behaviour of waste separation. The factor analysis started being widely applied in practical research such as marketing management during the 1960s. It is a statistical technique for data reduction, "representing a large number of measurements each made on many objects or persons in terms of some smaller number of artificial measurements (Collins, 1971: 211-2)." Initial extractions are further rotated through the Varimax Procedure with Kaiser Normalization in order to better interpret the data. By the rotation, ideally, each variable would be highly correlated with only one rotated factor so that each factor could represent a combination of highly correlated variables (Afifi et al., 2004). The factors can facilitate the comparison between the two cases.

After identify the principal factors, a cluster analysis was applied to explore and then compare the features of the market segments of participants in the two cases. The aim of this analysis was to divide the participants into smaller segments within each of which participants shared a commonality in motivations, and then to help create an effective and specific promotional strategy for the major segments. Clustering is a grouping technique through which clusters, or the market segments, are formed so that individual observations in each segment have similarities in the overall statistical measure and are therefore likely to exhibit similar behaviour (Weinstein, 1994). Cluster analysis was also widely used in marketing analyses to identify market segments within each of which customers are "homogeneous in terms of their response to marketing stimuli and marketing strategies (FitzRoy, 1976: 80)." Technically, there are no statistical guidelines for choosing proper variables as the basis for clustering. Rather, conceptual and methodological reasons are referred to for selecting variable sets (Wagner, 1997). In this study, the variables in the two surveys were slightly different as they were designed for different local conditions. Therefore, the synthesized factors identified in the factor analysis were chosen as the basis for clustering because they provided each cluster with compiled, abstract meanings that can be compared.

Another critical issue concerning cluster analysis is to choose a proper cluster algorithm. Two types of clustering methods are available: hierarchical and non- hierarchical. A

hierarchical cluster algorithm starts with individual cases and groups the two closest sub-clusters in each step, until all cases are grouped into one cluster. A disadvantage of this method is that "subjects who have once been joined in a cluster can not be separated again at a latter stage, which means that 'errors' at an early stage can not be corrected later (Wagner, 1997: 102)." A non-hierarchical method, by contrast, is an iterative process that starts with arbitrary clusters, then move individual cases to the cluster where the center is the closest, recalculate cluster centres, and will end if no case is closer to other cluster centre than to its current cluster centre. However, a challenge for the non-hierarchical method is that the number of clusters has to be predetermined, and deciding this cluster number is an interpretative task (Wagner, 1997). That is, it requires multiple attempts to find a cluster result in which both the internal cohesion and external isolation are maximum. In this study, a widely applied non-hierarchical cluster method, the K-means method, was adopted. The first reason for choosing the non-hierarchical method was to avoid the possible irreversible errors that may occur in hierarchical methods. Second, the number of clusters could be decided regarding to both study areas so as to better interpret each case in the comparative analysis. The results from the factor and cluster analyses would be applied in the comparison of the residents and would provide some implications on how waste diversion programs could be better promoted. However, because of the limitations associated with the sampling, limited reserved suggestions have been made based on the results of the quantitative analysis.

3.4 Limitations of the Study

3.4.1 Limited Generalisability of Suggestions

Generalization could usually be conducted through two methods: analytical and statistical generalization. Statistical generalization is the most common generalizing method used in surveys, whose limitations will be discussed in section 3.4.2. This section focuses only on analytical generalization. In analytical generalization, individual cases are not "sampling units"; their empirical results are used to test if a previously developed theory is supported. "If two or more cases are shown to support the same theory, replication may be claimed (Yin, 1989: 38)." In this thesis, the organic waste diversion programs in City

of Hamilton and Orangeville were studied as references for the Green Bin pilot program in the RMOW. In fact, these programs share a similar form with one another with only minor variations.

However, the applicability of the suggestions to improve Dalian's MSWM system is limited, because, given the limited resource and time, no other cases have been analyzed to test if these suggestions are applicable in other cites. Derived from the systematic comparison and analysis, the suggestions made in this thesis are based on a number of institutional, economic, and social factors. These factors could vary significantly among metropolis and small cities. In addition, the analyses were based heavily on the existing waste management systems that are also different in various cities.

3.4.2 Limitations in Survey Sample Size and Collection Methods

Sample size is an important factors that determine the validity of statistical generalization (Yin, 1989). 72 and 44 valid copies of surveys were collected in the RMOW and Dalian respectively. The sample size is relatively small compared with the population size in the study areas. The small sample size also results in relatively low representativeness. The response rates to the survey were 34.3% in the RMOW and 57.9% in Dalian. According to Berdie & Anderson (1976), however, a more accurate figure presenting a survey's representativeness is the ratio of the number of responses to the total number of residents in the study area, including those who did not receive the survey. If this ratio is considered, the response rates become much lower.

Limitations are also present in the reliability of the survey. Due to the differences in population density and culture, different survey collection methods were employed in the two study areas. First, sampling strategies in both areas were not completely random. In the RMOW, the survey areas were chosen in line with the areas being continuously audited by the regional government, so the results could be compared to confirm whether participation rates are under- or over-estimated. Nevertheless, whether the tested variables in these audit areas were statistically significantly different than other areas was not tested. In Dalian, cases are randomly chosen at public spaces near residential communities. This method excludes those families who did not spend their evening times

at public spaces. Whether there was a difference in the waste separation behaviours between the families going out and not going out in evenings was not tested. Secondly, whereas a mail-back survey was delivered in the RMOW, a face-to-face survey was conducted in Dalian. That is, verbal communication was involved. Whether the involvement of verbal descriptions influences survey participants' choices was not tested.

3.4.3 A Lack of Informants from Civil Society

The informants in this study included waste managers from the municipal governments, managers and employees from private enterprises, and residents. One limitation of this study is that it did not specifically involve informants from civil society, such as NGOs, CBOs, and other non-governmental interest groups. In both cases, the present or proposed waste diversion programs were initiated and operated by local governments or private companies. Civil society had not yet played a key role at the outset. However, they may contribute to particular aspects of MSWM along the way and their roles may differ in the two cases. Therefore, the relevant informants from the civil society should be involved in further studies on MSWM systems.

CHAPTER 4 CASE STUDIES

4.1 MSWM in the RMOW

4.1.1 Background: MSWM in Canada

4.1.1.1 Waste Generation and Treatments

In Canada, as population and economy grow, waste generation has also gradually growing at about 2% annually from 1996 to 2002 (Figure 4.1). In 2004, Canada generated approximately 12.5 million tonnes of MSW, about 22% of which was diverted by various waste diversion programs. Recycling and composting are the major approaches for waste diversion. The remaining 78% were disposed of (Table 4.1). Landfill remains the major disposal method: 95% wastes that were disposed of were landfilled, while the remaining 5% was incinerated (Statistics Canada, 2005).

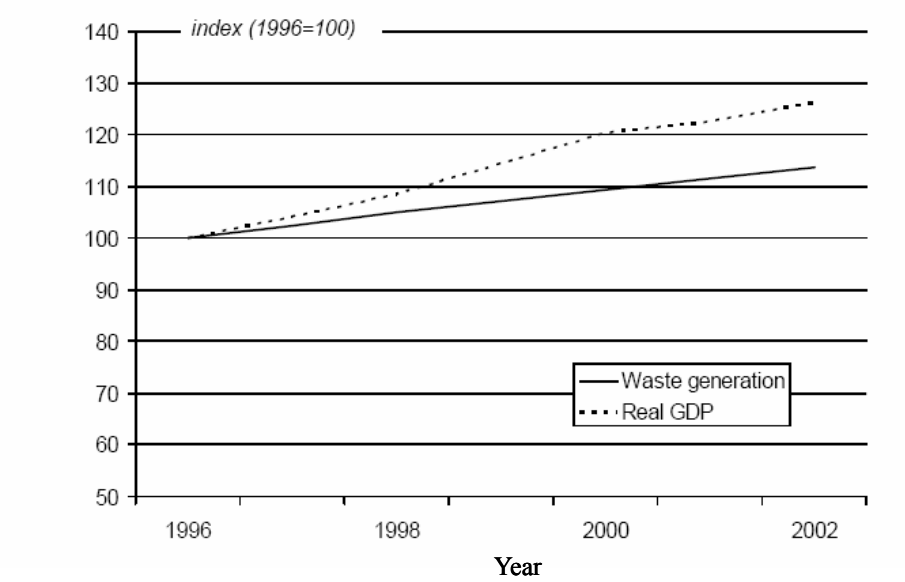

Figure 4.1: Solid Waste Generation and Real GDP in Canada

Source: (Statistics Canada, 2005)

Table 4.1: Residential Waste Generation and Disposal in Canada

Territory		2000[1]	2002[1]	2004[2]
Ontario	Generation (t)	4,191,337	4,388,239	4,551,411
	Disposal (t)	3,318,478	3,438,408	3,522,369
	Disposal Rate (%)	79.2	78.3	77.4
Canada	Generation (t)	11,242,405	12,008,338	12,582,456
	Disposal (t)	9,069,170	9,455,204	9,792,787
	Disposal Rate (%)	80.7	78.7	77.8

Source: 1: (Statistics Canada, 2005); 2: (Statistics Canada, 2006)

4.1.1.2 Regulations and Policies

Multiple levels of governments are involved in MSWM. Major Acts and policies on waste management are usually promulgated and issued by provincial governments, while the federal government is mainly responsible for trans-boundary waste movements, especially of hazardous wastes, and developing national standards and initiatives for waste management. The major legislation pertaining specifically to MSWM includes Acts at the provincial level and By-Laws at the municipal level, e.g., the Waste Management Act (S.O. 1992, C.1) and Waste Diversion Act (S.O. 2002, C.6) (WDA) in Ontario, and the By-law to Regulate the Receiving, Dumping and Disposing of Waste (98-87) and By-law to Prohibit and Regulate the Collection of Waste (02-011) in the RMOW.

Recent regulations and policies or changes in the existing ones clearly showed the intention to encourage and facilitate waste diversion. These initiatives have contributed to the plans for and implementations of new waste diversion programs in Ontario. For example, the WDA states that its purpose is "to promote the reduction, reuse and recycling of waste and to provide for the development, implementation and operation of waste diversion programs (section 1)". Shortly after this Act came into effect, a corporation without share capital was established, known as Waste Diversion Ontario (WDO) (required in WDA, section 3). The Minister of Environment may require WDO to develop waste diversion programs for designated wastes. Up until 2006, WDO has received five program request letters from the Minister of the Environment including

programs diverting Blue Box Wastes, Used Oil Material, Used Tires, Waste Electronic and Electrical Equipment and Municipal Hazardous or Special Waste (WDO, 2006). Except for used oil material, diversion plans for other four programs have been so far approved.

Meanwhile, the provincial government passed the Waste Management Project Regulation (O. Reg. 101/07) and released the Guide to Environmental Assessment Requirements for Waste Management Projects in March, 2007. This Regulation set up a new environmental assessment process specifically for waste management projects, favouring small communities, new technologies, and recycling projects. Some projects are exempt from the Environmental Assessment Act or can follow a new screening process. For instance, "recycling facilities of any size will not have to go through the environmental assessment process providing just 1,000 tonnes per day of residual waste ends up going to disposal (Ministry of the Environment, 2007)." The provincial government also set a goal of "diverting 60% of Ontario's waste from disposal by the end of 2008 (Ministry of the Environment, 2004)", and suggested centralized composting as an alternative for organic waste disposal. This goal has contributed to the implementation of organic diversion programs in Ontarian municipalities, such as the Green Bin in the RMOW (Interview W01 and W02).

4.1.1.3 Financial Resources

The total costs of various waste diversion programs are considerably high. A part of the cost is the investment on infrastructure. For example, the City of Hamilton spent $30 million to build a centralized in-vessel composting facility and $7 million on new trucks for organic waste collection (Interview H01). Other costs are generated from operation and treatment. The total cost for a diversion program can be very high. According to WDO (2007), the net cost of the Blue Box in Ontario in 2006 was $133.05 million.

Municipalities pay the highest proportion of the bills for their waste diversion programs.

Provincial government driven programs planned by WDO, such as the Blue Box, Waste Electronic and Electrical Equipment recycling program, and Municipal Hazardous or Special Waste diversion program, receive funds from WDO and various industrial stewardships. According to the WDA (section 25(5)), municipalities are receiving Blue Box funding that equals to 50% of the net cost of the Blue Box program from Stewardship Ontario. However, this fund covers only a limited portion of the budget for waste management at the municipal level. In the RMOW, for example, the Blue Box funding accounts for only 5% of the total funds for waste management (see details in Section 4.1.2) (Region of Waterloo, 2006).

4.1.1.4 The Blue Box Recycling Program

The Blue Box is one of the most successful curbside recycling programs in the world. It is currently a provincial government-driven program: In 2003, the Blue Box recycling program was requested by the Minister of the Environment under the authorization by WDA (Ministry of the Environment, 2003). The WDO incorporating with Stewardship Ontario administers and partly supports the Blue Box program. They prepare the plan, monitor and analyze program performances, improve public awareness, and distribute funds (WDO & Stewardship Ontario, 2003). The Blue Box is designed to divert glass, metal, paper, plastic, and textile materials, or any combination of them. Total recovery of materials from the Blue Box has almost doubled in the last decade, reaching 938,000 metric tonnes in 2006 (Figure 4.2).

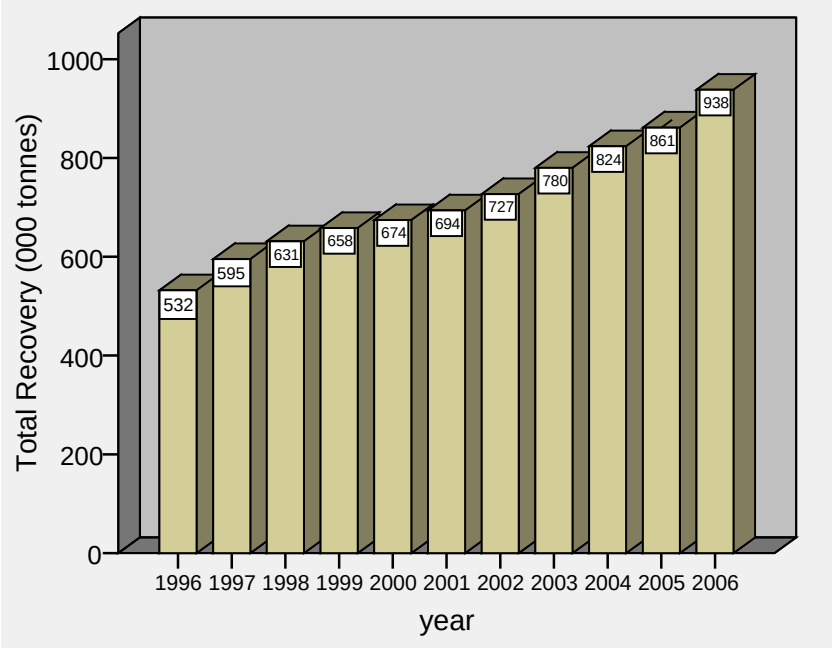

Figure 4.2: The Blue Box Recovery in Ontario

Source: (WDO, 2006; 2007)

4.1.2 An Overview of MSWM Systems in the Region of Waterloo

The RMOW is located at the heart of southern Ontario (Figure 4.3). The total population at the end of 2005 in the Region was 478,121 with a total of 187,008 private dwellings (Statistics Canada, 2006). The region consists of seven municipalities: the cities of Kitchener, Waterloo and Cambridge; and the townships of North Dumfries, Wellesley, Wilmot, and Woolwich. In 2004, wastes generated from the residential sector were 171,556 metric tonnes or 0.98 kg per capita per day. 45% of these wastes was diverted by various programs (Region of Waterloo, 2006) (Figure 4.4). The RMOW is one of the few municipalities in Ontario with a large disposal capacity: It has approximately 25-year landfill capacity at the current landfilling pace. Residential wastes account for approximately 40% of total wastes disposed at the landfill, declining from 60% in 1996 (Region of Waterloo, 2006).

Figure 4.3: The Location of the RMOW

Source: Atlas-Xpeditions, Retrieved June, 2008 from http://www.nationalgeographic.com/xpeditions/atlas/

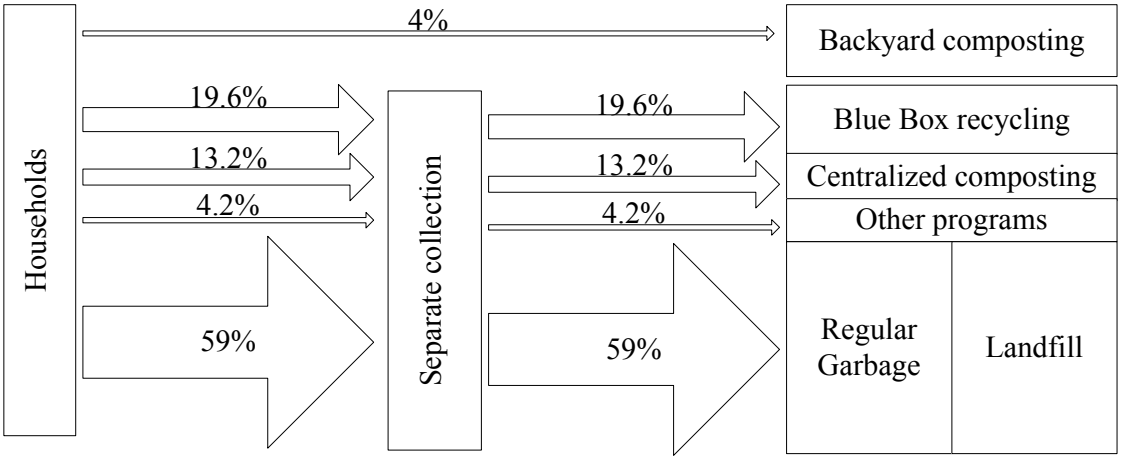

Figure 4.4: The Waste Stream in the Region of Waterloo

Note: based on the statistic of 2004.

