RECYCLING BEHAVIOUR: EXTENDED THEORY OF PLANNED BEHAVIOUR AND SYSTEM DYNAMICS APPROACH

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Recycling Behaviour: Extended Theory of Planned Behaviour And System Dynamics Approach

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Certificate of Originality

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Mak Man Wah Tiffany

Abstract

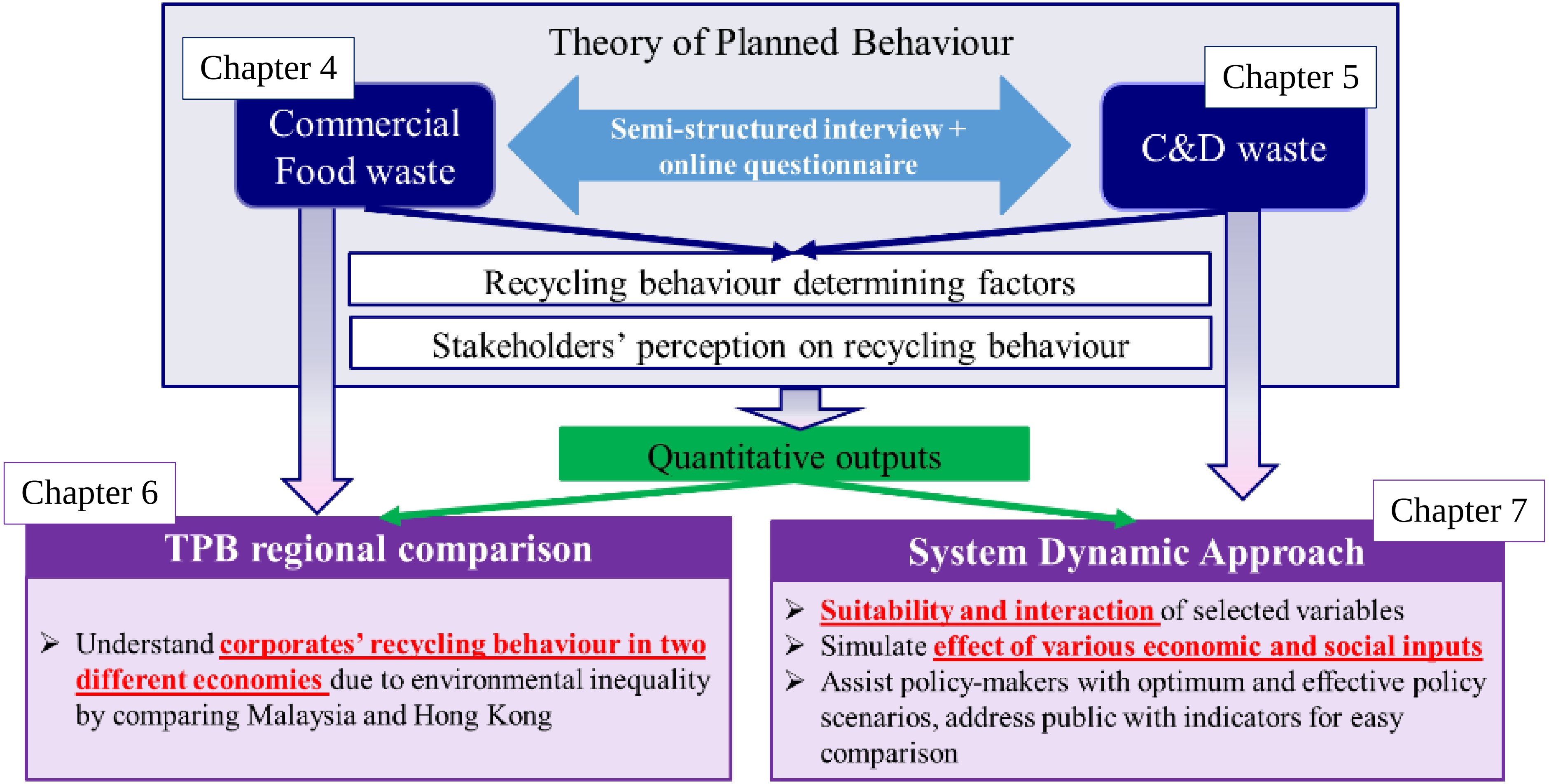
To bring changes in recycling behaviour, one must consider its intention. Decision-analytical approach from a micro-structural perspective is therefore necessary to identify determinants of environmental behaviour that affect individual's intention with the aid of effective and consistent policies. Changing individual's recycling attitude and behaviour is of utmost importance in achieving sustainable construction and demolition (C&D) waste and food waste management, yet it has often been underachieved. To understand the motivations for recycling, this thesis first identifies, prioritizes, and quantifies the key factors and relationship among key latent variables that affect food waste recycling behaviour of relevant industries and C&D waste recycling behaviour of various stakeholders in Hong Kong. With an integration of qualitative and quantitative manner with semi-structured interviews and survey questionnaire on the basis of Theory of Planned Behaviour (TPB), content analysis and structural equation modelling were performed to analyse the collected responses from interviews and questionnaires, followed by correlation analysis to quantify the relationships between variables. Different from conventional waste management studies, quantitative outputs from the TPB study of both food waste in commercial sector and C&D waste are subsequently utilized for regional comparison with Malaysia and system dynamics simulation to obtain optimum waste disposal charging fee, respectively.

Food waste recycling behaviour in Hong Kong commercial sector is determined by three latent variables, i.e., Administrative incentives and corporate support, Perceived behavioural control, and Economic incentives, while that in Malaysia is substantially affected by perceived behavioural control, and logistics and management incentives. Hotel industries from both Hong Kong and Malaysia have a higher acceptance level on human resources for food waste

recycling. In comparison, food and beverage industries from both regions have a lower acceptance level. Corporates in Hong Kong generally found the recycling cost more affordable than those in Malaysia did. In particular, property management industries in Hong Kong tend to pass on the recycling costs to their tenants, while property managers in Malaysia are less likely to perform recycling as they have their own right to outsource the waste collection and source separation schemes to any licensed contractors. These findings could enrich our knowledge of the concerns in establishing regional policy strategies to foster commercial behavioural change for sustainable development.

Apart from conducting regional comparison on food waste recycling determinants in commercial sector, TPB study on C&D waste recycling indicated that four key factors: (i) regulatory compliance, (ii) economic incentives, (iii) accreditation scheme, and (iv) logistics and management incentives directly influenced recycling behaviour of individuals. Regulatory compliance was the most determining factor for consultants, contractors, experts, and government officials, whereas economic incentives were of great concern to the public. Under the factor of economic incentives, strong positive relationships were identified between disposal costs and collection and sorting costs, thus increasing waste disposal charging fee may promote recycling behaviour. In comparison, accreditation scheme deserved better recognition to facilitate a closed-loop material flow in the construction industry. To further incorporate our understanding on the determining factors of recycling behaviour to develop a generic solid waste system structure over time to cater future needs, a comprehensive system dynamics model was constructed with the quantitative outputs from TPB study on C&D waste recycling. Waste disposal charging scheme is an effective tool in fostering waste reduction and minimising environmental burden. However, the determination of waste disposal charging fee was mostly designed for cost recovery at present rather than meeting the future needs. The use of this model assesses and projects the structure, interactions of the complex system in waste disposal charges in an integrated and holistic manner. Two sets of policy scenario analysis were conducted for evaluating the effects of the newly modified waste disposal charging fee implemented by the Hong Kong government and identifying an optimum range of waste disposal charging fee. The simulation results indicated that the newly modified waste disposal charging fee is ineffective to achieve construction and demolition waste reduction in the long term. To devise policy strategy for sustainable waste reduction, the optimum increment percentage on original landfill and public fill charging fees should not exceed 250% and 400%, respectively. The proposed model serves as a scientific approach for decision-makers to better design the architecture in the complex system of construction and demolition waste management. These findings help to devise more effective and stakeholder-oriented policy tools to raise awareness and encourage behavioural change towards food and C&D waste recycling, and assist policy makers to establish regulations and practices for sustainable resource management.

Graphical Abstract



Publications Arising from PhD Study

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Chapter 1 - Introduction

1.1 Background

Recycling refers to the recovery of materials, such as food waste, and construction and demolition (C&D) material from the waste stream such as municipal solid waste (MSW), to produce new products and minimize the amount of virgin raw materials required to satisfy increasing demand of consumers. The community and the environment can be benefited by reducing the amount of waste sending to landfills and incinerators, conserving natural resources, preventing pollution, saving energy for waste treatment and creating job opportunities in the recycling industries in various countries (USEPA, 2016). According to the World Bank Group (2018a), the total world solid waste generation amounted to 2.01 x 10^6 tonnes in 2016 (i.e. average 0.74 kg per capita per day) and the projected total solid waste would be 3.40 x 10^6 tonnes by 2050. Germany has the highest recycling rate of MSW (*i.e.* 56.1%) when comparing to other countries from The Organization for Economic Co-operation and Development (OECD), followed by Austria (*i.e.* 53.8%) and South Korea (i.e. 53.7%) (EEB, 2016). Although some of the nations have adopted recycling and environmental policies, greater effort is inevitable to achieve sustainable tread to meet their goals (Jordan and Lenschow, 2010). Therefore, the need to understand the motivations to achieve environmentally responsible behaviour such as recycling becomes one of the major society's priorities (Tabernero et al., 2015).

Globally, food and green waste is the largest municipal solid waste (MSW) generation, which amounts to 44% of the global waste (Kaza et al., 2018). The food loss accounts for 30% of the food produced globally equating to 1.3 x 10^6 tonnes annually (FAO, 2015). In East Asia regions that have relatively high Gross Domestic Product (GDP) such as Hong Kong

(USD$9363), Malaysia (USD$354), and Singapore (USD$361) (IMF, 2018), the MSW generation rate are 2.14, 1.21, and 3.72 kg per capita per day, respectively. The amounts are much higher than that of the average in the East Asia (i.e., 0.56 kg per capita per day) (Kaza et al., 2018). Average waste management budget in low-income, middle-income and high-income regions amount to an average of 20%, 11% and 4%, respectively (World Bank Group, 2018a). National and local governments have reacted to the waste escalation by initiating regulations and campaigns. France passed legislation to forbid supermarkets from disposing or destroying unsold food. Instead, food must be donated to charities or food banks (Chrisafis, 2015). Other jurisdictions such as the United States and China required some residents and tourists to compost food waste (McClellan, 2017) where some were also treated at anaerobic digestion facilities (Lee, et al. 2014). Non-monetary motivations are also important as the determinants of human behaviour in recycling (Bénabou and Tirole, 2006). As of Hong Kong, problems of food waste are likewise impeding the sustainability of a city (Othman et al., 2013). For instance, the daily disposal of food waste disposal is 3339 tonnes in Hong Kong, contributing to nearly 40% of the disposal of MSW from 2005 to 2015 (HK EPD, 2017). Although "Food Waste Recycling Partnership Scheme" was launched in 2010 for food waste recycling operation and management with twelve public and private corporate participants from the commercial and industrial (C&I) sector (HK EPD, 2010) and a comprehensive strategy has unveiled for the goal of reducing food waste disposal by 40% in 2022 (HK ENB, 2014), the reduction of food waste production (4-8%) and average amount of recycled food waste (< 1%) remain low. Comparing to other Asia cities that with similar Gross Domestic Product (GDP) per capita, Singapore maintains a high recycling rate (13%) over the ten years (NEA, 2018) while Japan food industry recycles 70 percent of its leftovers (MOE, 2018). Previous studies suggested that household's recycling behaviour of food waste depends on a wide range of determinants such as food waste awareness (Parizeau et al., 2015), lifestyle (Ponis et al., 2017), attitude and behaviour towards recycling (Ko and Poon, 2009), consequences and impacts (Refsgaard and Magnussen, 2009), and technologies for packaging and storage solutions (Hebrok and Boks, 2017). New models to explain individual actions were built, which includes models of motivations other than the pursuit of self-interest. Recent studies suggested the substantial relationships between different types of motivations (D'Amato et al., 2016), and recognised interactions between external rewards (e.g., unit price systems) and internal motivation (e.g., pro-environmental behaviour) (Gilli et al., 2018). While the literatures mostly focus on decentralized sources in the domestic sector (Schmidt, 2016), there is limited understanding on recycling behaviour of corporates in the C&I sector, in which the food waste producers are centralized and better managed for performing efficient waste collection and recycling if motivated by effective determinants. For example, bulk amount of pre-consumer and post-consumer food waste is produced from hotel buffets and restaurants, there is room for improvement in enhancing food waste recycling in the commercial sector.

C&D waste is another major contributors to the overall waste composition in different continents (Poon, 2007; Wang et al., 2016). Although waste reduction and material reuse have been promoted via different political tools, for example, the C&D waste disposal charging scheme adopted in Hong Kong since 2005, recycling is of utmost importance in the waste management hierarchy for sustainable use of energy and resources (HK ENB, 2013). The recycling rate of C&D waste depends on a range of determinants such as waste management regulations (Lu and Yuan, 2010; Yuan, 2013), employee training (Poon et al., 2004; Lu and Yuan, 2010), and economic concern (Yuan, 2013; Saez et al., 2013). In addition, the attitude and behaviour of individuals towards recycling are important as revealed by factor analysis of municipal solid waste (MSW) management (Ko and Poon,

2009) and investigation of organizational variables on waste management by multilevel analysis (Taberero et al., 2015).

Recent research interests extend to the effectiveness of policy instruments adopted. Better understanding of individual's attitude and behaviour is needed to devise effective strategies for nurturing the community preference towards recycling, which is critical for enhancing the recycling rate (Vermeir and Verbeke, 2006; Mont and Plepys, 2008). However, the results obtained might be complex and complicated to elucidate for the application in other nations. Internal and external factors such as personal and contextual determinants (Schultz, 2013) and satisfaction with infrastructural and economic (Corral-Verdugo, 2012) influence environmentally responsible behaviour. However, the link connecting individuals' intention and behaviour is ill-defined. Intentions refer to how hard people are willing to try and to what level of effort they are planning to spend on one's behaviour (Ajzen, 1991), whereas attitude and behaviour are critical considerations to devise effective strategies for nurturing the industry's preference towards enhancement of recycling rate (Vermeir and Verbeke, 2006; Mont and Plepys, 2008). Decision-analytical approach from a micro-structural perspective is therefore necessary for understanding the determinants of environmental behaviour (Best and Kneip, 2011). The link can be addressed by the adoption of a widely recognised Theory of Planned Behaviour (TPB) in the area of environmental management.

Further to the identification of determinants in recycling behaviour, dynamic relationships of these determinants on environmental policy such as the construction waste charging fee is subsequently investigated with the adoption of System Dynamics (SD) approach. Therefore, this research scrutinises the fundamental structure in investigating recycling behaviour with TPB to master the underlying structure of recycling behaviour and simulate with the application of SD to serve as a scientific approach for decision-makers to better design the architecture in the complex system of waste management.

1.2 Scope and objectives

Food waste and construction and demolition waste are the major waste streams that investigated in this research. TPB was first applied to determine factors that affected recycling behaviour of food waste in commercial sector and C&D waste in the community. Qualitative and quantitative statistical analysis were performed to analyze responses from semi-structured interviews and questionnaires. Subsequently, SD approach was adopted to assess and project the structure and interactions of the complex system in waste disposal charges in an integrated manner.

The objectives of the thesis are listed below.

- To identify, prioritize and quantify connections between intentions and actual behaviour of recycling;
- To elucidate stakeholders' differentiated perceptions on recycling costs and manpower in different economies and industries;
- To address correlation between C&D waste disposal costs and collection and sorting costs;
- To incorporate understanding on recycling behaviour determinants and construct a generic C&D waste disposal charging fee (WDCF) system to identify dynamic relationships among qualitative and quantitative variables.

1.3 Thesis overview

This thesis contains eight chapters in total. Following **Chapter 1** as the introduction, **Chapter 2** is the literature review that summarizes a psychological model, which is commonly known as TPB, provides theoretical framework to assist our understanding of the factors influencing behavioural choices. Also, the chapter introduces a system analysis approach, commonly known as SD method, and concerns designing models or representations of real-world systems and investigating their dynamics. As such, research gaps are highlighted, which lay the cornerstone of this thesis. **Chapter 3** proposes the methodology adopted in investigating recycling behaviour in food waste and construction and demolition waste, which includes the development of extended TPB framework and application of SD approach. Also, data collection methods such as semi-structured interviews and questionnaire survey are further elaborated, which the approach in validating different models is discussed. **Chapter 4 -7** investigates the determinants on recycling behaviour and other policy analysis to its adoption in different economies and compare their differences. The first step is to identify, prioritize and quantify the motives to change stakeholders' food waste recycling behaviour from the commercial and industrial sector (**Chapter 4**). To further broaden the scope of solid waste management, construction and demolition waste recycling behaviour is also investigated. Not only considering related industries, various stakeholders such as government officials are included (**Chapter 5**). With the extended TPB in recycling behaviour, a cross-regions case study is performed to discover the difference in recycling behaviour in different economies, taking Malaysia and Hong Kong as examples (**Chapter 6**). It is necessary to adopt the concept of recycling behaviour into policy-making process to optimum decision-making. Therefore, insights from Chapter 5 are subsequently input as factors in the complex system structure in determining the optimum construction waste disposal charges in Hong Kong (**Chapter 7**). **Chapter 8** concludes the key findings in this thesis and proposes future research directions to achieve sustainable resources and waste management.

Chapter 2 – Literature Review

2.1 Theory of Planned Behaviour on Food Waste Recycling

Abstract

This chapter introduces a psychological model, which is commonly known as TPB, provides theoretical framework to assist in our understanding of the factors influencing behavioural choices. Three key constructs are proposed in TPB that directly affect individuals' intention and thus their behaviour, namely attitude, subjective norms and perceived behaviour control. Each of these constructs is an indicator of perceptions and beliefs of how individuals behave. By the end of the chapter, the major components and theory behind the development of TPB are explained comprehensively. A full discussion of the current implementation of TPB to predict food consumption pattern and to promote safe food handling and food waste recycling in household and commercial sectors are included. This thus illustrates the application of TPB to understand food waste recycling behaviour of various stakeholders.

2.1.1 Introduction

Extensive attention has been paid by policy makers and institutions at various administrative levels to the issue of sustainable food management (Gustavsson et al., 2011; Katajajuuri et al., 2014; Miliute-Plepiene and Plepys, 2015; Secondi et al., 2015). A vast quantity of food available for individuals' consumption is wasted in various stages along the food supply chain. Globally, food losses and waste account for approximately about 20% of supplied food for human consumption (Kummu et al., 2012). 'Food losses' refer to those losses in the processes of preparation, post-harvest and processing, and 'food waste' refers to wastage during distribution and consumption stages (Gustavsson et al., 2011; Kummu et al., 2012). In countries with higher gross domestic product such as Europe, food distribution and consumption account for the biggest wastage in household food waste. In contrast, countries with lower gross domestic product, such as the Sub-Saharan Africa, have the highest food loss in the agricultural and post-harvest stages (Parfitt et al., 2010; Kummu et al., 2012). Annually around the globe, one-third of food, which is equivalent to 1.32 x 10^6 tonnes of food produced for human consumption is lost or wasted (Gustavsson et al., 2011). In 2007, over 3 giga tonnes of carbon dioxide were released for the sake of food waste production (FAO, 2013). Organizations, such as the European Commission, are taking preventive measures to resolve the problem, reduce economical costs, alleviate the environmental impacts of food wastage, and prevent social impacts related to this phenomenon (Graham-Rowe et al., 2014; Garrone et al., 2014; Gobel et al., 2015). To address such global issue, a well-established theory is indispensable to illustrate determinants in bettering sustainable food management to assist in related decision-making processes. The literature review of this paper would systematically introduce the development of the theory of planned behaviour (TPB), its current implementation to predict food consumption pattern and to promote safe food handling, and food waste recycling behaviour in household and commercial sectors.

2.1.2 Current Implementation of TPB on Food Management Study

TPB models have been widely adopted in food management from pre- to post -consumer processes. They assist in predicting the behaviour of individuals to provide conceptual order that allows decision-makers to identify the behaviour-driving substantive elements and to design effective interventions. A systematic literature review was conducted to identify relevant studies on two aspects, including studies predicting food consumption patterns and food handling, and food waste recycling in household and commercial sectors.

2.1.2.1 Application of TPB to Predict Food Consumption and Food Handling Behaviour

Sustainability is defined as an integrated consideration of economic, environmental, and social aspects. Economically, there should be a balance between agricultural entrepreneurs and consumers. Environmentally, sufficient attention should be paid to the natural environment, including biotic and abiotic factors, the living environment and the quality of life for individuals. Socially, one should be concerned about how production processes match the priorities and needs of the society, thus implementing sustainability supporting policy. Consumers show increasing demands for convenience foods to reduce time and effort (Faber et al., 2002), and a growing concern on consumers consciously purchasing ethical or sustainable products (Crane, 2001). Sustainable consumption is based on a decision-making process that considers not only individual needs such as taste, price, convenience and health but also takes consumers' social responsibility into account (Meulenberg, 2003). Studies focus on investigating attitudes towards sustainability and sustainable consumption behaviour (Shrum et al., 1995; Verbeke and Viaene, 1999; De Pelsmacker et al., 2003).

Previous research suggested that perceived behavioural control reflected both inner factors such as attitude and external perceived factors such as perceived behavioural control (Sparks et al., 1997), particularly significant in, perceived product availability (Sparks et al., 1992) and perceived consumer effectiveness (Roberts, 1996). 'Perceived availability' refers to a consumer feeling in terms of the ease to purchase or consume a product. Although consumers might be motivated to buy sustainable products, the intention to purchase sustainable products might be hampered if there was low perceived availability of the product (Vermeir and Verbeke, 2006). "Perceived consumer effectiveness" refers to the extent that consumers thought that their personal efforts could contribute to ease the environmental problem, which stimulates consumers to express their positive attitudes towards sustainable products in actual consumption (Roberts, 1996). Previous literature also indicated that purchase intention of sustainable products could be independently predicted by attitudes, perceived behavioural control, and subjective norms (Robinson and Smith, 2002). Some studies argued that research on food consumption patterns should include self-related variables (Sparks and Shepherd, 1992; Robinson and Smith, 2002). Contextual factors would prohibit positive attitudes from being expressed in action, which personal or situational factors predicted or translated the extent of attitudes that influence behaviour intention (Tanner and Kast, 2003). For instance, researchers argued that youngsters have higher intention to buy sustainable products as they may be more interested about or aware of the potential impact of specific food production practices (Bisonette and Contento, 2001). It was also significant that the more environmentally concerned an individual was, the more probably he/she would buy sustainable products (Grunert and Juhl, 1995)

In the context of food consumption, researches considered new factors such as perceived moral obligations into the TPB model (Raats et al., 1995; Sparks et al., 1995; Sparks and Shepherd, 2002; Shaw and Shiu, 2003). However, studies casted doubts on the effect of the predictive ability of a moral measure on individual's behaviour. It is believed that the inclusion of moral obligation only slightly assisted in the prediction of intentions while other researchers failed to find any significant improvement (Sparks et al., 1995). In a previous study about the moral issues in the context of organic foods, controlling attitudes and subjective norms would influence consumers' choice between organic and conventional wine in the measure of personal norms (Thøgersen, 2002). The latter was also suggested as the most important determinant of consumers' ratings of their purchase frequency on various organic foods (Thøgersen and O¨ lander, 2006). In addition, consumer's confidence in products and human values were considered as possible self-related factors on intention (Vermeir and Verbeke, 2006). Generally, consumers were not confident in evaluating food quality (Verbeke et al., 2007), and to purchase sustainable products (Robinson and Smith, 2002). If an individual has relatively high confidence in the outcome of his/her behaviour, he /she intends not to solely consider the behaviour or opinion of others as a major source of information (Jager and Vlek, 2000). On the other hand, human values are considered as possible influencers of behavioural intentions towards sustainable food (Vermeir and Verbeke, 2006). Human values refer to personal or social desirability of behaviours and modes of existence (Rokeach, 1973; Jager and Vlek, 2000). Individuals living in a stable environment would result in cultivating stable values, which influenced both their sustainable attitudes and behaviour in areas such as recycling (McCarthy and Shrum, 1994) and green procurement (Chan, 2001). It was also indispensable in consumer decision-making processes, such as sustainable food choice (Burges, 1992). Previous studies linked sustainable behaviour to personal values (Finegan, 1994; Sikula and Costa, 1994; Fritzsche, 1995; Grunert and Juhl, 1995; Thogersen, 2001; De Pelsmacker et al., 2003). Causal relation between certain values such as universalism, and a sustainable consumption pattern was confirmed, and it boosted these values through socialization and national institutions that could achieve sustainable consumption in the long run (Thogersen, 2001).

Apart from predicting food consumption pattern, food handling behaviour is also a popular application of TPB due to an increasing concern in food safety, which has been a global concern (Kuchenmüller et al., 2009) that affects individual health and increase social expenses on medical welfare (Hall et al., 2005; Mullan, 2009). In particular, approximately one quarter of the population in Australia and North America has suffered from illnesses caused by foodborne pathogens every year [(Scallan et al., 2011; McKercher, 2012).

Recently, it has been evident that the number of foodborne diseases is increasing (McKercher, 2012). To reduce foodborne diseases, it was essential to handle food properly at all stages from preparation, storage, to disposal (NHMRC, 2003). Previous researches investigated people's knowledge about food safety behaviour. For instance, consumer food safety information was compared and found that individuals had sufficient knowledge on cross contamination (Redmond and Griffith, 2003). Previous researches explained and predicted safe food-handling behaviours by using various theoretical frameworks, including the Health Action Process Approach (Chow and Mullan, 2010), and the Health Belief Model (Rimal, 2000; Bearth et al., 2014). However, TPB appeared to account for the most variance in behaviour (Mullan and Wong, 2009; Seaman and Eves, 2010; Shapiro et al., 2011; Mari et al., 2012; Mullan et al., 2013), applying to both overall safe food-handling behaviour and specific behaviours such as hand hygiene (Clayon and Griffith, 2008).