Source: (Region of Waterloo, 2006)

Source separation is a basic feature of waste management in the RMOW. Currently, regular wastes, yard wastes, and recyclables are separated by residents and picked up at curbside weekly. Other wastes are either picked up by request or dropped off at designated sites. Most municipalities in Ontario share a similar form of waste separation and collection with the RMOW. Typically, source separation is realized through various waste diversion programs. For example, the Blue Box collects recyclables, and the Green Bin will collect organic wastes. In RMOW, these programs are organized and managed by the regional municipal government, but services in collection and treatment are delivered by qualified private companies. Currently, the RMOW diverts recyclables, yard wastes, house hazardous wastes, textile, tire and scrap metal, used motor oil, electronic wastes, etc. (Region of Waterloo, 2006). These diversion programs are parallel to one another and constitute a strip-shape structure, which becomes a major feature of the waste management system in the RMOW (Figure 4.5). However, not all diverted wastes are processed within the Region. Exporting some of the recyclables remains controversial. For example, up to 680 tonnes of mixed plastics collected in the RMOW's Blue Box were exported to China and India for processing in 2006 because processing was not cost-effective in North America: the average price of mixed plastics was about $16 per tonne, as opposed to the plastic used in soft drink bottles that could be priced up to $634 per tonne (Outhit, 2007). Environmentalists in the RMOW were questioning the impact of these plastics during processing or possible reuse. Since the Blue Box wastes were sold to private companies after collection, the regional municipal government did not know what exactly happened during processing (Outhit, 2007).

The collection of the Blue Box, yard wastes and garbage is a duty of the regional municipal government and thus mainly financed by it. The Green Bin pilot program—from program promotion to waste collection and processing—was fully financed by the regional government. Major sources of the funding for MSWM are the revenues from the commercial tipping fee charged for garbage disposed at landfills ($62 per tonne in 2008), the property tax, and the sale of recyclables. Other sources include Blue Box funding transferred from WDO, royalties paid by private companies for the collection and usage of landfill gases (Figure 4.6). In addition to the municipal services, residents may have to pay for the disposal of particular types of wastes and associated services.

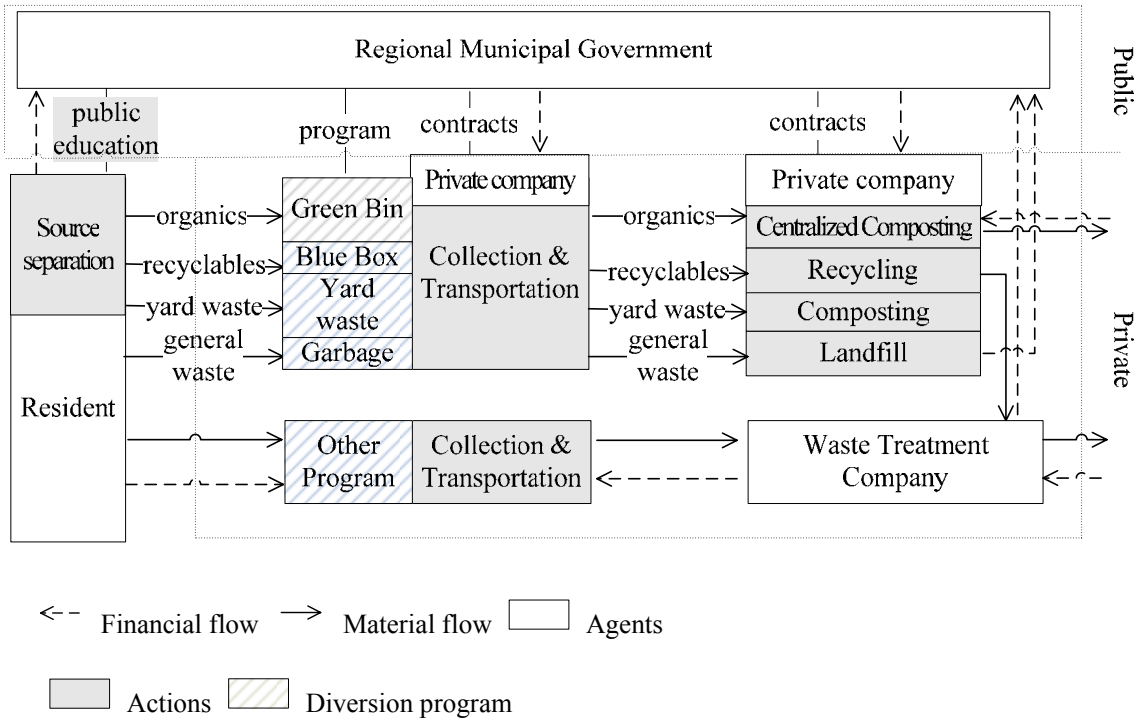

Figure 4.5: The Waste Management System in the RMOW

Source: (Region of Waterloo, 2006); interview with managers in Waste Management Division, Regional Municipality Government.

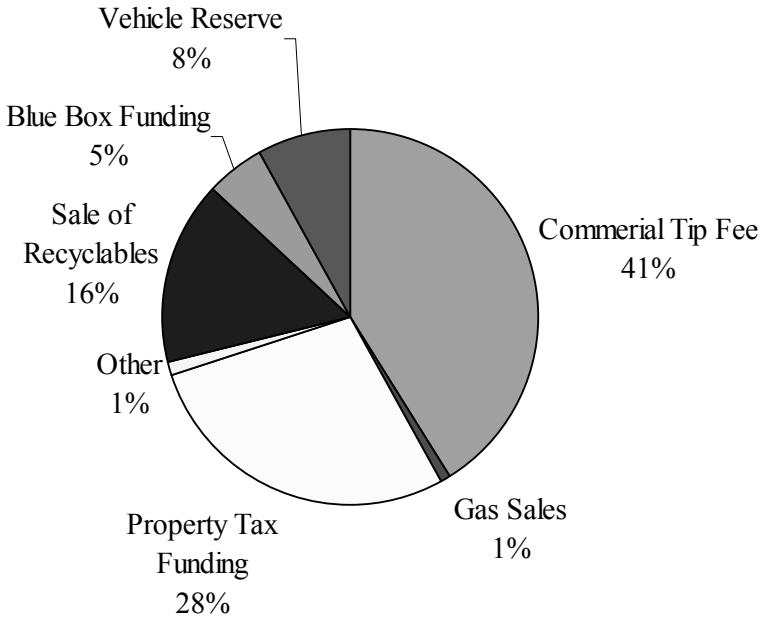

Figure 4.6: Sources of Revenue for Waste Management Fund

Source: (Waste Management Master Plan, updated in 2006).

4.1.3 The Green Bin Pilot Program

The Green Bin is an organic waste diversion program in the RMOW. Kitchen waste, paper products, and other compostable wastes including cat litters are collected in the Green Bin. This program is referred to as "green bin" because residents are given a 40-liter green garbage bin for curbside collection. Collection occurs weekly on the regular waste collection day and is served by separately dedicated trucks. The Green Bin program was initiated in 2004 as a part of the Three-Year Reduction Sequencing Plan in the RMOW (Interview W01). Initially, the plan for the Green Bin pilot program was a one-year pilot from October 2006 to September 2007, including approximately 5,000 homes in five communities. The plan was later extended to June 2008, adding another 5,000 homes, to allow the Council to consider the implications of a full-scale program in the tri-city area during the normal budget process (Interview W02).

The RMOW was rather conservative in rolling out the pilot program because it has a relatively large landfill capacity, which gives the RMOW time to learn from other municipalities' experiences in operating similar organic diversion programs and to better plan for its own. The RMOW is also rather affluent so that is relatively flexible in budget and able to implement various strategies to prolong the landfill's life-span (Interview W02). The Council has recognized that it is beneficial to divert more wastes from the landfill when there is another better and viable alternative for treatment. Following the diversion of Blue Box wastes, yard wastes, and electronic wastes, a rational step is to divert organics, because they are the biggest proportion the remaining garbage stream. Organic wastes made up of 36% of the garbage stream, and over a half of these organic wastes were not suitable for backyard composting (Interview W02). Furthermore, the current waste diversion rate in the RMOW is about 40%. The diversion of organic wastes is a crucial step towards the 60% diversion target set up by the provincial government (interview W01; W02).

A series of activities were carried out to promote this program. An information letter was delivered to residents before the outset of the pilot program, followed by open house sessions in each pilot area. Two weeks prior to the beginning of collection, each home in pilot areas received a green bin, a kitchen container, sample liner bags (15 large and 50

small bags), and an information package including instructions on the operation of and participation in the pilot program. According to the regional municipal government's survey, over 90% homes in the pilot areas are participating in the Green Bin program; the audit showed average weekly participation rates in the five areas are anywhere between 50% to 74% (Interview W01). However, program promotion requires a large amount of resources, accounting for 40% of the total cost of the program (Table 4.2).

Over half of the budget the Green Bin pilot program was allocated to collection and processing, both of which are contracted to private companies. Waste Management Inc. collects the Green Bin waste at a cost of $770 per day. The same company also collects the Blue Box, regular garbage, leaves, and yard wastes (Interview W01). A private processor external to the region, Integrated Municipal Services, is contracted to process the collected organic waste in Thorold, Ontario, about 130 km away from the RMOW. In order to maintain a high quality of feedstock, no plastic is allowed in the Green Bin. The organic wastes collected from the RMOW are mingled with leaves and yard wastes and source separated organics from other municipalities, mainly the Region of Niagara and the City of Toronto, and further composted in open windrows, which produce class-A compost as the final product. The processor is fairly optimistic on marketing the compost and is able to sell all compost produced. Most of the compost goes to the wholesale markets. Major market demand for compost comes from some terra-seeders, who can find a good use of the compost applied in seeding (Interview T01).

Considering the costs of promotion, collection, processing, and personnel, the Green Bin program is an expensive program for diverting organics. The processor, Integrated Municipal Services, assumes ownership of the organic waste once received, so that the program as currently operated does not guarantee additional financial revenues other than saving the costs associated with the landfill capacity that is being saved. Originally, $1.52 million was budgeted for the one-year pilot program. An update report presented to Council showed that the actual cost is about 58% of the original estimate, approximately $875,000 (Table 4.2). The remaining budget will enable regional municipal government to extend the pilot program without the need to seek additional funds.

Table 4.2: Budgets and Costs of the Green Bin Pilot Program in the RMOW

Items	Original Budget	Costs to Oct. 2007	Expansion Costs	Costs to June 2008
Green Bins/Liners	$400,000	$350,000	$375,000	$752,000
Collection/Processing	$800,000	$400,000	$200,000	$600,000
Temporary Staff	$120,000	$100,000	$40,000	$140,000
Promotion/Education	$200,000	$25,000	$30,000	$55,000
Total	$1,520,000	$875,000	$645,000	$1,520,000

Source: Waste Management Division, Transportation and Environmental Services, Region of Waterloo. May 15, 2007. *Green Bin Pilot Project Update*. Report to Region Chair and Members of the Planning and Works Committee. Report: E-07-062.

One of the major benefits of the Green Bin program is saving landfill space. On a weekly basis, the pilot program diverts eleven to twelve tonnes of organic wastes from the landfill. This achievement has exceeded slightly the original objective which was ten tonnes (Interview W01). In addition, according to the continuous audit and the survey conducted by the regional municipal government, the Green Bin program has also led to some concomitant benefits: Residents' purchasing behaviour changes towards products with compostable or recyclable containers and packages; the Blue Box participation rates in the pilot areas have also slightly increased (Interview W01).

Although the majority of feedback to the Green Bin pilot program is supportive, there are some complaints and challenges. One issue concerns the liner bag design at the outset of the pilot program (Interview W01). Because plastics are strictly prohibited, special cellulous liner bags are recommended for lining the bin and the kitchen container in order to avoid leachate and other nuisance during maintenance. The squared small bags that were available at the beginning did not fit the rounded kitchen container. The bag manufacture resolved this problem by coming up with a new design for the containers. A common complaint raised by residents was about the cost of liner bags (Interview W01; Survey). After the depletion of the sample bags, residents had to purchase their own liner bags at cost or utilize compostable substitutes. As tax payers, residents were not satisfied with paying extra expenses in a government-driven waste program. Another challenge to the program was to find an effective service form for apartment buildings. The pilot communities are chosen to cover various building types and population densities. The pilot area in the City of Waterloo contains several apartment buildings, where the

participation rates in the current service were very low, because in such buildings the green bin has become a public property and requires more effort in operation and maintenance, and the major dwellers in these apartment buildings are students who are rather transitory and have less sense of belonging to the community (Interview W01; W02). Currently, there are no effective forms of service that would significantly increase the participation rate in such apartment buildings.

4.1.4 Participation in the Green Bin Pilot Program

In the RMOW, 210 copies of surveys were dropped off in the audit areas in two communities: Hazel/Cardill area in the City of Waterloo (H/C Waterloo) and Downtown Kitchener (DT Kitchener). 72 surveys (34.3%) were collected, in which 12 were invalid due to missing responses to questions (Table 4.3). A summary of the survey is tabulated in Appendix II.

Table 4.3: The Summary of Survey Collected in the RMOW

Area	Survey Delivered	Valid	Invalid	Total	Response rate %
H/C Waterloo	105	15	9	24	22.9
DT Kitchener	105	45	3	48	45.7
Total	210	60	12	72	34.3

Prior to the Green Bin pilot program, a series of promotions were carried out. The survey results show that newsletter is the most effective medium for promotion. Government hotlines and open houses are less effective media, but they are considered important for program promotion because of direct face-to-face contact (Figure 4.7). By the time the survey was conducted, the pilot program has been in operation for about eight months. Over 90% residents set out their green bin at least once every three weeks (Figure 4.8). This setout rate equals to a weekly participation rate of 79.7%. This result is higher than the on-site audit results, which showed a 50% weekly participation rate in H/C Waterloo and 74% in DT Kitchener. In addition, the overall participation rate of the Green Bin pilot program is slightly lower than that of the Blue Box (Figure 4.9).

The pilot program diverts about twelve metric tonnes of organic wastes on average per week. Before the rollout of the Green Bin pilot program, about 70% of residents treated some or all of their organic wastes as regular garbage, and close to 60% of residents have been operating backyard composters. A few other approaches are also adopted, e.g., using food leftovers to feed pets, digesting, or applying organics directly onto their own farms (Figure 4.10).

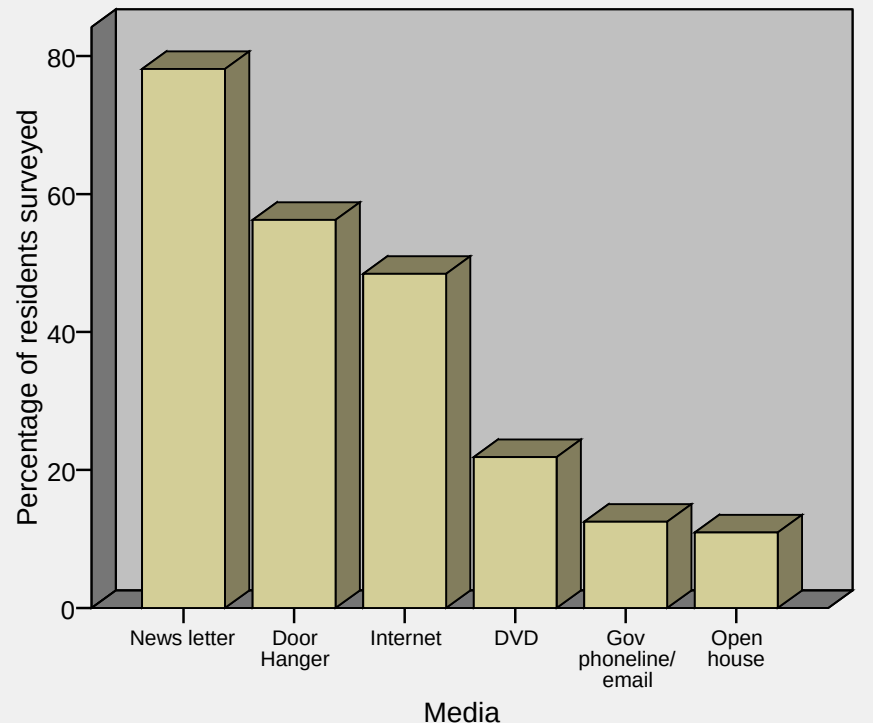

Figure 4.7: Media for Green Bin Program Promotion in the RMOW

Source: survey.

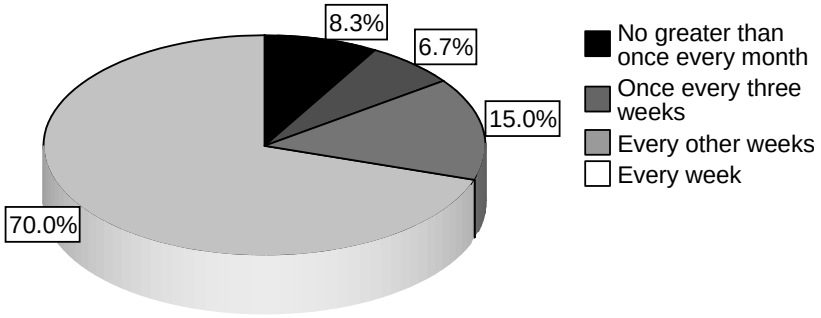

Figure 4.8: The Green Bin Setout Rate

Source: survey.

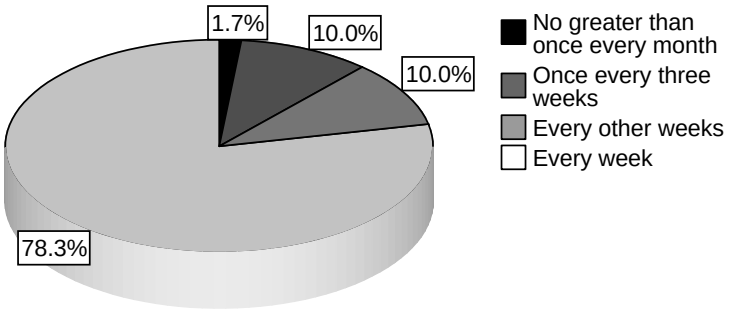

Figure 4.9: The Blue Box Setout Rate

Source: survey.

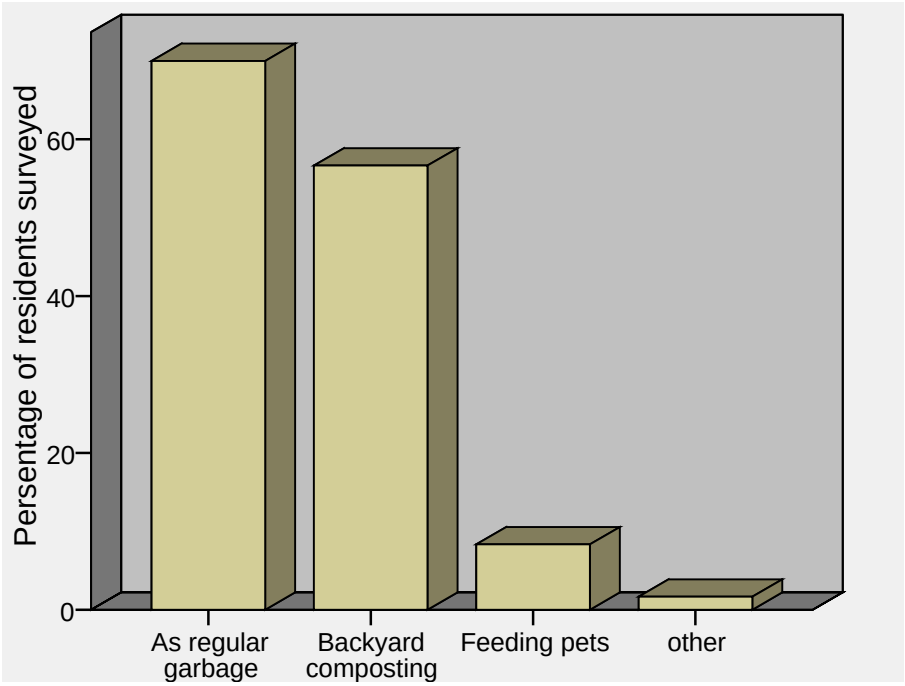

Figure 4.10: Approaches Taken for Dealing with Organic Wastes before the Green Bin

Source: survey.

4.1.5 Motivators for Waste Separation

In order to explore the key motivators for waste separation, cases that did not actively participate in the Green Bin pilot program (with a setout rate no greater than once per month) are excluded in the following analyses. Consequently, 55 cases are included. Four factors with eigenvalues greater than 1.0 are extracted. These factors in aggregate explain 66.7% of the sample's total variance (Table 4.4). The initial extraction is rotated through the Varimax Procedure with Kaiser Normalization for a better interpretation of the data.

Ideally, each variable would be highly correlated with only one rotated factor. As shown in Table 4.5, for each rotated factor, the variable that is highly correlated (with a correlation greater than 0.5) with that factor is underlined; the variable that is relatively highly correlated (with a correlation greater than 0.48) is highlighted in bold.

Table 4.4: Total Variance Explained: the Case of the RMOW

Factor	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.855	29.651	29.651	3.394	26.104	26.104
2	1.942	14.938	44.589	1.896	14.581	40.686
3	1.563	12.025	56.615	1.701	13.088	53.774
4	1.306	10.046	66.661	1.675	12.887	66.661
5	.927	7.130	73.791			
6	.776	5.971	79.763			
7	.672	5.172	84.934			
8	.544	4.182	89.116			
9	.463	3.565	92.681			
10	.394	3.034	95.715			
11	.255	1.962	97.677			
12	.194	1.495	99.172			
13	.108	.828	100.000			

Extraction Method: Principal Component Analysis.

According to Table 4.5, four major motivators can be extracted: (1) attitude and service quality, (2) associated knowledge and willingness, (3) associated costs, and (4) social norm and responsibility. The strongest factor is attitude and service quality (accounting for 26% of the total variance). It is highly correlated with positive attitudes towards the Green Bin program, the environment, and waste management, and quality services that are easy to access and operate with limited nuisance. The other three factors have similar accountability for the total variance (Table 4.4). The second factor, Knowledge and self-realization, is concerned more with intrinsic motives, i.e., self-realization and acknowledgements of treatment procedures. The major cost is the purchase of liner bags. A high score on this factor represents “reasonable costs”, while lower score indicates

"high costs" of participation. Finally, social norm and responsibility is associated mainly with the influence from neighbour's behaviour, sense of citizenship, and direct request.

Table 4.5: Rotated Factor Matrix: the Case of the RMOW

	Factor			
	attitude & service quality	knowledge & self-realization	costs	social norm & responsibility
service frequency and accessibility	**.859**	.236	-.017	.046
easy to follow instructions of operation	**.798**	.062	.144	.156
Reducing the volume of regular garbage	**.770**	-.052	-.111	-.085
benefiting the natural environment	**.764**	.401	.044	-.207
important for better managing solid wastes	**.609**	**.498**	-.027	-.126
limited odours	**.567**	-.250	-.157	.318
knowledge about treatment site and procedure	-.058	**.745**	.230	.135
self- contribution to environmental protection	.259	**.715**	-.175	.035
the price of liner bags	-.031	-5.26E-005	**.863**	.041
the accessibility of liner bags	-.017	.026	**.851**	.008
requested to participate	-.196	-.176	-.100	**.767**
sense of citizenship	.103	**.486**	-.033	**.692**
neighbours' behaviour	.167	.167	.278	**.628**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 5 iterations.

4.1.6 Market Segmentation and Features

Built on these factors, a further step is to explore the feature of various groups of participants, i.e., the market segments. For each case, factor scores are assigned by the regression method. A non-hierarchical clustering method, K-means clustering, is adopted for the cluster analysis. To begin with, scatterplot diagrams are drawn to visually show the agglomeration of cases and to assist in determining the number of clusters. A scatterplot displaying the pair of factor 1 (attitude & service quality) and 2 (knowledge &

self-realization) is illustrated in Figure 4.11. Two major clusters can be identified on the right-hand side with a possible outlier on the left. A tentative clustering result confirmed the outlier as it was grouped with any other cases. After the outlier is excluded, the clustering result is shown in Tables 4.6 and 4.7.

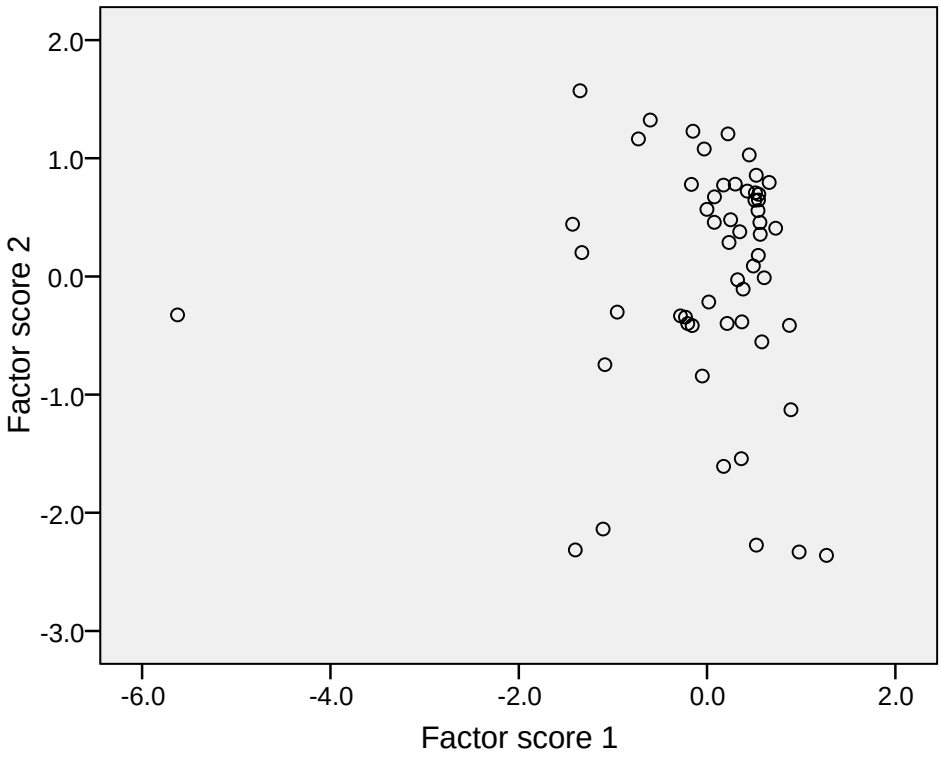

Figure 4.11: Scatterplot of Factor 1 and 2 in the RMOW

Approximately 31% of cases are grouped in cluster 1 and 69% in cluster 2. An independent T-test reveals that the factor scores on knowledge and self-realization, and costs in the two clusters are statistically significantly different between these two clusters at the 1% significant level. This difference makes the two clusters distinct in their features (Figure 4.12). About one third of participants in the Green Bin pilot program, in comparison with the other two thirds, have less knowledge about waste treatment and less strong intrinsic motives of participation but consider the money and time spent on operating the Green Bin rather reasonable. The other two thirds, by contrast, are more self-motivated participants: They have more knowledge and stronger willingness and

participate in spite of the high perceived costs.

Table 4.6: The Number of Cases in Each Cluster in the RMOW

Cluster	Number of cases	% of total cases
1	17	31.481
2	37	68.519
Total valid	54	100.000

Table 4.7: Final Cluster Centers in the RMOW

Factor	Cluster	
	1	2
attitude & service quality	.15967	.07862
knowledge & self-realization	-.99585 ***	.46636 ***
costs	.54455 ***	-.29945 ***
social norm & responsibility	-.30590	.10665

***: Statistically significantly different (α=0.01).

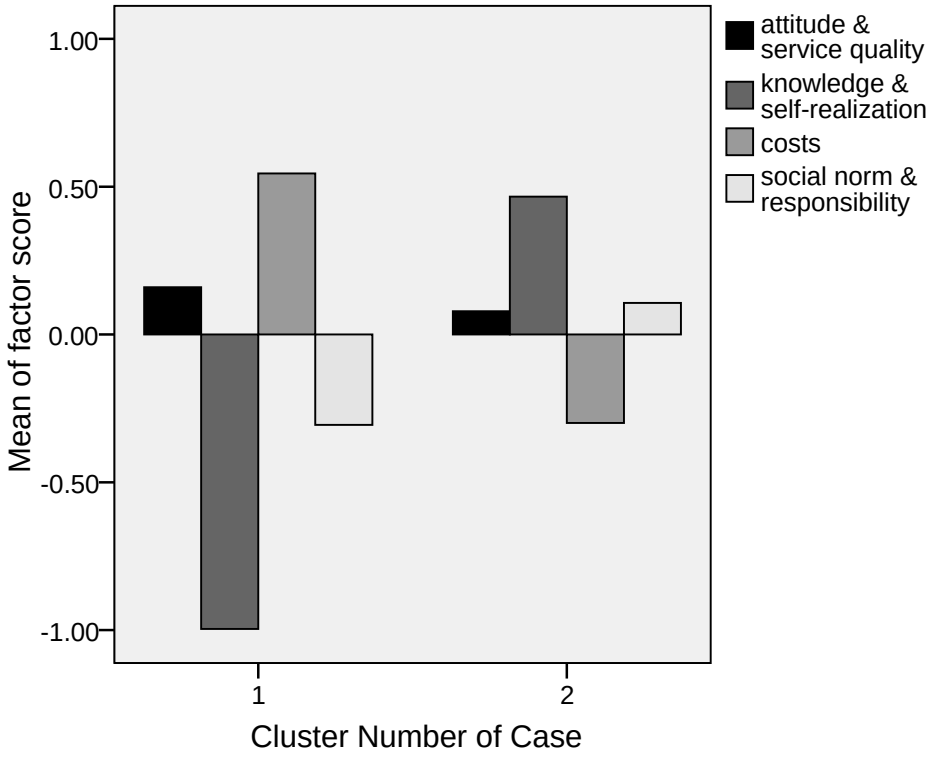

Figure 4.12: The Segments' Characteristics in the RMOW

4.2 MSWM in Dalian

4.2.1 Background: MSWM in China

4.2.1.1 Waste Generation and Treatments

The trend in waste generation in China also parallels the trend in economic growth. From 1979 to 1995, the average annual rate of increase in MSW in China had been 9% (Zang, 1998), slightly below the average annual growth of the gross domestic product at 10% in the same period of time (United Nations Statistics Division, 2007). Soon after entering the new century, China overtook and outstripped the US, becoming the biggest MSW generator in the world. Moreover, the amount of MSW is projected to double by 2030 (Dan Hoornweg et al., 2005) (Figure 4.13). Most cities are facing the challenge of dealing with a large amount of MSW. Safe disposal remains the primary goal for waste management in China. According to the Urban Construction Statistical Year Book, 63% of MSW was safely disposed of in 1999; however, landfill remains the major disposal method, and most of these "safe" landfills do not meet the national standards (Xu, 2002). The Economist (2004) reported that only about 20% of MSW in China has been safely treated and disposed. Approximately two thirds of China's cities are surrounded by garbage dumps (Min et al., 2002). With their more rapid economic growth, cities in the eastern coast faces a stronger pressure and more challenges then cities in central and western China as they need to deal with a larger amount of net increase (Figure 4.14).

Facing the pressure of increasing MSW, large cities started to direct greater efforts towards recycling and recovery. Eight cities – Bejing, Shanghai, Xiamen, Guilin, Guangzhou, Nanjing, Shenzhen, and Hangzhou – were designated in 2000 as pilots for MSW separation systems. However, none of these programs has been viably and effectively operated at the city level mainly because of unsatisfied participation rates in formal programs and difficulties in finding good uses of certain end products such as composting. Some successful cases have only been implemented in residential

communities with property management (Interview D02).

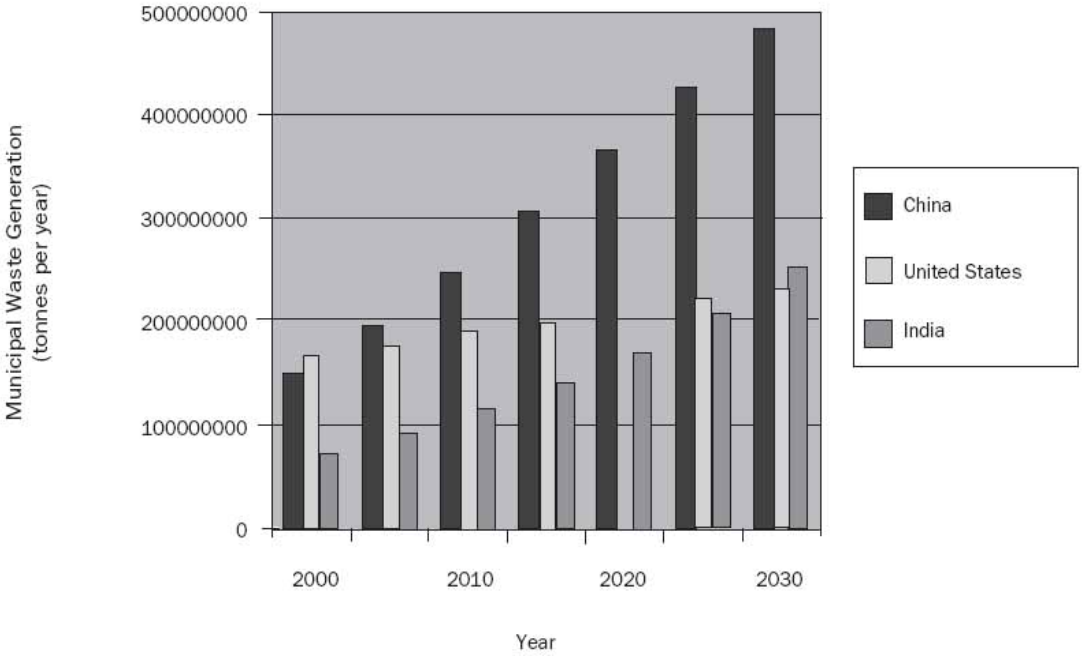

Figure 4.13: Projected MSW Generation in China, India and the US

Source: (Dan Hoornweg et al., 2005)

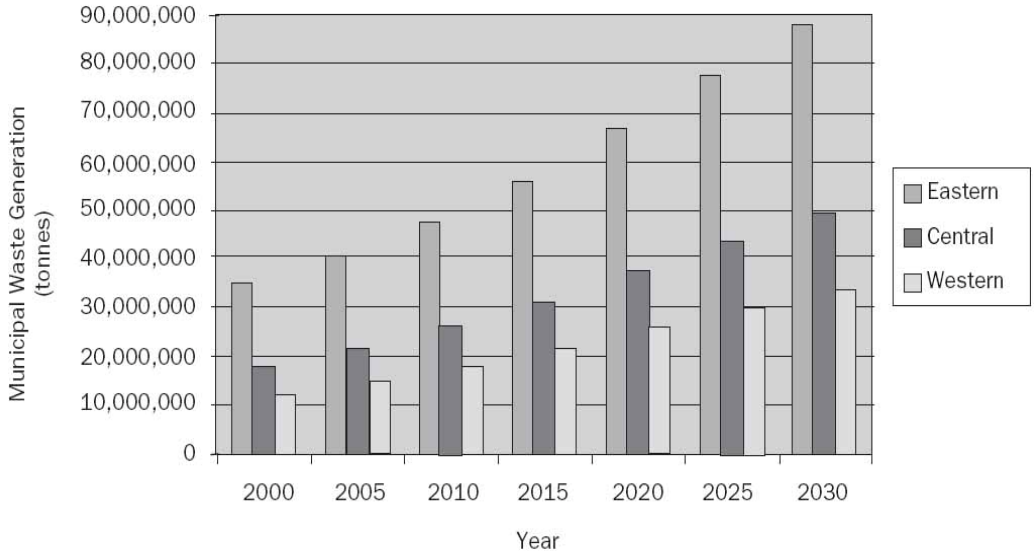

Figure 4.14: Projected Municipal Waste Generation in Urban Areas in China

Source: (Dan Hoornweg et al., 2005).