In the context of safe food-handling behaviour, TPB explained 34% of the variance in hand hygiene malpractices in the workplace (Clayton et al., 2003), and the TPB model could successfully predict food safety practices in small-scaled food retailers (Seaman and Eves, 2010). The theory has also applied to predict consumer food handling practices among Australian young adults, explaining over 60% of the variance in intention and over 20% of the variance in behaviour. It was also revealed that only subjective norms and perceived behaviour control were significant predictors, instead of attitudes (Mullan and Wong, 2009). Studies also show that TPB predicted 79% of intention and 97% of self- reported hygiene practice (Jenner et al., 2002). It is common to find that individuals are unable to translate their positive intention into behaviour, which is often referred as "intention-behaviour gap" (Sheeran, 2002). For instance, intention was predicted to account for only about 20% of the variance in safe food handling behaviour, i.e., 80% remained unexplained (Mullan and

Wong, 2009). Consequently, TPB was criticized as an incomplete model due to volitional characteristics (Sniehotta et al., 2014). Therefore, new variables were included to improve the predictive power of the model and to explain the phenomenon of "intention-behaviour gap" (e.g. Sniehotta et al., 2005; Reuter et al., 2010; Sainsbury et al., 2013). Moral norm, which acted as both a pre-intentional predictor (Conner and Armitage, 1998; Manstead, 2000) and a direct predictor of behaviour (Godin et al., 2005a), has been added to the standard TPB to bridge the gap between intentions and behaviour (Godin et al., 2005b). To investigate the influence of moral norms on actual behaviour, a moderation analysis was conducted with data collected from five previous studies (Godin et al., 2005a). The study demonstrated that 'morally-aligned intentions', which formed on the basis of the perceived moral correctness, was a better predictor of behaviour than 'attitudinally-aligned intentions' formed based on the likely outcomes (Godin et al., 2005a). Another commonly added variable to TPB was habit strength, which narrowed and explained the intention–behaviour gap (Gardner et al., 2011). Habit strength refers to the degree to which a behaviour becomes habitual or automatized (Verplanken and Orbell, 2003). It is particularly important in determining safe food handling behaviour in food preparation is routine and regular. Researcher discovered that the conscious intention was unnecessary when behaviour was constant in stable conditions and became habit eventually. Since safe food-handling behaviour was typically regular, it was possible that the majority of people turn such behaviour into habits (Ouellette and Wood, 1998). In addition, habit and past experience were important determinants to engage in future safe food handling behaviour (Brennan et al., 2007).

2.1.2.2 Application of TPB on Household and Commercial Food Waste Recycling

Many resources such as energy, water, and land are required to produce food, and a significant portion of the greenhouse gases were emitted from households (UNEP, 2010; Tukker and Jansen, 2006). In the United Kingdom, it currently costs a family an estimate of

£680 a year to purchase and dispose of food without eating. Greenhouse gases which are equivalent to approximately 17 Mt of carbon dioxide are released (WRAP, 2011; WRAP, 2013). For the sake of the seriousness to the environment, a number of past researches are about food waste in relation to consumers' perceptions and behaviours (Evans, 2011, Stefan et al., 2013; Quested et al., 2013; Abeliotis et al., 2014; Graham-Rowe et al., 2015).

Some situational characteristics were identified in relation to the amount of household food waste. For example, the larger the household size was, the more food was wasted (e.g. Van Garde and Woodburn, 1987; Koivupuro et al., 2012; Williams et al., 2012; Parizeau et al., 2015). However, larger households generated less waste per capita than that of smaller households (Quested et al., 2013). In particular, households with more children tended to generate more food waste (Van Garde and Woodburn, 1987; Parizeau et al., 2015), and parents reported challenges in predicting the quantity of food that children consume (Evans, 2011). Moreover, as different family members preferred different types of foods, a large variety of foods was available (Evans, 2012). In the literature, a wide range of predictors were suggested that affected households' food waste recycling behaviour such as awareness of food disposal (Parizeau et al., 2015), lifestyle (Ponis et al., 2017), recycling attitude and behaviour (Ko and Poon, 2009), impacts of recycling (Refsgaard and Magnussen, 2009), and availability of packaging technologies and storage area (Hebrok and Boks, 2017). Socio-cultural drivers were quantified by previous studies, such as available knowledge of food waste (Refsgaard and Magnussen, 2009), and the interaction of diverse factors along the globalized food chain (Hebroks and Boks, 2017). Multi-faceted policy levers and public commitment are essential to improve performance in various major aspects of values, skills, and logistics (Thyberg and Tonjes, 2015; Schmidt, 2016).

The first important step in recognizing some major factors to reduce household food waste and barriers is crucial in conducting qualitative research. Nevertheless, researchers argued that investigations should be theory-driven to discover the determinants of potentially modifiable behaviours. Theories can provide a framework to identify causal processes, thus facilitating drawing up and implementing constructive, replicable, and parsimonious policies (Michie and Abraham, 2004; Steg and Vlek, 2009). It is suitable to conceptualize the relationship between attitudes and behaviour even when behaviour is self-reported, according to the TPB principle. The TPB accounted for more than 11% of the variability in behaviour, no matter the behaviour is objective or observed (Armitage and Conner, 2001; Ghani et al., 2013). It was also proved additional role of concepts can be easily and flexibly adopted upon the scope of the original model (Collins and Mullan ,2011).

In the context of household food waste, the role of food-related practices and the core cognitive constructs specified by the TPB are explored. In particular, researchers investigated the impacts of attitude, subjective norm, and perceived behavioural control on individual's intention to reduce household food waste. Results revealed that only attitude as a significant factor to predict intention not to waste food, which comprised two constructs, i.e., moral attitude and lack of concern. Evidence showed that neither subjective norm nor perceived behavioural control drove intention. In addition, cross-sectional food waste behaviour was not significantly related to intention of food waste reduction (Stefan et al., 2013). In the domestic sector, marketing and sales strategies of shops affect critical individuals' food-wasting habits (Mondéjar-Jiménez et al., 2016). The key predictors of domestic food waste behaviour are mainly associated with attitude (Ghani et al., 2013), followed by moral norms (Russell et al., 2017) and perceived behavioural control (Visschers et al., 2016), while an indirect impact is caused by reuse/recycling habits (Stancu et al., 2016). Consumers' attitudes towards food waste are divided into two groups of measured variables, which are moral aspects and concern-based variables (Barr, 2007; Stefan et al., 2013). Results revealed that the moral aspects of attitudes significantly affected food waste in comparison to concern-based variables as consumers felt guilty when they wasted food (Bolton and Alba, 2012; Evans, 2012; Stefan et al., 2013). TPB is further extended and applied to predict household waste collection behaviours among Iranians, which include attitudes, subjective norms, perceived behavioural control, moral obligations, self-identify, intention, action planning, and past behaviour (Pakpour et al., 2014). Researchers also applied TPB model to identify that culture, participation dimensions, and reputational concerns played important roles in influencing recycling behaviour and shaping pro-environmental behaviours (Alpízar and Gsottbauer, 2015; Crociata et al., 2015). The use of economic incentives, legislation, and public education are implemented in pilot recycling projects to motivate citizens. However, it is challenging to specify the exact effects of these factors through direct observation while previous studies suggest a volatile relationship between these factors and individual behaviours (Valle et al., 2004).

Previous studies suggested the significance of intention in food waste reduction (Stefan et al., 2013; Graham-Rowe et al., 2015). However, planning and shopping routines were identified as additional determinants in the explanatory model and intention was not a significant determinant of food waste behaviour anymore (Stefan et al., 2013) Both the intentions and behaviour of consumers were affected by marketing strategies carried out by retailers. For instance, promotional offers in limited time drive consumers to purchase excessive quantities of food, emerging as one of the major factors of food waste generation (Lyndhurst, 2007, WRAP, 2007).

Other daily activities are also considered to bring substantial behavioural changes in households. Firstly, understanding the food labelling information is essential and it has often been misunderstood by consumers. Recently in the European Union, a consumer market survey showed that only about 30% of consumers understood the meaning of the 'best before' date. The meaning of the food labelling, including ‘best before’, ‘expiry date’ and ‘use by’, are clarified to improve customer certainties and knowledge of food edibility. In particular, the ‘best before’ date is related to the minimum durability while the ‘use by’ date is related to safety, which can assist consumers to make informed decisions (EU, 2015). Secondly, consuming household leftovers is crucial as it can save money and reduce household food waste. However, educational campaigns concerning the re-use of leftovers are inadequate. In Belgium, a series of cooking courses were arranged for citizens, targeted to assist households to reduce the food waste generation and increased their flexibility in meal planning. Lastly, a shopping list is advised. Planning routines can avoid unplanned purchases (Bell et al., 2011; Stefan et al., 2013; Principato et al., 2015), and preparing an shopping list by checking food stocks prior to shopping can minimize food waste generation (Chandon and Wansink, 2006; Exodus, 2006; WRAP, 2007).

In view of the existing household solid waste separation and collection, scholars start to be extensive concerned about the formation mechanism of household solid waste recycling behaviours. Such fundamental understanding helps promoting knowledge of the available recycling programs in community and thus encouraging the participation of individuals. Researchers believed that public relations could be used as an important platform to motivate involvement of individuals in recycling programs. Public relations activities must target at specific groups, with carefully designed projects, an analysis of the target group and choice of media. It was observed that there was limited public participation in recycling despite the strong governmental support and encouragement (Salhofer and Issac, 2002). Concerns are thus raised to address such discrepancy. An extensive meta-analysis of over 60 empirical studies on the effect on recycling behaviour by several variables was conducted. Incentives for social behaviour and barriers to social behaviour, which could either be internal or external to the individual were discovered (Hornil et al., 1995). An analysis of household recycling by apartment dwellers was conducted and two related strategies to motivate daily recycling were suggested. First, Containers were placed at accessible locations for the convenience of residents nearby. Second, food was recycled during the preparation process (Hormuth et al., 1993). Similarly, researchers proposed a different theoretical approach in recycling. An open-ended questionnaire was distributed to individuals to find out whether manageability contributes to desired recycling by organizing their activities with regard to effective self-regulation. It is indispensable for individuals to understand their environment in order to support desired behaviour (Zimmerman, 1989). Social influence is defined as a concern over how one's recycling behaviour be affected by friends and families. Social influence can significantly affect and sustain recycling behaviour (Vining and Ebreo, 1990). Moreover, motivation as a strong influence on recycling when individuals feel satisfied when contributing to the environment (De Young, 1988).

Recycling which household waste must be sorted, prepared, and stored, is a behaviour requiring substantial effort from individuals (Boldero, 1995). As a result, the recycling decision involves complex consideration of various factors, such as convenience. Researcher discovered that an effective motivator to drive recycling could make recycling with greater convenience (Nyamwange, 1996). Recently, researchers paid extensive attention to the motivational factors behind recycling attitude and behaviour, aiming to isolate specific characteristics that contribute to recycling participation. The need to understand the influences of consumer environmental behaviour is emphasized and predictors to such behaviour are identified. To conclude this study, there was insignificant relationship between social norm and behaviour (Bratt, 1999). It was contrary to the findings of a study conducted in California, in which peer pressure appears as a major predictor or motivational factor of recycling behaviour. This implied that individuals intend to make more socially responsible decisions when their peers recycle (Oskamp et al., 1991). In view of the determinants that promote sorting and collection, the formation of strong recycling habits across communities was investigated, and the social influences and altruistic and regulatory factors were considered important (Vining and Ebreo, 1990; Ewing, 2001). The TPB is combined with norm-activation theory to explain that recycling intentions are affected by perceived policy effectiveness in Hong Kong (Wan et al., 2014). The importance of public understanding is emphasized in participation rates in recycling. Attention should be paid to the frequency and effectiveness of households instead of the number of householders participating in recycling (Thomas, 2001). The awareness of local authority and promotion campaigns are important as poorly designed and implemented campaigns lead to constantly low recycling participation rates (Evison and Read, 2001). Moreover, a recent investigation discovers that insufficient resources can lead to difficulties in lowering food waste disposal and changing recycling behaviour in restaurants (Sakaguchi et al., 2018).

2.2 System Dynamics on Construction Waste Management

This chapter introduces a system analysis approach, commonly known as System Dynamics (SD) method, and concerns designing models or representations of real-world systems and investigating their dynamics. The application of SD facilitates the understanding of the relationship between the behaviour of a system over time and its underlying structure. By the end of the chapter, the major components and theory lay behind the use of SD are explained.

A full discussion of the applications of SD on various environmental issues, comprehensive literature review on construction and demolition waste management in the stream of municipal solid waste to demonstrate its broad application to explore “what-if” scenarios and policy analysis.

2.2.1 Introduction

MSW consists of waste generated from residential, commercial, institutional, and industrial sources, including wood, yard trimmings, durable and nondurable goods, food waste, and inorganic waste. In 2010, over 250 Mt of MSW were generated in the United States (USEPA, 2010), over 30% of which is recovered for recycling from processes such as composting. Among different types of MSW, there are two types which contain solid wood, namely “wood” and “yard trimmings”. Because of the wood component, the type of “wood” can further be categorized into items such as wooden furniture and cabinets, wooden panels, wood formwork, and wood from manufacturing facilities. However, round wood, unprocessed wood, repaired wood, or recycled pallets are not included. Meanwhile, “yard trimmings” refers to leaves and grass clippings, brush, and tree trimmings (USEPA, 2010). In 2010, approximately 16 Mt of MSW wood waste were produced, with a low recovery rate at 15 %. In MSW, the total wood waste is approximately 14 percent. However, the quantity of wood waste varies by countries. At the same time, over 30 Mt of yard trimmings were generated, comprising of 55% wood and 45% herbaceous material (Falk and McKeever, 2004; McKeever, 2004). Yard trimmings waste has a higher recovery rate of 58% compared with that of wood waste (USEPA, 2010).

Construction industry influences the socio-economic development of all regions and the industry has been rapidly growing due to the increase of living standard, demands of infrastructure projects to meet the growing population, and reshaping of consumption traits. Such growth is associated with the waste generation that causes severe social and environmental problems globally (Begum et al., 2010; Katz and Baum, 2011; Nagapan et al., 2011). C&D wastes which are originated from different types of activities and have various characteristics, and differ in separation, recovery and recyclability processes. C&D waste is defined as one of the waste streams in MSW. Construction waste is generated from the process of construction, repair and remodelling of residential and non-residential structures while demolition waste is produced when structures are demolished, which is often contaminated with paints, adhesives, wall covering materials. C&D waste is one of the heaviest and most voluminous waste streams generated worldwide (Ng and Engelsen, 2018), which accounts for over 30% of global waste (Llatas, 2011). C&D waste even accounts for over 70%, 50%, 40%, 35%, and 30% of the total waste in Spain, United Kingdom, Australia, Japan and Italy, respectively (Poon et al., 2013). In China, C&D waste generation accounts for 40% of the total waste (Wang and Li, 2011). In the past decades, environmental pollution, resource over-depletion, and increasing land price have been caused by improper C&D waste treatment and disposal, exerting great threat to the living environment (Chen et al., 2017). Previous researchers indicated that waste is generated from planning, design, procurement, and construction stage (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000) and it affects the economical dynamics of community and poses impacts on the environment (Kralj, 2011). Over 130 Mt of C&D waste were generated in the United States in 2010, which contained 28% of wood. In particular, over 80% of wood debris was from demolition activities while the rest was from construction activities. C&D waste generation and recovery rates are affected by various economic drivers such as housing completions and the changing population (Falk and McKeever, 2004; McKeever, 2004). In the United States, wood waste generation is significantly influenced by the general economic recession, specifically new residential construction. Over 35 Mt of C&D wood generated, nearly 48% of waste was recoverable. The percentage of wood varied from around 25% to 55%, which the total amount of wood in the C&D waste stream is about 30% (Staley and Barlaz, 2009). Construction waste can be classified into two groups, namely physical and non-physical waste. Physical waste contributes significantly to landfill. Previous studies reported that the construction industry generates more than 50% of waste material ending up in landfills (Hwang and Yeo, 2011). On the other hand, non-physical construction wastes refer to intangible expenses such as time and expense incurred in completion delay inconstruction projects (Formoso et al., 1999; Alwi et al., 2002).

This chapter aims to provide a holistic literature review on the management of wood and yard waste from the MSW and C&D waste streams. This chapter gives a brief overview of global solid waste composition, then introduces system dynamics (SD) approach and its development, applications of SD on various environmental issues, comprehensive literature review on wood and yard waste management in the stream of MSW and C&D, and the current implementation of SD on MSW and C&D waste management.

2.2.2 Current Implementation on SD Model

SD can be applied to numerous areas. For instance, SD has been applied in social studies, such as business administration, physical and social sciences, mathematics, law, medicine, and education (Alessi, 2000). Business administration is often the starting point and ending up in resolving some environmental problems to predict individual's behaviour or search for solutions in more complex issues. Regarding business administration, previous researches made use of SD to investigate production cycles of hogs, chickens and cattle and the generation of business cycle for demonstrating production scheduling and workforce management policies. Studies find that business cycles are caused by “capital investment policies that fail to account for delays in acquiring long-lead time plant and equipment” (Sastry and Sterman, 1992). Other applications of SD such as management and the use of marketing models on corporate planning, policy design, strategy support models and organizational learning are emphasized. The use of SD also extends from business administration to dealing with environmental problems. For instance, studies on climate change and solid waste management (Aboyade, 2004), and mining problem (Coyle, 1998) are prominent.

Improving organizational performance is a general approach of the SD application. SD, can be applied in multidiscipline, aims to simulate the reality in order to achieve improvements and. In terms of Industrial Dynamics, which is one of the most common application areas of SD. In the context of enterprise design approach (EDA), the problem managed is first recognized that the modeller is responsible for creating the structure system of the problem definition. Results from EDA helps develop SD model that only contains the factors affecting the problem. This state-of-the-art approach is that the interactions of variables in the structure are also under consideration when SD facilitates the development of the organization. Model development provides basic knowledge on the system structure and testing of improvements on the model provides more knowledge that lead to findings of possible improvements. The process may be perhaps simple, but it is time-consuming and requires effort in understanding and hypothesizing relationships of variables within one system. The complexity of developing a valid SD model and the characteristics of problem depends on the types of organizational application that modeller chooses. Theoretically, there is no limitation on the area of the organization that SD can be applied. SD simulation is a possible organizational application to understand the characteristic behaviour of the actual system on any dilemma that can be quantified and validated.

SD has been considered as a quantitative method, which all relationships among variables are assigned with values. Previous literature discovers that the outcome of qualitative analysis is not measurable and cannot be validated. SD founder, Forrester, believed that simulation was the only solution to reveal systems' behaviour since they are too complicated. SD is a method with great capacity and the system behaviour can be further understood when making a model for perception of the system (Forrester, 1961). At the same time, systems thinking comes from the application of SD approach but not from the simulation. In particular, SD applications on some environmental problems are further investigated, such as water management, energy policy and solid waste management.

An SD model is developed for determining the most suitable utilization scenario for water resources system in China, which initiates a dynamic hypothesis by separating the regional water resources system into subsystems and then into different departments. In order to illustrate the overall feedback mechanism of the water resources system in China, researchers define the causal feedback structure of water supply and demand (Gao and Liu, 1997). Previous literature emphasizes on the demand-sided approach by developing a set of mathematical equations to project water demand, water supply and the effect of water price on demand in Yulin city in China. It is more effective to resolve the issue of water scarcity, when compared to supply-sided approach (Wang et al., 2011). Moreover, the supply and demand balances trend of water resources in Shandong Province in China is predicted by establishing an SD model to analyze the regression equation of the growing population (Huang and Yin, 2017). In the global context, a participatory SD model is initiated to establish a model for sustainable water resource management for the Palouse basin in the United States. Researchers perform an iterative process that includes workshops and model building between workshops to propose a dynamic hypothesis (Beall et al., 2011). In order to improve the effectiveness of irrigation water systems in Australia, an SD model is developed to assist irrigators, water policy decision makers and water supply authorities (Elmahdi et al., 2007). While in Florida, the domestic water demand for Manatee County is estimated by an SD model consisting of three submodels, namely socioeconomic, population and water demand. Researchers have successfully quantified the interrelationships among variables of these submodels by collecting respective data from US Census Bureau and US Department of Labor and other relevant literature to formulate regression and empirical equations (Qi and Chang, 2011).

SD is often applied in policy analysis, which aims to investigate how specific change in a parameter in the model impacts its response. It allows modellers to recognize the policy levers that would have the desired effects on the proposed model (Saleh et al., 2010). Ten different policies and scenarios are proposed in previous research on the exploration of water supply and demand scenarios to examine the sustainability of the water resources in China. The targeted outcome of the above policy analysis aims to provide decision-makers with viable options of higher contributions to sustain water supply in the Yellow River Basin. Each scenario consists of various interconnected factors and inputs from different socio-economic sectors (Xu et al., 2002). Other researchers compare the effect of different policy options such as low flow appliances, xeriscaping and pricing with the status quo scenario over a time horizon of 25 years to reduce municipal water demands. Results reveal that a maximum possible reduction in the municipal water demands can be achieved by integrating the use of different policies (Ahmad and Prashar, 2010). In Canada, researchers conduct policy analysis to uncover the significant relationships between the future development and a sustainable and acceptable quality of water resources and restraining demand. An integrated water resource management SD model is developed by classifying twelve scenarios into four groups that are population, water, economy and energy. Each scenario contains multiple policy variables from different sectors (Simonvic and Rajasekaram, 2004). Previous literature creates five alternatives from a different combination of four policy options on the aquifer management plan in Idaho to evaluate system reliability. The system reliability which is at 97% is highly satisfactory in simulating the outcomes of the designed policy options stipulated for Snake River Basin (Ryu et al., 2012). In order to determine the maximum possible growth in variables such as crop yield, net-farm income, population, agricultural, domestic and industrial, water demand by 2050, three different policy scenarios, including the development of water infrastructure, cropland expansion and dry conditions, are designed for the sustainable water resources management in the Volta River Basin, Ghana (Kotir et al., 2016).

Besides water management, energy policy analysis is another popular application of SD model. Three categories can be classified in the context of energy policy formulation, which are strategic, tactical and operational problems. To better understand the use of SD model on energy system policy, problems are categorized into energy-economy-environment (3Es) including energy demand-supply management problem, new product innovation problem, capacity management problem and energy pricing problem (Jebaraj and Iniyan, 2006; Mutingi and Mbohwa, 2013).

The 3Es concept is desired to be incorporated in energy policies by decision makers (Mutingi and Mbohwa, 2013; Qudrat-Ullah, 2013), that models developed emphasize on fulfilling both economic profit focused objectives and the sustainability of energy resources, and environmental health (Gimenez, 2012). For instance, polluter pays principle is promoted by the implementation of the emissions tax policy (Shafiei et al., 2015). Firstly, energy demand and energy supply related factors are investigated by researchers and energy policy makers by establishing energy systems models (Jebaraj and Iniyan, 2006; Mutingi and Mbohwa, 2013). Important dynamic factors, such as time delays and non-linear relationships among variables within system, are considered (Shafiei et al., 2015; Sisodia et al., 2016). Previous literature recognized two limitations to the growth of demand-supply related factors, which are energy resources and supply capacity. Demand-supply related factors in this study refer to variables such as economic growth, status of energy resources, industrial activity, propensity for investment, societal development, customer pressure, and technological supply capacity (Jebaraj and Iniyan, 2006; Gimenez et al., 2012) Secondly, new strategies for innovative energy technologies are crucial to meet the growing global energy demand in an economically and environmentally competitive manner (Jebaraj and Iniyan, 2006; Gimenez et al., 2012; Mutingi and Mbohwa, 2013) It is vital to develop new and clean energy sources, which can be commercialized and adopted by users to benefit our communities. Nevertheless, it is complex to establish innovative energy systems, which are time-consuming and with high failure rate to successfully implement all energy innovation projects. Extensive support from a combination of different operators, commercial disciplines, public and private entities that are in partnerships and investors are necessary to commercialize new energy technology (Mutingi and Mbohwa, 2013). Thirdly, capacity adjustment decisions can resolve capacity management problem in light of energy demand-supply factors (Jebaraj and Iniyan, 2006) such as availability of energy resources. Policy makers would like to forecast the possible impacts of their decisions during the implementation of energy policies, such problem would be affected by investment opportunities from the commercial companies (Braun, 2002;

Wolstenholme, 2003; Wolstenholme, 2004). Fourthly, energy pricing problem can be resolved with the consideration of the dynamic relationships between energy demand, supply and pricing, which are non-linear (Liuguo et al., 2012). Energy systems constantly move towards the point of equilibrium when the market prices are adjusted by dynamic changes of energy supply. SD model is a suitable approach to evaluate nonlinearities interactions among dynamic variables by formulating multiple feedback loops and time delays that lead to unexpected system behaviour (Qudrat-Ullah, 2013).

2.2.3 Current Implementation on C&D Waste Management

USEPA defines MSW wood waste which include two types – wood and yard trimmings. "Wood" includes wood generated from construction and demolition processes such as scrap lumber, cabinets, and wooden furniture, and others such as wood containers and pallets. On the other hand, yard trimmings refer to brush, leaves, grass clippings, tree trimmings, and removals (Falk and McKeever, 2012; USEPA, 2013). However, it appears that the major regulatory agency dealing with waste has a different definition for urban wood waste. They define urban wood waste as landfill disposal of yard trimmings, wood waste generated from C&D projects, site removals, pallets, furniture, packaging, and other commercial or household wood waste (USEPA, 2007). Also, some regions put more emphasis on residential and community yard waste than C&D waste. For instance, urban wood waste is described as "yard waste in the regulations of North Carolina, which yard waste is categorized into two classes: (1) wood waste generated from land-clearing debris and (2) trash that contains yard. During the construction of households, infrastructure, and other commercial buildings, land-clearing debris including trees and other vegetations are generated. On the other hand, plantations and shrub branches, logs, wood from landscaping, and debris from natural disasters are referred to as yard trash (Heinen et al., 2012). Urban tree removals are identified as a crucial part of the urban wood waste stream in the wood recycling campaign in the San Francisco Bay area (Fairchild , 2003). The above examples illustrate that the emphasis is put on trees and yard waste as urban wood waste, while wood from MSW stream and C&D debris are excluded.

Previous literature intend to increase the market value of some low-value products, such as mulch or firewood by conducting urban wood utilization studies and examining the utilization of urban trees and woody yard residues from municipalities (Bratkovich , 2001; Cesa et al., 2003; McKeever and Skog, 2003). Some of these studies discover that plantation accounts for the major constitution of the urban wood waste stream (Bratkovich , 2001; McKeever and Skog, 2003). Previous studies emphasize on the utilization of plantation from urban wood waste, and neglect the composition of urban wood waste. International organizations, such as The Urban Forest Products Alliance and The Tree Care Industry Association, define urban wood as wood from felled urban trees and trimmings (Urban Forest Products Alliance, 2013) and describe a wood product produced from an urban or community tree harvested from residential or public lands as "urban forest product" (Tree Care Industry Association, Inc., 2012), respectively. The Urban Forest Products Alliance, which consists of representatives from industry and public authorities, aims at promoting sustainable recovery and uses of products from urban forests. The Tree Care Industry Association is a group of leading corporates that work in trade association for commercial tree care. Similarly, corporates consider urban trees and woody debris as urban wood waste (Little et al., 2011). The above section provides discussion on the various definitions of wood and yard waste globally. In short, wood and yard waste can be considered as C&D waste within the MSW stream. In order to conduct a comprehensive literature review on both wood and yard waste in general, studies of the implementation of the SD model on MSW and C&D waste are investigated.