4.2.1.2 Regulations and Policies

In China, legislation exists pertaining specifically to solid waste management. It consists of laws (promulgated by the People's Congress), administrative regulations (issued by the State Council), ministerial regulations (issued by SEPA and other Ministries), local regulations (issued by provincial and municipal governments), and technical standards (issued by SEPA and other Ministries) (J. Li et al., 1998). The duties of MSWM are specified by the *Law of the P. R. China on Prevention of Environmental Pollution Caused by Solid Waste* (Article 10) [Zhonghuarenmingongheguo guti feiwu huanjing wuran fangzhifa]: "The administrative department in charge of the environment and public health under the local people's government at the county level or above shall be in charge of the supervision and administration of cleaning, collection, storage, transportation, and disposal of residential wastes." This department usually also delivers waste collection and treatment services. This mixed mission of the local administrative department results in a lack of external supervision for waste services. The State Environment Protection Administration administers and monitors hazardous waste disposal and waste trade, and regards the waste treatment facilities as general projects during construction and as general pollution sources during operation (Interview B01). However, the administration of waste recycling and recovery is more complicated since it is under the umbrella of the circular economy and other general policies involving multiple divisions in the government. The efficiency of the current legal system declines when multiple divisions are involved as duties often overlap with various divisions within governments, and legal responsibility is not specifically defined for each division or administrative department (J. Li et al., 1998).

National policies are also present to encourage recycling and recovery, e.g., "Vigorously promote incineration, composting, and other comprehensive utilization of MSW (NDRC, 2006a)", and "establish waste separation and collection systems and continuously improve renewable resource recycling systems (The State Council, 2005)". Financial

incentives also exist concomitant with the policies. For example, enterprises for waste recycling are exempted from the Value Added Tax (MOF, 2001), and electricity produced from renewable energy including MSW incineration enjoys a subsidized price (NDRC, 2006b). Thesis initiatives have encouraged various treatment methods other than landfilling. For instance, the waste incineration plant and waste recycling companies, such as Shengda, in Dalian have been benefited from and encouraged by these policies.

4.2.1.3 Financial Resources

The shortage of technical and financial resources is a common impediment to waste management in developing countries (ISWA, 2002). The financial resources for MSWM in China are also insufficient. Xu (2002) argued that the financial resources budgeted for MSWM were only approximately 18% of the total demand for treatment in line with the national standards. In 2002, municipal governments were allowed to charge a waste service fee according to the *Circular* jointly issued by four Ministries (NDPC et al., 2002). However, this fee does not solve all the financial difficulties widely to be encountered. Hu et al. (2006) argued that in 171 cities that started charging the waste service fee from 2002, the revenue could only cover 20% to 50% of the total budget, and in some cities, as few as 20% of households had been paying this fee as required. The financial difficulties limited cities' capacity for carrying out effective plans for increasing safe disposal and diversion rates.

4.2.1.4 Informal Diversion Activities

ISWA (2002) reported that scavenging activities usually took place in developing countries, either before and during collection or at disposal sites. Scavengers are a major component of the informal sector in China's waste management system. It is estimated that approximately two million scavengers are present in China (Zhang, 2004: 231) and 80,000 in Beijing alone (Jin et al., 2001). Efforts have been made to better manage these itinerant scavengers, but none of them has been successful. The mass media reported the

failure of China's "first case" of the enterprisation of scavengers in Lin'an, Zhejiang Province in 2004 due to the charge to scavengers for registration (Qian & Wang, 2004). How this unskilled, uneducated labour force could be better managed remains a challenge to municipal governments. As one of the most significant differences in MSWM systems between developed and developing countries, issues pertaining to the informal sector will receive great considerations in the comparisons and discussions in the following chapters.

4.2.2 An Overview of MSWM Systems in Dalian

Dalian City is located at the southern end of Liaodong Peninsula, Liaoning Province, north-eastern China (Figure 4.15). It is comprised of ten Districts. This thesis is concerned with five of ten, whose MSWM duties are unified under the Dalian municipal government. These Districts include Zhongshan, Xigang, Shahekou, Ganjingzi, and Lüshunkou Districts, in which approximately 2.07 million people dwell in 740,678 homes (Dalian Statistical Year Book, 2004). It is estimated that approximately 294,700 metric tonnes of wastes are generated from these dwellings annually or 0.39 kg per capita per day (Interview D02). Residential wastes account for approximately 40% of the total MSW stream. Commercial, institutional, and street sweeping wastes make up the remaining proportion. About 3% of residential wastes, mainly plastics, metals, beer bottles, and obsolete electronic wastes, are sold directly by residents to informal agents such as itinerant junk-buyers and redemption centres (Interview D02). Some valuable items remain in the mixed garbage stream and are further diverted during collection and at the landfill site by sanitary workers and scavengers. The major proportion (up to over 80%) remaining in the garbage stream are the organics (Wang et al., 2001). However, no reliable study has been conducted on the aggregate diversion rate (Figure 4.16). Currently, landfill remains the major disposal method. Nevertheless, Dalian faces a severe shortage of landfill capacity. The landfill site will close in five years at the current landfilling pace (Interview D02). As a response to this shortage, an incineration plant is under construction and will start operating by the end of 2008.

Figure 4.15: The Location of Dalian

Source: Atlas-Xpeditions, Retrieved June, 2008 from http://www.nationalgeographic.com/xpeditions/atlas/

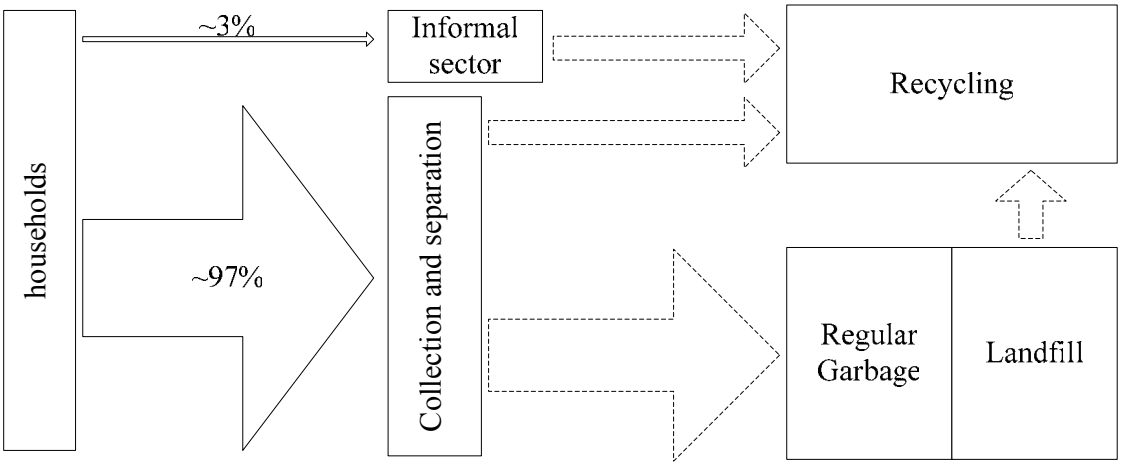

Figure 4.16: The Waste Stream in Dalian City

Note: the dotted line represents that reliable figures of the indicated waste stream are absent.

Source: the interview with the manager in the Environment and Sanitation Department, Dalian Construction Bureau.

The structure of the MSWM system in Dalian is more complicated than in the RMOW. Wastes in homes are roughly separated into two categories: garbage and recyclables (Figure 4.17). The municipal government has the responsibility for garbage collection, transportation, and disposal. Garbage is thrown out at designated collection points near residential buildings and then put into black plastic bags or, in some communities, interred garbage bins, which prevent scavenging. The bagged garbage is picked up daily by compact trucks, and transported to the landfill site. Construction wastes and large stiff items that can not be handled by compact trucks are collected and transported separately (Interview D02). By the end of 2008, most garbage will be sent to the incineration plant for energy recovery with electricity production. Residents pay for such services and street sweeping at about RMB¥ 2 (about CAN¢ 30) per household per month, and it is expected to be increased to RMB¥ 6 in the next few years (Interview D02). This revenue only covers approximately 20% of the total waste management budget. The remaining proportion is made up by tipping fees and government appropriations.

As opposed to garbage collection, recycling is undertaken mainly by informal agents, who divert items that have market value, e.g., plastics, paper products, metals, beer bottles, and obsolete electronic wastes. The diversion of these items is a profit-driven activity and is neither authorized by nor directly supported by the government. The diversion is conducted in three major ways: First, residents directly sell wastes to junk-buyers or nearby primary redemption centres; second, sanitary workers who collect garbage in residential communities collect and sell valuable wastes; and third, scavengers pick up valuable wastes at garbage collection points or the landfill site and sell them to redemption centres. Most of these redemption centres had been state-owned enterprises until the structural reform in 1993 when all these redemption centres were divorced from the public sector (Interview D02). It is estimated that approximately 600 primary and 200 secondary and tertiary redemption centres are present in Dalian (Interview D04). The primary redemption centres receive assorted wastes and further separate and sell them to secondary and tertiary redemption centres that are generally bigger in size and deal mainly with separate wastes. For example, approximately 40 secondary and two tertiary redemption centres are dealing mainly with paper wastes (Interview D04). The sorted

wastes are further sold for material recovery. However, some wastes are transported to small recycling plants outside of the city for processing due to competitive prices, causing pollution to the environment and risks to health in transportation and treatment. Pollution and health risks are severe shortcomings of the unregulated recycling system in China (Interview D05).

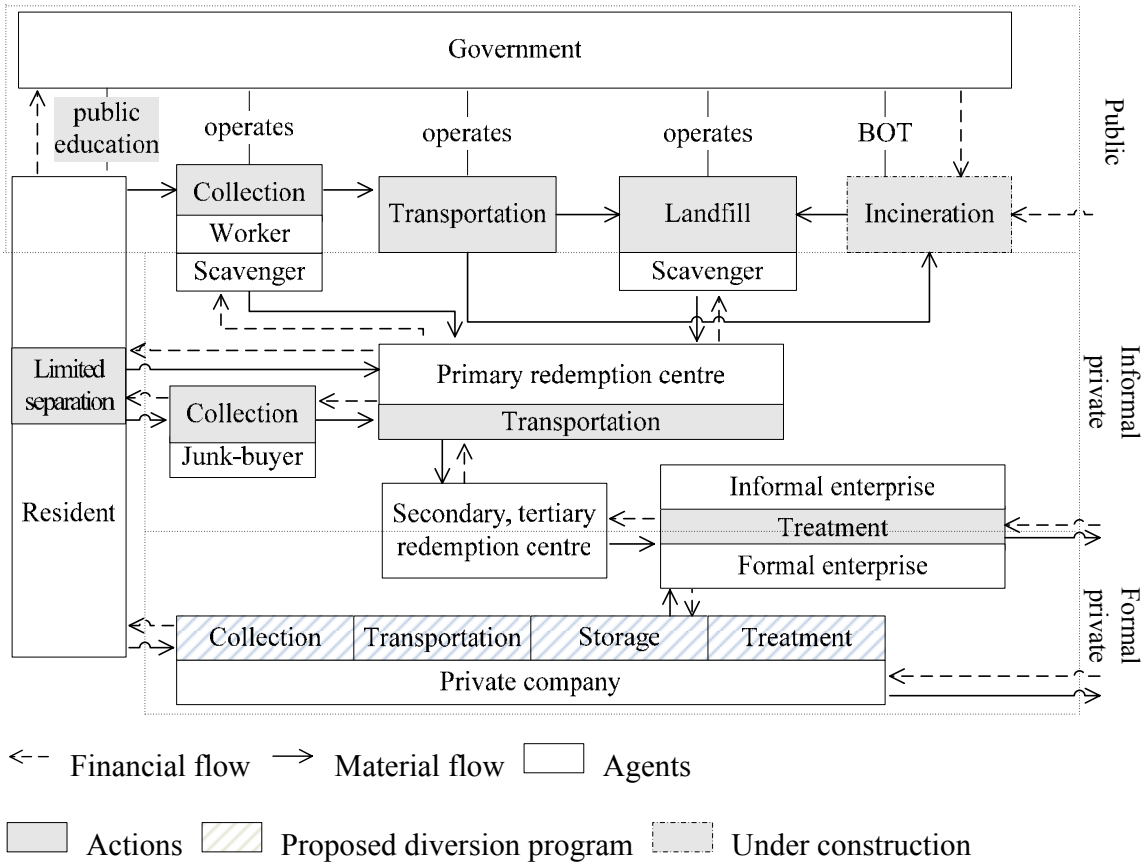

Figure 4.17: The Waste Management System in Dalian

Note: BOT stands for Build-Operation-Transfer contract.

Source: Interviews with the manager in the Environment and Sanitation Department, Dalian Construction Bureau, and Dalian Environmental Protection Association.

4.2.3 Efforts on Waste Diversion Programs

4.2.3.1 The Recycling Pilot Program

Excluded from the state-owned enterprises, waste redemption centres have been largely operated by the informal sector. In May 2007, Shengda Holding Inc., a private company

specialized in recycling plastics and obsolete products, officially proposed to establish a city-wide recycling system with new redemption centres. The program aims to improve recycling and recovery, to promote environmental protection, and to create job opportunities for the unemployed (Interview D03). These aims are consistent with the national policy on waste reduction, recycling, and recovery. Establishing a recycling system is also one of major tasks to support the circular economy in Dalian.

The proposed recycling network includes primary redemption centres in residential communities, a logistic system, and two storage and processing centres where wastes are further separated, sorted, and then freighted (Figure 4.17). The full-scale city-wide program includes about 300 primary redemption centres, each one of which serves 1,500 to 2,000 homes (Interview D01). In the first phase, a pilot program in Shahekou District was granted by the municipal government and it resulted in 30 redemption centres being scattered throughout various types of residential communities. Each redemption centre will be equipped with four to eight itinerant collection vehicles and on average six employees (Interview D03). As a part of the unified management in this program, all the redemption centres will share an open, identical redemption price for each type of waste received. All recyclables received will be transported to storage and processing centres and collectively freighted to processors (Interview D03).

This project presents a brand new city-level recycling system independent of the current informal recycling system. Shengda designated a brand name, as a part of the unified visual identification, for the recycling system: “Ximin”, a Chinese name meaning connecting people. The manager also set up standards for this formal waste service: the so-called “six unifications” – unified administration, qualification, visual identification, measurements, vehicles, and clothing (Interview D03). The rationale for this program was that multiple levels of informal agents were present in the route from waste generation at homes to final processing, i.e., junk-buyers, primary, secondary, and maybe tertiary redemption centres, who all made profits from the same items recycled. Therefore, if the entire process was managed by one administrative system, the route of recycling would be shortened, and recycling would become a viable business as long as it remains above a scale threshold (Interview D04).

However, this plan is easier said than done. The first challenge is to mitigate the impacts on the city image. According to the proposal, each redemption centre requires a 20 m^2 cabin beside the street for auditing, bookkeeping, and temporary storage of recyclables. At the initial stage when the draft plan was reviewed by the municipal government, the number of redemption centres was considered too large. The government is concerned with the risk that these cabins will blemish the urban landscape and city image. Thus the final number appearing in the official proposal has been curtailed to 300 and 30 in the pilot area with careful location to mitigate any negative impact (Interview D02). Secondly, this program is a totally self-funded program that is relying mainly on commercial loans. Viability and profitability inevitably become top priorities. The government, however, considers the program a public service that is for public interests and contributes to waste recycling and recovery rather than a private project that is subjected to market demands, and thus pushes the program to divert more types of wastes that are technically recyclable but not profitable, such as non-beer glass bottles and containers (Interview D02). Meanwhile, Shengda has to strive for a large volume of recycling to reach a breakeven point. It can only be accomplished with a satisfactory participation rate, for which Shengda will inevitably compete with informal agents. Encouraging participation will require considerable promotion, but no specific promotional strategy was articulated in the project proposal.

4.2.3.2 The Community Organic Diversion Program

Another example of waste diversion in Dalian is a community-level organic waste diversion program in Dayou Tianyuan a "National Environmentally Friendly Project" (*guojia huanjing youhao gongcheng*) (Xinhua News Agency, 2006). It is an enclosed residential community with approximately 1,600 homes (Interview D06). Waste separation and organic waste treatment are a part of the integral plan of Dayou Tianyuan. The program is organized and exercised by the property management corporation. Multi-level waste separation is applied: Residents are requested to separate wastes and put them in in-organic or organic waste garbage bins. After collection, all wastes are further manually separated at the processing centres located within the community. The waste separation program is promoted by the property management company, e.g.,

calendars and campaigns for “environmentally friendly family” (Interview D06). In spite of these efforts to communicate with and educate the residents, wastes are not being sufficiently separated at source so that manual separation is still required. The organic wastes are processed at the processing centres in bioreactors for biological decomposition. Currently, Dayou Tianyuan has two bioreactors that have a 400 to 500 kg daily treatment capacity, basically satisfying the demand within the community. Other residential wastes in Dayou Tianyuan are treated the same as they are in other residential communities: Recyclables are sold to adjacent redemption centres, and the remaining mixed garbage is collected by regular waste services and landfilled (Interview D06). All products from biological decomposition are used within the community for vegetation maintenance. No financial revenue is generated from the diverted organic wastes. As a part of the services offered by the property management company, the major resource financing this program is the property management fee paid by the residents in the community (Interview D06).

As a proportion of the demonstration “National Environmentally Friendly Project”, the diversion and in-site treatment of organic wastes offer a feasible alternative approach to deal with residential organic waste. However, there are a number of barriers to the expansion of such community-based organic diversion programs. First, the organic diversion program in Dayou Tianyuan is a profit-free, private company driven project. It is a part of the whole project plan, which has earned Dayou the honour of “National Environmentally Friendly Project”. For other developers and property management companies, no incentive or financial subsidy is in place to encourage a single waste diversion program without being embedded in a bigger plan. Second, although it is limited, the odour resulting from manual waste separation and treatment is still a nuisance to the homes adjacent to the processing centres (Interview D01; Observation). Third, the local Construction Bureau is concerned with the risk of pollution and contamination within the community caused by the treatment facility (Interview D01). The risk might not be significant in one project, but would be if such treatment facilities are scattered in a large number of communities. Finally, the Bureau also considers such programs not economically efficient compared with centralized treatment centres (Interview D01). Consequently, most property management companies have not yet shown interest in setting up their own bioreactors in their communities.

4.2.4 Participation in Waste Separation

A face-to-face interview-based survey was conducted in two communities at Jiefang Square and Heishijiao in Dalian. 44 valid copies of the survey were conducted, while 32 attempts were declined (Table 4.8). A summary of the survey in Dalian is attached in Appendix III.

Table 4.8: The Summary of Survey Collected in Dalian

Area	Valid	Declined	Total Attempted	Response rate %
Jiefang Square.	23	14	37	62.16
Heishijiao St.	21	18	39	53.85
Total	44	32	76	57.89

According to the survey, public service advertisements on TV and newspaper are deemed the most effective media for publicizing waste separation and other issues concerning environmental protection. The government also set up a hotline for enquiries for MSWM, but only a few residents have taken advantage of it (Figure 4.18). These channels are rarely set up specifically for publicizing waste separation, but for waste management and environmental protection in general. Information disseminated can be comprehensive and not oriented to specific programs. The survey result showed over half of residents reported “do not know” or “know little” about the requirements pertaining to waste separation (Figure 4.19). Approximately 80% of residents ordinarily separate wastes at home (Figure 4.20). Items commonly separated from garbage include recyclables (metals, cans, beer and plastic bottles, and paper products) and electronic wastes, both of which can be redeemed. In addition, big items and construction wastes that can not be transported by compact trucks and hazardous wastes, such as explosive and toxic wastes, are required to be separated and are collected separately. Only a minor proportion of residents actually separate these types of wastes (Figure 4.21).

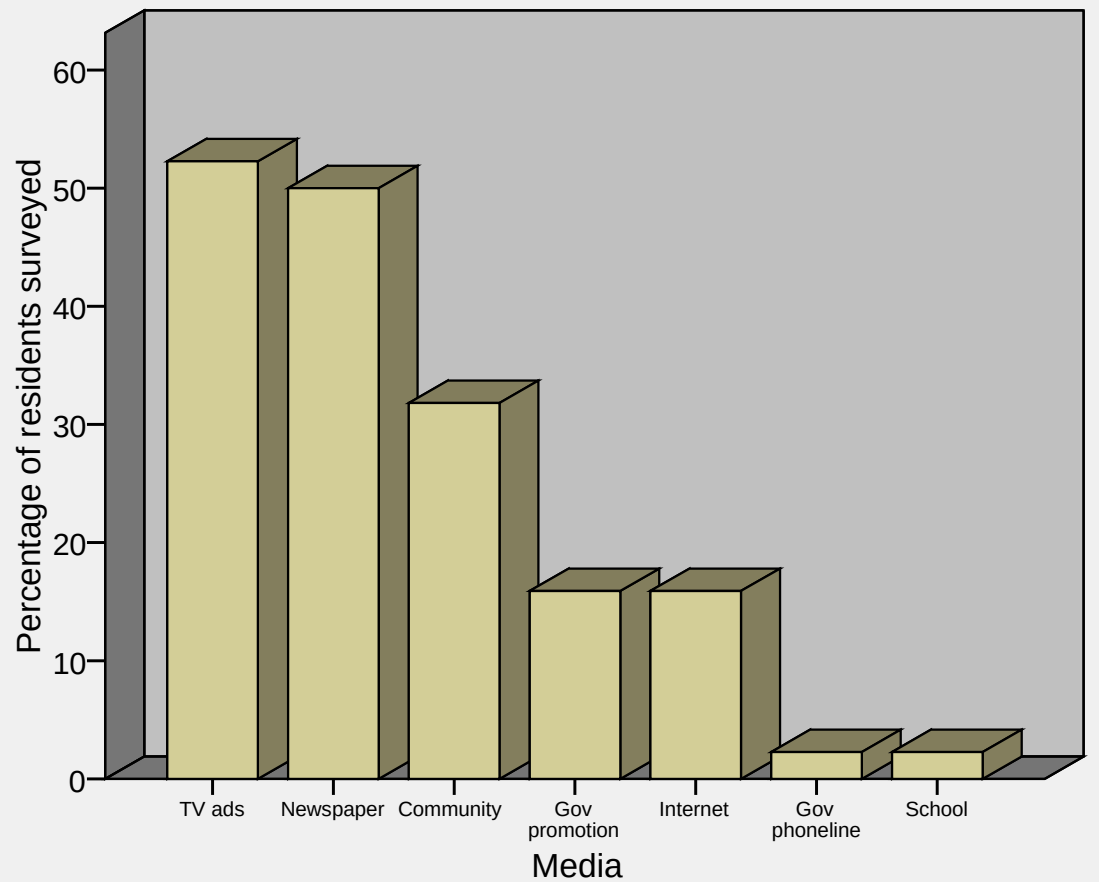

Figure 4.18: Media for Publicizing Waste Separation in Dalian

Source: survey.

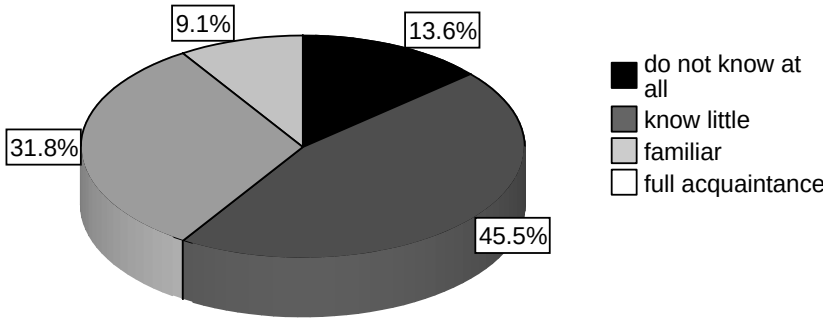

Figure 4.19: Acquaintance with Waste Separation Requirements in Dalian

Source: survey.

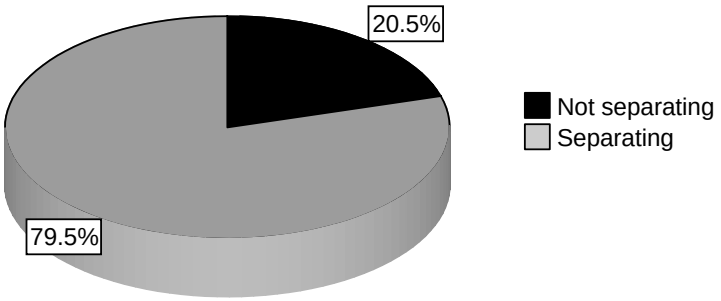

Figure 4.20: The Percentage of Residents Separating Wastes in Dalian

Source: survey.

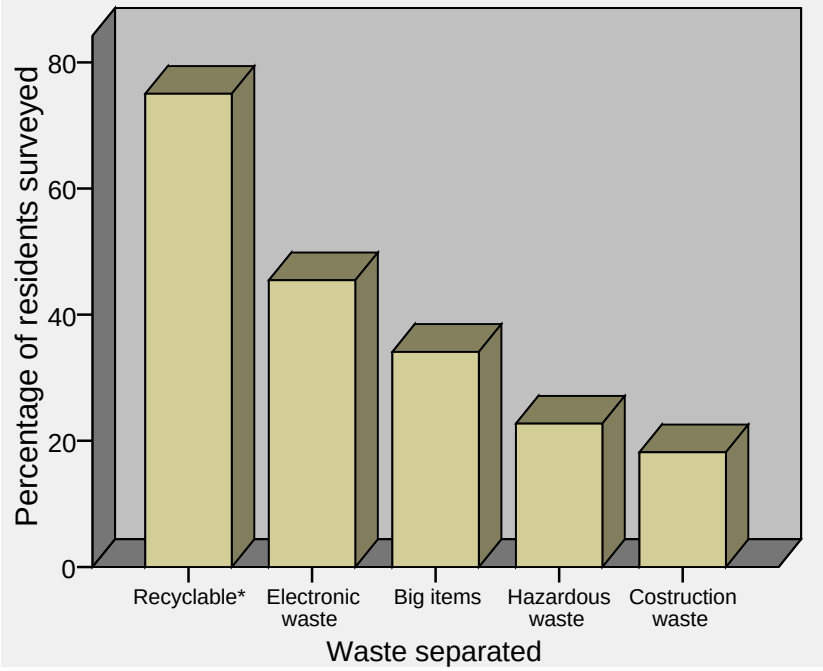

Figure 4.21: Types of Wastes Separated in Dalian

* : including metal, plastics, cardboard, cans, beer bottles, etc.

Source: surveyOver 90% of those who separate wastes at home sell or give recyclables or electronic wastes to junk-buyers, while approximately 45% also sell wastes directly to redemption centres (Figure 4.22). A portion of obsolete electronic products are also sold to second hand markets for reuse. Separate garbage bins in residential communities become the least common destination of separated wastes.

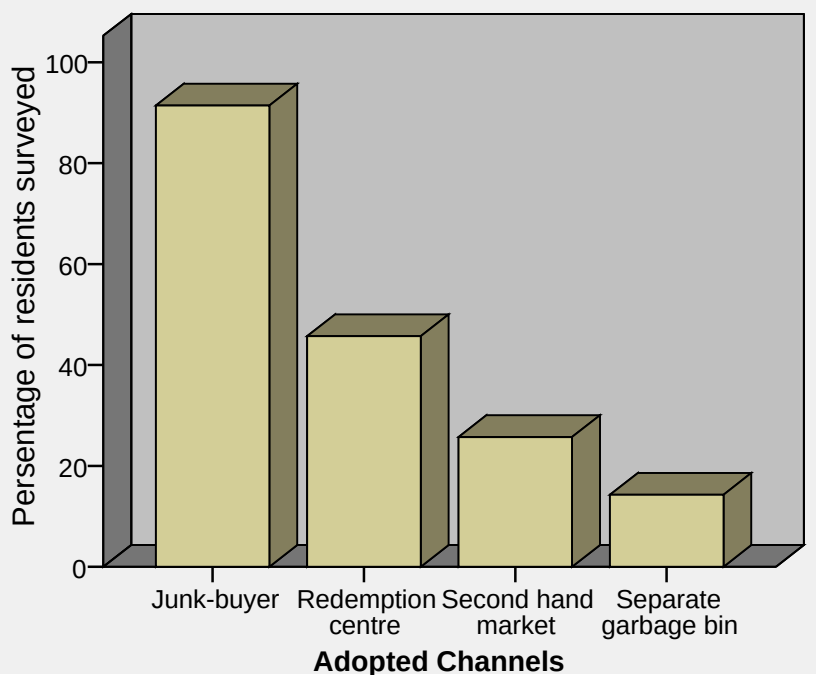

Figure 4.22: Channels of Source Separated Waste Collection in Dalian

Source: survey.

4.2.5 Motivators for Waste Separation

The factor analysis for Dalian's case includes 35 individual cases that ordinarily separate wastes at home. Five factors with the eigenvaluse greater than 1.0 were obtained, which in aggregate explain 68.5% of the total variance (Table 4.9). For each variable, the factor that has a correlation greater than 0.5 with that variable is underlined (Table 4.10).

These five major motivators can be summarized as: (1) attitude and self-realization, (2) municipal service quality, (3) social norm and knowledge, (4) obedience, and (5) compensation. The first two motivators have a similar accountability for the total variance (about 17% for each). The first factor is highly correlated with environmental attitudes and self-realization in terms of contributing to environmental protection and realizing their obligations of citizenship; the second factor concerns the convenience and clearness of municipal waste services. The third factor is correlated with the social norm and knowledge about waste treatment and negatively correlated with the convenience of recyclable collection. The fourth factor indicates the degree to which participants are

obedient to the request and consider the charge for waste service reasonable. Finally, the fifth factor concerns monetary compensation from waste redemption and is negatively correlated with garbage reduction.

Table 4.9: Total Variance Explained: the Case of Dalian

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.896	22.279	22.279	2.259	17.380	17.380
2	1.845	14.193	36.473	2.225	17.119	34.499
3	1.774	13.647	50.120	1.662	12.786	47.284
4	1.284	9.878	59.998	1.469	11.297	58.581
5	1.107	8.512	68.510	1.291	9.929	68.510
6	.947	7.282	75.792			
7	.769	5.917	81.709			
8	.723	5.558	87.268			
9	.628	4.827	92.095			
10	.465	3.577	95.672			
11	.244	1.879	97.551			
12	.175	1.350	98.901			
13	.143	1.099	100.000			

Extraction Method: Principal Component Analysis.

4.2.6 Market Segmentation and Features

In the case of Dalian, the K-means clustering method is also employed. For each case, the factor scores are also assigned by the regression method. The first two factor scores, however, are scattered without an apparent agglomeration (Figure 4.23). After excluding the outliers, a revised result with two cluster centres is shown in Table 4.11, and the cluster centres of each cluster are tabulated in Table 4.12.

Table 4.10: Rotated Factor Matrix: the Case of Dalian

	Factor				
	attitude & self-realization	Municipal service quality	social norm & knowledge	obedience	compensation
benefiting the natural environment	**.834**	.151	-.126	-.173	.256
self contribution to environmental protection	**.827**	.175	.100	.035	-.135
sense of citizenship	**.531**	-.017	.345	.233	-.101
service quality	-.192	**.852**	-.031	.092	.108
convenience of garbage collection	.303	**.787**	-.238	-.044	.087
important for better managing wastes	.274	**.709**	.150	.173	.005
convenience of recyclable collection	-.135	.199	**-.684**	.151	.066
neighbours' behaviour	-.075	.037	**.629**	.055	.193
knowledge about the treatment site and procedure	.165	.493	**.597**	-.060	-.250
requested to participate	-.180	.175	.127	**.835**	.112
reasonable service fee	.323	.007	-.368	**.649**	-.010
the revenue of selling recyclables	.076	.097	-.009	.132	**.887**
reducing the volume of garbage	.448	-.026	-.257	.422	**-.524**

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 10 iterations.

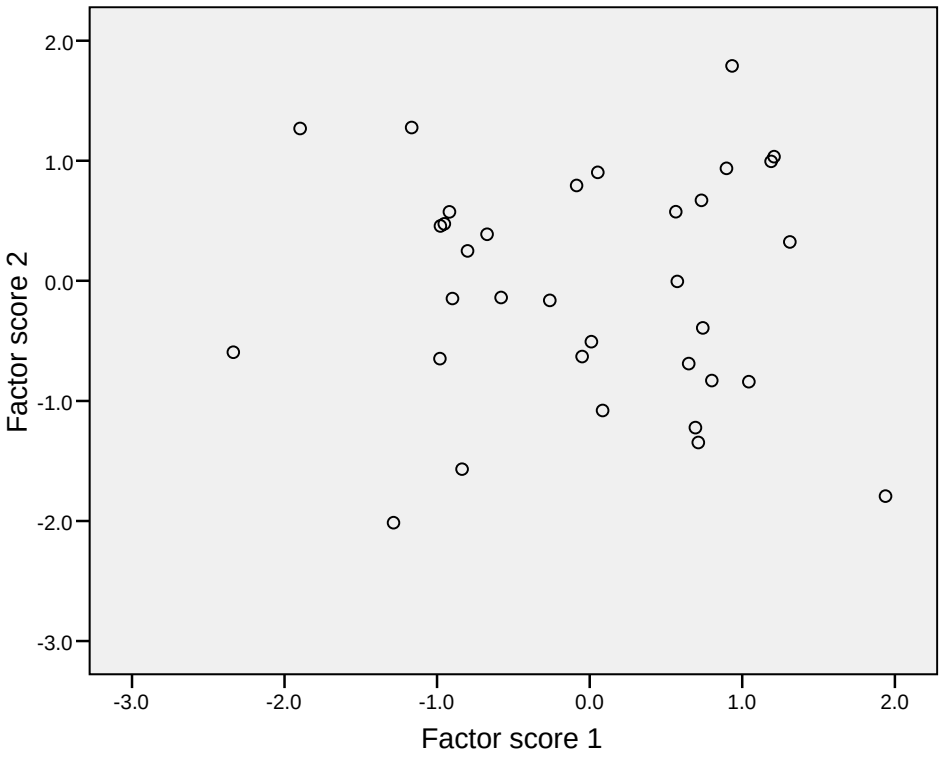

Figure 4.23: Scatterplot of Factor 1 and 2 in Dalian

Table 4.11: The Number of Cases in Each Cluster in Dalian

Cluster	Number of cases	% of total cases
1	23	67.65
2	11	32.35
Total valid	34	100.000

Table 4.12: Final Cluster Centers in Dalian

Factor	Cluster	
	1	2
attitude and self-realization	-.16017	.28353
municipal service quality	-.14121	.12307
social norm and knowledge	-.42072***	.57089***
Obedience	-.24072***	.73585***
Compensation	.29021***	-.70886***

***: Statistically significantly different (α=0.01).

Approximately 68% of cases are grouped in cluster one and 32% in cluster two. An independent T-test reveals that three factors in the two clusters are statistically different at the 1% significant level so that there is a significant discrepancy between clusters and the clustering results are acceptable. The other two factors, attitude and self-realization and municipal service quality, are not statistically different between these two clusters (Table 4.12).

About two thirds of participants—cluster one—scored higher on monetary compensation but lower on social norm and knowledge, and obedience. This cluster represents a segment that is strongly encouraged by the compensation from waste redemption. The remaining one third – cluster two – is encouraged more by non-monetary stimuli, i.e., the social norm, knowledge, and direct requests (Figure 4.24).