2.2.3.1 Literature Review on the Implementation of SD on MSW Waste Management

The causal interactions of different variables are studied by conducting simulation on the performance of a closed-loop chain (Llgin and Gupta, 2010). The complexity of the waste generation and management process are incorporated by combining some simpler sub-processes to develop the dynamic system. Parameters that influence waste generation are identified and input into the model for further interpolation with the consideration of a specific prosperity level, depending on the income level of individuals. The dynamic characteristics of the changing environment of a city are captured. Over the past decades, a wide range of disciplines have been studied with the applications of SD, such as the comparison of MSW management systems of the Netherlands and India (Yücel et al., 2008); environmental sustainability (Kunsch and Springael, 2008); strategic management (Warren, 2005); systems to assist decision-making processes (Nail et al., 1992), and environmental impact assessment (Vizayakumar and Mohapatra, 1993). At different prosperity levels, the generation of total MSW is estimated by formulating the suitable regression equations derived through time-series and cross-sectional data analysis for the assessment year. In order to further process the consequences and deepen the understanding of authorities in the complex interactions, it is indispensable to predict and consider recyclables, organic waste, and other discards including mixed and un-separated residual waste. Estimations should also consider the relationships between socio-economic and demographic conditions and the waste generation rate. Significant parameters in affecting MSW generation are discovered in previous studies, including gross domestic product per capita, infant mortality rates, population distribution, size of household, life expectancy and labor force in agriculture sector (Beigl et al., 2003). The above six indicators are recognized as strong economic outputs and related process to influence the waste generation. According to established principles and relationships, the basic model structure for city-scale waste generation is developed in Newark city, which is one of the larger urban centres in the New Jersey (Beigl et al., 2003). A ten-year assessment horizon, the year 2003 to 2013, is selected for modeling. The projections of total waste generation and the collected waste fraction are performed independently. Paper and cardboard, metals, plastic, glass, hazardous waste and organic waste are the modeled waste fraction, which data is collected from the municipal recycling tonnage records at the Essex County Utilities Authority (ECUA, 2003). The state variables include total annual MSW generated per person as stock, the total MSW generation in the assessment period and the available space of landfill with and without respective waste prevention measures. Other studies also investigate factors of waste generation (Liu and Li, 2015).

Economic factors such as gross domestic products are often emphasized in previous waste generation studies. However, earlier literature proposed other additional factors such as purchasing power (Lam and Chan, 2014). Furthermore, interactions between these additional factors and MSW generation are conceptualized due to an increasing economic growth on regions. This leads to higher spending per capita and results in more MSW generation (Hong et al., 2010). Qualitative aspects of waste generation and the separation of recyclable waste at source are analyzed by SD model with their respective impacts of transition from landfill to other waste disposal options (Mashayekhi, 1993). Such model is utilized as a basis to project MSW generation and formulate sustainable waste policies in developing countries (Hao et al., 2007). At the same time, an integrated MSW waste management system is established with the emphasis on the collection, transport means and its associated economic and environmental impacts (Wang, 2001). Five different SD models are simulated to investigate the associated impacts on the future generated quantities of MSW in terms of site selection, cost assessment, and capacity planning of MSW (Dyson and Chang, 2005). Other potential applications of SD model include the assessment of MSW treatment facilities to achieve a desired improvement on the environmental quality by developing MSW generation models (Sufian and Bala, 2007).

2.2.3.2 Literature Review on the Implementation of SD on C&D Waste Management

General studies on C&D waste management are further explored to provide a broader review to address the problems caused by C&D waste. Over the past two decades, C&D waste management have been emphasized and people aim to reduce its amount and impacts on the environment (Faniran and Caban, 1998; Yuan and Shen, 2011). The generation of waste influences the economic, environmental and social aspects in undertaking construction projects either positively or negatively. Therefore, the attempts on its management are of utmost importance to improve C&D waste practices (Yuan and Shen, 2011). To investigate the economic benefits of suitable C&D recycling techniques, many studies are conducted on the economic suitability of CDW recycling plants. A comparison is conducted in the implementation of a fixed recycling C&D plant between mobile recycling stations in China and the recycling centres with mobile stations in the Netherlands. It aims to investigate the success factors influencing the viability of a recycling plant. Results demonstrate that both fixed and mobile recycling centres with used equipment have higher commercial viability than centres equipped with new apparatus. This further explains that a higher profit margin is resulted for recycling centres with used equipment and location advantage while recycling costs are reduced with the scale of economy in fixed centres. Furthermore, investment risks can be reduced by introducing economic and political instruments (Zhao et al. 2011). The importance of creating an economic system to allow reusable and recyclable material flow is emphasized, that is in line with a critical principle of industrial ecology (Allenby, 1999). In the global context, studies on evaluating the economic suitability of a large-scale recycling plant in a densely populated urban region in Portugal are conducted. The recycling plant can achieve a high-profit potential in about two years with the return of invested capital despite the absence of regulatory government policy and high initial investment (Coelho and de Brito, 2013a). The authors further conduct a life cycle assessment on the above large-scale recycling plant in Portugal about the primary energy consumption and carbon dioxide equivalent emissions. The results show that the plant has a capacity of 350 tonnes per hour and 60-year operating lifespan. This means the performance in using recycled materials in the plant was good at saving energy and carbon dioxide equivalent emissions are lower during the operating lifespan (Coelho and de Brito, 2013b). The above studies affirm the commercial viability of operating a recycling centre of C&D waste when different conditions are considered.

Another research endeavours to minimize C&D waste by the implementation of various management measures. A wide range of aspects such as building design, on-site management, handling and storage of raw materials (Chen and Wong, 2002), and the transportation, recycling and disposal of C&D waste are examined (Hu et al., 2010). For instance, survey is conducted among large Singapore contractors to gather information on project design-related waste sources and to assess building design (Ekanayake and Ofori, 2004). At the same time, in China, major determinants influencing the implementation of on-site management are explored for improving the efficiency (Wang et al., 2010). The generation of construction waste in developing countries is grievous due to the following reasons. On one hand, a vast amount of construction waste is resulted from increasing large-scale construction activities in these countries due to urbanization and infrastructure development (Wang et al., 2010). On the other hand, decision makers neglect the impacts of increasing construction activities on the environment and focus on conventional project objectives such as cost, duration, quality, and safety (Shen et al., 2006). Therefore, the regulatory environment is immature and the application of waste management practices is insufficient to achieve a high level of C&D waste management (Lu and Yuan, 2010). Social impacts of poor management on C&D waste are seldomly investigated. Previous literature suggests that the collective development of economic, environmental, and social aspects can achieve sustainable construction in the long-run (Yao, 2009).

The unique characteristics of SD approach are proved to be an effective tool for simulating the effects on policy implementation (Tam et al., 2014). SD improves the soundness and effectiveness of the decision-making process, which makes it a prevailing technique for modelling construction project and waste management (Hao et al., 2007). While each construction activity involves various stakeholders [97], SD approach provides decision makers with analytical hierarchy processes to model sustainable waste management measures (Rong, 2004) and predicts the materials flow of concrete waste by simulation to reduce C&D waste (Hsiao et al., 2002). SD also interrelates subsystems within a complex system and provide knowledge on the dynamic interactions and interdependencies of the key areas in C&D management (Hao et al., 2007). To help decision makers and various stakeholders better grasp and understand the architecture involved in C&D waste management, SD approach for strategic planning of construction waste management is applied to explain the complex information from different perspectives. Quantitative studies are conducted to assess the social performance of C&D waste management in China. Results indicate that ‘‘physical working environment’’, ‘‘safety of operatives’’ and ‘‘practitioners’ long-term health’’ significantly contribute to poor social performance. Also, scenarios integrating various management measures can maximize the effect on enhancing the social performance of C&D waste management (Yuan, 2012). Besides quantifying social impacts on different C&D management strategies, studies which analyze the cost-effectiveness of implementing C&D waste management define the construction waste chain in Shenzhen, China. Conducting C&D waste management is beneficial, while a higher landfill charge, which gives higher net benefit, an earlier realization. Moreover, a higher environmental cost is resulted from illegal dumping when the general public is required to pay a higher landfill charge. Results also reveal some key characteristics of the dynamic system, including various elements involved, such as waste generation, reduction, reuse, recycling, and disposal. The dynamic system is different from the conventional researches that solely focus on the system from a static point of view (Yuan et al., 2011). Lastly, SD models compare and evaluate alternatives for a better operation of C&D recycling centres with the consideration of different policies and economic environments. Three major determinants, including profit, unit of recycling costs and extra revenue from location advantage contribute significantly to the economic feasibility of C&D recycling and the ratio of savings to costs. And the optimum ratio of savings to costs, the design of recycling centres and selection of governmental instruments can be achieved at a low level of the above three determinants upon the comparison between the ratios of public and private sectors.

Chapter 3- Methodology

3.1 Development of the Theory of Planned Behaviour on Food Waste

Important predictors of recycling behaviour have been identified as environmental attitudes and situational and psychological variables. However, a theoretical framework for systematically identifying the determinants of recycling behaviour is required to explore the further implications of these factors. The TPB as noted by Ajzen (Ajzen, 1991), provides such a theoretical framework. TPB has been applied successfully in many areas such as investigating dishonest actions (Beck and Ajzen, 1991). It is extended from the earlier theory of reasoned action (TRA) as suggested by Ajzen and Fishbein (Ajzen and Fishbein, 1980). From the original theory of reasoned action, the major factor in TPB is the individual's intention leading to a behaviour. Intentions involving motivational factors influence behaviour, which indicate the extent that individuals are willing to attempt or plan to take an action. Generally, the stronger the intention, the more likely one would turn the intention into an action. Both TRA and TPB can be applied to situations involving choices of behaviour and reasons could be provided for justifying such actions (East, 1993).

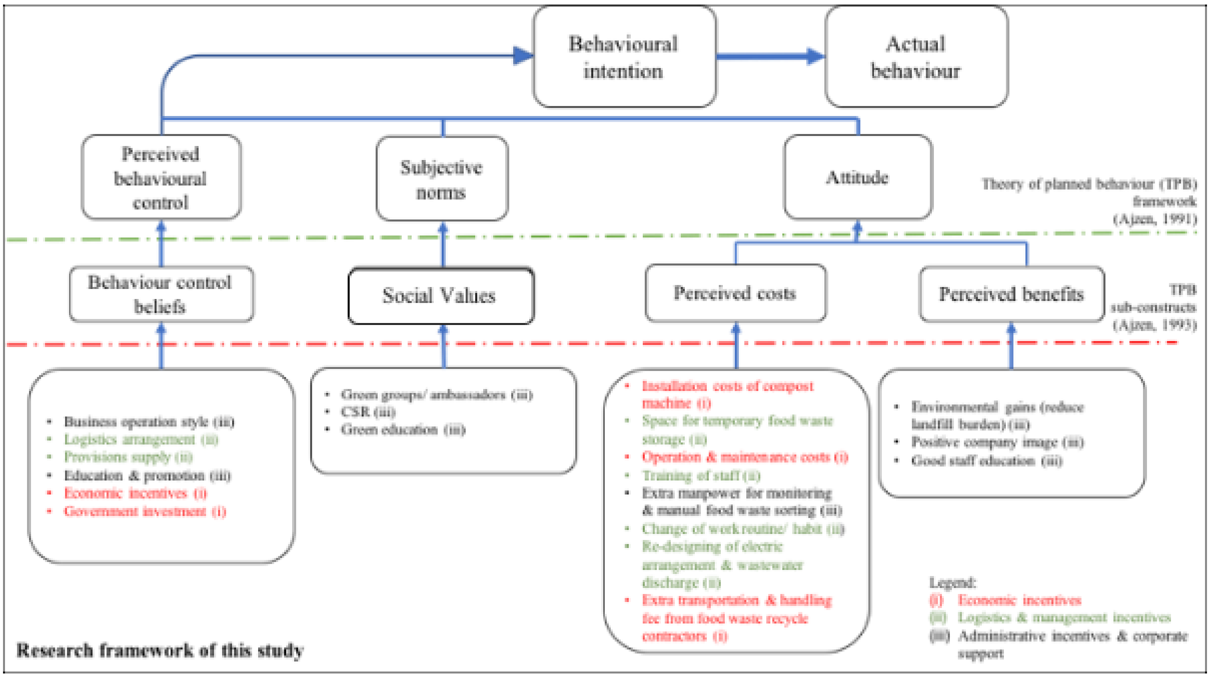
TRA hypothesizes two factors that influence intentions, including attitude and subjective norm. 'Attitude' refers to an individual's favourable or unfavourable evaluation leading to a behaviour while 'subjective norm' refers to the perception of social pressure leading to a behaviour (Ajzen and Fishbein, 1980). TRA assumes that most behaviours are under volitional control and individuals can decide on their own whether or not to take an action. Liska (Liska, 1984) suggests that such behaviour would be restricted by the lack of resources. In view of this, TPB could be extended to TRA by proposing the third variable – that is perceived behavioural control. It measures an individual's perception of the ease or difficulty in having a certain behaviour. The concept is most compatible with Bandura's concept of perceived self-efficacy, which concerns "judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1977). Previous researches (Bandura et al., 1977) suggested that individuals' actions are greatly influenced by their confidence in their ability to perform them (i.e., by perceived behavioural control). Therefore, perceived behavioural control can be used directly in TPB to predict behavioural achievement. Overall, the relative importance of attitude, subjective norm, and perceived behavioural control in the prediction of intention vary across different conditions. TPB is currently one of the most popular and well-established social-psychological models to understand and predict human behaviours. Generally, the more favorable the attitude and subjective norm with respect to engaging in the behaviour, and the greater the perceived behavioural control, the more likely an individual would come up with an intention, which may turn into a behaviour. Beyond the factors that constitute the theory itself as discussed above, the potential importance of other variables in TPB, such as demographic characteristics, personality traits and emotions, were recognized. These variables are considered as background factors in TPB, which are expected to indirectly influence intentions and behaviour (Ajzen, 2015).

Empirical validation of TPB is well-justified, with researches indicating that it reliably explains 40-50% of the variance in intention, with intention subsequently explaining 20-40% of the variance in behaviour (Armitage and Conner, 2001). Although TPB is well accepted as an important framework for predicting behaviour and health behaviour specifically, it could not capture all the determinants of a more complex behaviour. This may be explained by other related researches which do not incorporate exploratory studies in investigating the nature of the behavioural beliefs. Aizen argued that measuring underlying beliefs is of utmost importance as attitudes, intentions, and behaviour are most successfully altered when such beliefs are fully understood (Ajzen, 2002).

3.1.1 Development of an extended TPB framework on food waste recycling in the C&I sector

On the basis of TPB framework (Ajzen, 1993), an explanatory behaviour model tailored for food waste recycling was developed in this study, with behaviour-determining factors identified in the semi-structured interviews with management representatives. “Attitude” is related to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour (Ajzen, 1991) and as suggested that individuals would especially consider the costs and benefits of environmental behaviour personally if they have high egoistic concerns (Schultz, 2000) (Schultz, 2001); “Subjective Norms” refer to the influence of external social factors on individual behaviour; “Perceived Behavioural Control” refers to perceived ease or difficulty of performing the behaviour and it is assumed to reflect past experience as well as anticipated impediments and obstacles (Ajzen, 1991). The conventional TPB framework (Ajzen, 1991): (i) perceived costs, (ii) perceived benefits, (iii) social values, and (iv) behaviour control beliefs were under the three main constructs (Attitude, Subjective Norms, and Perceived Behavioural Control) **(Figure 3.1**). These constructs defined the questions prepared for the semi-structured interviews (Section 2.2), from which an extended TPB framework with three new TPB factors were established.

Semi-structured interviews were conducted face-to-face with nine management representatives from three industries, including: (1) hotel industry; (2) property management companies; (3) food and beverages industry (detailed interviewee’s profile was summarised in **Table C1**). . Representative sampling was useful for the purpose of the case study reported herein, to generate more universally acceptable results. This can be achieved via a combination of sampling techniques. For instance, purposive sampling gives a useful starting point by selecting participants who are thought to be information rich, which randomly select sampling units from a part of the population that possible contain the most information on the characteristics of interest to the researcher (Guarte and Barrios, 2006). Purposive sampling is often used to highlight and study extreme or deviant cases and allow interviewees to be selected based on their characteristics (Keeffe, et. al., 2016). In this thesis, interviewees were selected based on purposive sampling to provide expertise and knowledge in food-waste-related industries which represented the major food waste generation industries in the C&I sector of Hong Kong. Maximum variability was ensured by applying heterogeneous sampling to maintain diverse characteristics of interviewees (Black, 2010). Interviewees in different operative levels including both operation and management were selected to ensure interview results would not over-represent or bias towards a single operative level. Six semi-structured interview questions were asked regarding individuals' past behaviour and practices to recycle or dump food waste from commercial areas, perceived costs and benefits resulting from food waste recycling, social pressure identified, and factors determining the implementation of food waste recycling within the industry.



Research framework of this study

Figure 3.1 Extended theory of planned behaviour for food waste recycling in commercial and industrial sector.

3.1.2 Qualitative interview analysis and statistical questionnaire survey analysis

Perceived thoughts of interviewees on their respective consideration towards food waste recycling were compared with respective frequencies of keywords from the three interviewee categories (*i.e.*, hotel industry, property management companies, and food and beverages industry). **Figure A1** illustrates the flowchart of methodology section. Qualitative content analysis of the interviews was carried out by familiarizing with the collected information, *i.e.*, transcribing the verbal conversations and reading the scripts repeatedly (Braun and Clarke, 2006) and transcription (Stemler, 2001). Initial codes were then generated with open coding method to break down, examine, compare, conceptualize, and categorize data (Corbin and Strauss, 1990). Relevant keywords were coded in a systematic fashion in accordance to identification and grouping. Fundamental elements of the received information were then indicated (Boyatzis, 1998). Relevance of themes was reviewed and referred to the coded extracts and the entire interview scripts before naming each theme. In particular, (i) money, fee, charges, and incentives were grouped and coded under Economic incentives; (ii) education or company image was categorised under Administrative incentives and corporate support; and (iii) space, training, and provisions supply were grouped under Logistics and management incentives. These themes generated from thematic analysis of interview scripts were further examined and quantitatively compared by conducting questionnaire survey.

In order to evaluate the initiatives that determine the recycling behaviour of different stakeholders on a broader scale, online questionnaire survey with representatives from hotel industry, property management industry, and food and beverages industry was subsequently performed, which consisted of two sections: (1) detailed sub-questions related to each category;

(3) demographic characteristics of respondents, including gender, education level, age group, relevant work experience, respective industry, and relative role in corporates. Random sampling of questionnaire survey was adopted as it was open to the relevant industry and public stakeholders to ensure representativeness of the survey results. There was no limitation on the distribution of questionnaire as online open link was provided to all stakeholders. This approach was distinctive from the experience-derived and literature review-derived questionnaires, which were adopted in most of the previous studies. A five-point Likert response scale was adopted to quantify the perspectives of respondents on different issues addressed in the questionnaire, with "5" indicating strong positive view, "3" indicating neutral view, and "1" indicating strong negative view.

To quantify the significance of factors controlling individual's environmental behaviour based on the three new TPB factors (identified from semi-structured interviews) and three conventional TPB constructs, Partial-Least Squares Structural Equation Modelling (PLS-SEM) was adopted with SmartPLS software. PLS-SEM model focuses on the analysis of variance, and it has been widely used for explaining consumer behaviour and attitudes by identifying a set of proxy indicators that can directly measure indirect behaviour factors, known as LVs (**Table 3.1**), such as Logistics and management incentives and Moral attitudes (Results discussed in Section 3.1.1). There were two submodels in this Structural Equation Modelling (SEM). The inner model specified the relationships between independent and dependent LVs, while the outer model referred to the sub-questions asked in each LV and highlighted the interactions between LVs and their observed indicators (**Table 3.1**) (Monecke and Leisch, 2012).

Table 3.1 Latent variables and indicators of Hong Kong respondents.

Latent variables	Indicators
LV1: Economic incentives	How important are the following economic factors for promoting food waste recycling in your corporates? 1a. Capital costs of recycling equipment 1b. Operation & maintenance costs of recycling equipment 1c. Cost of off-site recycling: Transportation & handling fee to food waste recyclers 1d. Disposal charging fee imposed by the Government [Scale: 1: Strongly disagree; 5: Strongly agree]
LV2: Logistics and management incentives	Which of the following logistics and management factors can help to reduce food waste disposal in your corporates? 2a. Amenities that support food waste recycling activities on site 2b. Sufficient space for collection and separation of food waste 2c. Sufficient space for temporary storage of food waste 2d. Sufficient space for food waste recycling equipment 2e. Daily routine / work habit of operation staff regarding food waste disposal [Scale: 1: Strongly disagree; 5: Strongly agree]
LV3: Administrative incentive and corporate support	Which of the following administrative factors can help to reduce food waste disposal in your corporates? 3a. Corporate Social Responsibility (CSR) 3b. Corporate Environmental Responsibility (CER) 3c. Mature market of recycled products from food waste recycling 3d. Corporate culture 3e. Staff education and rewarding scheme to enhance awareness 3f. Extra manpower for food waste recycling training and on-site monitoring [Scale: 1: Strongly disagree; 5: Strongly agree]
LV4: Moral attitudes	4a. Less food waste would be generated if … a) I had more physical support (e.g., equipment) from the Government b) I had more management support from the corporate c) There are more financial incentives (e.g., charges/rewards) d) There is more education on food waste recycling 4b: It upsets me when there is a large quantity of wasted food for landfill disposal. [Scale: 1: Strongly disagree; 5: Strongly agree]
LV5: Subjective norms	5a: Wasting food makes me feel guilty about others who have insufficient food. 5b: My colleagues find my attempts to reduce food waste unnecessary.

	5c: My colleagues think that they should be more involved in food waste recycling. [Scale: 1: Strongly disagree; 5: Strongly agree]
LV6: Perceived behavioural control	6a: I have complete control in my position in deciding whether or not to separate and recycle food waste. 6b: It is difficult to reduce food waste generation from my corporate even if I want to. 6c: It is avoidable to load the environment with disposal of food waste generated from my corporate. [Scale: 1: Strongly disagree; 5: Strongly agree]
LV7: Recycling Intention	7a: In my opinion, food waste generation from my corporate is … [Scale: 1: not harmful to environment; 5: extremely harmful to environment]
LV8: Recycling behaviour	8a: My acceptable range of food waste recycling costs is a) HK$200 - 350/ t b) HK$350 - 500/ t c) HK$500 - 650/ t d) HK$650 - 800/ t e) >HK$800/ t 8b: My acceptable range of extra manpower for recycling food waste is a) 1-2 staff per 100 staff b) 3-4 staff per 100 staff c) 5-6 staff per 100 staff d) 7-8 staff per 100 staff e) >8 staff per 100 staff

The reliability of PLS-SEM model was tested with the indicator reliability and internal consistency reliability of LVs. Outer loadings were examined to assess the reliability of this SEM reflective model. Such loadings represent the paths from LVs to their respective indicators. Indicator reliability was assessed by considering the standardized outer loadings greater than 0.4 for an exploratory study (Henseler et al., 2012; Shields and Rangarjan, 2013). Internal consistency reliability of the inner model was examined with composite reliability, which varied from 0 to 1 (perfect estimated reliability). In a model adequate for exploratory purposes, composite reliabilities should be equal to or greater than 0.6 (Chin, 1998; Höck and Ringle, 2006).

The validity of the model was assessed with convergent and discriminant validity. The average variance extracted (AVE) can be used to test both convergent and discriminant validity of model, which should be greater than 0.5 such that error variance does not exceed explained variance (Chin, 1998; Höck and Ringle, 2006). Discriminant validity of LVs was assessed by Fornell-Larcker test to compare the square root of AVE values with LVs correlation. The standardised root mean square residual (SRMR) that less than 0.8 demonstrates a good fit of model (Hu and Bentler, 1998). The fitted model was then evaluated by comparing the coefficients of determination of constructs (R^2 value), path coefficients, and correlations among LVs. The R^2 values represent the overall effect size measure for the structural model. As suggested by the literature, the cut-off values of 0.67, 0.33, and 0.19 are classified as "substantial", "moderate", and "weak", respectively (Chin, 1998; Höck and Ringle, 2006). In order to prioritize the determinants of commercial food waste recycling, path coefficients that represent the correlation between each independent variable and dependent variable were compared. LVs correlations demonstrate the extent of correlation between the exogenous LVs (*i.e.*, variables that does not have an effect of any other latent variable in the model), with scores varying from 0 to 1.

3.1.3 Background of questionnaire design in Malaysia

A questionnaire was designed to quantify and compare the determinants of recycling behaviour of various regional employees, based on a previous research in Hong Kong under the TPB framework (Mak et al., 2018). In the original TPB theory (Ajzen, 1993), 'attitude' is the belief about the likely consequences of the behaviour (Ajzen, 1991). If individuals have high egoistic concerns, the costs and benefits of environmental practices will be evaluated by the individuals (Schultz, 2001). 'Subjective norms' is a normative belief that the perception about a particular behaviour is affected by the judgment of significant others, e.g., friends and parents (Ajzen and Fishbein, 1972). ‘Perceived behavioural control’ is the belief that the presence of factors that may encourage or hinder performance of the behaviour (Ajzen, 1991). Apart from the original TPB factors, three new factors including economic incentives, logistics and management incentives, and administrative incentives and corporate support were identified from the previous research of semi-structured interviews with Hong Kong expertises from the hotel, property management, and food and beverages industries (Mak et al., 2018) (**Figure 3.2**).

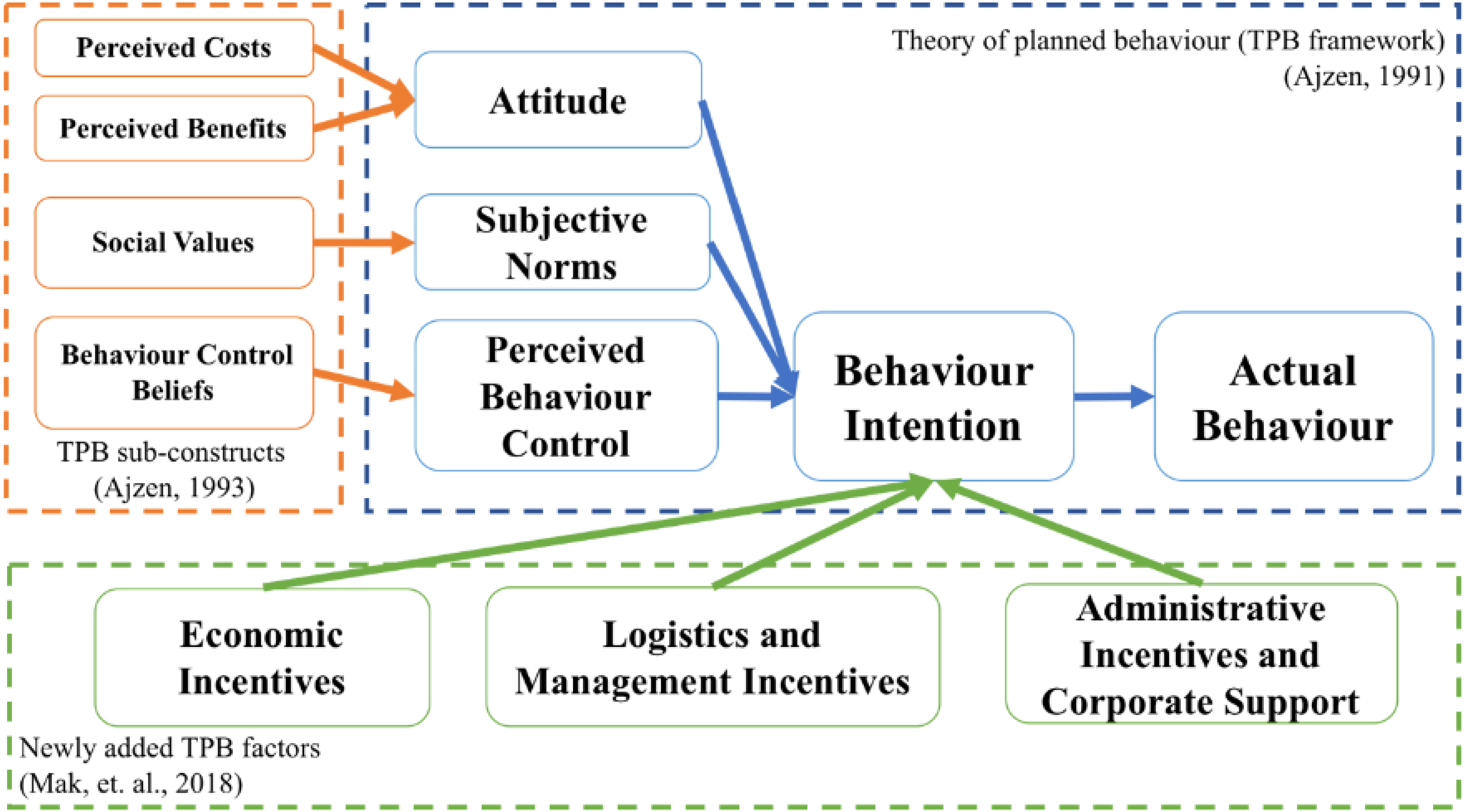


Figure 3.2 Extended theory of planned behaviour for food waste recycling in commercial sector in Malaysia.