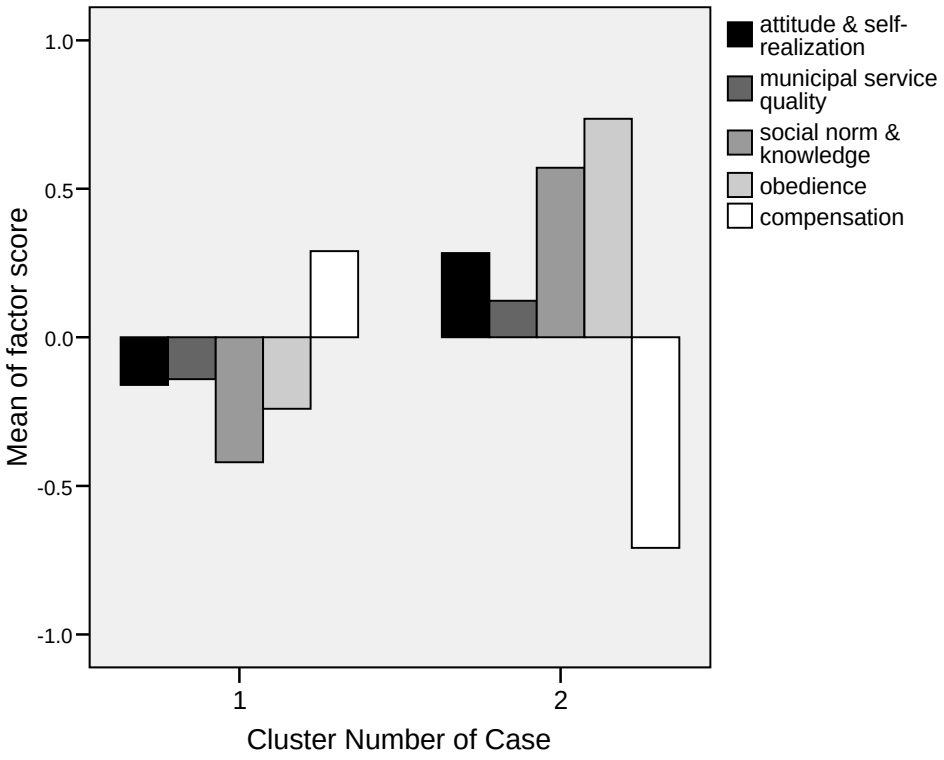

Figure 4.24: The Segments' Characteristics in Dalian

4.3 A Summary of Case Studies

The descriptions of these two case studies illustrated major elements of the systematic model that was illustrated in Section 2.4.2. Waste generation and diversion rates, regulations, policies, and resources available for MSWM in Canada and China were introduced as overall backgrounds for the two cases. At the municipal level, the description of population, waste generation, collection, treatment, and organizations of and markets for specific programs touched upon some key components in the system model: residents, governments, the formal private sector, and the informal sector. Particular attention was paid to residents to explore the major motivators for participation and features of the two market segments that were respectively identified in the two case studies. Based on the systematic model, the waste and financial flows in the two cases were also depicted to illustrate the structures of the waste management systems. These components and structures will be compared respectively in the following chapter.

CHAPTER 5 THE COMPARISON OF MSWM SYSTEMS

Major contents of the comparison in this Chapter are organized based on the system model proposed in Section 2.2.4. In order to gain a better understanding of the background of MSWM in each case, the comparison begins with analysing and contrasting the overall stage of waste diversion and administration which pertains to factors of policies and budgets in the systematic model (Section 5.1). Following the overall stage of waste diversion and administration, comparisons are focused on the three essential aspects of systems, i.e., components, structures, and processes (interaction and integration) (Section 5.2 to 5.4). These sections do not intend to investigate an exhaustive list of all components and their interactions, and all aspects concerning the structures, but concentrate on the ones that represent significant differences observed in this study. Finally, a summary of the comparisons is presented to offer some reflections from a perspective of integrated approaches (Section 5.5).

5.1 Overall Stage

5.1.1 Safe Disposal and Diversion Rates

In China, the average safe waste disposal rate is reported as low as 20% (The Economist, 2004). In Dalian, to achieve safe disposal – detoxification and reducing contamination of air, water, and soil – is still the principal goal of MSWM, while further goals are recycling and energy recovery (Interview D01). Dalian has recently completed the third phase project of the landfill site, setting up leachate and landfill gas collection facilities to limit contaminations. In Canada, safe disposal is not a current focal point of MSWM. A higher waste diversion rate is deemed to be the present objective. In the RMOW, the waste diversion rate is over 40% but still short of the 60% target set by the provincial government. This provincial target of diversion has boosted efforts towards organic waste diversion programs as they are considered necessary to attain the provincial objective. In Dalian, a formal waste diversion program has recently been proposed, but the data of aggregate waste diversion rates are unavailable, and no clear objective for recycling and recovery has been defined.

5.1.2 Overall Waste Planning and Administration

Whether and to what extent waste diversion is emphasized in overall waste planning and administration is contingent upon the motivation and capacity to make such an emphasis. Waste diversion in the RMOW is motivated by potential costs associated with siting new landfills and the provincial objective of 60% diversion by the end of 2008. After all, landfill remains a necessary disposal method, and lessons in the past two decades have repeatedly shown that siting new landfills could take over 10 years and cost millions of dollars, and would possibly also cause political and social pressures which can not be labelled in strict terms (Hostovsky, 2006). In Dalian, waste diversion is driven more by positive incentives such as national policies that promote waste recycling and recovery and tax exemptions for recycling companies; however, strict requirements or diversion targets remain absent. In both cases, local governments tend to be rather conservative and risk-adverse in their decision making. With the specific provincial target on diversion rates and tangible evidence and experiences in the past two decades in Ontario where siting new landfills had resulted in large expenses and controversies, the RMOW is more motivated to make a strong emphasis on planning for waste diversion. In Dalian, on the contrary, motivations are merely incentives where no risk of punishments or controversies was solidly associated with inaction.

The capacities for effective and efficient waste planning and administration are built on basic data and research on waste management. In the RMOW, the regional municipal government is auditing the waste stream, reviewing diversion programs, and sharing experiences with neighbouring communities. Prior to the Green Bin pilot program, for example, the government referenced similar organic waste diversion programs in other municipalities such as Halton and Halifax before the outset (Interview W01). After the first phase of the pilot program, a survey of residents in all pilot areas was conducted to obtain feedback. The research and studies both before and after a pilot program help improve the plan for and the operation of diversion programs. In spite of these efforts, to budget this program initially remained difficult due to the uncertainty in participation rates. In Dalian, limited successful experiences in waste diversion could be shared with other Chinese cities in a similar context since no one has been operating an effective

diversion program at the city level. The government keeps monitoring the garbage stream. However, some basic data, such as the inter-city movement of recyclables and aggregated diversion rates, are either absent or inaccurate (Interview D05). The absence and inaccuracy of necessary information create difficulties for waste management research and planning, and ultimately to decision making concerning waste diversion.

Resources, especially financial resources, are a crucial determinator of the extent to which waste diversion initiatives can be implemented because, as exemplified by the Blue Box and Green Bin programs in Ontario, waste diversion programs can be considerably expensive. The RMOW is a relatively affluent region. Plus, the government is rather "green" and supportive of efforts aimed at improving waste diversion. Residents, as tax payers who are the source of governments' funds, are also supportive of "green" practices as reflected in the Green Bin pilot program where the majority of residents participated in and support the program. The opportunity cost of the resources spent on waste diversion is relatively low in comparison with that in Dalian. Generally in China, available resources for waste management are insufficient (Xu, 2002). Dalian is not an exception. As a part of a rapidly growing region located in the east coast, Dalian continuously demands a large amount of resources to upgrade and maintain its infrastructure. Given the uncertain viability and profitability and the high opportunity cost, waste diversion programs can hardly be fully financed by governments alone. In short, the Dalian government has less strong capacities in planning and administration and less sufficient resources to be allocated for waste management. Appropriate public-private cooperation must be involved in the operation of waste diversion programs.

5.2 System Components

5.2.1 Residents

A fundamental difference which directly impacts waste services is population density and major types of residential buildings. As opposed to townhouses in the RMOW, the major residential building type in Dalian is apartments where both indoor storage areas and outside public spaces are limited. The total number of households in Dailan is

approximately four times that found in the RMOW. Waste services for densely populated communities need to be different from those for low density townhouses. Such dense communities require, for example, larger garbage bins, shared collection points, and more frequent cleaning and transportation. In fact, curbside-pick-up service is not very effective for apartment buildings in the RMOW and Hamilton, and managers are considering the options to improve services and participation in apartment buildings (Interview W02; H01).

According to the survey, the chief motivators for residents to separate wastes share certain similarities in the two cases. Attitude and self-realization are the major psychological factors, while service convenience and quality are the major programmatic factors. These factors – the first one in the RMOW and the first two in Dalian – are equally important for all segments and explain a large proportion of the total variance: 40.7% in the RMOW and 34.5% in Dalian. That is, a commonality of the motivators among participants is their attitude towards the environment and the degree to which they consider waste services as being satisfactory and convenient. A study has also concluded similar results from the other way around: being indifference (a lack of pro-environmental attitude), and location issues and household nuisance (poor service convenience and quality) could be identified as "salient dimensions" of the reason for not participating in diversion programs (Howenstine, 1993).

The cluster analysis has further revealed several different features in the main motivators for waste separation of each segment. The majority (two thirds) of participants in the RMOW are more self-motivated: They have more knowledge about waste treatment and deem contributing to the environment through participating in waste separation programs; meanwhile they consider the cost for participation relatively high compared with the remaining one third of the participants. In Dalian, by contrast, two thirds of the participants are motivated more by financial incentives, i.e., the compensation from waste redemption, whereas the fee charged for waste services does not provide any incentive for

reducing waste generation. The remaining one third of the participants in Dalian are motivated more by other factors such as social norm and direct requests. In both cases, the perception of financial factors – in terms of costs in the RMOW and compensation in Dalian – is an important feature that segments the customers. In RMOW, more highly self-motivated participants could accept a more highly perceived cost, whereas in Dalian, participants who are less motivated by social norm and request perceive compensation being more important.

5.2.2 The Informal Private Sector

The informal sector, which is absent in the RMOW, plays an important role in waste diversion in Dalian. It is common in China that junk-buyers, scavengers, and informal redemption centres are major agents who collect recyclables (Guo & Chen, 2000). There is no particular estimate on the number of informal agents in Dalian. The existence of these agents is a result of their economic status and the overall state of waste management. The unbalanced economic development in urban and rural areas leads to a significant gap between the poor from the rich in terms of income, education, and living standards. Such a gap resulted in an attraction for the rural labour force to migrate into large cities. In cities, a market for recyclables exists, and municipal governments and formal private enterprises are often not sufficiently capable of effective waste separation and recycling due to a shortage of resources and expertise. This niche is filled by the unskilled, uneducated residual labour force from rural areas who choose to migrate to cities for better lives. Some of them become junk-buyers and scavengers collecting and selling recyclables for a living. Although unregulated, these informal agents have a relatively clear specialization in scavenging, collecting, or operating redemption centres. They contribute significantly to waste recycling in China. However, the current informal sector may not be a lasting solution for waste diversion. For one reason, local residents in Dalian are concerned with their security as scavengers occasionally steal clothes or metal scraps for use or sale (open ended questions in the survey); for another, the dirty, fetid working environment at landfill sites poses significant risks to the health of scavengers (Observation).

5.2.3 The Formal Private Sector

In the RMOW, private companies are the major agents providing waste collection and treatment services. In Dalian, private companies have not yet demonstrated sufficient competitiveness and reliability to gain the trust from the local government in dealing with MSW. Up until now, waste services in Dalian have been delivered mainly by the municipal government. Since governments typically do not have subordinate enterprises for recycling and recovery, promoting such services will need to rely more on the private sector. Despite of various national policies and financial incentives (MOF, 2001; NDRC, 2006a; the State Council, 2005), the development of the waste industry in Dalian is rather slow. Impediments to its viability and reliability are not caused by technical difficulties in treatment, but by programmatic and economic issues, e.g., competitiveness in collection, consistency and quality of services, and economical viability. The less trust and support the private sector receives from local governments, the more difficult it will be able to overcome these impediments. Consequently, when considering a more beneficial method to treatment MSW, Dalian has chosen incineration, which is more stable and reliable than recycling programs and does not require significant changes in public behaviour for waste separation and collection. Meanwhile, incineration with energy recovery also conforms to the national policy on the comprehensive utilization of renewable resource. (NDRC, 2006b).

5.3 System Structures

As illustrated in Figures 4.5 and 4.17, the structures of MSWM systems in the RMOW and Dalian are apparently different. In the RMOW, as discussed in Section 4.1.2, all waste diversion programs and associated waste flows are parallel to one another. Such a system structure has two advantages compared with Dalian. First, service efficiency and quality are improved by separating administrative authorities from service delivery. The regional municipal government is in charge of supervision, organization, mediation, and public education for multiple programs, while services are delivered by private contractors. This separation is built on the fact that most municipalities in Ontario, in Canada, and even in North America share a similar structure of MSWM systems. This

commonality provides a large scale of similar service demands and thus enables enterprises to specialize in certain services, such as collection or treatment, so as to improve the efficiency and quality of services. The second advantage of such a system structure is that it is rather easy to expand and divert more wastes by either adding more types of wastes in existing programs or rolling out new programs for other types of wastes. The new programs can be in a similar form to the existing ones so that they introduce only minor changes in public behaviour and reduce costs by sharing infrastructures, such as transportation or treatment facilities, with other programs within the same municipality or similar programs in neighbouring municipalities.

In Dalian, the service and administration of garbage collection are united under the local government, but residential waste recycling is neither serviced nor administered by any authority. Such a MSWM system lacks flexibility to expand and divert more types of wastes. For one reason, the system is more complex compared with the RMOW as the waste and financial flows concerning garbage and recyclables are intertwined. Valuable items are collected and sold before, during, and after garbage collection. For another reason, recycling is mainly profit motivated, i.e., financial flows are paired with waste flows but in opposite direction. Because the informal agents are largely unauthorized, it is hard to regulate them to conform to certain standards or divert more items that have lower market value. Residents are also less encouraged to separate low-value waste since the financial compensation from redemption is one of the motivators for separating wastes.

5.4 Interactions and Integration

5.4.1 Intra-government Integration

The intra-governmental integration refers to multiple government divisions to share common objectives and assume specific responsibilities concerning MSWM. In the RMOW, the Waste Management Division, under the regional municipal government, is the major division that administers and manages MSW within the Region. Diverting more wastes to save the landfill space seems to be a common acknowledgement among staff and councillors as they planned and budgeted for the Green Bin pilot program—a program that was endorsed by council without controversy. In Dalian, the government

division in charge of MSWM is the Environment and Sanitation Department. However, multiple divisions, such as the Development and Reform Committee and the Environmental Protection Bureau, are also involved because recycling and recovery are under the umbrella of the Circular Economy, which promotes an economy with high energy and material efficiency realized partially by reuse, recycling, and recovery (Interview D05). The responsibility of each of these divisions is not clearly defined. The primary objectives and concerns among these divisions are not the same. As opposed to the general objective promoting recycling and recovery, the Environment and Sanitation Department, which delivers waste services on a day to day basis, is concerned more with disposal safety and cost-effectiveness and is rather conservative in proposing new waste diversion systems (Interview D02). Effective communication on MSWM issues among these divisions is also lacking except for large projects such as the incineration plant where multiple divisions participated and voted in the processes of siting, public bidding, and environmental assessments (Interview D02).

5.4.2 Public-Private Cooperation

Cooperation between the public and private sectors is necessary for efficient waste management. In the RMOW, this cooperation is based on market mechanisms: Qualified private companies are contracted by the government to deliver waste services. Such a market mechanism allows for competition among private companies and thus may improve service efficiency and quality. For example, at least two companies are bidding for waste collection in the RMOW so that neither will become complacent over time (Interview W02). The public sector also has to make efforts to sign a qualified contractor at low costs. In the RMOW, the government has committed to preclude plastic contamination in the Green Bin in order to attain a high feedstock quality so as to satisfy the processor's requirement for a lower processing cost. However, such a market mechanism would leave the contractors with full responsibility to ensure the entire process is in line with relevant environmental and social standards. Although guidelines and regulations are in place to prevent negative impacts from occurring, controversies may still arise in aspects where monitoring and supervision are insufficient. The discussion about exporting Blue Box materials to China and India for processing has

posted the challenge of how to properly oversee the contractors' marketing actions that are beyond what has been committed in their contracts (Outhit, 2007).

In Dalian, the incineration project is an example of public-private partnerships, which was formed via a Build-Operate-Transfer (BOT) contract (Interview D01). According to the BOT contract, private enterprises build and operate a government-driven project and transfer the facility back to the government after a certain period of time. Under BOT, the private sector is not contracted to provide service immediately but to finance and construct the project, which will eventually be owned by the State. The government is still not completely relying on the private sector in MSW treatment and disposal but taking an advantage of the private sector for financing, management, and marketing. Besides this case, such public-private partnerships have not yet been firmly built for collection, separation, and recycling. When the informal private sector is involved, public-private cooperation becomes more difficult. Qian and Wang (2004) have shown a failure of attempting to establish a partnership between the local government and informal agents in Lin'an because of the absence of sufficient and substantial support from the local government, which led to a charge to junk-buyers and scavengers for registration. The unsuccessful attempt in turn sent signals of untrustworthy viability of such cooperation, which further discourages the government to actively engage in similar programs.

5.4.3 Communication and Public Education

An important condition for a successful waste diversion program is the active participation of residents. As discussed in Section 2.4.3 concerning the marketing model for MSWM, effective communication and public education are crucial approaches to promote program and encourage participation (Bryce et al., 1997; Mee et al., 2004). In the RMOW, most promotions are program based. For instance, a series of promotions were conducted specifically for the Green Bin pilot program: newsletters, open houses, and a package of DVD, door hangers, and other materials indicating program instructions (Interview W01). In Dalian, publicizing waste management provides much less specific instructions in terms of what should be separated and where the separated wastes should be directed. The plan for the recycling program proposed by Shengda also did not contain

specific strategies for program promotion and public education. Public education deals more with concepts that, for example, MSW should be separated to improve recycling and to protect the natural environment. According to the survey, residents in Dalian are poorly informed with the specific requirements for waste separation, about which close to 60% stated “don’t know” or “know a little” in the survey. A proper strategy for promotion should be addressed in the waste planning and program promotion.