There were two sections in the questionnaire, which included the sub-questions associated with each LV and demographic characteristics of respondents (i.e. gender, educational level, age group, relevant work experience, respective industry, and relative role in corporate sector) (**Table 3.2**). Random sampling was adopted to invite interviewees from respective industries to ensure representativeness of the results. A five-point Likert response scale was used in order to quantify the perspectives of respondents in various LV, which a substantial positive perception is represented by the highest number '5' , a neutral perception is represented by '3', and a substantial negative perception is represented by '1'.

Table 3.2 Latent variables and indicators of Malaysian respondents.

Latent variables	Indicators
LV1: Economic incentives	How important are the following economic factors for promoting food waste recycling in your corporates? 1a. Capital costs of recycling equipment 1b. Operation & maintenance costs of recycling equipment 1c. Cost of off-site recycling: Transportation & handling fee to food waste recyclers 1d. Disposal charging fee imposed by the Government [Scale: 1: Strongly disagree; 5: Strongly agree]
LV2: Logistics and management incentives	Which of the following logistics and management factors can help to reduce food waste disposal in your corporates? 2a. Amenities that support food waste recycling activities on site 2b. Sufficient space for collection and separation of food waste 2c. Sufficient space for temporary storage of food waste 2d. Sufficient space for food waste recycling equipment 2e. Daily routine / work habit of operation staff regarding food waste disposal [Scale: 1: Strongly disagree; 5: Strongly agree]

LV3: Administrative incentive and corporate support	Which of the following administrative factors can help to reduce food waste disposal in your corporates? 3a. Corporate Social Responsibility (CSR) 3b. Corporate Environmental Responsibility (CER) 3c. Mature market of recycled products from food waste recycling 3d. Corporate culture 3e. Staff education and rewarding scheme to enhance awareness 3f. Extra manpower for food waste recycling training and on-site monitoring [Scale: 1: Strongly disagree; 5: Strongly agree]
LV4: Moral attitudes	4a. Less food waste would be generated if … e) I had more physical support (e.g., equipment) from the Government f) I had more management support from the corporate g) There are more financial incentives (e.g., charges/rewards) h) There is more education on food waste recycling 4b: It upsets me when there is a large quantity of wasted food for landfill disposal. [Scale: 1: Strongly disagree; 5: Strongly agree]
LV5: Subjective norms	5a: Wasting food makes me feel guilty about others who have insufficient food. 5b: My colleagues find my attempts to reduce food waste unnecessary. 5c: My colleagues think that they should be more involved in food waste recycling. [Scale: 1: Strongly disagree; 5: Strongly agree]
LV6: Perceived behavioural control	6a: I have complete control in my position in deciding whether or not to separate and recycle food waste. 6b: It is difficult to reduce food waste generation from my corporate even if I want to. 6c: It is avoidable to load the environment with disposal of food waste generated from my corporate. [Scale: 1: Strongly disagree; 5: Strongly agree]
LV7: Recycling Intention	7a: In my opinion, food waste generation from my corporate is … [Scale: 1: not harmful to environment; 5: extremely harmful to environment]

LV8: Recycling behaviour	8a: My acceptable range of food waste recycling costs is f) RM$30- 60/ t g) RM$60- 90/ t h) RM$90- 120/ t i) RM$120- 150/ t j) >RM$150/ t 8b: My acceptable range of extra manpower for recycling food waste is f) 1-2 staff per 100 staff g) 3-4 staff per 100 staff h) 5-6 staff per 100 staff i) 7-8 staff per 100 staff j) >8 staff per 100 staff

3.2 Development of The Theory of Planned Behaviour on Construction and Demolition Waste

3.2.1 Development of Advanced TPB Framework

An extended TPB was proposed as the fundamental behaviour model in this study, which includes *perceived costs*, *perceived benefits*, *social values*, and *behaviour control beliefs* under the three main constructs (Attitude, Subjective Norms, and Perceived Behavioural Control) (**Fig. 3.3**). These constructs defined the questions prepared for the semi-structured interviews (Section 3.2.2), because pilot work that is representing our research population is necessary to explain TPB framework with appropriate respondents (Ajzen, 1991). On the basis of TPB framework (Ajzen, 1993), an explanatory behaviour model tailored for the recycling of C&D waste was developed in this study, by incorporating the significant intention- and behaviour-governing factors identified in the semi-structured interviews with construction-related experts.

3.2.2 Semi-structured interviews with construction-related experts

Semi-structured interviews were conducted face-to-face with eleven professionals, which represented three groups: (1) government officials (Civil Engineering and Development Department and Environmental Protection Department; including Chief Engineer, Senior

Engineer, and Engineer); (2) construction-waste-related organizations (Construction Industry Council, Hong Kong Productivity Council, and Hong Kong Waste Management Association; including Principal Consultant, Assistant Director, and Chairman); (3) environmental consultants and contractors (AECOM Asia Company Ltd., ATAL Engineering Ltd., Gammon Construction Ltd., and Ove Arup & Partners Hong Kong Ltd.; including Directors, Engineer, Senior Site Administrator and Waste Management Consultant). The sample size of the semi-structured interviews was determined with reference to the literature (Guest et al., 2006), which suggested twelve responses for qualitative interviews with a homogenous group of interviewees. Purposive sampling of interviewees was conducted to provide expertise and knowledge in construction-waste-related area, in which Heterogeneous sampling was applied to maintain diverse characteristics of interviewees. Maximum variability was ensured within the primary data obtained (Black, 2010). Selection of interviewees was based on the types of stakeholders within the construction industry and demonstrated similarities in terms of their own experience related to construction waste management. Selection of relevant individuals at different positions from diverse backgrounds, e.g., government, construction-waste-related organizations, and environmental consultants and contractors, can maximise the coverage and depth of interviews, and avoid biased results. Detailed profiles of the interviewees are summarised in **Table B1**. Seven questions were raised in the interviews concerning the past behaviour, perceived costs and benefits, social pressure identified, and factors determining the use of recycled materials.

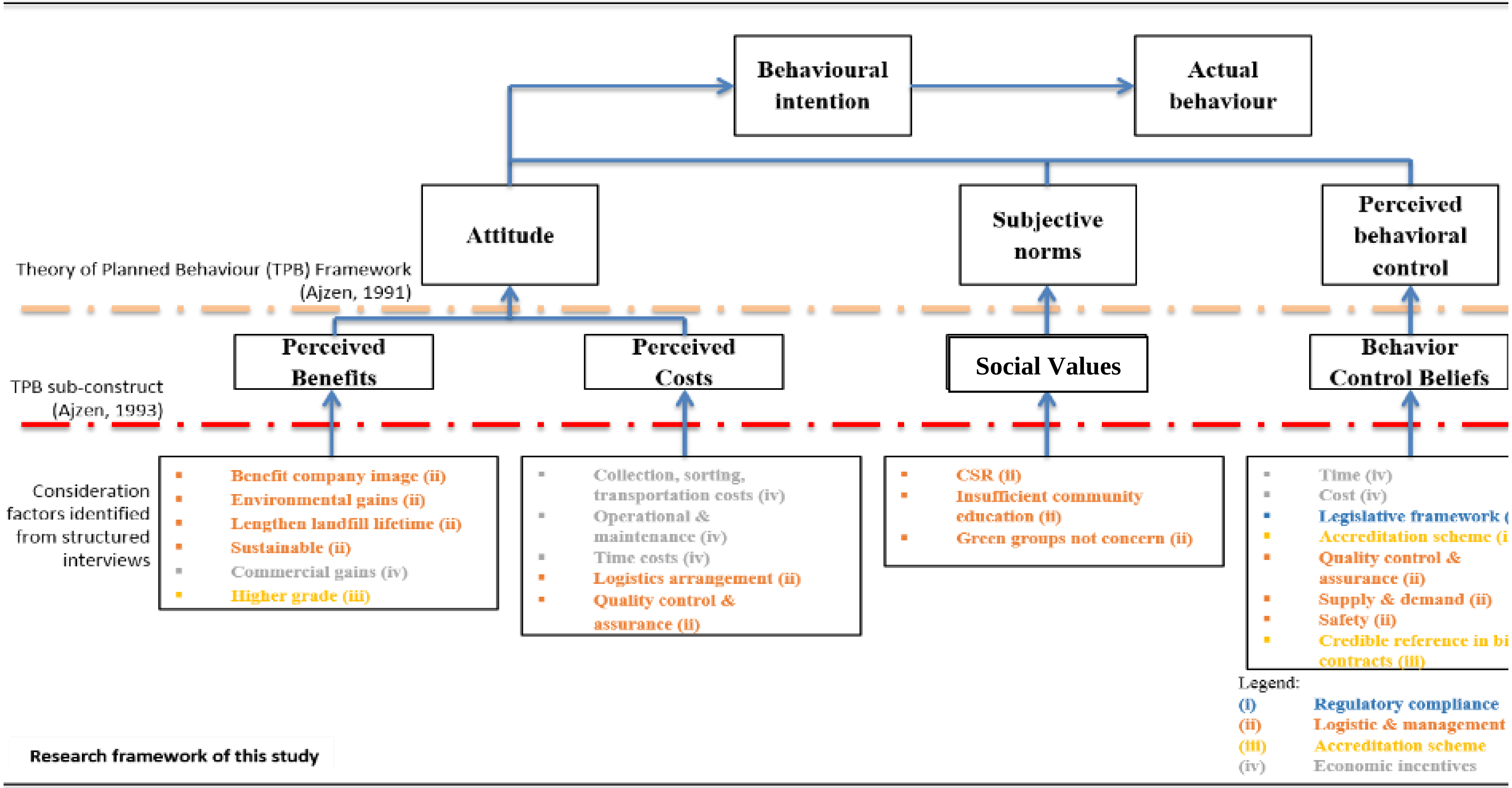


Figure 3.3 Extended theory of planned behaviour for C&D waste recycling.

Qualitative content analysis of the interviews was carried out after transcription (Stemler, 2001). Keywords were counted under each factor (i.e., perceived costs, perceived benefits, social values, and behaviour control beliefs (**Figure 3.3**). To ensure the reliability and validity of the qualitative semi-structured interview, the "truth value" (Guba and Lincoln, 1981) and "consistency" (Lincoln and Guba, 1985) were established. After transcription, scripts were returned to interviewees to check the creditability and see if the interpretation truly reflected their comments. Therefore, the "truth value" was ensured to reveal the accurate descriptions of individuals' experiences. The "consistency" was ensured throughout the interviews by standardising interview schedule (Brink, 1989), which included the use of recording equipment and the supervision of an experienced interviewer. Thematic analysis was performed to qualitatively analyse the content from scripts to highlight similarities and differences as well as generate unanticipated insights for studying social behaviour. Five phases of thematic analysis were applied in this study (Braun and Clarke, 2006). They included: (1) proposing preliminary ideas by familiarizing with the collected information, i.e., transcribing the verbal conversations and reading the scripts repeatedly; (2) generating initial codes using open coding method, which included breaking down, examining, comparing, conceptualizing, and categorizing of data (Corbin and Strauss, 1990). Relevant keywords were identified from the script and grouped according to relevance (Ryan and Bernard, 2003). They were then coded in a systematic fashion, for example, money, fee, and incentives were grouped and coded under Economic incentives. The codes indicated data features because they referred to the fundamental elements of the received information (Boyatzis, 1998); (3) defining the themes by identifying the common areas among the codes; (4) reviewing the developed themes to check their relevance to the coded extracts and the entire interview scripts; and lastly (5) naming each theme. Further analysis on each theme was conducted to refine specifics and generate clearer definitions.

In addition, frequencies of the keywords in the three interviewee categories (i.e., construction-waste-related organizations, environmental consultants and contractors, and government engineers) were compared to understand the perceived thoughts of interviewees on their respective consideration towards recycling. Afterwards, themes generated from thematic analysis of interview scripts were examined by questionnaire survey with the public. Significant factors controlling the recycling intention and behaviour were identified in the semi-structured interviews. These factors were added to the original TPB framework to develop an explanatory behaviour model that is relevant to the real-life construction industry.

3.2.3 Questionnaire survey and statistical analysis

Questionnaire survey with the community was then performed to investigate initiatives that determine the recycling behaviour of different stakeholders on a broader scale after conducting semi-structured interviews. Our questionnaire was established based on the comments and results from semi-structured interviews and consisted of three sections: (1) general views of respondents on recyclables application in Hong Kong; (2) detailed items related to each factor, such as scoring of the importance of recycling value of recyclables under the factor of Economic incentives; (3) demographic characteristics of respondents, including age group, relevant work experience, and occupation. The questions were designed based on the key factors (i.e., Regulatory compliance, Economic incentives, Accreditation schemes and Logistics and management incentives) identified from the above-mentioned semi-structured interviews. Items of each factor were established based on responses from the semi-structured interviews. This approach develops a questionnaire design with higher relevance to the real-life situation, in comparison with the experience-derived and literature review-derived questionnaires in most of the previous studies (Li, et al., 2015; Wu, et al., 2016; Bakshan, et al., 2017). Random sampling of questionnaire survey was adopted as it was open to the relevant industry and public stakeholders to ensure representativeness of the survey results. There was no limitation on the distribution of questionnaire as online open link was provided to all stakeholders. The questions of the questionnaire survey are provided in the Supplementary Information.

A five-point Likert response scale was adopted to quantify the perspective of respondent on different issues addressed in the questionnaire, with “5” indicating strong positive view, “3” indicating neutral view, and “1” indicating strong negative view. Online questionnaires were distributed to individuals from relevant fields, including contractors, consultants, government officials, construction-related experts in academics and green groups, and the public. Statistical analysis was performed to compare the mean scores of factors after confirming the reliability of questionnaire results in terms of the Cronbach’s alpha (α). The higher the value of α (ranging from 0 to +1), the more reliable the measured constructs, for which $\alpha \geq 0.7$ is considered highly reliable (Hairs et al., 1998; Tonglet et al., 2004). The table of Reliability statistics (**Table 3.3**) showed that the α value this questionnaire was 0.83, which demonstrated high internal consistency among the four identified factors and corresponding items. “Cronbach’s alpha if item deleted” of each item demonstrated that all items in the questionnaire were reliable (**Table B2**). Pearson’s correlation coefficient (r) was adopted in the range of +1 to -1, where values larger than 0.5 are considered having a significant correlation.

Table 3.3 Descriptive statistics of questionnaire responses

Category	Regulatory compliance	Logistics & management incentives	Economic incentives	Accreditation scheme	
				Understanding	Importance
Mean	4.17	3.90	4.07	2.91	3.90
SD	0.73	0.82	0.88	1.29	0.88
Cronbach’s alpha	0.83				

3.3 Development of System Dynamics Model

A model is defined as "an external and explicit representation of part of reality as seen by the people who wish to use that model to understand, to change, to manage and to control that part of reality" (Pidd, 1997). The development process of a model emphasizes a part of reality that requires deeper understanding and better management when creating an external and specific representation of this reality (Duggan, 2016). In different scenarios, decision makers encounter a social system that is complex and highly interacting with communities. Development of models offers a platform to decision makers to understand their communities as an interconnected system, which can consequently test the effect of policy interventions. Researcher provides a classification on the types of model that are available to predict future behaviour. Firstly, it is a model that provides absolute and precise predictions. Secondly, it provides conditional and precise predictions. Lastly, it provides conditional but imprecise projections on dynamic behaviour (Meadows et al., 1974). System dynamics (SD) primarily provides modelling for economic and policy simulations (Homer, 2012), and it can be categorized into the third class of model which provides conditional but imprecise projections on dynamic behaviour. This may due to the characteristics that social and economic systems can never be predicted in absolute accuracy (Meadows et al., 1974). Since researcher proposes that most of the models are in fact wrong (Box, 1976) that they are unable to produce precise point-predictions on future social events, it is challenging to create beneficial models through extensive validation of projected results with data from the real world (Sterman, 2002).

The environmental problem is known as a complex and dynamic issue that involves various disciplines to address the issue (Aronson et al., 2007). SD approach offers a suitable tool to capture and model the key components of environmental systems, which has a wide range of economic and environmental applications. Although SD can be applied to model restoration, it has been limited to either wetland or watershed issue (e.g. Arquitt, and Johnstone, 2008; Liu et al., 2008; Bendor, 2009). Other SD applications are widespread and incresingly prominent in resolving water, agricultural and other environmental problems, etc. For instance, researchers develop a model to understand the restoration of mountain fynbos ecosystems South Africa (Higgins et al., 1997). Some researchers focus on modelling wetland management in the Limpopo river basin (Jogo and Hassan, 2010) and estuaries (Turpie et al., 2008). Other studies include the modelling of the Indonesian agroforestry sector (Wise and Cacho, 2005) and the aquaculture sector in China (Nobre et al., 2009).

Systems includes four main components: (1) State variables, whichact as reservoirs, control variables for referring to ongoing processes within the system to decide reservoir. (2) Converters which are system variables, often influence the rates of operating processes. Positive or negative relationships represent the connections of all components within the system (Deaton and Winebrake, 2000). In SD model, the four main components to develop various system scenarios include stocks (state variables); flows (processes entering and exiting the state variable), auxiliary variables (converter) and information flows (connectors) (Kollikkathara et al., 2010). In particular, a stock acts as the foundation of any system (Meadows, 2008), which distinguishes the state of the system under investigation and provide the required information to assist in further decisions and actions (Sterman, 2000). Stocks can only be changed by flows, which are the quantities inflowing, or outflowing from stock over time (Duggan, 2016) There are three steps in forming the SD model. Firstly, develop connections of the generic structures of system or consider structural variables that may result in causing conflicts. Secondly, analyze results from a casual loop diagram to envisage the relationship of the problematic system. Lastly, provide answers for future improvement.

Components within the system are envisaged to interact with other recognized variables as feedback processes (Kollikkathara et al., 2010). The feedback mechanism defines SD (Lane, 2006), and it is indispensable in model development to recognize feedback loops within social systems in high complexity. A feedback loop is a series of circular causal connections, which a stock influences a flow and consequently changes another stock (Hannon and Ruth, 2001). Two types of feedback loops are identified by researchers: negative feedback and positive feedback. Negative feedback counteracts the direction of change while positive feedback drives exponential growth of stocks (Duggan, 2016). The merit of the SD model is to form complex feedback mechanisms effectively by integrating changes from small to large parameters that are incidental or continual. It is easier to analyze and manage complex environmental systems by developing interconnections across various sectors of a process structure, such as the waste-management system. Time-lag refers to the response time of a stimulus to the system. Variation, which occurs when the control variables do not depend on other variables linearly, has arisen in the feedback mechanism due to the presence of non-linear relationships (Hannon and Ruth, 2001). SD has the following distinctive methodological principles to facilitate the combination of various kinds of data sources via recognizing numerous interactions and significant time delays (Sterman et al., 2015). Firstly, SD models represent the system structure. Since the behaviour of a system originates from its structure, it also represents the behaviour of a system. Secondly, SD models capture disequilibrium. Thirdly, SD emphasizes on a broad boundary, and considers the feedback and the delayed impacts of decisions on its system. Lastly, interactions among system components are consistent with the real world since they are captured when modellers test the models with grounded methods (Sterman et al., 2015).

3.3.1 Development of SD model to determine waste disposal charge

SD was originally developed to provide simulations for long-term decision-making analysis in industrial management (Forrester, 1961; Hao et al., 2007). It is particularly suitable for complex systems as it can identify and monitor changes within and across different subsystems. Four major processes are identified in SD system, i.e., identifying essential variables to address problems, constructing major structure unit causal loop diagrams (CLD) to propose dynamic hypotheses, converting key variables relationships into quantitative stock-flow model, and validating the model with historical data (Chaerul et al., 2007). The CLD reflects major feedback mechanisms and serves as preliminary sketches of hypothesis and simplification of models. **Figure 3.4** illustrates the causal relationships between variables of concern in this case study in Hong Kong. Positive and negative signs represent the directions of causality. A reinforcing loop indicates the change of originating components that strengthens the original process, whereas a balancing loop indicates the response of other components that counteracts with the change of the originating component (Hannon and Ruth, 2001).

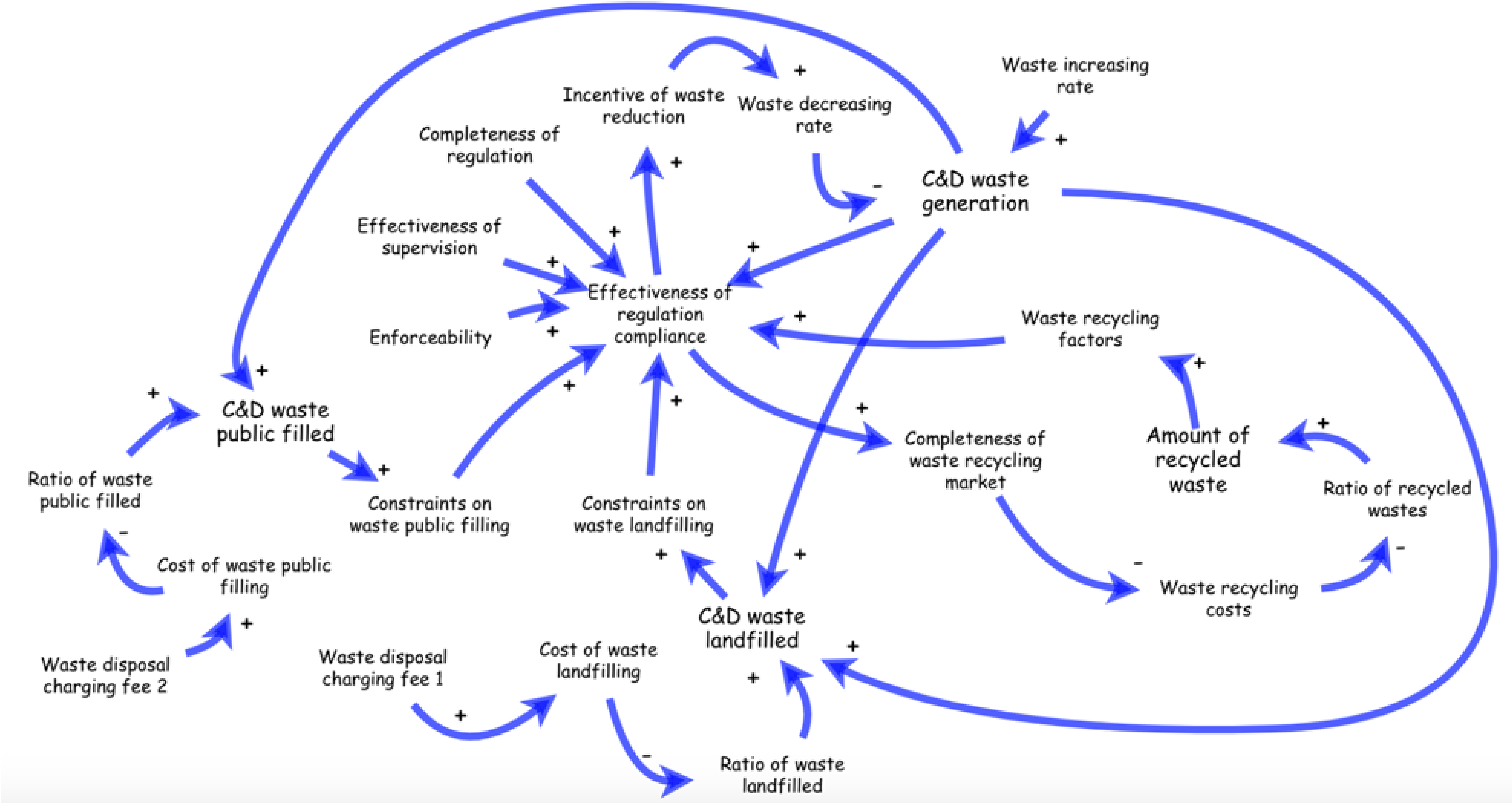


Figure 3.4 Causal loop diagram of model.

There are four feedback loops in the proposed SD model (**Figure 3.5**). The first loop (R1) is a balancing feedback loop. Within this loop, when the amount of C&D waste landfilled increases, the constraints on its landfilling become more significant and lead to an increasing influence on the effectiveness of regulation. Then, the incentive of waste reduction is enhanced and leads to a rise in waste decreasing rate that results in less C&D waste generation. Eventually, there will be less amount of C&D waste being landfilled. The second loop (R2) is also a balancing feedback loop. When there is an increase in C&D waste generation, there is an enhancement in the effectiveness of regulation. Thus, there will be a greater incentive to reduce waste, which results in a higher waste decreasing rate and produces less C&D waste. The third loop (R3) is a balancing feedback loop too. When there is an increase in C&D waste being public filled, the constraints on C&D waste public filling increase and the effectiveness of regulation rises. As a result, there will be higher incentives for waste reduction, leading to a higher decreasing rate of waste and reduced amount of C&D waste public filled. The last loop (R4) is a reinforcing feedback loop. When there is an increase of the amount of recycled wastes, there is a positive impact on the driving factor for waste recycling and the effectiveness of regulation enhance. Waste recycling market is then promoted and leads to a lower waste recycling costs due to a better economic environment of the industry. The ratio of recycled waste is higher and further reduces the amount of recycled waste. The CLD is then constructed through the Stella Architect software package to demonstrate a better understanding of the causal relationships among factors **(Figure 3.6)**. The construction of the causal loops referred to previous studies on C&D waste management in Chongqing (Zhao et al., 2011), Shenzhen (Tam et al., 2014), nationwide in China (Yuan and Wang, 2014; Ding et al., 2016), and the results from semi-structured interviews with construction-related experts in Hong Kong (Mak et al., 2019). Stock, flow, converter, and connector are the major components in the CLD. Stock refers to state variables and shows major accumulation within the system. Flow indicates the rate of change in stock and shows activities that fill in or drain stock. Converter is intermediate variables. Connector shows the positive and negative information links for cause-effect relationship between stocks (Chaerul et al., 2007).

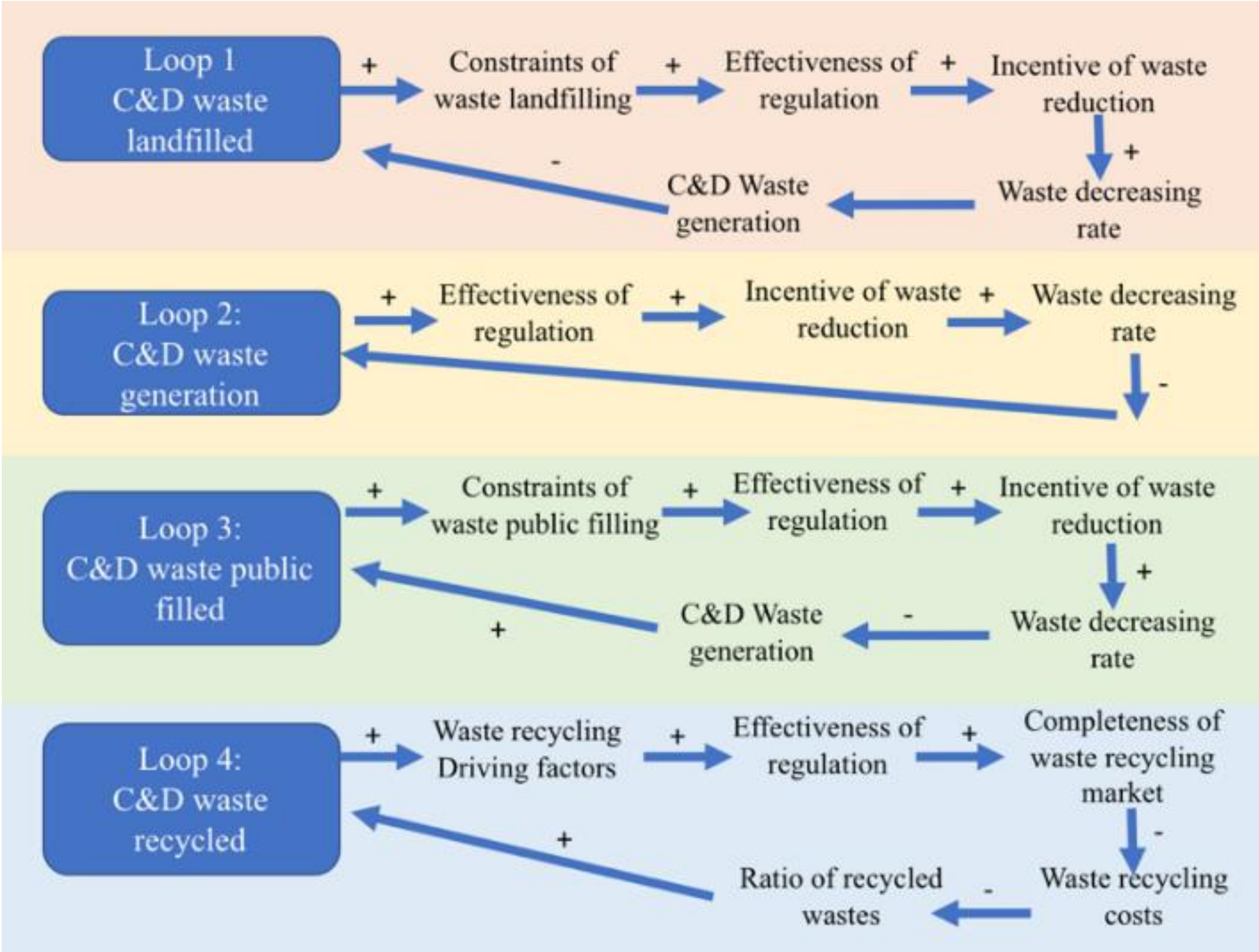


Figure 3.5 Four feedback loops of model.

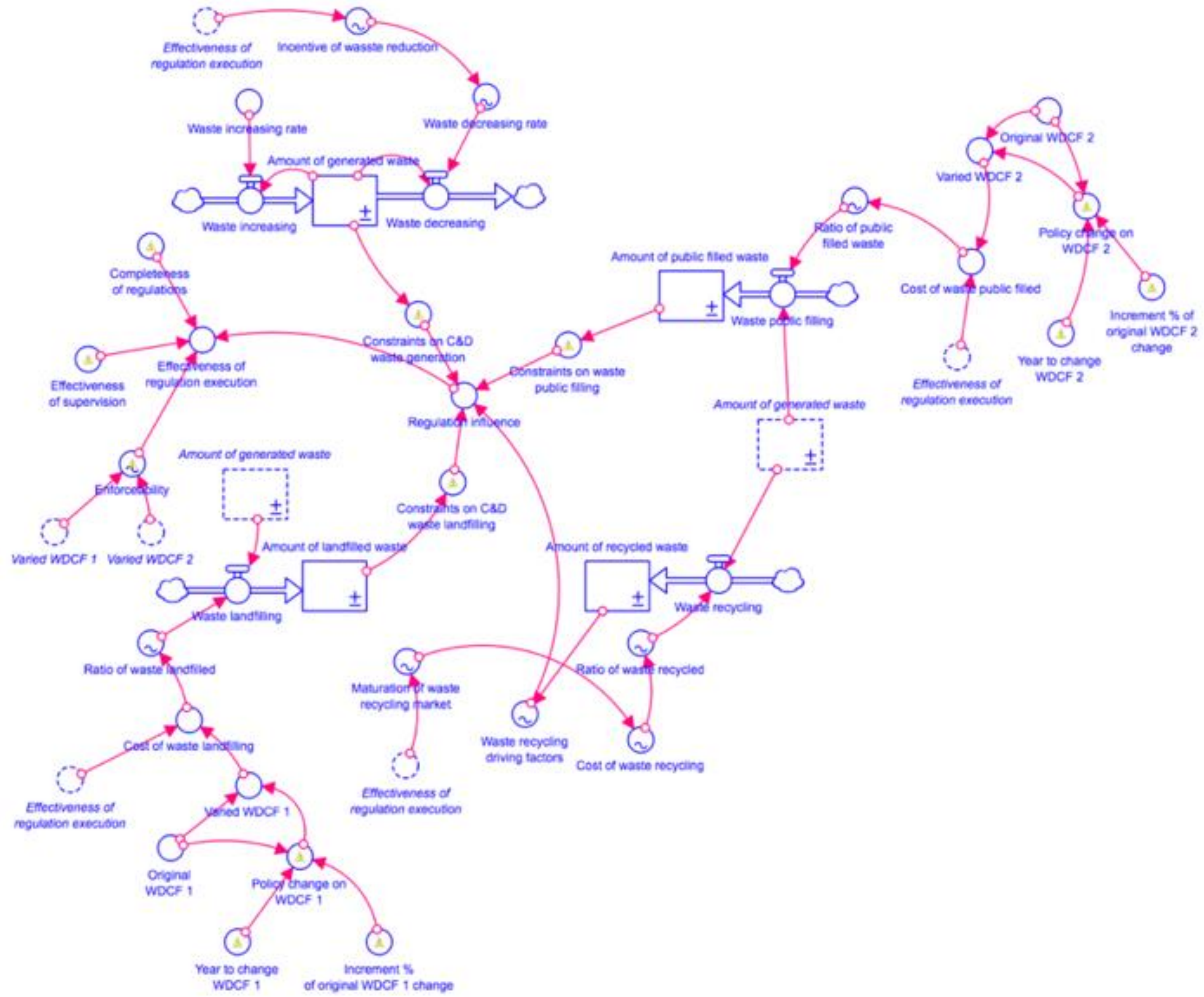


Figure 3.6 Causal loop diagram of SD model.

3.3.2 Model Formulation

Based on the latest literature review, it is recognized that WDCF determination was mostly based on the full-cost recovery at the present state rather than being designed to cater for the future needs. Hence, there is a need to better understand the behavioural dynamics of the complex system in WDCF and C&D waste generation, C&D waste landfilled, C&D waste public filled, and recycled C&D waste, for the purpose of supporting strategic decision-making of WDCF for sustainable development in the future. The model boundary concentrated on C&D waste generation, the amount of landfilled, public filled and recycled waste upon the change in WDCF. Upon the input of all variables into the model, a series of case studies were analyzed. The model was simulated from the year 2005 to 2040, a total of 35 years. The major purpose was to investigate how the amount of waste going to landfill, public fill, and recycling would respond to the changes in the WDCF to landfill and public fill, respectively. The independent variable in the simulation was the increment percentage of original WDCF change. Simulation results were compared with the actual data to assess the model behaviour. The model formulated first compared the effect of the newly revised and the original WDCF upon the revision of related regulation in 2017 on waste disposal in landfill and public fill. Then, optimum ranges of WDCF were determined by comparing 13 additional alternatives of the increment percentage change of initial WDCF. Three alternatives that caused a greater reduction in public filled and landfilled waste, respectively, were selected for subsequent scenario analysis. Therefore, six scenarios with various combinations of the three alternatives were established for further analysis.

Four major stocks in this system, including the amount of C&D waste generated, amount of C&D waste landfilled, amount of C&D waste public filled, and amount of recycled waste are quantified by obtaining historical statistics from 2005 to 2015 (HK EPD, 2017b). Since the

Construction Waste Disposal Charging Scheme (Charging Scheme) was legislated in Hong Kong in 2005, historical statistics from 2005 was selected for better comparison of the effects of the original WDCF and newly revised WDCF. In 2005, the amount of C&D waste landfilled and public filled were 2.40 Mt and 8.11 Mt, and the amount of recycled waste was 8.40 Mt, respectively (HK EPD, 2006), which serve as baseline values of this study scope **(Table 3.4)**.

The effectiveness of regulation execution relies on three major factors, that is, enforceability, completeness of regulations, and effectiveness of supervision. The rating values of these factors were inputted into the SD model with the range from 0 to 1, with 0 suggesting the worst situation and 1 indicating the best situation. The respective input values of the above three factors were designed based on the recycling behaviour of C&D waste recycling in Hong Kong. Mak et al. (2019) conducted semi-structured interviews with representatives from construction-related organizations, environmental consultants and contractors, and government engineers to identify these three factors. The importance of these factors was further quantified by conducting questionnaire survey with about 200 various stakeholders including public, government officials, and practitioners in the construction sector that were randomly selected. Among all factors, enforceability of regulation was considered as the most important factor when formulating C&D recycling policy, followed by the effectiveness of supervision and completeness of regulations (Mak et al., 2019). According to the survey results, their weightings are assigned with 0.35, 0.33, and 0.31, respectively **(Table 3.4)**.

Table 3.4 Equations in SD model.

Variables	Definition	Type	Unit	Equations
Waste increasing	Amount of waste generated over specific time period	Flow	10000 tonnes/ year	Waste increasing = waste increasing rate * amount of generated waste
Waste decreasing	Amount of reduced waste generated over specific time period	Flow	10000 tonnes/ year	Waste decreasing = waste decreasing rate * amount of generated waste
Waste increasing rate	Ratio of increased waste to waste generated over a specific time period	Constant	-	0.045
Waste decreasing rate	Ratio of reduced waste to waste generated over a specific time period	Auxiliary	-	Waste decreasing rate = LOOKUP (Incentive of waste reduction)
Incentive of waste reduction	Major stakeholders' incentives to reduce waste generation	Auxiliary	-	Incentive of waste reduction = LOOKUP (Effectiveness of regulation of execution)
Effectiveness of regulation execution	Government's performance in executing waste management regulations	Auxiliary	-	Effectiveness of regulation execution = Regulation influence * (Enforceability * 0.35 + Effectiveness of supervision * 0.33 + Completeness of regulations * 0.31)
Completeness of regulations	To what extent existing regulations can guide regional waste management	Auxiliary	-	Completeness of regulations = LOOKUP (Years(), {2005,2010,2015,2020,2025,2030}, {0.2,0.25,0.45,0.5,0.55,0.6})
Effectiveness of supervision	To what extent the government supervision can contribute to effective waste management	Auxiliary	-	Effectiveness of supervision = LOOKUP (Years(), {2005,2010,2015,2020,2025,2032}, {0.2,0.25,0.67,0.75,0.8,0.85})
Enforceability	To what extent the regulations issued can be	Auxiliary	-	Enforceability = LOOKUP (Varied $WDCF_1$ + Varied $WDCF_2$)

	exactly followed in practices			
C&D waste recycling	Amount of waste recycled over a specific time period	Flow	10000 tonnes/ year	C&D waste recycling = Amount of generated waste * ratio of waste recycled
Ratio of waste recycled	Ratio of amount of recycled waste to total amount of generated waste	Auxiliary	-	Ratio of waste recycled = LOOKUP (Cost of waste recycling)
Cost of waste recycling	The per capital cost of recycling waste generated	Auxiliary	HKD/ t	Cost of waste recycling = LOOKUP (Maturation of waste recycling market)
Maturation of waste recycling market	Market availability to trade recycled materials	Auxiliary	-	Maturation of waste recycling market = LOOKUP (Effectiveness of regulation execution)
Waste landfilling	Amount of waste landfilled over a specific time period	Flow	10000 tonnes/ year	Waste landfilling = Amount of generated waste * Ratio of waste landfilled
Ratio of waste landfilled	Ratio of amount of landfilled waste to total amount of generated waste	Auxiliary	-	Ratio of waste landfilled = LOOKUP (Cost of waste landfilling)
Cost of waste landfilling	The per capital cost of landfilling waste generated from sites to landfills	Auxiliary	HKD/ t	Cost of waste landfilling = Effectiveness of regulation execution * varied $WDCF_1$
Varied $WDCF_1$	New WDCF on waste landfilling	Auxiliary	HKD/ t	Varied $WDCF_1$ = Original $WDCF_1$ + Policy change on $WDCF_1$
Original $WDCF_1$	Original C&D disposal charge to landfills	Auxiliary	HKD/ t	HKD$125/Tonne
Policy change on $WDCF_1$	Total change of WDCF to landfill over time	Auxiliary	-	Policy change on WDCF1 = Step ({[Year to change $WDCF_1$] Years}, [Original $WDCF_1$]*[Increment % of original charge])

Year to change $WDCF_1$	Year starting to change WDCF on waste going to landfill	Auxiliary	-	2017
Increment % of original $WDCF_1$ change	Percentage change on original WDCF to landfill	Auxiliary	-	Independent variable
Waste public filling	Amount of waste public filled over a specific time period	Flow	10000 tonnes/ year	Waste public filling = Amount of generated waste * Ratio of waste public filled
Ratio of waste public filled	Ratio of amount of public filled waste to total amount of generated waste	Auxiliary	-	Ratio of waste public filled = LOOKUP (Cost of waste public filling)
Cost of waste public filling	The per capital cost of public filling waste generated from sites to public fills	Auxiliary	HKD/ t	Cost of waste public filling = Effectiveness of regulation execution * varied $WDCF_2$
Varied $WDCF_2$	New WDCF on waste public filling	Auxiliary	HKD/ t	Varied $WDCF_2$ = Original $WDCF_2$ + Policy change on $WDCF_2$
Original $WDCF_2$	Original C&D disposal charge to public filling facility	Auxiliary	HKD/ t	HKD$27/Tonne
Policy change on $WDCF_2$	Total change of WDCF to public fill over time	Auxiliary	-	Policy change on $WDCF_2$ = Step ({[Year to change $WDCF_2$] Years},[original $WDCF_2$]*[Increment % of original charge])
Year to change $WDCF_2$	Year starting to change WDCF on waste going to public fill	Auxiliary	-	2017
Increment % of original $WDCF_2$ change	Percentage change on original WDCF to public fill	Auxiliary	-	Independent variable
Regulation influence	Effects of regulations on local waste management	Auxiliary	-	Regulation influence = (Constraints on C&D waste generation * 0.2 + Constraints on waste public filling * 0.3 + Constraints on

				C&D waste landfilling * 0.3 + waste recycling driving factors * 0.2)
Waste recycling driving factors	To what extent waste recycling activities are motivated	Auxiliary	-	Waste recycling driving factors = LOOKUP (Amount of recycled waste)
Constraints on C&D waste generation	Overall factor limiting C&D waste generation activities	Auxiliary	-	Constraints on C&D waste generation = LOOKUP (Amount of generated waste)
Constraints on C&D waste landfilling	Overall factor limiting C&D waste landfilling activities (In base run, value is assumed as 1)	Constant	-	1
Constraints on C&D waste public filling	Overall factor limiting C&D waste public filling activities (In base run, value is assumed as 1)	Constant	-	1

An increase in WDCF has proved to promote the incentive for construction site contractors to implement on-site waste reduction measures. Therefore, it is assumed that WDCF exerts subsequent effects on the effectiveness of regulation execution and influences the incentive for waste reduction, which ranges from 0 to 1. In particular, 0 represents the lowest incentive situation while 1 indicates the highest incentive situation **(Table D1)**. It is also assumed that the cost of C&D waste recycling would decrease when the recycling activities are encouraged in the industry. Therefore, the maturation of waste recycling market is a factor affecting the cost of recycling and their relationship is illustrated in **Table D1**. It is well recognized that negative correlations are obtained between the ratio of waste being landfilled and its costs, and the ratio of waste being public filled and its relative costs.

3.3.3 Model Validation

The model validation is crucial to demonstrate a high degree of confidence about the model-based inferences about the real system (Sterman, 2000). In general, validation of SD models are based on two basic assumptions that the models are developed to achieve a purpose and the model structure drives its behaviour (Forrester, 1961). In this study, both structural validity and behaviour validity were assessed. Structural validity was assessed by methods suggested by Qudrat-Ullah (2005) and Martis (2006), which can develop confidence in the model structure by conducting (1) structure verification test, (2) dimentional consistency test, and (3) extreme condition test. As suggested by some researchers, some standard statistical test such as statistical hypothesis tests cannot be used in validating the behaviour of the SD model (Barlas, 1996). However, other statistical indicators such as adjusted R-squared goodness-to-fit could be used to validate model fitness (Henseler et al., 2009). Instead, structure verification test should review the system with generalized knowledge from literature and assess whether or not the model contradicts to the general knowledge of the structure in real world by inspections and reviews (Forrester and Senge, 1980; Balci, 1994; Barlas, 1996). Dimensional consistency test assesses whether all equations are dimensionally constant. The extreme conditions test determines whether the model exhibits a logical behaviour when selected parameters are assigned with extreme values (Forrester and Senge, 1980), which can detect major structural flaws of the model (Barlas, 1989). On the other hand, behaviour validity was assessed to evaluate the model fitness by two methods, which were error analysis and Theil inequality statistics (Qudrat-Ullah and Seong, 2010). The root mean squared (RMS) percent error demonstrates a normalized measure of the error magnitude. The Theil inequality statistics represents the breakdown of total error into bias (U^m), unequal variance (U^s), and unequal covariance (U^c) (Sterman, 1984). The RMS and Theil's inequality statistics are common measures of predictive accuracy of ex post and ex ante forecasts, which ex post forecast uses actual values of exogenous variables and ex ante forecast uses estimated values of exogenour variables (Fair, 1986). Also, the adjusted R-squared value refers to the goodness of fit of the sets of data, which over 75% demonstrates a strong effect size (Henseler et al., 2009).

Chapter 4- Extended Theory of Planned Behaviour for Promoting Food Waste Recycling in the Commercial and Industrial Sector in Hong Kong

4.1 Research Questions

Recent studies have quantified the socio-cultural drivers such as available food waste information (Refsgaard and Magnussen, 2009), highlighted the complexity involving diverse factors in globalized food chain (Hebrok and Boks, 2017), suggested the need of multi-faceted policy levers in key aspects of values, skills, and logistics (Thyberg and Tonjes, 2015), and emphasized public commitment to improve performance (Schmidt, 2016). However, the connections between intentions and actual behaviour of recycling are still ill-defined. Intentions refer to how hard people are willing to try and to what level of effort they are planning to spend on one's behaviour (Ajzen, 1991), whereas attitude and behaviour are critical considerations to devise effective strategies for nurturing the industry's preference towards enhancement of recycling rate (Vermeir and Verbeke, 2006; Mont and Plepys, 2008). It is necessary to elucidate the relationship between intentions and actual behaviour, and identify the determinants that drive environmental behaviour (Best and Kneip, 2011). The Theory of Planned Behaviour (TPB) explains the three constructs that govern individuals' behaviour, which are attitudes, subjective norms, and perceived behavioural control (Ajzen, 1993). Previous implementation of TPB framework indicated strong correlations between the constructs and recycling behaviour by using path analysis (Chan and Bishop, 2013).

Under the TPB framework in the domestic sector, critical individuals' habits influencing household generation of food waste are associated with marketing and sales strategies (Mondéjar-Jiménez et al., 2016) and shopping routines (Stancu et al., 2016). The determinants of domestic food waste behaviour are mainly attributed to personal attitude (Ghani et al., 2013), followed by moral norms (Russell et al., 2017) and perceived behavioural control (Visschers et al., 2016), while reuse/recycling habits contribute indirectly (Stancu et al., 2016). However, these findings may be inapplicable to the C&I sector where food waste is generated by the major service provided by industries such as hotels and food and beverages. Recycling behaviour within these industries will be influenced by other attributes such as corporate strategies and company system. Despite its distinctive nature compared to the domestic sources, C&I sector may encounter managerial challenges such as extra manpower and logistics arrangement. There is a need to prioritize factors and challenges that the C&I sector faced in food waste recycling. It is of importance to investigate the corporates' motivations and priorities for devising effective policy tools to enhance food waste recycling.

This chapter intended to elucidate the corporates' intention pertaining to the recycling intentions, which are yet to be evaluated in the literature, by: (1) discussing the information gaps in the literature; (2) identifying major determinants to drive behaviour; (3) articulating direct and indirect relationship of influencing factors towards intention; and (4) elaborating stakeholders' differentiated perceptions on recycling issues. TPB framework was extended by identifying and prioritizing the major constructs that affect food waste recycling intention and behaviour in the C&I sector through semi-structured interviews followed by qualitative analysis and quantitative modelling. Latent variables (LVs) refer to variables that are inferred through a mathematical model from other variables that can be directly measured (Jan, 1986), and their direct and indirect correlations are further examined. The variations on perceptions and concerns of stakeholders about food waste recycling in different industries (e.g., acceptance on recycling costs and required manpower) are evaluated by questionnaire survey. These findings can fill in our knowledge gaps in establishing political/managerial strategies to foster behavioural change for sustainable resource utilization.

4.2 Results and Discussions

4.2.1 Structured interviews with experts from hotel, food and beverage, and property management industries

Three newly found TPB factors were identified in this study: Economic incentives, Logistics and management incentives, Administrative incentives and corporate support. The food waste recycling behaviour model (**Figure 4.1**) was established on the basis of content analysis of semi-structured interviews with experts. Interviewees from hotel industry, property management companies, and food and beverages industry generally considered Economic Incentives as the most effective motivating factors to enhance food waste recycling behaviour in the C&I sector in Hong Kong. Interviewees raised different economic considerations about on-site and off-site food waste recycling. Interviewees R1 and R7 raised concerns about capital costs (such as installation costs and extra investment) and operation and maintenance costs of recycling equipment for on-site recycling, while there would be extra logistics and handling fee charged by food waste recyclers for off-site recycling. Interviewee R6 opined that savings on food waste recycling may be insignificant when compared to the proposed MSW disposal charging scheme, which could not impose strong commercial incentives on corporates' behavioural change. Assuming that the total MSW disposal costs would be about HKD$435/t (i.e., HKD$105/t MSW transportation cost plus HKD$305-365/t proposed MSW charging fee (HK ISD, 2017)), the current market price for food waste recycling by small- and mediumsized enterprises was HKD$300-350/t, which would barely cover the costs of MSW disposal fee while extra manpower and costs of on-site source separation remain uncovered (HKD$435/t). The interviewed managements such as R2, R5 and R9 suggested that the government should provide greater incentives such as subsidies and tax reduction to reduce recycling costs in the industry, which could indirectly encourage corporates to recycle food waste.

A recent study in Europe (Canali et al., 2017) explained the multifaceted problem of food waste generation and policy interventions for waste reduction with regard to the following three major aspects. It is of paramount importance to establish (i) technological interventions (Zan et al., 2018), (ii) institutional factors related to business management, legislation (Iacovidou et al., 2012) and economy (Rutten, 2013), and (iii) social factors related to consumers' behaviour and lifestyles (Mallinson et al., 2016). Similar findings were shown from the semi-structured interviews in this study, indicating that economic factor was of high initiative for corporates to recycle food waste. Interviewee R5 even considered technology interventions and legislation not as important as economic incentives and corporate support.

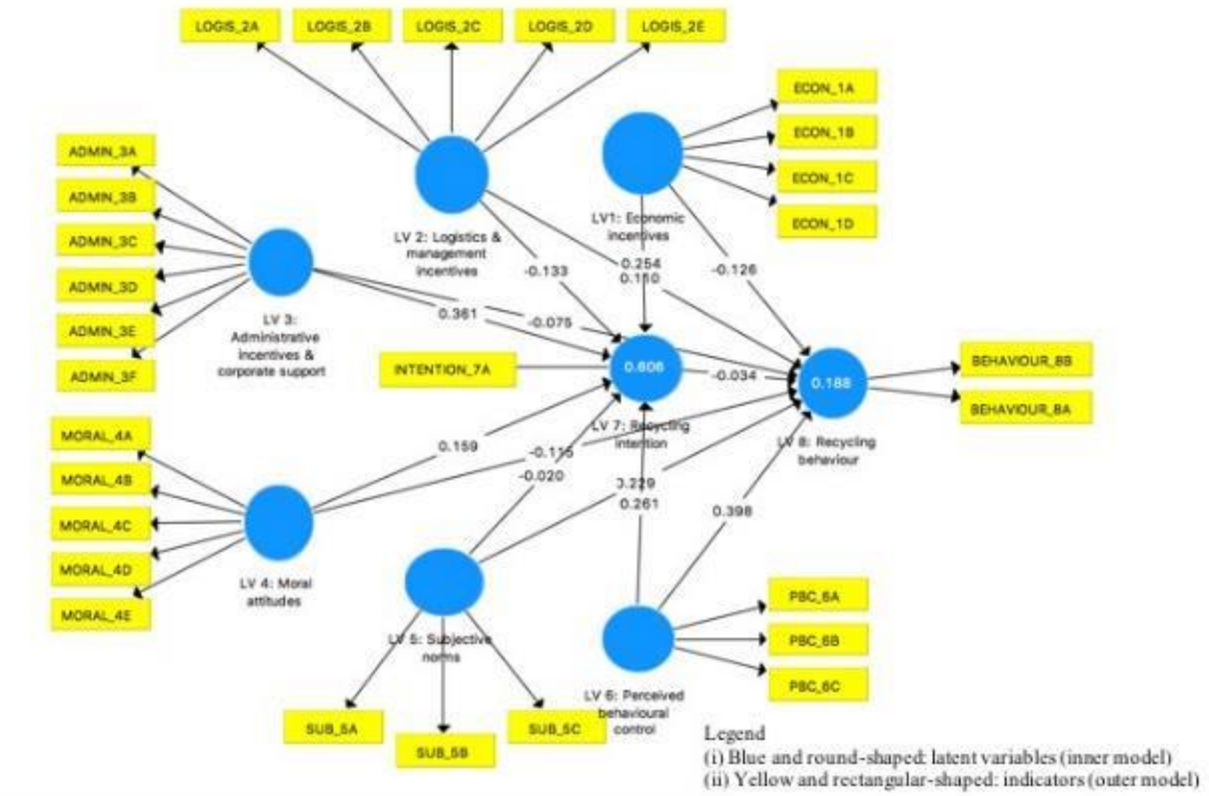


Figure 4.1 The conceptual SEM inner and outer models.