5.5 Summary

The comparison of the two cases demonstrated the differences between MSWM systems in a municipality with substantial experience in waste diversion and one that is starting to engage in more efforts in waste diversion. The differences in residents, the private secoter, governments, and their interactions explained why a simple replication of management tools or employment of advanced technology would unlikely be able to solve all the waste-related problems in developing countries. Some of these differences are tightly linked with macro-economic or social conditions such as population density and the existence of the informal sector, which can not be altered in a short period of time and go far beyond what waste managers can achieve. Other differences are related to the plan for and design of waste management systems, which can and should be improved.

The differences discussed in this chapter also reflected that the RMOW, in comparison with Dalian, has implemented a superior integrated approach to waste management and planning. First, an effective integrated approach requires an overall objective that is accepted by the agents involved. Such a common objective is important because it ties the intention and contribution of each agent towards the same outcome and encourages efforts and resources to be engaged in for such contributions. In the RMOW, improving waste diversion while reducing the demands for new landfill spaces seemed a common objective of MSWM shared by provincial and municipal government, and the public. The WDA was an example of recent legislation that encourages waste reduction, reuse, and recycling. The provincial government also set up an aggressive goal for waste diversion. Municipal governments accordingly engaged in efforts to divert more wastes from landfills. Several residents surveyed in the RMOW also stated that saving landfill space

was one of the reasons for their participation in the Green Bin program. In Dalian, although it is explicitly encouraged by national policies, waste diversion has not yet become a common objective shared by all agents. The Environment and Sanitation Department is concerned more with safe disposal and cost-effectiveness, while the informal sector is predominately motivated by revenues from wastes. Over half of the residents surveyed stated "don't know" or "know a little" about the requirements concerning waste separation.

Another aspect in which the RMOW demonstrated a superior integrated approach is that multiple agents' interests, needs, capacities, and constraints are considered in waste planning and program operation. Such considerations will help reduce conflicts among agents in the operation of diversion programs and avoid frequent changes in established plans and policies. The consideration of and communication with the private sector in the RMOW are realized through a market mechanism. Private corporations that meet certain conditions in producing products involved in provincial diversion programs are supporting these programs through various stewardships, and other companies in the waste industry that provide services are contracted to municipal governments, with their rights, duties, and responsibilities discussed during negotiations and specified in contracts. For the public, such consideration and communication are performed during the public participation process in waste planning (e.g., open houses for the Green Bin program) and during program promotion and evaluation (e.g., the survey following the pilot program). In Dalian, due to a lack of formal waste diversion programs, such extended considerations of and cooperation with the private sector and residents remain absent.

The third aspect that illustrates a better integrated approach in the RMOW is its system structure that allows for effective communication, stimulating competition, and substantial cooperation. As discussed in Section 5.3, the structure of the MSWM system in the RMOW, with the separation of administration and service delivery and the separation of wastes, helped improve service quality and efficiency and offer the flexibility for expansion.

CHAPTER 6 DISCUSSIONS AND CONCLUSIONS

6.1 Suggestions and Implications

6.1.1 Collaboration of Multiple Agents

From a systematic perspective, to improve MSWM requires collaborative efforts of governments, the private sector, and residents. Given the complexity of MSWM systems and the comprehensiveness of managing waste from its generation to collection to final treatment and disposal, no single agent alone can be sufficiently competent. Such cooperative efforts should be reflected in both waste planning processes and program operation. For waste planning, there are two recommendations for Dalian:

- Establishing a common objective for all agents concerned and a proper structure for effective communication, competition, and cooperation; and
- Incorporating multiple agents in the waste planning process.

First, as discussed in Section 5.5, a common objective shared by all agents is a vital element that contributes to effective cooperation. Planners need to understand the needs and concerns of multiple agents with regards to their social and economic status in order to identify a common objective and design a proper structure that allows for communication, competition, and cooperation. Second, in order to profoundly understand their needs and concerns, agents involved in MSWM should be brought into the planning process. In the participatory planning model, it was argued that the public should be incorporated at early stages of the planning process (Rowe, 1992). From a system perspective, both the formal and informal private sectors, as important components of waste management systems, should also be considered in the planning process. In Dalian, such extended participation has not been performed in waste planning. For example, when planning for the pilot recycling program proposed, Shengda made some amendments to the original plan based on the local government's opinion. However, no public input was considered.

Cooperation, as discussed in IWM, is also crucial in the operation of diversion programs

and in service delivery (Seadon, 2006). From a systematic perspective, such cooperation is the interaction among various components within the waste management system and thus requires efforts made by multiple agents. Several key aspects will be elaborated in the remainder of this section. In these aspects, Dalian can learn from some substantial experiences in the RMOW.

6.1.2 Strengthening Capacities for Waste Service and Treatment

In order to better facilitate collaboration, waste planning, from the systematic perspective, needs an emphasis on supporting the relatively incompetent components in a waste management system, as the carrying capacity of a wooden barrel is not determined by the longest bar, but by the shortest. Such an emphasis on certain components is different from what has been argued in the advocacy model. First, from the systematic perspective, efforts to support certain components are made based on an understanding of the strengths and weaknesses of each component. The objective is to improve the system's efficacy by strengthen the relatively weak components and enhance their interactions with others, rather than advocating for the clients' value and goals or lobbying for policies to favour certain agents. Therefore, the emphasis is contingent on the local context and may be different in different places and at different times. Second, with the aim to improve cooperation, supporting certain components in a waste management system should not harm other. For example, if disposal capacity is insufficient, it should be strengthened; however, it should not be supported to the extent where other agents' rights are being compromised, e.g., "notwithstanding the objections of the NIMBYists (Kovacs, 1993: 113)".

During the planning process for the Green Bin program in the RMOW, an emphasis has been made on program promotion to improve participation rates. Given the capacities of qualified private companies in waste collection, transportation, and treatment to support the pilot program, residents' participation is the relatively weak aspect in the system. From the systematic perspective, an emphasis on program promotion is a reasonable strategy. As opposed to the conditions in Canadian communities, the major aspect that needs to be emphasized for waste diversion in Dalian instead is viable, reliable, and constant service and treatment capacities. Even if promotion were sufficiently effective,

the best motivated residents would eventually turn to informal agents if an accessible, creditable recycling system is absent. Therefore, a proper strategy should emphasize the enhancement of the capacities for waste service and treatment. To strengthen the capacities for waste service and treatment does not rely merely on updating facilities and technologies. Several aspects in planning and management are also crucial, in which Dalian can learn from some useful experiences in the RMOW. Two recommendations for Dalian to better strengthen its capacities for waste service and treatment are:

- Following an incremental path of development in the waste industry and diversion programs, beginning with limited types and gradually expending the scope; and
- Designing new programs based on the existing system to lower costs and to reduce public behavioural changes in operation.

First, diversion should start with limited types of wastes that can sustain a viable and reliable industry for waste service and treatment. Service and treatment capacities are contingent on the development of the waste industry. As "the tail (waste management) cannot wag the dog (the entire economy) (ISWA, 2002: 31)", the development of the waste industry can not be realized overnight. The waste industry should seek an incremental path for development, beginning with focusing on certain types of wastes, e.g., plastic, metals, and electronic wastes, which can sustain a viable diversion system and allow for gradual expansion. Recycling has economies of scale but diseconomies of scope (Porter, 2002). That is, it is cost-efficient to divert limited types of waste as much as possible but not many types in small volumes. The economies of scale will help increase profitability and reliability so that will provide the public, as well as the local government and the private sector, with a time to adapt to a new diversion system. In the RMOW, waste diversion started with recyclables in the Blue Box, gradually expanded to divert more items such as tires and obsolete electronic products, and recently was targeted at organic waste. Which types of wastes need to be diverted and which treatment methods need to be employed should be determined by the characteristics of waste composition, costs of diversion, treatment capacity, and markets for end-products. Qu (2007) suggested that Dalian should first separate organic waste at home in order to reduce the contamination to the recyclables so as to facilitate the following processes of separation

and treatment. Following the decision on which types of waste will be diverted, infrastructure for waste collection and transportation should be provided. Private companies should be given the opportunities to be contracted to deliver service of collection and treatment.

The second aspect in which the RMOW offers a useful experience is that new diversion programs should be designed based on the existing system. As illustrated by the Green Bin program in the RMOW, being embedded in the existing system, a new program could share infrastructure with the existing programs and reduce the demand for public behavioural changes to adapt to new programs. Changes in public behaviour usually require a long time and a large information campaign (ISWA, 2002). In Dalian, to promote formal waste diversion programs under the current circumstance should avoid pushing informal agents out of the city in a short time but should cooperate with them. The informal sector is playing an important role in waste separation and recycling. Without the informal sector at the current stage, recycling in China will be seriously impeded. In addition, eliminating junk-buyers and scavengers would not help release the pressure of the influx of the residual labour force, but result in high costs on regulation and supervision, and sever social problems concerning resettlement. However, regulating or "formalizing" the informal sector is a challenging task. An example in Lin'an, Zhejiang Province, China showed that the trial to "formalize" the informal agents by registering them to an independent administrative entity failed due to the controversies over the charge of administration fees (Qian & Wang, 2004).

Because of the absence of the informal sector in Canada, Dalian can not learn from the RMOW's experiences in this aspect, but can refer to successful cases in other developing countries in Asia and Latin America. Two recommendations for Dalian in the aspect of incorporating with the informal sector include:

- Relying more on economic and market-related tools to share benefits with and to support informal agents, and
- Considering establishing partnerships among governments, private companies, and informal agents to provide waste services with the assistance by NGOs or other organizations in civil society.

Economic and market-related tools are recommended for the administration of informal agents because informal waste diversion activities are profit-driven. By their mathematical model that has considered informal agents Moreno-Sanchez & Maldonado (2006) proved that under social optimality and competitive equilibrium conditions, scavengers theoretically should receive a per-unit subsidy on recovered materials given by the marginal benefit generated to society for avoiding the use of landfill space. In fact, however, scavengers in most developing countries are nowhere near being subsidized but are paid for recovered materials at a price that is much lower than their nominal value (5% of the price industry pays for recyclables in some cases), because high-level redemption centres and middlemen control the price and exploit scavengers (Medina, 2000). In order to effectively administer the informal sector in practice, an entity must be able to share benefits with the informal agents.

In order to effectively organize and share benefits with informal agents, an effective administration entity should encourage the assistance and mediation by NGOs and other organizations in civil society to establish partnerships that involve the informal sector. Successful policies and administrative practices in Asia and Latin America include national legislation supporting scavengers (e.g., Indonesia), formatting scavenger cooperatives to break the price controlled by middlemen (e.g., the National Recycling Program in Colombia, and the Linis Ganda program in The Philippines), contracting informal agents for waste services (e.g., The Cooperativa Recuperar in Colombia and waste collection in Madras, India), and establishing partnerships with governments or industries (e.g., services for curbside recycling program in Porto Alegre, Brazil and the Sociedad de Seleccionadores de Materiales in Mexico) (Lepsoe, 2006; Medina, 2000). NGOs, industrial organizations, and other organizations in civil society have played a critical role in these programs in assisting the formation of cooperatives, providing funding and infrastructure, and offering technical supports, educational opportunities, and health and legal services. Medina (2000) also argued that another condition that contributed to the success of these programs was supportive leaders in the local government who inclined to demonstrate their commitments with the poor and who also favoured change. Under the current circumstance in Dalian where private companies have proposed to build a formal recycling system, Dalian should consider, with the

assistance and mediation by local or international organizations, to establish a partnership among the local government, private companies, and informal agents in waste collection and transportation.

6.1.3 The Role of Local Governments

In Dalian, the local government administers and offers services for garbage collection and disposal. As waste diversion progresses, more services will eventually be delivered by private companies, whereas the local government should make more efforts on other aspects, such as monitoring and improving quality, and promoting waste diversion. Governments' roles in MSWM are discussed mostly in the incremental planning model and economic model where regulator and economic management tools are involved as essential elements. Dalian plans to increase the garbage service fee in the coming year to support a better waste service, but given the relevant national policy and local conditions, the fee will still be flat and thus will not introduce incentives for diversion (Interview D02).

For better promoting waste diversion, in addition to regulatory and economic tools, from a systematic perspective, the local government in Dalian should also strive to improve the integration and cooperation of multiple agents. Three recommendations, based on RMOW's experiences, for Dalian to explore some important roles of the local government are summarized as follows:

- Performing more actively in public-private partnerships,
- Improving intra-governmental cooperation among various divisions by preparing a waste management master plan and improving information transparency, and
- Conducting research and investigations to support waste planning and decision making.

First, the local government should involve itself more actively in public-private partnerships. Such partnerships can be tightened through a contract-based commitment. Such contracts need to be localized, i.e., consistent with the forms and procedures of other government singed contracts. Some are cities in China, such as Guangzhou and Wuhan, started to contract private companies for street sweeping and garbage collection

and were able to lower costs and improve service quality (The Department of Urban Environment and Sanitation, 2006; Xiong, 2005). Another type of public and private cooperation can be formed through the BOT contract, which was proved applicable by the incineration plant in Dalian.

Second, the local government in Dalian should improve intra-government cooperation among various divisions. At the strategic level, a waste management master plan should be prepared. The plan should review the current MSWM system, propose objectives for future development, and specify duties and roles of relevant government divisions. In practice, dialogues among multiple divisions should be encouraged and information transparency should be increased. In Dalian, currently, effective communication and substantial information share occur mostly in large project, such as the incineration plant, where strong administrative will is involved. For small pilot programs and routine management activities where special attentions are lacking, regular communication and an information sharing mechanism should be established and maintained to the extend that multiple divisions act harmoniously in waste planning and management and support the decisions made by one another.

Third, the local government in Dalian should also conduct more proactive investigations and research concerning waste management. In Ontario, municipal governments collect primary data and conduct investigations concerning waste management to support waste planning at both municipal and provincial levels. In the RMOW, a survey was conducted following the Green Bin programs to obtain feedback from the participants. As ISWA (2002: 50) stated in its report, “the access to transparent and coherent waste data is crucial if strategies are to be successful and sustainable waste management practices achieved.” The data about waste diversion rates and the movements of recyclables are either absent or inaccurate in Dalian, as well as in most big cities in China. Research concerning waste management should be encouraged to collect reliable baseline data to assist planning and decision making. Especially in the current stage when a pilot program has been rolled out, investigation should follow up to gain timely feedback from the private sector and residents.

6.1.4 Public Education and Program Promotion

Program promotion and public education, as being addressed in the RMOW, are indispensable elements for successful diversion programs. Some experiences can be learned from the RMOW. Three recommendations for the subject, content, and channel of more effective public education and program promotion in Dalian include:

- Providing more specific program-based information to specific agents,
- Emphasizing both pro-environmental attitude, and service convenience and quality, and
- Integrating waste program promotion with public education for other environmental issues.

Public education should address more specific program-based instructions in terms of what wastes should be separated and what participants need to be concerned with during operation. Promotion should be designed specifically for all agents who will perform waste separation. In the RMOW, wastes are mainly separated in the homes, so program promotion packages are delivered directly to homes. If wastes are to be separated at multiple levels in Dalian, e.g., residents and sanitary workers, both should be involved in public education and program promotion, particularly with information about what each group is entailed to do and how to do it.

A series of socio-demographical, psychological, and programmatic factors, as discussed in Section 2.3.3, could influence residents' behaviour in waste separation and thus need to be addressed in program promotion. The survey results did not reveal essential differences between the major motivators in Dalian and the RMOW. Two elements need to be emphasized to improve participation: (1) attitudes towards waste separation programs and environments and (2) service quality and convenience. The current public education in Dalian largely concerns the first element, focusing on a pro-environmental attitude. Due to the lack of specific diversion programs, no effort in public education has been made on promoting a more quality and convenient service. Service convenience and quality are necessary for a high participation rate. As opposed to weekly curbside collection for town houses, a more collective form and a higher frequency are needed for the service for apartments. In Dalian, the junk buyers are actually already offering a

frequent door-to-door service collecting recyclables in most residential communities. Promoting a pilot program, if which incorporates with informal agents, should aim to address that service quality will constantly be improved. Reasonable redemption prices would also be presented in program promotion because a major proportion of participants are relatively strongly motivated by the financial compensation.

According the survey results, mass media, such as TV and newspaper, seem a widely acceptable channel for a majority of residents in Dalian to obtain environment-related information. In addition to specific promotional programs for waste diversion, the importance and benefits of waste diversion can also be publicized along with a broad discussion about environmental and even political issues, such as municipal election and international relationships (Gorham, 2007; Spears & Vincent, 2006). Integrating waste diversion in public education with other environmental and political issues would also help improve the public's awareness of the stage of waste management and promote waste diversion. In China, waste recycling and recovery are under the notion of the circular economy, which similarly has a strong administrative power involved that can effectively deliver information on waste management to the public.

6.1.5 Discouraging Scavenging at Landfill Sites

Scavenging at landfill sites should be discouraged in order to protect scavengers from working in a detrimental environment, which poses significant risks to scavengers' health. The researcher toured the landfill site in Dalian where hundreds of scavengers working in the fetid detrimental environment (see Picture 6 in Appendix IV). Studies showed that the life expectancy of scavengers in dumpsites in Mexico City is 39 years, much lower than 67 years of the general population; in Port Said, Egypt, one third of the children living the scavenger communities died before their first birthday (summarized in Medina, 2000). ISWA (2002) had the same concern with scavengers in developing countries and suggested that scavenging should be limited to specific location and under safe and "clean" conditions. A recommendation for Dalian in this aspect is:

- Discouraging scavenging at landfill sties by a more effective diversion of valuable wastes from landfill sties.