Logistics and management incentives were another important factor. Interviewees R1 and R9 expressed concerns about the availability of amenities to support recycling activities, such as re-designing power supply and wastewater discharge system within premises. The majority of interviewees such as R2, R5, R8 and R9 agreed that limited space for collection, separation, and temporary storage of food waste was the major operational challenge, in addition to change of work habit of frontline staff on daily food waste disposal.

Administrative incentives and corporate support was an intangible determining factor to encourage recycling behaviour within corporates. Interviewees R1, R2, R4 and R8 agreed that corporate culture and company goals or policy could shape a positive company image and nurture environmental awareness of employees, such as corporate social responsibility (CSR), corporate environmental responsibility (CER), and staff education/reward scheme. These results echoed the importance of desire to do the right thing (Graham-Rowe et al., 2014) and deeper understanding of environmental impairments caused by food waste (Richter, 2017).

4.2.2 Questionnaire survey

4.2.2.1 Reliability and validity of reflective SEM measurement model

There were 155 questionnaire responses, of which the practitioners engaging in hotel industry, food and beverage industry, and property management industry accounted for 29.7%, 35.5%, and 34.8%, respectively, showing an even distribution of respondents. Their majority role in corporates were in operation (24.5%) and management (20%) divisions. Over 70% of respondents indicated that there was not any current implemention of food waste reduction/recycling scheme within their corporates. Only 28% of respondents reflected corporates' participation in joint food donation programs with non-governmental organizations including Sita Waste Services Limited, Food Angel, and Super Panda Asia; used cooking oil collection collaboration program with recyclers; and on-site composting. **Figure A3** presents the score distribution of various respondents from questionnaire and **Table A2** summarizes the information of respondent profile.

Reliability and validity of model was ensured as the majority of the indicators' outer loadings were scored between 0.49 to 0.941 (**Table 4.1**), which demonstrated a satisfying indicator reliability. All eight LVs were satisfied with their internal consistency reliability as their composite reliability values ranged from 0.678 to 0.956 (**Table 4.1**). Convergent validity of this model was satisfied as AVE values were ranged from 0.582 to 0.814. Discriminant validity of LVs was also satisfied (**Table 4.2**) as the square root of AVE value of each latent variable that are highlighted in bold was greater than its highest correlation with other LVs (e.g., 0.902 of LV2 > 0.801 of LV2- LV3 correlation).

Table 4.1 Reflective model: reliability measurement

Construct/ Latent variable	Indicators	Indicators reliability	Composite reliability	AVE
LV 1: Economic incentives	ECON_1A	0.846	0.903	0.701
	ECON_1B	0.877		
	ECON_1C	0.884		
	ECON_1D	0.732		
LV 2: Logistics & management incentives	LOGIS_2A	0.895	0.956	0.814
	LOGIS_2B	0.91		
	LOGIS_2C	0.941		
	LOGIS_2D	0.863		
	LOGIS_2E	0.899		
LV 3: Administrative incentives & corporate support	ADMIN_3A	0.873	0.943	0.733
	ADMIN_3B	0.899		
	ADMIN_3C	0.818		
	ADMIN_3D	0.882		
	ADMIN_3E	0.86		
	ADMIN_3F	0.794		
LV 4: Moral attitudes	MORAL_4A	0.814	0.91	0.669
	MORAL_4B	0.872		
	MORAL_4C	0.8		
	MORAL_4D	0.77		
	MORAL_4E	0.829		
LV 5: Subjective norms	SUB_5A	0.84	0.796	0.579
	SUB_5B	0.49		
	SUB_5C	0.89		
LV 6: Perceived behavioural control	PBC_6A	0.759	0.806	0.582
	PBC_6B	0.724		
	PBC_6C	0.803		
LV 7: Recycling intention	INTENTION_7A	Single item construct	Single item construct	Single item construct
LV 8: Recycling behaviour	BEHAVIOUR_8A	0.877	0.678	0.527
	BEHAVIOUR_8B	0.533		

Table 4.2 Fornell-Larcker discriminant validity measurement

	LV 2	LV 3	LV 4	LV 5	LV 6	LV 7	LV 8	LV1
LV 2	**0.902**							
LV 3	0.801	**0.856**						
LV 4	0.852	0.849	**0.818**					
LV 5	0.594	0.758	0.692	**0.761**				
LV 6	0.571	0.517	0.612	0.63	**0.763**			
LV 7	0.606	0.704	0.693	0.625	0.604	**Single item construct**		
LV 8	0.207	0.175	0.197	0.301	0.403	0.196	**0.726**	
LV1	0.699	0.768	0.771	0.694	0.579	0.698	0.171	**0.837**

4.2.2.2 Priorities in key categories of food waste recycling behaviour and correlation analysis

The determination of constructs (R^2 value) of 0.61 indicated that 61% of the variance in recycling intention was explained by the independent LVs (**Figure 4.1**). The R^2 was considered to be of substantial strength in this study, given the complexity of food waste behaviour (Quested et al., 2013). Among the six proposed TPB constructs, Administrative incentives and corporate support (0.361) showed the strongest effect on recycling intention of individuals, followed by Perceived behavioural control (0.261) and Economic incentives (0.254). This differed from the previous studies that suggested Perceived behavioural control was the major driver in food waste separation and recycling in Europe (Visschers et al., 2016; Stancu et al., 2016). Subjective norms and Logistics and management incentives demonstrated negative effects on recycling intention. Subjective norms made no significant contribution to changing behaviour regarding household food waste generation, as reported in a Denmark-based psycho-social study (Stancu et al., 2016). This clearly showed the importance of incorporating political strategies to nurture corporates' culture in food waste recycling awareness and economic incentives that would determine staff's perception to perform recycling behaviour.

All estimated direct and indirect effects were further analysed **(Table 4.3)**. Strong direct effects towards positive recycling behaviour were discovered on LVs: Perceived behavioural control (0.398), Subjective norms (0.229), and Economic incentives (0.254). This reinforced the significance of direct effects of Perceived behavioural control (Yuan et al., 2016) and Subjective norm (Bortoleto et al., 2012) reported for household kitchen waste separation behaviour. Significant direct effects in these three LVs on recycling behaviour were not intercepted by other LVs, implying that these three LVs could be adopted independently to promote recycling behaviour of individuals. Administrative incentives and corporate support showed an estimated indirect effect of -0.012, which suggested a mediation effect on recycling behaviour. Such significant indirect paths indicated that the model considering only direct effects would probably result in ineffective change of recycling behaviour within corporates. Direct and indirect effects are yet to be considered in previous food waste studies, while the results of this study provided insights for policy-makers in devising more effective food waste policies in the C&I sector.

Significant positive correlations were identified between Moral attitudes and Logistics and management incentives (0.852), and between Moral attitudes and Administrative incentives and corporate support (0.849) (**Table A3**). Such results inferred that individuals' social values could be substantially influenced by available resources and institutions. These results echoed with an earlier study, which suggested that institutional context would contribute to positive attitudes and increase in recycling behaviour (Refsgaard and Magnussen, 2009). Our observation further proposed the need for Logistics and management incentives as well as Administrative incentives and corporate support to motivate moral attitudes among the C&I sector, and demonstrated that perceived costs and benefits were not the only determining factor to affect moral attitudes.

Table 4.3 Estimated direct, indirect and total effects

Interaction	Direct effects	Indirect effects	Total effects = Direct + Indirect
LV 1: Economic incentives → LV 7: Recycling intention	**0.254**	-	0.254
LV 1: Economic incentives → LV 8: Recycling behaviour	-0.126	-0.009	-0.135
LV 2: Logistics & management incentives → LV 7: Recycling intention	-0.133	-	-0.133
LV 2: Logistics & management incentives → LV 8: Recycling behaviour	0.11	0.005	0.115
LV 3: Administrative incentives & corporate support → LV 7: Recycling intention	0.361	-	0.361
LV 3: Administrative incentives & corporate support → LV 8: Recycling behaviour	-0.075	**-0.012**	-0.087
LV 4: Moral attitudes → LV 7: Recycling intention	0.159	-	0.159
LV 4: Moral attitudes → LV 8: Recycling behaviour	-0.115	-0.005	-0.12
LV 5: Subjective norms → LV 7: Recycling intention	-0.02	-	-0.02
LV 5: Subjective norms → LV 8: Recycling behaviour	**0.229**	0.001	0.23
LV 6: Perceived behavioural control → LV 7: Recycling intention	0.261	-	0.261
LV 6: Perceived behavioural control → LV 8: Recycling behaviour	**0.398**	-0.009	0.389

4.2.2.3 Varying stakeholders' perceptions on key LVs

This study indicated the difference in the priority considerations in the C&I sector. Administrative incentives and corporate support was the major category that earned the overall high score from the professionals in hotel industry (3.68) and food and beverage industry (3.67) (**Figure 4.2**), which were the major commercial food waste producers. In contrast, respondents from property management industry scored Logistics and management incentives (3.70) slightly higher than Administrative incentives and corporate support (3.63) (**Figure 4.2**). Because of their business nature, property management corporates act as a mediator between food waste producers and food waste recyclers. Hence, property management corporates tend to consider hardware and manpower available for food waste recycling by their tenants, whereas hotels and restaurants put emphasis on tactics that enhance employees' environmental awareness.

Such observation enables policy-makers to establish tailor-made food waste policies and specific managerial strategies to effectively motivate industries to recycle food waste and encourage a change of their behaviour in food waste recycling. Stakeholders' acceptance level on extra costs and manpower required for food waste recycling were also investigated. Breakdown of mean score of indicators was summarised in **Table A4**.

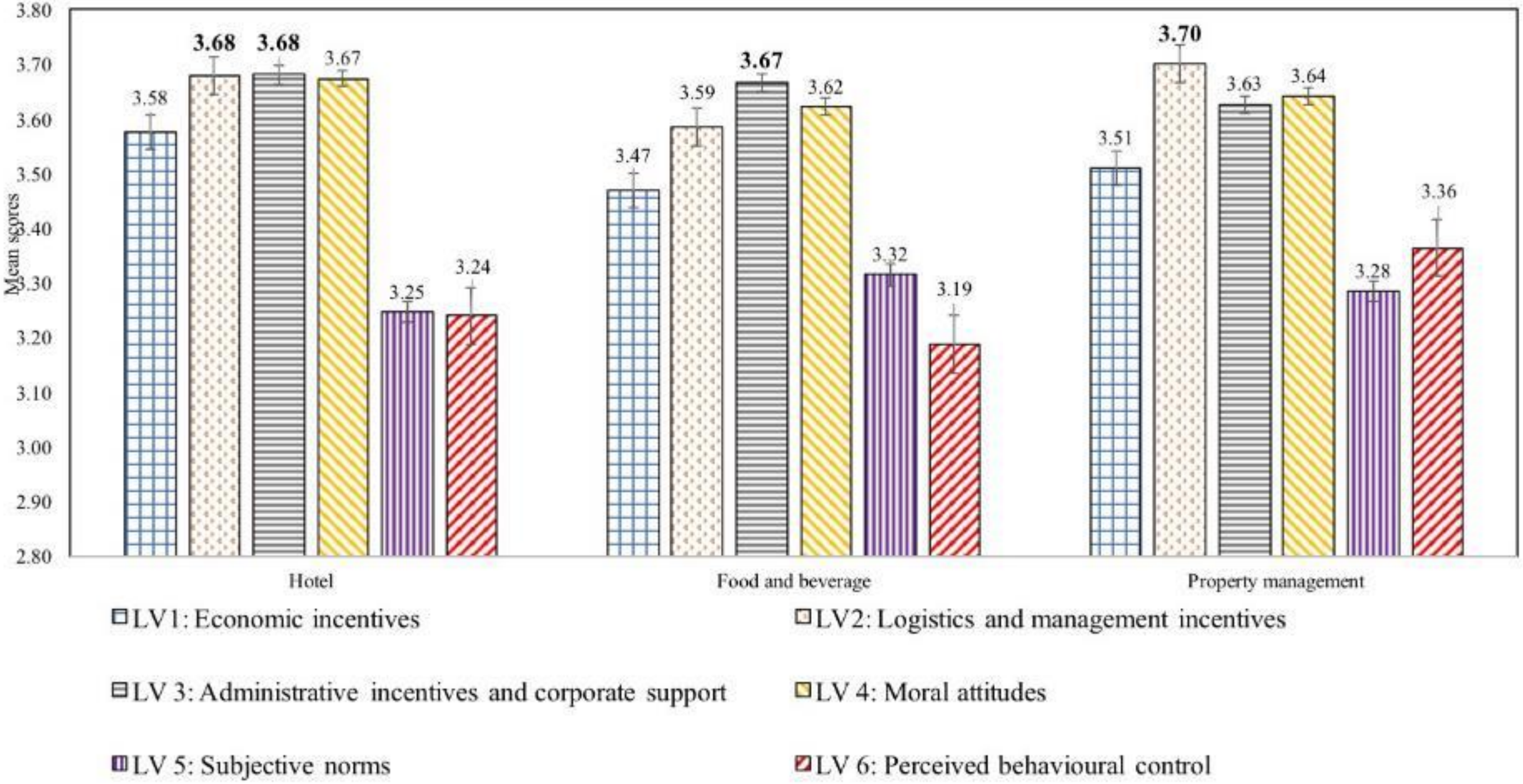


Figure 4.2 Mean score of different categories given by the three respondent groups in the questionnaire survey.

Both hotel (34.8%) and food and beverage (49.1%) industries showed the highest percentage of respondents in the acceptable range of food waste recycling costs of HKD$350-500/t (**Figure 4.3a**). When compared to the proposed MSW charging fee (*i.e.*, HKD$305-365/t) (HK ISD, 2017) , it indicated that food waste producers would have little incentives in recycling food waste if the disposal costs were similar or even lower than recycling costs. Meanwhile, 38.9% of respondents from the property management industry opined that the acceptable range of costs could be higher as HKD$500-650/t (**Figure 4.3a**), which, however, may be passed on to their tenants by increasing property management fee.

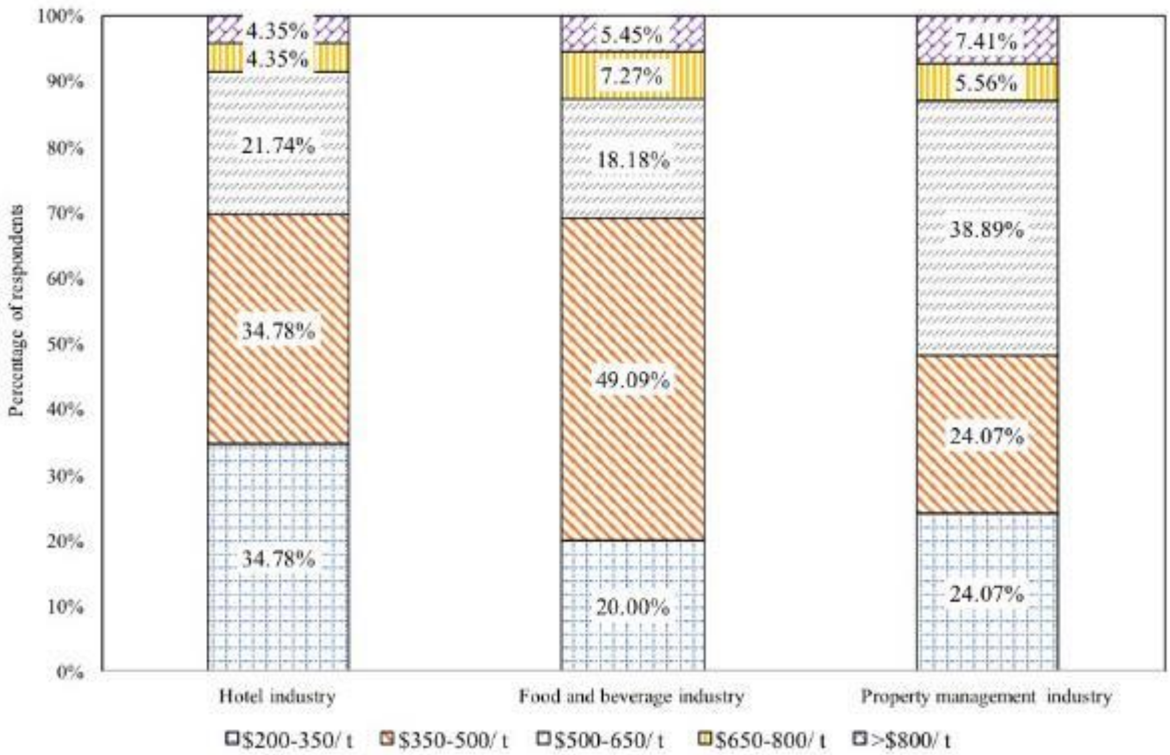


Figure 4.3a Percentage distribution of various respondents in the questionnaire survey under the category of acceptable range of food waste recycling costs.

Regarding manpower, respondents from hotel (36.7%) and property management (46.3%) industries revealed that their acceptable range of extra manpower for recycling food waste was three to four staff if there were 100 staff (i.e., 3-4% of total manpower). Such results supported a recent investigation of restaurants in Berkeley that insufficient resources would lead to difficulties in changing their behaviour upon food waste disposal and recycling (Sakaguchi et al., 2018). Respondents from food and beverage industry showed an even lower acceptance level on the extra manpower on food waste recycling, as 40% of respondents preferred to have one to two staff if there were 100 staff (i.e., 1-2% of total manpower) (**Figure 4.3b**). This might be due to intensive labour requirement in restaurants and comparatively large portion of temporary employees when compared to other industries.

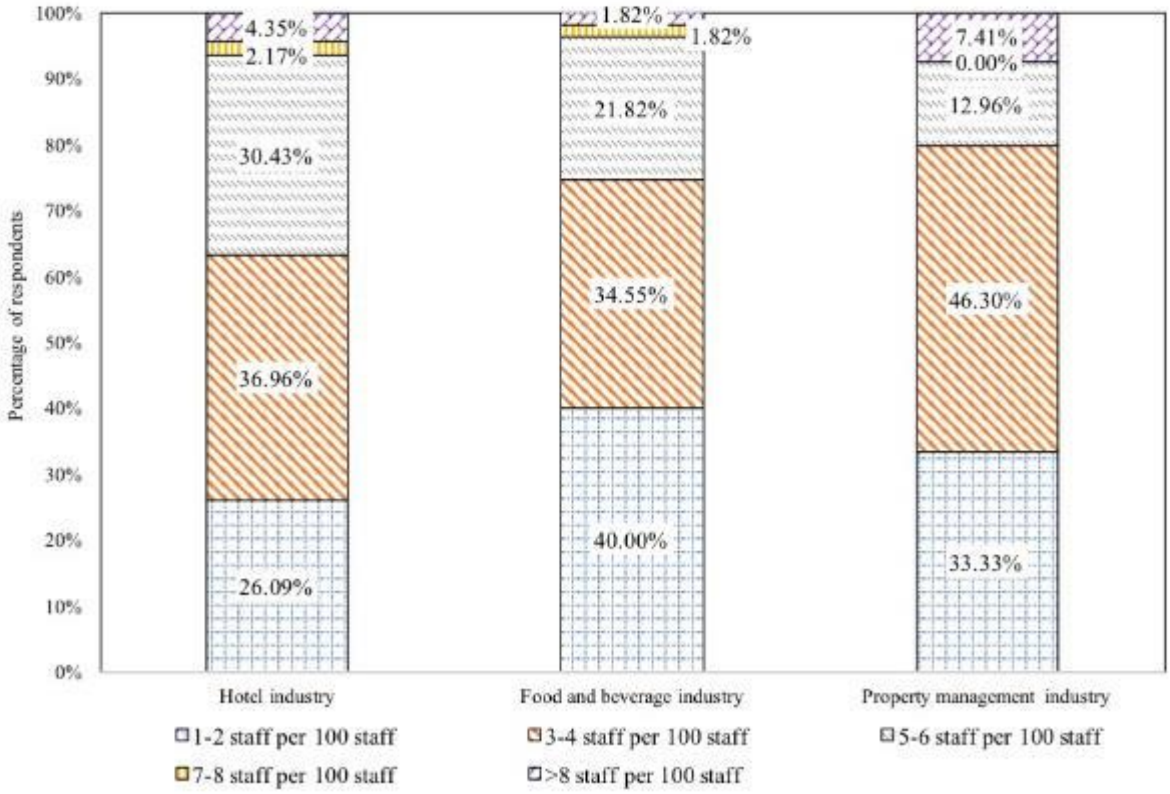


Figure 4.3b Percentage distribution of various respondents in the questionnaire survey under the category of acceptable range of extra manpower for recycling food waste.

Respondents further suggested that food waste policy in Korea such as wider adoption of food donation policy within restaurants, tax reduction schemes and rewarding programs to volunteering corporates, land supply for food waste collection, and education platform to share information on facts, should be made reference in revising Hong Kong’s policy. Expanded enforcement of volume-based waste fee system and three-folded billing methods (Kim and Kim, 2012) may also provide valuable insights for the upcoming MSW charging scheme in Hong Kong. Further research is necessary to assist policy-makers to encourage resources circulation within the community.

It is noted that the TPB theory may be unable to explain change of behaviour over time and predict future behaviour because it assumes that behaviour is a result of linear decision-making process (McEachan et al., 2011; Sutton, 1994). Further research should consider the dynamic condition of different variables by establishing system dynamic modelling. This study collected data on a voluntary basis and from employees across various industries, while future studies could conduct quesionnaire for targeted interviewees with even portion of different operative levels in each industry to ensure the diversity of results and balanced expression of perspectives. More objective measures of recycling behaviour of employees and corporates could be introduced, such as measurement of money spent on initiatives, such that strategies and outcomes of food waste policy implementation of different jurisdictions could be compared to develop nationwide strategies for the C&I sector.

Chapter 5- Extended Theory of Planned Behaviour for Promoting Construction Waste Recycling in Hong Kong

5.1 Research Questions

Better understanding of individual's attitude and behaviour is needed to devise effective strategies for nurturing the community preference towards recycling, which is critical for enhancing the recycling rate (Vermeir and Verbeke, 2006; Mont and Plepys, 2008). Although factors affecting recycling behaviour such as training and supervision within corporates have been acknowledged (Bakshan et al., 2017), linkage between the intentions and behaviour of individuals was ill-defined in the literature. Intentions are the indications of how hard people are willing to try and to what level of effort they are planning to exert, which directly drive and affect one's behaviour (Ajzen, 1991). Decision-analytical approach from a micro-structural perspective is therefore necessary for understanding the determinants of environmental behaviour (Best and Kneip, 2011).

The well-supported theory, namely the Theory of Planned Behaviour (TPB), illustrates that the individual intention is governed by three constructs, including attitudes, subjective norms, and perceived behavioural control (Ajzen, 1993). "Attitude" refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour (Ajzen, 1991) and as suggested that people with high egoistic concerns would especially consider the costs and benefits of environmental behaviour for them personally (Schultz, 2000) (Schultz, 2001); "Subjective Norms" refer to the influence of external social factors on individual behaviour (Ajzen, 1991); and "Perceived Behavioural Control" refers to people's perception on the ease of performing the behaviour of interest (Ajzen, 1993) **(Figure 5.1)**. Although the predictive validity of TPB in health-related study was limited (Orbell and Sheeran, 1998), high suitability of adopting TPB framework in this study of recycling intention is evident through the strong positive correlations between the above three constructs and recycling behaviour by path analysis (Chan and Bishop, 2013).

Under the TPB framework, attitudinal forces such as management support and incentives were found significant in determining the individual’s recycling intention in a previous study on C&D waste management (Teo and Loosemore, 2001). However, the social norms and perceived behavioural control pertaining to the recycling intention are yet to be elucidated, for which integrated qualitative and quantitative analysis is required. Despite recent investigations into the determinants of C&D waste management attitude and behaviour of designers (Li et al., 2015) and contractors (Wu et al., 2016), there is a lack of understanding about other stakeholders such as government departments and private corporates. Potential differences in the perception of the various sectors remain unrevealed. It is essential to understand the priorities of different stakeholders to tailor behaviour-oriented management strategies, which can help to develop an advanced TPB framework.

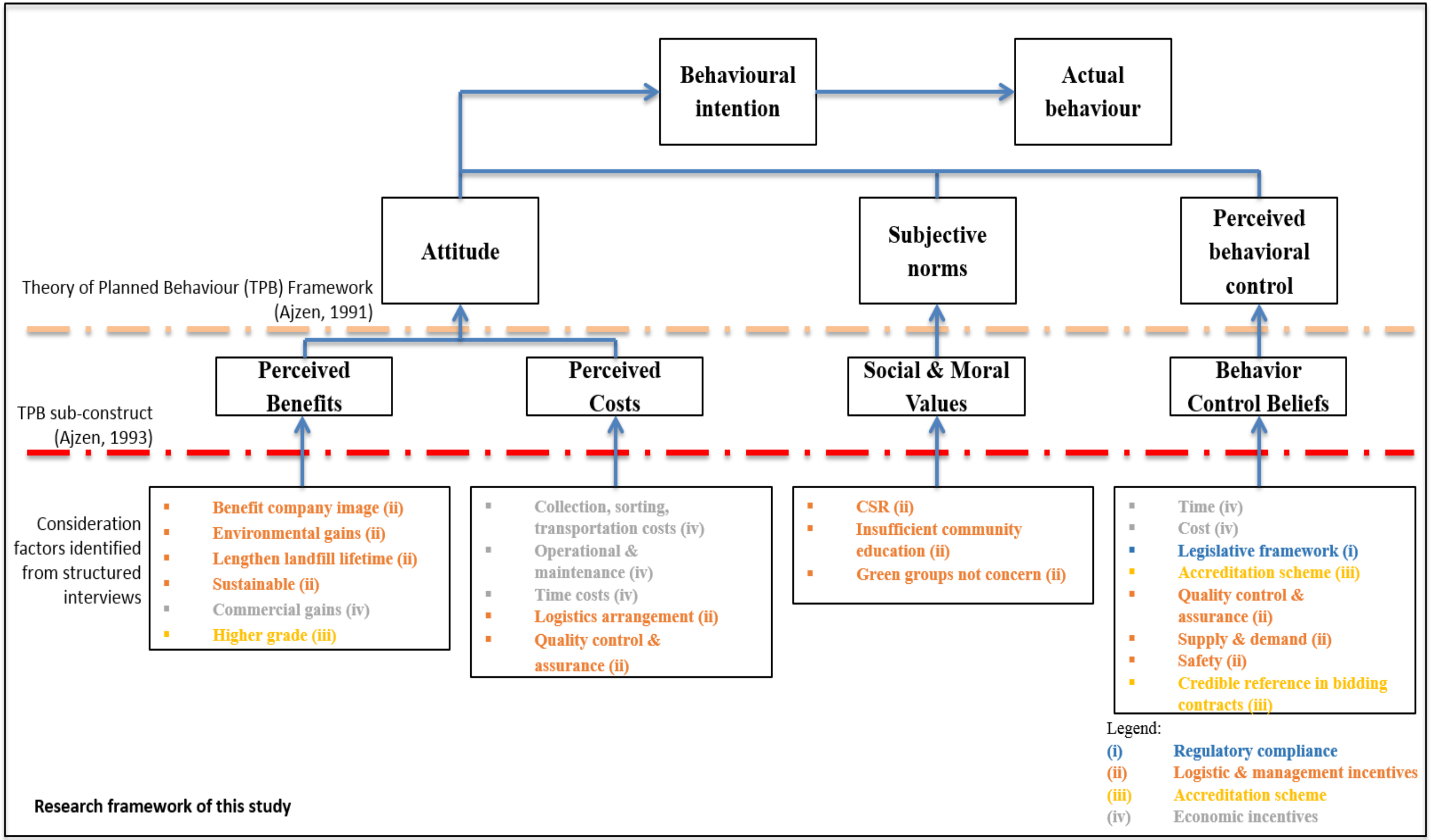


Figure 5.1 Extended theory of planned behaviour for C&D waste recycling

In this chapter, I aim to understand the determinants of intention and behaviour towards recycling of C&D waste in the community. The first objective is to identify and prioritize the key factors that influence the C&D waste recycling intention and behaviour through TPB-based semi-structured interviews with representatives from construction-waste-related organizations, environmental consultants and contractors, and government engineers. The second objective is to investigate the differences in the perceptions and concerns of stakeholders in different sectors over the C&D waste recycling promotion by questionnaire survey. The third objective is to examine the inter-relationships among various factors via a quantitative correlation analysis. This research could improve our understanding about the considerations and preferences of different operative levels in the community using well-defined TPB framework, thus formulating appropriate strategies for effective promotion of C&D waste recycling.

5.2 Results and Discussions

5.2.1 Semi-structured Interviews

5.2.1.1 Key factors identified for establishment of C&D waste-specific TPB

Three groups of interviewees considered legislation and regulation as an effective measure to enhance recycling behaviour. With reference to the revision of charging fee under Construction Waste Disposal Charging Scheme, all interviewees recognised the effort of increasing Economic incentives as to promote waste sorting at source as the foundation of recycling. For example, Interviewee R2 opined that "amended fees provide certain incentives to changing their behaviours, and they will search for more options to recycle construction waste instead of landfilling". Interviewee R7 also expressed that "financial incentives can make recycling worthwhile and individuals need financial incentives". The interviewees from consultant and contractor firms demonstrated their priority consideration about the relative magnitude of sorting cost for recycling and charging fee for direct disposal as a decision-making process. For instance, Interviewee R8 commented "if the disposal cost can be up to HKD$1,000 per tonne, waste producers will consider waste sorting." Interviewee R9 showed concern on "willingness to invest on waste sorting by corporates if the associated costs are too high". The increment of charging fee, however, should be a gradual and orderly progress with the mutual support from the local industry. Interviewee R1 referred to "the UK landfill charging roadmap, emphasizing a progress can be as long as 50 years". A previous study also suggested a carrot-and-stick approach for regulation formulation to provide incentive and encouragement for construction industry stakeholders in waste recycling (Tam et al., 2007). Apart from Construction Waste Disposal Charging Scheme, a spectrum of policies on waste management in Hong Kong discussed among the interviewees is summarised in **Table 5.1**.

Table 5.1 Generalization of Hong Kong policies on waste management

Legislation	Regulation	Contractual / Specification / Requirement	Voluntary Scheme
• Waste Disposal Ordinance (Cap. 354) • Amendment for the Waste Disposal Ordinance (Cap. 354N)	• Trip Ticket System • Construction Waste Disposal Charging Scheme • Off-site Construction Waste Sorting Programme	• Building Environmental Assessment Method (HK-BEAM) • Green Product Accreditation and Standards (HK G-PASS)	• Recycled materials • Guidance for Selective Demolition & On Site Sorting • Recycling fund

Time was another commonly considered factor during the semi-structured interviews, which influenced recycling behaviour in the construction industry. Uptight project schedule in high-density cities such as Hong Kong inhibited the implementation of C&D waste recycling, as highlighted by Interviewee R6 that "time, effectiveness, and meeting project schedule are important to developers". The majority of interviewees expressed concerns about the use of recyclables if virgin materials exhibited better performance over recyclables in terms of steady supply, cost, and quality. The variation in quality of recyclables depending on waste sources might hinder the construction progress. As revealed by Interviewees R6, R8, and R9, "degree of convenience (regarding recyclable supply and quality) and absolute safety are the most important issue". Narrow market and user's concerns for recyclables corroborated previous findings (Yuan et al., 2011).

Accreditation scheme, as an emerging concept in the construction industry, could provide incentives towards recycling as reflected from some interviewees. For example, granting of bonus gross floor area is an appealing motivation for the project clients to apply for various accreditation schemes, which ultimately serves as an economic incentive. While interviewee R10 and R11 agreed with the concept of accreditation scheme, they expressed concerns on the actual application because of bureaucracy and tick-box exercise for relevant statutory bodies.

Content analysis for other identified factors from the semi-structured interviews was carried out in similar fashion, followed by a comparison of the identified factors with the existing literature (**Table 5.2**). The C&D waste-specific recycling behaviour model is accordingly established by fitting the factors identified into the sub-constructs of the TPB framework (Fig. 1), i.e., perceived benefits, perceived costs, social values, and behaviour control beliefs. The identified factors are further classified into four key factors, i.e., Regulatory compliance, Economic incentives, Accreditation Scheme, and Logistic and management incentives, which facilitate readers' reference and subsequent frequency analysis. The details are elaborated in the Supplementary Information.

Table 5.2 Comparison table between identified factors and prior studies

Identified factors	TPB Sub-Category	Reference	Summary of Reference
Benefit Company Image	Perceived Benefit	Hwang and Yeo, 2011	Recycling as a company policy help shape company image in terms of environmental awareness
Environmental gains	Perceived Benefit	/	/
Lengthen landfill lifetime	Perceived Benefit	Pitt, 2005	Landfill space is a key factors towards construction waste management
Sustainable	Perceived Benefit	Schultmann and Sunke, 2007; McDonough and Braungrat, 2002	Closed-loop material flow is emphasised for a sustainable construction, subsequent life cycle, and ultimately achieving a cradle-to-cradle ideology
Commercial gains	Perceived Benefit	Kofoworola and Gheewala, 2009	Value of recyclables benefits company
Higher grade in tendering evaluation	Perceived Benefit	/	/
Time	Perceived Cost, Behaviour Control Beliefs	Lawson et al., 2001	Tight construction schedule hinder the implementation of recycling
Collection, sorting, transportation costs	Perceived Cost	Shakantu et al., 2008	Economic incentives are present for recycling
Quality control & assurance	Perceived Cost, Behaviour Control Beliefs	Richardson et al., 2010	Quality of recyclables is a major concern
Operational & maintenance	Perceived Cost	/	/
Logistic arrangement	Perceived Cost	Shakantu et al., 2008	Economic incentives are present for recycling
Corporate Social Responsibility	Social & Moral Values	Hwang and Yeo, 2011	Recycling as a company policy help shape company image in terms of environmental awareness
Insufficient community education	Social & Moral Values	Kofoworola and Gheewala, 2009	Environmental awareness are weak at worker's level in terms of waste handling
Green groups not concern	Social & Moral Values	/	/
Cost	Behaviour Control Beliefs	/	/
Legislative framework	Behaviour Control Beliefs	Tam et al., 2007; Leigh and Patterson, 2004	Carrot and Stick approach as to give incentive and encouragement to project stakeholders in performing recycling
Accreditation scheme	Behaviour Control Beliefs	/	/
Supply & demand	Behaviour Control Beliefs	Yuan et al., 2011	Narrow market for recycled product and lead to a low recycling rate in construction
Safety	Behaviour Control Beliefs	/	/
Credible reference in bidding contract	Behaviour Control Beliefs	/	/

5.2.1.2 Frequency distribution of identified key factors

The content analysis showed that Regulatory compliance with the highest repetition rate of 291 counts was the most important factor determining C&D waste recycling behaviour, followed by Economic incentives (284 counts) and Logistics and management incentives (128 counts). In particular, Accreditation schemes (83 counts) were also identified as a key factor in the semi-structured interviews. This enriched the scope of considerations in the literature, which mostly emphasized the attitudinal forces (Teo and Loosemore, 2001; Begum et al., 2009). Frequency distribution of the four factors of keywords is illustrated in **Figure 5.2**. Construction-waste-related organizations and government engineers showed the highest concern about Regulatory compliance, of which the keywords accounted for 44.4 and 35.8% of the total keyword count, respectively. Both sectors considered Economic incentives with the second highest importance (e.g., 31.8% keyword count for government), followed by Logistic and management incentives (e.g., 23% keyword count for government). This differed from a recent study on C&D waste recycling in Vietnam (Lockrey et al., 2016), where the government valued logistics and economic incentives over effective regulation. Such discrepancy might originate from relatively higher rule of law index (0.77) and regulatory enforcement (0.8) in Hong Kong when compared to Vietnam (0.51 and 0.43, respectively) (WJP, 2016).

In comparison, environmental consultants and contractors indicated the highest concern over Economic incentives (36.4% total keyword count), which was in agreement with previous findings (Knoeri et al., 2011; Wu et al., 2016). For the contractors in Shenzhen (Wu et al, 2016) and Switzerland (Knoeri et al., 2011), the most important behaviour determinant for C&D waste management was economic viability. Nevertheless, Accreditation schemes received the lowest concern, i.e., the construction-related representatives gave the least concern (4% total keyword count), followed by government engineers and environmental consultants and contractors (i.e., 9.5% and 14.5%, respectively) (**Figure 5.2**). The interviewees implied that the inadequate social recognition of accreditation scheme impeded its effectiveness in promoting C&D waste recycling. The government should play a critical role to improve, for example, by enacting statutory accreditation in the governmental and/or commercial bidding contracts.

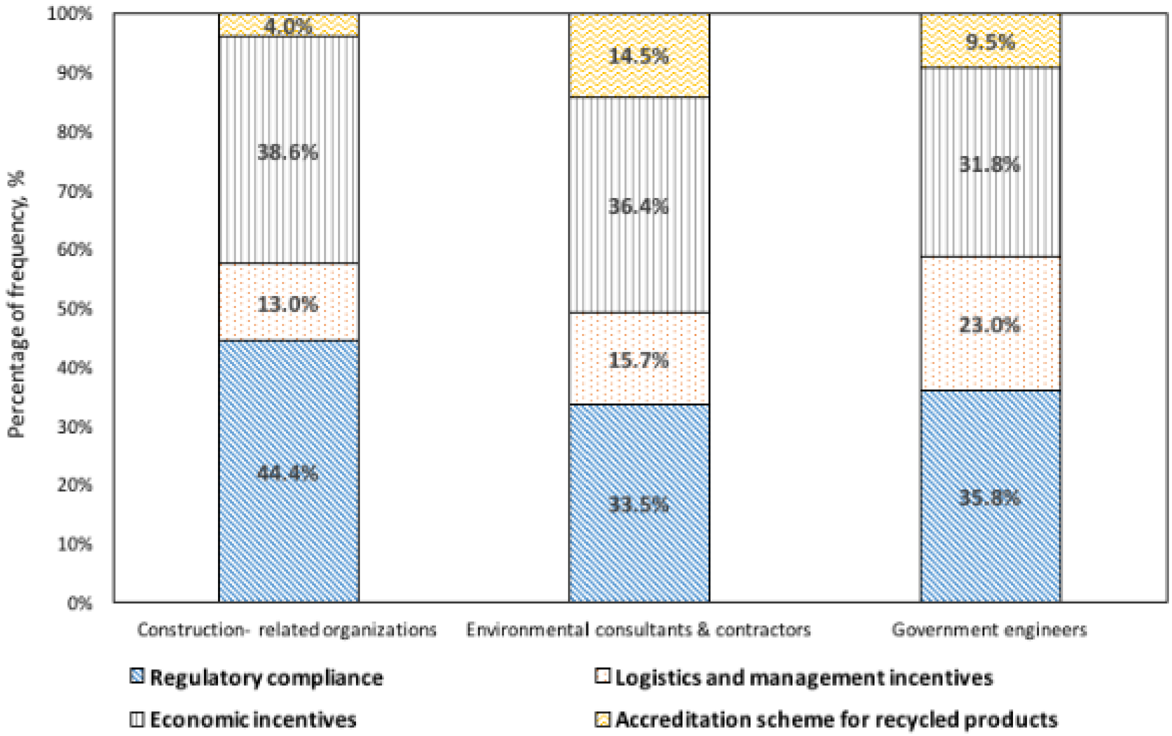


Figure 5.2 Frequency percentage of the four categories of keywords mentioned by the three groups of professionals in the structured interviews.

Therefore, as shown in this study, it is important to focus not only on corporates such as consultants and contractors, but also social and political stakeholders who place different emphasis on C&D waste recycling. The significant intention- and behaviour-governing factors were identified from the semi-structured interview and were accordingly added to the existing TPB framework. This development of extended TPB framework (**Figure 5.1**) presents a clear picture of recycling behaviour determinants to decision makers envisioning future directions for effective waste management policy.

5.2.2 Questionnaire Survey

5.2.2.1 Priorities in key factors of C&D waste recycling behaviour

There were 191 questionnaire responses in total, of which practitioners engaging in consultant and contractor firms accounted for 37 and 25%, respectively, representing the two major groups of respondents. Construction-related experts shared the least responses (9%) among all groups due to limited representatives in this group. Up to 40% of the respondents had work experience over six years, while age group of 18-35 contributed to over 60% of the total responses. **Table B3** summarizes the information of respondent profile.

The questionnaire results showed that Regulatory compliance had the highest mean score of 4.17 among the four factors of recycling behaviour determinants (**Table 3.2**), suggesting that in general the respondents viewed Regulatory compliance as the most important element to motivate the use of C&D recyclables. This agreed with previous studies in China where effective regulation was deemed the most critical success factor to promote C&D waste recycling (Lu, 2010; Yuan et al., 2013). Therefore, three factors including effectiveness of supervision, coverage of regulation, and enforceability of regulation were compared in the Regulatory compliance factor (**Table B4**). It clearly showed that enforceability of regulation was considered the most important factor when formulating C&D recycling policy, with a mean score of 4.41. Effectiveness of supervision was the second most important element (4.16) followed by coverage of regulation (3.94) (**Table B4**).

Economic incentives with the mean score of 4.07 was the second most important element in promoting the recycling behaviour (**Table 3.2**), contrasting a previous study in Shenzhen, where Economic incentives were the least important (Wang et al., 2014), probably because social behaviour theory was not considered. In our study, the respondents agreed that the implementation of disposal charging fee by the government (4.15) and reasonable collection and sorting costs for on-site and off-site activities (4.15) had equal importance, followed by the disposal costs (4.07) and recycling values of recyclables (4.04). The costs associated with waste transportation to disposal sites were comparatively less concerned (3.89) (**Table B4**).

It was noteworthy that the results of questionnaire survey (**Figure 5.2**) aligned well with the frequency distribution of views expressed in the semi-structured interviews (**Figure 5.1**). Both analyses indicated the importance of the factors in the following descending order: Regulatory compliance, Economic incentives, Accreditation schemes, and Logistics and management incentives, which help to advise the key factors that policy makers should make concerted efforts with priorities. These four key factors were the major determinants of individuals' intention and behaviour towards recycling of construction waste, by influencing the Attitude, Subjective norms, and Perceived behaviour control of individuals.

5.2.2.2 Varying stakeholders' perceptions on key factors

Regulatory compliance earned the highest score among the recycling behaviour-determining factors from all the professionals, i.e., contractors (4.09), consultants (4.25), construction-related experts (4.20), and government officials (4.33) (**Figure 5.2**). This was distinctive from the findings of a China-based study, which indicated that economic viability was more significant than government supervision in governing the C&D waste management behaviour of contractors (Wu et al., 2016). This highlighted the importance of the local background, i.e., culture and enforceability of governmental inspection, in deciding an appropriate management strategy. It was noted that effective implementation of the policy was critical on top of a comprehensive regulatory framework (Ma and Hipel, 2016). The score distribution further illustrated that the majority of the Hong Kong professionals strongly agreed (31-45% score "5") or agreed (41-48% score "4") with the importance of Regulatory compliance, while nearly none of them disagreed with it (< 2% score "2" and "1") (**Figure 5.3a**). Such responses showed high consistency in the opinion of the professionals towards regulations.

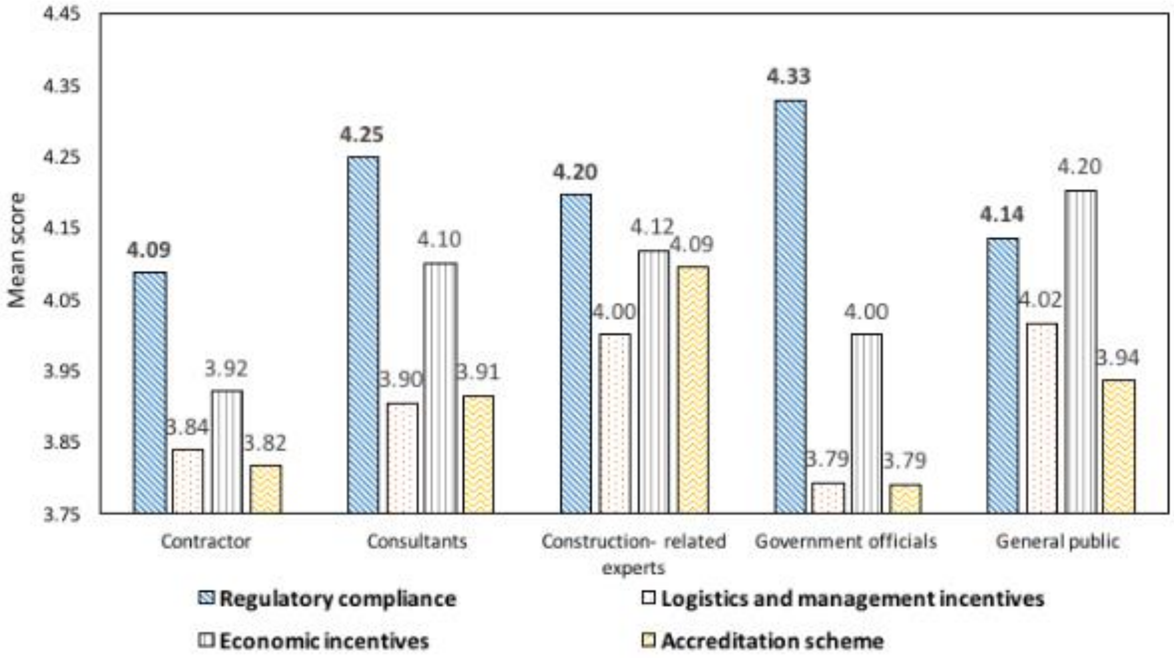


Figure 5.2 Mean score of different categories given by the five respondent groups in the questionnaire survey.

It is interesting to note that contractors, consultants, and construction-related experts placed Regulatory compliance above Economic incentives (**Figure 5.2**), implying that the industry tended to exercise a recycling practice as long as it was legislated despite possibly higher expenditure. This corroborated an earlier study on C&D waste disposal charging scheme in Hong Kong that the contractors paid great attention to comply with the regulations (Yu et al., 2013). Such compliance was also observed in other countries, for example, from the perspective of consultant in Europe (Knoeri et al., 2011) and from the government in

Bangladesh (Matter et al, 2015). Therefore, clearly defined regulations substantiated by adequate supervision and inspection from the government were the key to mobilize behavioural change in the industry for reduction and recycling of C&D waste (Wu et al., 2016).

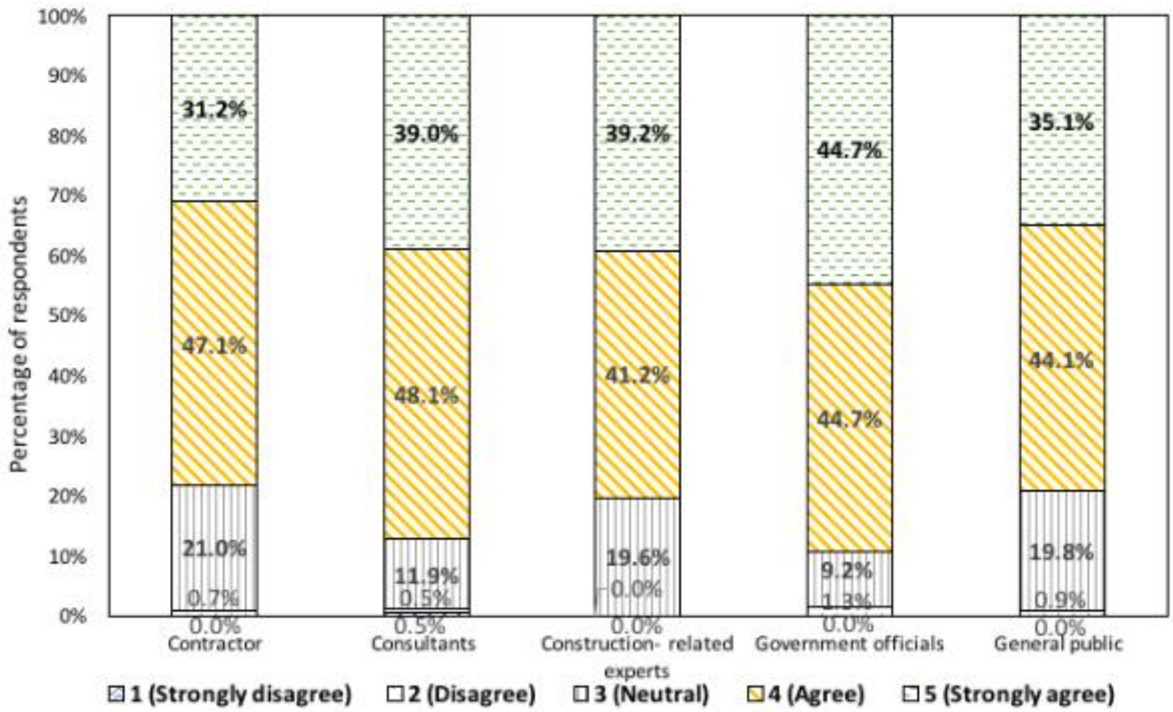


Figure 5.3a Score distribution of various respondents in the questionnaire survey under the category of Regulatory compliance.

In contrast to the professionals, the public scored Economic incentives (4.2) higher than Regulatory compliance (4.14) (**Figure 5.2**), in which about 81% of the layman respondent strongly agreed or agreed (score “4” or “5”) on the impacts of economic incentives and nearly all of the remaining (18%) took a neutral stance (score “3”) (**Figure 5.3b**). This was probably because the public had a lower awareness and understanding about the relevant legislations compared to the construction corporates and government, hence financial considerations emerged as the top priority. A recent study on electronic waste recycling in Finland similarly reported that the public expressed the highest degree of concern over the economic incentives (Ylä-Mella et al., 2015). This implied that the Economic incentives would be an effective driving force to motivate public engagement in waste recycling, which may not be limited to

C&D waste. The environmental consciousness of the public will also influence decision making of corporates that place varying degree of emphasis on Corporate Social Responsibility (CSR).

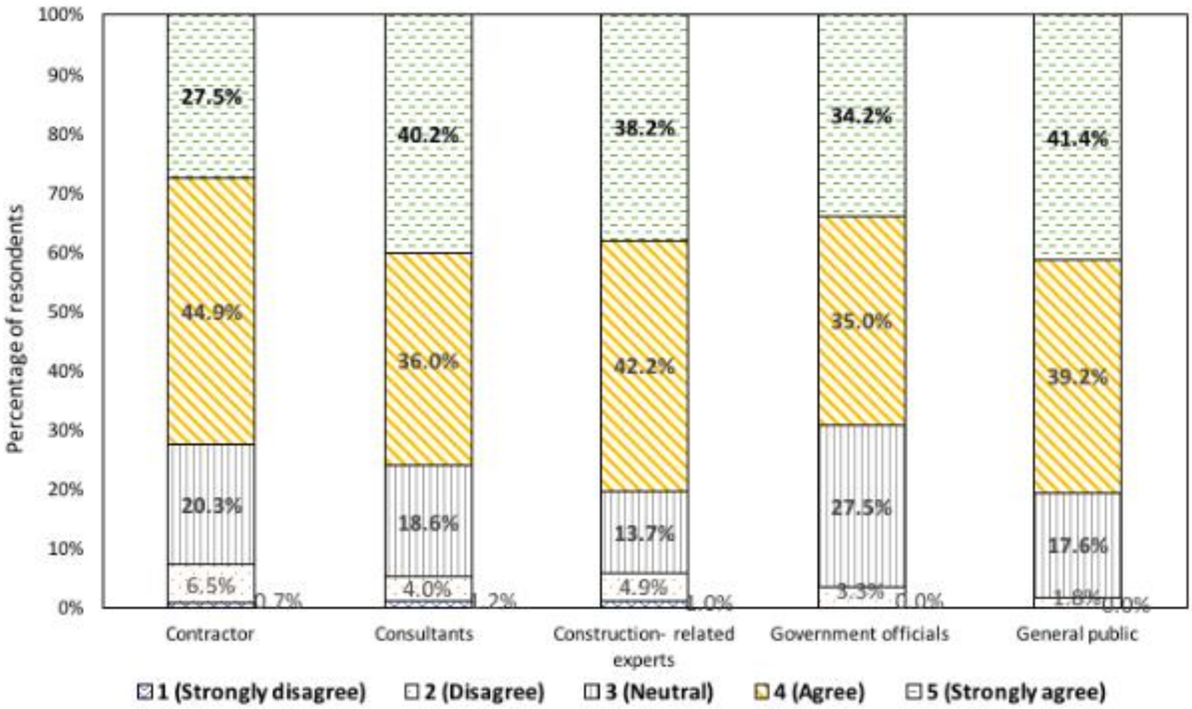


Figure 5.3b Score distribution of various respondents in the questionnaire survey under the category of Economic incentives.