In fact, to reduce scavenging at landfill sites does not merely mean to enact strict regulations. It can be assisted by improving waste diversion. As scavenging activities are profit-driven, they will decrease if valuable items are properly diverted before they are hauled to the landfill site. In fact, scavengers in Dalian's landfill site today are much fewer than in ten years ago, at which time approximately as much as four times the present volume of valuable items could be picked up at the landfill site.

6.2 Future Research

Challenges are still present in implementing planning and management strategies to improve waste management. Further research is needed to extend the results of this study and to continue exploring the application of the systematic approach in various contexts. One issue that requires closer scrutiny is the development and administration of the waste industry. The development of waste industries can not be simply achieved by policies and financial incentives but are determined by a combination of forces, e.g., the market demand for recycled products, participation rates, the competition of the informal sector, and government's attitude towards waste services. More in-depth research is needed to closely investigate different cases; identify their strengths, weaknesses, opportunities, and threats; and summarize the key elements for a viable and reliable waste industry.

Another challenging issue that needs to be addressed in the future concerns public-private partnerships in MSWM in China. Both the development of the waste industry and the promotion of waste diversion programs require collaborative efforts. Different agents may have different concerns, interests, and objectives. In the case of Dalian, for example, the municipal government is rather conservative and risk-adverse. It considers a diversion program to be a public service and requires it to be comprehensive and reliable. Meanwhile, the private sector is concerned more with benefits and viability. What mechanism and who will be able to mediate these various concerns, interests, and objectives? Future research should investigate and explore effective and viable forms of public-private partnerships in terms of alleviating the tension between the public and the private sectors, and, perhaps more importantly, building linkages and trusts between these two sectors.

Research on waste management from a systematic perspective needs to expand the scope to enclose product design and demand management. In spite of its advantages and improvements it may achieve, the systematic approach that only manages what has been discarded as "waste", either by different diversion methods, better disposal methods, or their combinations, can not solve all the waste-related problems. Taking the RMOW as an example, with the current IWM approach, the amount of waste is still growing, over half of the wastes are still sent to landfill, and some Blue Box wastes—with their potential contamination during processing—are still exported to developing countries for economically cost-effective considerations. Moreover, even if all recyclables are properly diverted, the efforts only help, to certain extent, reduce the usage of raw materials and alleviate the negative environmental impacts caused by waste disposal. Recycled materials are degraded in quality during the recycling process because mainly of inevitable contaminations and thus can not fully substitute raw materials (McDonough & Braungart, 2002). Fundamentally, the so-called waste crisis can not be overcome without improvements in design and reductions in consumption.

6.3 Conclusions

Compared with Canada, China is confronted with a more complex context and more stubborn challenges to MSWM including: a more rapid increase of MSW; a larger number of populations in high density and at various economic statuses; and, a more complicated waste management system where most recyclables are currently diverted by informal agents who are unskilled, uneducated, and completely living on the sale of wastes. The waste industry, which is the foundation of waste diversion, is less developed so that effective waste diversion programs are hindered. The waste industry faces several difficulties in practice, for example, the lack of steady, sufficient demands for municipal waste services; and, the competition with the informal sector in waste collection. Worse still, rarely do local governments demonstrate sufficient trust in the private sector to provide waste services. In the current MSMW system, the unification of service delivery and supervision under the local government and the lack of integration of various government divisions have decreased the efficiency and quality of services.

From a systematic perspective, to improve the performance of the MSWM system requires collaborative efforts to strengthen the relatively inefficient components and their connections with other components. MSWM is not isolated from other economic and social activities. Local contexts must be considered when decisions are made to upgrade the MSWM system. To strengthen capacities for service and treatment is the foundation of improving Dalian's MSWM system and needs to be achieved through an incremental path based on the existing system. The practice of MSWM in the RMOW provided useful experiences in several aspects. First, waste diversion should begin with focusing on certain types of wastes and gradually expand in scope. Second, new diversion programs should be based on the existing system, cooperating with the informal sector rather than pushing it out of the city in a short period of time. Third, Dalian should promote cooperation among governmental divisions and between public and private sectors by encouraging multi-agent dialogues and improving information transparency. Fourth, program promotion needs to be more specific in instructions and to address both pro-environmental attitudes and service quality and convenience. Finally, scavenging at landfill sites should be discouraged in order to reduce the risk to scavengers' health.

No single agent, policy, or management tool can solve all waste-related problems. MSWM has never labelled itself as a health issue, an engineering issue, a planning issues, or an economic issue; it is the managers, researchers, and professionals working on MSWM that have named it. What would be highlighted today is the comprehensiveness of MSWM: It becomes an issue pertaining to a combination of multiple disciplines. It is also a context based issue, which might require various means to implement policies and plans in different locations. In practice, MSWM demands stronger horizontal cooperation among various divisions within the administrative body and among the agents from public and private sectors; in research, it raises a demand for a systematic, interdisciplinary approach to study MSWM from various perspectives and possibly through a broader lens with regards to other regional and global concerns.

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APPENDIX I: SUMMARY OF INFORMANTS IN INTERVIEWS

Summary of Informants in Interviews

Code	Affiliation	Position	Date of Interview
W01	Waste Management Division, RMOW	Program Coordinator	May 10, 2007
W02	Waste Management Division, RMOW	Manager	May 18, 2007
H01	Waste Management Division, City of Hamilton	Manager	June 12, 2007
T01	Integrated Municipal Services	Facility Manager	June 12, 2007
O01	County of Dufferin	Waste Management Coordinator	June 20, 2007
B01	Solid Waste Management Administrative Centre, State Environmental Protection Administration	Staff	July 2, 2007
D01	Dalian Construction Bureau	Vise Director	July 3, 2007
D02	Dalian Environment and Sanitation Department, Construction Bureau	Section Chief	July 3, 2007
D03	Shengda Holding Inc.	Administrative Manager	July 11, 2207
D04	Shengda Holding Inc.	Project Manager	July 11, 2007
D05	Dalian Environmental Protection Administration	Division Chief	July 23, 2007
D06	Dalian Dayou Tianyuan	Manager	August 2, 2007
D07	Dalian University of Technology	Ph.D.	August 9, 2007

APPENDIX II: THE SURVEY IN THE RMOW

Please check the one correct response for each of questions from 1 to 3.

1. How often do you place your Green Bin to the curb for collection?
   - ☐ Every week
   - ☐ Once every Two weeks
   - ☐ Once every Three weeks
   - ☐ Once every month or less
2. How often do you place your Blue Box to the curb for collection?
   - ☐ Every week
   - ☐ Once every Two weeks
   - ☐ Once every Three weeks
   - ☐ Once every month or less
3. How did you deal with organic wastes before the Green Bin program? (Please check all that are applicable)
   - ☐ Treated organic waste as general garbage.
   - ☐ Used food leftovers to feed pets.
   - ☐ Composting in my backyard.
   - ☐ Other _____

4 How important are the following reasons that let you participate in the Green Bin program? Please check the level of importance to each statement
①not important at all, ②not important, ③somewhat important,
④important, ⑤very important

4.1 The Green Bin program is beneficial to the natural environment.

① ② ③ ④ ⑤

4.2 If I participate in the Green Bin program, I feel I am contributing to environmental protection and proud of myself for doing so.

① ② ③ ④ ⑤

4.3 Most of my neighbours are participating in Green Bin.

① ② ③ ④ ⑤

4.4 As a citizen, I feel I should participate in programs operated by the government.

① ② ③ ④ ⑤

4.5 The Green Bin reduces the volume of regular garbage.

① ② ③ ④ ⑤

4.6 I was told to participate.

① ② ③ ④ ⑤

4.7 If there are other reasons, please specify:

_____

Please check the extent to which you agree or disagree with each of the following statement (5 to 11):

①strongly disagree ②somewhat disagree ③neutral
④somewhat agree ⑤strongly agree

5 I know where the collected organic waste is to go and how it is going to be treated.

① ② ③ ④ ⑤

6 I believe that separating different kinds of wastes from one another is important for better managing solid waste.

① ② ③ ④ ⑤

7 The collection of Green Bin is on time and easy to access.

① ② ③ ④ ⑤

8 The Green Bin is easy to operate and the instructions provided are easy to follow.

① ② ③ ④ ⑤

Which ones of the followings are the best means to get clear instructions and information about the Green Bin? (Please check all that are applicable)

☐ News letters ☐ Door hangers ☐ Open houses ☐ Web sites

☐ DVD ☐ E-mails or phone calls to the Regional Government

9 The Green Bin is airtight and does not generate odour.

① ② ③ ④ ⑤

10 The price of bags for the Green Bin is reasonable.

① ② ③ ④ ⑤

11 It is convenient to buy bags for the Green Bin.

① ② ③ ④ ⑤

12 What do you think is the major shortcoming of the Green Bin pilot program at the current stage?

_____

13 How should the Green Bin program be improved to overcome the shortcoming(s)?

_____

Summary of Survey

Question #	Minimum	Maximum	Mean	Std. Deviation
1	.00	1.00	.80	.33
2	.00	1.00	.87	.26
3-1	0	1	.70	.46
3-2	0	1	.08	.28
3-3	0	1	.57	.50
3-4	0	1	.02	.13
4.1	1	5	4.60	.72
4.2	1	5	4.25	1.05
4.3	1	5	3.25	1.48
4.4	1	5	3.30	1.32
4.5	1	5	4.53	.93
4.6	1	5	2.07	1.38
5	1	5	3.63	1.23
6	1	5	4.45	.91
7	2	5	4.72	.69
8	1	5	4.58	.83
8.1-1	0	1	.80	.40
8.1-2	0	1	.55	.50
8.1-3	0	1	.10	.30
8.1-4	0	1	.50	.50
8.1-5	0	1	.22	.42
8.1-6	0	1	.12	.32
9	1	5	3.82	1.07
10	1	5	2.57	1.25
11	1	5	2.80	1.23

APPENDIX III: THE SURVEY IN DALIAN

NOTE: The survey conducted was without English translation.

1．您是否了解大连市是如何建议、宣传对生活垃圾进行分类的？
[Do you know how Dalian is recommending and publicizing waste separation?]
☐ 很了解 [know thoroughly]
☐ 一般了解 [know somewhat]
☐ 不太了解 [know a little bit]
☐ 完全不了解 [do not know]

2．您平时在家中是否对垃圾进行分类？
[Do you often separate wastes at home?]
☐ 是 [Yes]☐ 否 （请跳过第 3 题继续回答）[No, please skip Question 3]
如果是，您将下列哪些废弃物从普通垃圾中分离出来？（可多选）
[If yes, which of the following items do you separate?]
☐ 可回收的废品（金属、塑料、纸板、易拉罐、啤酒瓶等）[Recyclables (metal, plastics, cardboard, cans, beer bottles, etc.)]
☐ 装修垃圾 [Construction and demolition wastes]
☐ 大件硬质垃圾（家具等） [Big, stiff wastes (furniture, etc.)]
☐ 电子废弃物（冰箱、彩电、洗衣机、电脑、空调、手机等）[Electronic wastes (fridges, TVs, wash machines, PCs, air conditions, cell phones, etc.)]
☐ 危险品（有毒、有害、爆炸性废物）[Hazardous wastes (toxic, poisonous, or explosive wastes)]
☐ 我还分离其他特殊组分： [Others:]

3．您如何处理分离出来的废物？（可多选）
[How do you deal with separated wastes? (Please check all that are applicable)]
☐ 卖给流动收购废物的人员 [selling them to itinerant junk-buyers]
☐ 转卖到二手市场 [selling them to second-hand markets]
☐ 卖到邻近的废品收购站 [selling them to nearby redemption centres]
☐ 投放到小区里的分类垃圾桶中 [putting them into separate garbage bins]
☐ 其他处理方式：_____[other methods:]

4. 下列哪些原因促使您对生活垃圾进行分类？请对以下每条可能原因的重要性进行打分：①完全不重要 ②不太重要, ③一般，④比较重要, ⑤非常重要
[How important are the following reasons that let you separate wastes? Please check the level of importance to each statement]
①not important at all, ②not important, ③somewhat important,
④important, ⑤very important

13.1 变卖可回收废物可以获得一定的收益。
[Redeeming wastes can gain some financial compensation.]
① ② ③ ④ ⑤

13.2 分离可回收废物有助于保护自然环境，减少不可再生资源的使用量。
[Waste separation is beneficial to the nature environment, reducing the usage of non-renewable resources.]
① ② ③ ④ ⑤

13.3 对生活垃圾进行分类是对环境保护做贡献，我很荣幸能做出这样的贡献
[If I separate wastes I feel I am contributing to environmental protection and proud of myself for doing so.]
① ② ③ ④ ⑤

13.4 我的大部分邻居都对生活垃圾进行分类，我受到了他们的影响。
[Most of my neighbours are separating wastes, and I am influenced by them.]
① ② ③ ④ ⑤

13.5 作为普通市民，我响应政府的号召自觉参与垃圾分类。
[As a citizen, I feel I should separate wastes as promoted by the government.]
① ② ③ ④ ⑤

13.6 垃圾分类能有效减少普通垃圾的量，方便垃圾投放。
[Waste separation reduces the volume of regular garbage and makes throwing convenient.]
① ② ③ ④ ⑤

13.7 我对垃圾进行分类是因为街道、小区物业或者地方政府要求我这么做。
[I separate wastes because I was told by the community property management company or the government to do so.]
① ② ③ ④ ⑤

13.8 我对垃圾分类还有其他重要的原因：（请写在下面的横线上）
[I have other important reasons for separating wastes. (Please specify)]

请您根据一般生活经验判断以下观点：
[Please assess the following statements according to your knowledge:]

5．您是否了解收集的垃圾和回收的可再利用的废物是如何进行处理的？
[Do you know how garbage and recyclables are processed?]

① 完全不了解	②不太了解	③一般	④比较了解	⑤ 很了解
Don’t know	A little bit	Somewhat	In general	Thoroughly

6．我认为垃圾分类是有益于城市生活垃圾管理的。
[I believe that separating different kinds of wastes from one another is important for better managing solid waste.]

① 完全不同意	② 不同意	③ 可以接受	④ 同意	⑤ 非常同意
Strongly disagree	Disagree	Natural	Agree	Strongly agree

7．我认为现在普通垃圾的投放是方便的，收集是及时的。

[I think throwing garbage is convenient, and collection is timely.]

① 完全不同意 ② 不同意 ③ 可以接受 ④ 同意 ⑤ 非常同意

Strongly disagree Disagree Natural Agree Strongly agree

8．我认为小区的垃圾收集点和待运点是清洁的。

[I think garbage collection point in my community is clean.]

① 完全不同意 ② 不同意 ③ 可以接受 ④ 同意 ⑤ 非常同意

Strongly disagree Disagree Natural Agree Strongly agree

9．我认为现在的可回收废品的收集和变卖是方便的。

[I think collection and redemption of recyclables are convenient.]

① 完全不同意 ② 不同意 ③ 可以接受 ④ 同意 ⑤ 非常同意

Strongly disagree Disagree Natural Agree Strongly agree

10．当前征收的生活垃圾管理费是否合理？

[Is the waste service fee reasonable?]

① 完全不合理 ②不太合理 ③ 一般 ④ 比较合理 ⑤ 很合理

Totally not Not so much Acceptable Rather reasonable Very reasonable

11．我认为现在废品回收的总体价格：

[I think the redemption prices in general are:]

□ 偏低 □ 合理 □ 偏高 □ 不知道

Relatively low Reasonable Relatively high No idea

12．您平时主要通过以下哪些渠道来了解有关生活垃圾管理和城市环境保护方面的信息？ [Through which media do you acquire information on waste management and environmental protection?]

□ 报纸 [news paper]

□ 小区和市区街道的海报 [posters in communities]

□ 小区内的宣传活动 [publicizing in communities]

□ 网络 [internet]

□ 电视公益广告 [public service ads on TV]

□ 政府热线电话 [government hot lines]

□ 政府的宣传活动和传单 [publicizing activities held by the local government]

□ 子女学校的宣传活动 [publicizing activities in kids' schools]

13．您认为现在大连市的生活垃圾管理所存在的最重要的问题是什么？

[What do you think is the major shortcoming of Dalian's waste management at the current stage?]

____

14．您建议城市环境卫生部门如何来解决这些问题？

[What would you suggest for the Environment and Sanitation Department to do in order to overcome the shortcoming(s)?]

Summary of Survey

Questions	Minimum	Maximum	Mean	Std. Deviation
1	1	4	2.36	.84
2	0	1	.80	.41
2-1	0	1	.75	.44
2-2	0	1	.18	.39
2-3	0	1	.34	.48
2-4	0	1	.45	.50
2-5	0	1	.23	.42
3-1	0	1	.73	.45
3-2	0	1	.20	.41
3-3	0	1	.36	.49
3-4	0	1	.11	.32
4.1	1	5	3.18	1.13
4.2	2	5	4.20	.95
4.3	1	5	3.91	1.03
4.4	1	5	2.55	1.13
4.5	1	5	3.64	1.01
4.6	1	5	3.39	.95
4.7	1	5	2.30	.98
5	1	5	2.23	1.10
6	2	5	4.30	.70
7	2	5	3.75	.89
8	1	5	3.14	.95
9	1	5	3.82	.97
10	1	4	3.11	.84
11	0	2	1.39	.72
12-1	0	1	.50	.51
12-2	0	1	.32	.47
12-3	0	1	.16	.37
12-4	0	1	.52	.51
12-5	0	1	.02	.15
12-6	0	1	.16	.37
12-7	0	1	.02	.15

APPENDIX IV: PICTURES FORM SITE OBSERVATION

Picture 1: The Green Bin, Garbage Cart, and Blue Box at the Curb in the RMOW

Picture 2: The Composting Site of IMS

Source: Interview T01

Picture3: The Interred Garbage Bins in Dalian

Picture 4: An Itinerant Junk-Buyer in Dalian

Picture 5: A Primary Redemption Centre in Dalian

Picture 6: The Sanitary Landfill and Scavengers in Dalian