Moreover, the questionnaire survey showed a linear relationship between understanding and importance of Accreditation scheme (**Figure 5.4**). In particular, the respondents from consultant firm and construction-related expert demonstrated a higher degree of understanding towards Accreditation scheme. This result seems to suggest that the respondents appreciate to a larger extent the importance of Accreditation scheme when they have a better prior understanding. This may also reflect that the recognition of Accreditation scheme in Hong Kong is still emerging and further promotion is required. In particular, the government officials, who gave the lowest scores among different groups, should acknowledge the significance of Accreditation scheme as a tool to provide incentives towards recycling by means of economic reward or social recognition of the construction industry.

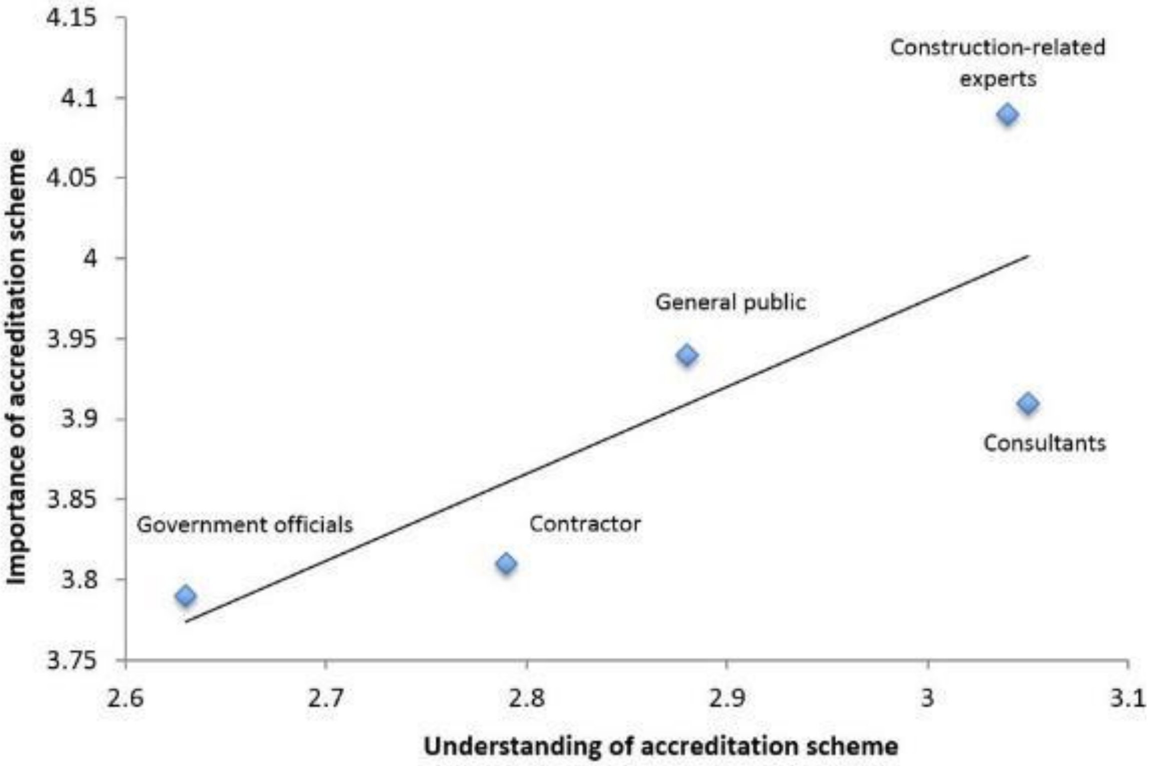


Figure 5.4 Relationship between understanding and importance of accreditation scheme for different respondent background.

Therefore, our study reveals the discrepancy in the priority of different considerations between the industry, government, and the public, which is important to be recognized upfront. This helps to formulate stakeholder-specific managerial strategies and public policy tools to encourage a particular sector to change their behaviour in waste recycling.

5.2.2.3 Correlation analysis and implications for policy formulation

The correlation among the considerations on the six types of costs under the Economic incentives factor was quantified **(Table 5.3**). In particular, there was a significant positive relationship between the perception of generic respondents towards *collection and sorting costs* and *disposal costs of waste*, of which the correlation coefficient was 0.53. Such result probably indicated that the costs associated with end-of-life product treatment were viewed in a collective manner by the stakeholders. Therefore, a larger margin between the *collection and sorting costs* and *disposal costs* should be provided to create economic incentives towards waste recycling over direct disposal, because after all the latter is a simpler and faster option to the construction industry. This observation echoed with the findings from content analysis of semi-structured interviews on the comparative considerations between the sorting cost and the waste disposal charging fee. Thus, increasing the disposal cost by waste charging would provide economic incentives for the implementation of sorting and recycling (Poon et al., 2013; Yu et al., 2013). In contrast, no correlation was identified among the four factors (**Table B5**), or among the factors under the factor of Regulatory compliance (**Table B6**) and Logistics and management incentives (**Table B7**).

Table 5.3 Correlation analysis of factors under the category of Economic incentives

Category D: economic incentives						
	Collection and sorting costs (On-site/ off-site)	*Transportation costs to disposal sites*	*Disposal costs of waste/ recycled materials*	*Recycling value of waste/ recycled materials*	*Disposal charging fee implementation by Government*	*Government subsidies and corporates funding*
Collection and sorting costs (On-site/ off- site)	1					
Transportation costs to disposal sites	0.47	1				
Disposal costs of waste/ recycled materials	0.53	0.54	1			
Recycling value of waste/ recycled materials	0.22	0.24	0.40	1		
Disposal charging fee implementation by Government	0.18	0.26	0.36	0.16	1	
Government subsidies and corporates funding	0.19	0.21	0.11	0.10	0.25	1

To develop an effective policy to promote recycling, it is important to recognize the difference in characteristics, handling procedure, and potential application of each type of waste. The inter-relationships among different stakeholders in the process of construction waste recycling are consolidated in **Figure 5.5** from the material flow perspective. A recent study in China (Zheng et al., 2017) also illustrated the cradle-to-grave life cycle of different construction materials. Take sustainable management of construction wood waste as an example, it is of paramount importance to develop: (i) thorough understanding of recycling option and handling approach (Bergeron, 2014), (ii) waste-specific classification guidelines with respect to the cleanliness and specification (WRAP, 2012), (iii) environmentally friendly and financially viable innovation in recycling technologies (Wang et al., 2016; Wang et al., 2017; Wang et al., 2018), and (iv) available market and supportive policy for recyclables (Knauf, 2015).

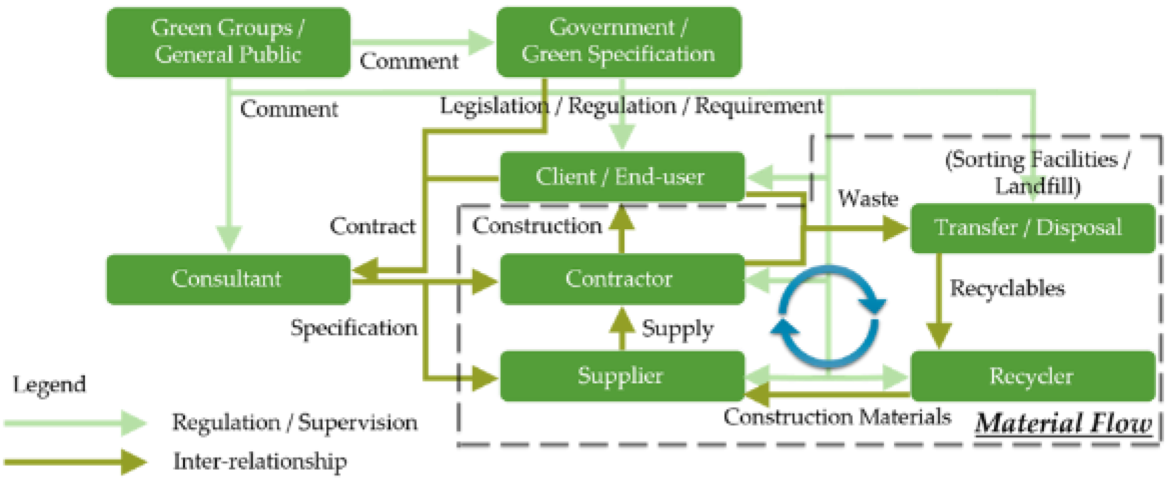


Figure 5.5 Sustainable material flow in the construction industry.

An ideal closed-loop material flow within construction industry can be established within the current structure (**Figure 5.5**), which provides economic incentives for the construction stakeholders to develop one-stop service from material supply to waste recycling and utilization. However, it is noted that the resource sustainability and material flow were rarely discussed even in the semi-structured interviews with the construction-related experts.

Currently, there is insufficient specification of the legitimate use of recycled materials in construction projects, and a platform is needed for different companies to communicate and collaborate for waste recycling. Thus, the policy makers should demonstrate vision and take the lead to construct the long-term blueprint for C&D waste recycling framework to establish sustainable resource management and circular economy in the construction industry.

Chapter 6- A Cross-region Analysis on Commercial Food Waste Recycling Behaviour

6.1 Research Questions

According to the 6Rs' principle, rethink, refuse, reduce, reuse, recycle, and replace are of emerging importance when designing waste strategies (Green Triangle Blog, 2012). In particular, rethink comes first as individuals consider and question their own habits. Drivers such as materialism values were proposed (Abdelradi, 2018; Diaz-Ruiz et al., 2018) and the complexity of food waste generation was suggested as a function of cultural, personal, political, geographic, and economic forces (Thyberg and Tonjes, 2015; Hebrok and Boks, 2017). Tackling the food waste problem would require multi-faceted policy levers for sustainable policy development (Thyberg and Tonjes, 2015; Schanes et al., 2018), based on the understanding of the combined effects of economic and regulatory factors (Chalak et al., 2016) and connections between intentions and recycling behaviour (Mak et al., 2018) across different countries. Previous studies also proposed the concept of environmental inequality in waste management and health due to various socio-economic status (Martuzzi et al., 2010). The correlation between income and residence affected some environmental outcomes such as a higher possibility of being exposed to environmental hazards, unbalanced impacts of environmental policies, and inequalities in the delivery of environmental services such as waste disposal and recycling (Taylor, 2000; Margai, 2001). However, it remains uncertain how corporates' recycling behaviour varies with different industry structures and economies. This study aimed to fill in the information gap that various factors might be influencing corporates' recycling behaviour in two different economies due to environmental inequality by comparing Malaysia and Hong Kong, which represent upper middle income region and high income region, respectively.

Organisations do not make decisions; individuals do. This observation is a statement of both structural and operational fact: organisations (as physical realities, not accounting or legal entities) are made by, and are composed of, people (Carley and Behrens, 1999). Therefore, it is fundamental to understand individuals' behaviour in order to achieve a change in recycling culture within corporates. Individuals' behaviour including attitudes, subjective norms, and perceived behavioural control are determined by the convention Theory of Planned Behaviour (TPB) (Ajzen, 1993) (**Figure 3.1**), which has successfully explained various environmentally responsible behaviour including recycling (such as William and Kelly, 2002; Davis et al., 2006; Omran et al., 2009). The applications of TPB extend to elucidating transportation in public (Bamberg and Schmidt, 2003) and convention conservation behaviour (Kaiser et al., 2005). In previous literature, path analysis was adopted to proof the substantial correlations between constructs and recycling behaviour. Attitude and personality (Arbuthnot, 1977; Chan and Bishop, 2013; Ghani et al., 2013), moral norms (Conner and Sparks, 2005; Russell et al., 2017) and perceived behavioural control (Visschers et al., 2016; Gilli et al., 2018) are correlated with household food waste behaviour, while an intervening relationship was discovered in administrative incentives and corporate support on recycling behaviour (Mak et al., 2018). Recycling behaviour within commercial industries can be associated with amenity problem and low awareness as well as interest in waste management (Papargyropoulou et al., 2014).

This study aims to explain and compare corporates' intentions about food waste recycling under different industry structures and economies. The objectives of this study include (i) identifying major drivers and their relationships of recycling behaviour in the commercial sector in Malaysia, and (ii) discovering generic differences in recycling behaviour of commercial food waste management systems in Malaysia and Hong Kong. New perspectives on the management of food waste across various economies would be beneficial for improving regional policy strategies. Commercial behavioural changes could also be fostered for the sake of more robust sustainable policy development.

Latent variables (LVs) were inferred from other measurable variables through a mathematical model (Jan, 1986), and employed to extend the existing TPB framework by quantitative modelling. In the commercial sector, new variables affecting food waste recycling intention and behaviour were identified and prioritised. Employees' acceptability on recycling costs and required human resources were evaluated and revealed the discrepancy in employees' awareness and concerns on food waste recycling in various industries and regions in the questionnaire.

6.2 Results and Discussions

6.2.1 Reliability and validity of reflective TPB model

An equal distribution of respondents was received (i.e. 206 questionnaire responses), which those from the Malaysian hotel, food and beverages, and property management industries consisted of 30.6%, 36.4%, and 33.0%, respectively **(Table C1).** The majority worked in the management (43.2%) and operation (27.2%) divisions, which was comparable to the Hong Kong-based study (24.5% and 20%, respectively; Mak et al., 2018). Over 70% of the Malaysian respondents mentioned a lack of food waste reduction/recycling schemes in their organisations. **Table C2** showed the breakdown of mean score of different indicators in the questionnaire.

As most of the reliability factors were scored between 0.44 and 0.857, reliability and validity of the model was assured (**Table 6.1**). The composite reliability values ranged from 0.769 to 0.901, which confirmed the internal consistency reliability of all eight LVs. As the AVE values ranged from 0.606 to 0.745, it was assured that the convergent validity of the model was confirmed. Since the square root of the AVE value of each LV exceeded its highest correlation with other LVs, the discriminant validity was assured (e.g. 0.803 of LV1 > 0.513 of LV1-LV2 correlation) (**Table 6.2**). Furthermore, the model demonstrated a good fit with a SRMR at 0.076.

Table 6.1 Reflective model of Malaysia respondents: reliability measurement

Constructs	Item	Indicatory Reliability	Composite Reliability	Average Variance Extracted (AVE)
LV1: Economic incentives	ECON_1A	0.746	0.843	0.644
	ECON_1B	0.701		
	ECON_1C	0.486		
LV2: Logistics & management incentives	LOGIS_2A	0.706	0.9	0.646
	LOGIS_2B	0.778		
	LOGIS_2C	0.484		
	LOGIS_2D	0.709		
	LOGIS_2E	0.551		
LV3: Administrative incentives & corporate support_	ADMIN_3A	0.709	0.901	0.606
	ADMIN_3B	0.787		
	ADMIN_3C	0.653		
	ADMIN_3D	0.441		
	ADMIN_3E	0.582		
	ADMIN_3F	0.462		
LV4: Moral attitudes	MORAL_4A	0.584	0.832	0.623
	MORAL_4B	0.692		
	MORAL_4E	0.590		
LV5: Subjective norms	SUB_5A	0.857	0.853	0.745
	SUB_5C	0.632		
LV6: Perceived behaviour control	PBC_6A	0.482	0.769	0.627
	PBC_6B	0.774		
LV7: Recycling intention	INTENTION_7A	Single Item Construct		
LV8: Recycling behaviour	BEHAVIOUR_8A	0.714	0.782	0.643
	BEHAVIOUR_8B	0.573		
Min		0.441	0.769	0.606
Max		0.857	0.901	0.745

Table 6.2 Fornell-Larcker discriminant validity measurement

	LV1: Economic incentives	**LV2: Logistics & management incentives**	**LV3: Administrative incentives & corporate support**	**LV4: Moral attitudes**	**LV5: Subjective norms**	**LV6: Perceived behaviour control**	**LV7: Recycling intention**	**LV8: Recycling behaviour**
LV1: Economic incentives	**0.803**							
LV2: Logistics & management incentives	0.513	**0.804**						
LV3: Administrative incentives & corporate support_	0.539	0.608	**0.778**					
LV4: Moral attitudes	0.477	0.566	0.622	**0.789**				
LV5: Subjective norms	0.378	0.48	0.512	0.591	**0.863**			
LV6: Perceived behaviour control	0.3	0.216	0.34	0.329	0.243	**0.792**		
LV7: Recycling intention	0.248	0.214	0.173	0.199	0.054	0.384	Single item construct	
LV8: Recycling behaviour	-0.058	-0.029	-0.098	-0.138	-0.289	0.171	0.155	0.802

6.2.2 Priorities in key LVs of food waste recycling behaviour and correlation analysis

The extended TPB is effective in explaining behaviour for food waste recycling, in which 78% of the variance that was explained by the independent LVs (**Figure 6.1a**). With the complexity of food waste behaviour, the model was considered to be of substantial strength (Quested et al., 2013). The most substantial factor on employees' recycling intention was perceived behavioural control (0.351), followed by logistics and management incentives (0.149) and economic incentives (0.129) when compared with the other three suggested LVs. It may be because the external factors, such as resource availability and past experiences, govern the beliefs or confidence of the Malaysian respondents in their ability to recycle. Such observation echoed with the literature that Europe's food waste sorting and recycling were mainly determined by perceived behavioural control (Visschers et al., 2016; Stancu et al., 2016) and it could drive behaviour through food-related routines (Stefan et al., 2013). In addition, incentives were significant towards recycling intention, such as the space and equipment for recycling as well as the associated costs and savings in procurement and operation. A similar observation was noted in Barcelona, where materialism values of individuals directly influenced household food waste generation (Diaz-Ruiz et al., 2018).

However, there are significant differences between Malaysia and Hong Kong in terms of the primary determinant of recycling intention. Commercial industries in Hong Kong emphasised administrative incentives and corporate support as the most critical LV while perceived behavioural control had a less critical impact (Mak et al., 2018). This may due to the intensive labour and resources need to meet the competitive commercial environment in Hong Kong.

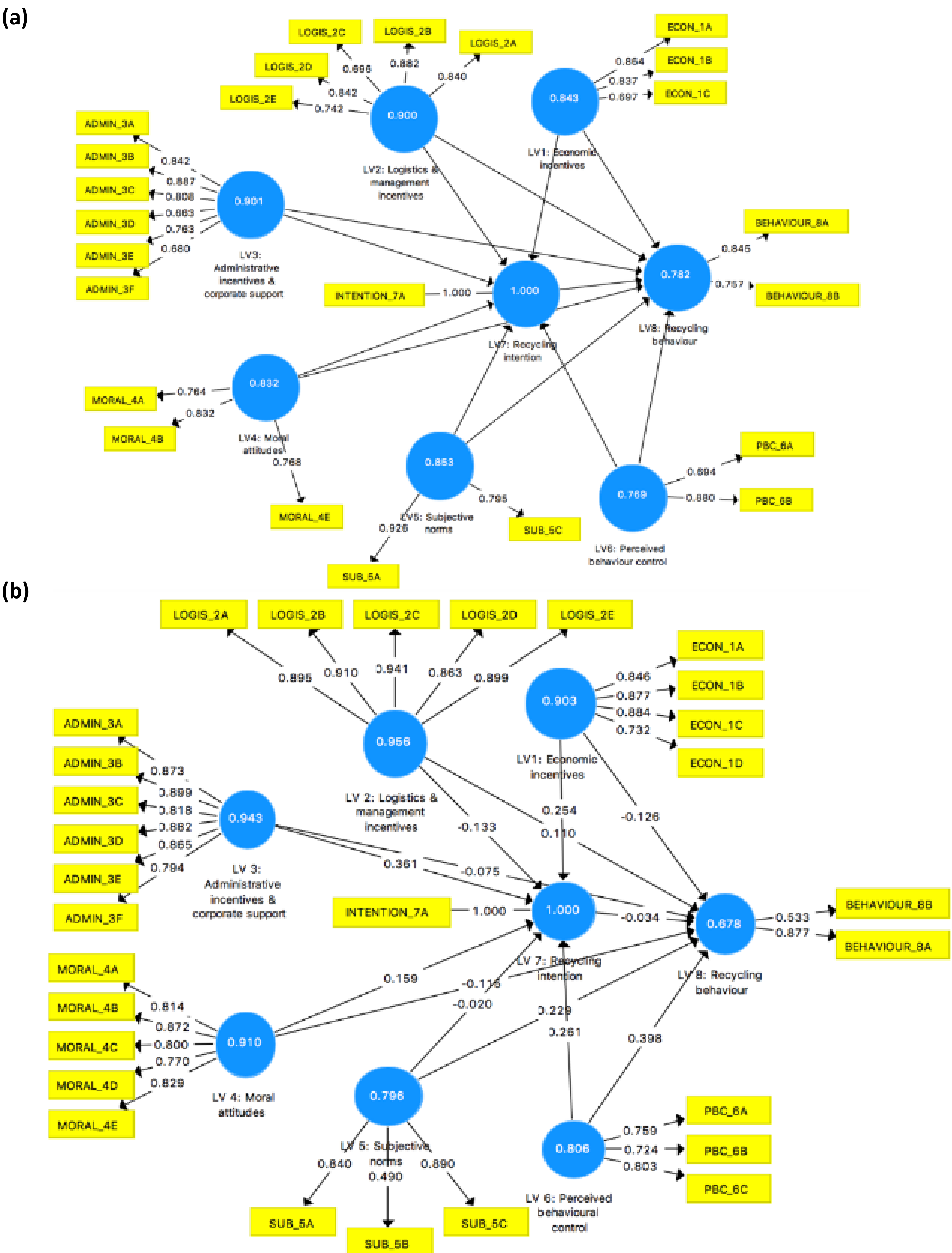


Figure 6.1 The conceptual SEM inner and outer models of (a) Malaysian respondents and (b) Hong Kong respondents.

Similar to Hong Kong, negative impact on recycling intention was observed in subjective norms (-0.16) and administrative incentives & corporate support (-0.073), which indicated that subjective norms and administrative incentives & corporate support might lead to a decrease in recycling intention Similarly, subjective norms was moderately related to the intention to reduce household food waste generation in the United Kingdom (Stefan et al., 2013; Graham-Rowe et al., 2015) and Denmark (Stancu et al., 2016). It was probably because food waste was not visible to others such that others could not judge one over this behaviour (Quested et al., 2013). The majority of the respondents from both Hong Kong and Malaysia did not experience any social pressure to recycle. It is believed that the recyclers tap their motivation from a source independent of the public expectation. The small influence of moral attitudes (0.077) on recycling intention suggested that a positive attitude towards recycling does not guarantee recycling behaviour. A moral component should be included in awareness-raising initiatives to enhance the chances of exercising recycling. For instance, a tailor-made recycling scheme that incorporates the concept of personal evaluation can be implemented (Strydom, 2018). Political strategies that provide sufficient opportunities and resources have been demonstrated significant in determining employee perceptions of recycling behaviour.

Indirect effects on food waste recycling behaviour have yet been discussed in the available literature. The indirect effects appear in the pathway from the exogenous variable to the outcome through the mediator (Chan, 2007), where recycling behaviour is the outcome and recycling intention is the mediator in this study. The substantial indirect effect was identified on perceived behaviour control (0.028), logistics and management incentives (0.012), and economic incentives (0.01) towards positive recycling intention, which proposed an intervening effect on recycling behaviour (**Table 6.3**). In contrast, only administrative incentives and corporate support (-0.012) had an intermediate indirect impact on recycling behaviour in Hong Kong. Such observation reinforced our understanding of the indirect relationship of perceived behavioural control in household recycling in the United Kingdom (Stefan et al., 2013; Graham-Rowe et al., 2015). Both direct and indirect effects should be taken into consideration when designing food waste policies to induce positive behavioural changes in the commercial sector.

Among all relationships, moral attitudes and administrative incentives and corporate support showed substantial positive correlations (0.622) (**Table C3**), which corroborates the results in Hong Kong (Mak et al., 2018). This echoed with the previous reports that institutional factor might contribute to positive attitudes and improvement in recycling behaviour (Refsgaard and Magnussen, 2009). The availability of resources in an institution could affect individuals' social values, as demonstrated in a previous study concluding amenity problem as a hurdle to managing commercial food waste in Malaysia (Papargyropoulou et al., 2014). Therefore, administrative incentives and corporate support should be well-considered in developing moral attitudes among the commercial sector. Administrative incentives and corporate support were also positively correlated to logistics and management incentives (0.608), whereas the latter might have a positive correlation with moral attitudes (0.622). These findings highlight that the determination of moral attitudes should not only be influenced by perceived costs and benefits, as suggested in the original TPB framework.

Table 6.3 Estimated direct, indirect and total effects

Interaction	Direct effects	Indirect effects	Total effects = Direct + Indirect
LV 1: Economic incentives → LV 7: Recycling intention	**0.129**		0.121
LV 1: Economic incentives → LV 8: Recycling behaviour	-0.041	**0.01**	-0.031
LV 2: Logistics & management incentives → LV 7: Recycling intention	**0.149**		0.16
LV 2: Logistics & management incentives → LV 8: Recycling behaviour	0.155	**0.012**	0.167
LV 3: Administrative incentives & corporate support → LV 7: Recycling intention	-0.073		-0.062
LV 3: Administrative incentives & corporate support → LV 8: Recycling behaviour	-0.047	-0.006	-0.053
LV 4: Moral attitudes → LV 7: Recycling intention	0.077		0.032
LV 4: Moral attitudes → LV 8: Recycling behaviour	-0.067	0.006	-0.061
LV 5: Subjective norms → LV 7: Recycling intention	-0.16		-0.162
LV 5: Subjective norms → LV 8: Recycling behaviour	-0.347	-0.013	-0.36
LV 6: Perceived behavioural control → LV 7: Recycling intention	**0.351**		0.357
LV 6: Perceived behavioural control → LV 8: Recycling behaviour	0.241	**0.028**	0.269

6.2.3 Comparison of employees' varying perceptions of key LVs in Hong Kong and Malaysia

In the commercial sector, the three industries in Malaysia expressed similar considerations over the priorities of recycling behaviour. Respondents from hotel (3.99), food and beverage (3.62), and property management (3.94) industries valued administrative incentives and corporate support the most, all of which had the highest mean score among the six LVs (**Figure 6.2**). The above observation only considered the scoring of respondents from different sectors, while the structural relationship that estimated the multiple and interrelated dependency between these variables were considered in Section 6.2.2. The responses of the Malaysian commercial industry are in agreement with studies by Papargyropoulou et al. (2014) and Jereme et al. (2016). Corporates should implement incentive and supporting schemes to raise awareness on food waste impact, which is the primary driver to improve commercial and household food waste management in Malaysia. Similar to Malaysia respondents, administrative incentives and corporate support also earned an overall high score from professionals in the hotel (3.68) and food and beverages (3.67) industries in Hong Kong (Mak et al., 2018). However, logistics and management incentives (3.70) was emphasised by the property management industry in Hong Kong more than that in Malaysia. This is probably associated with the space constraints in Hong Kong residential buildings, which hampers the effort by property management companies in providing sufficient area for food waste collection, separation, temporary storage, and recycling equipment.

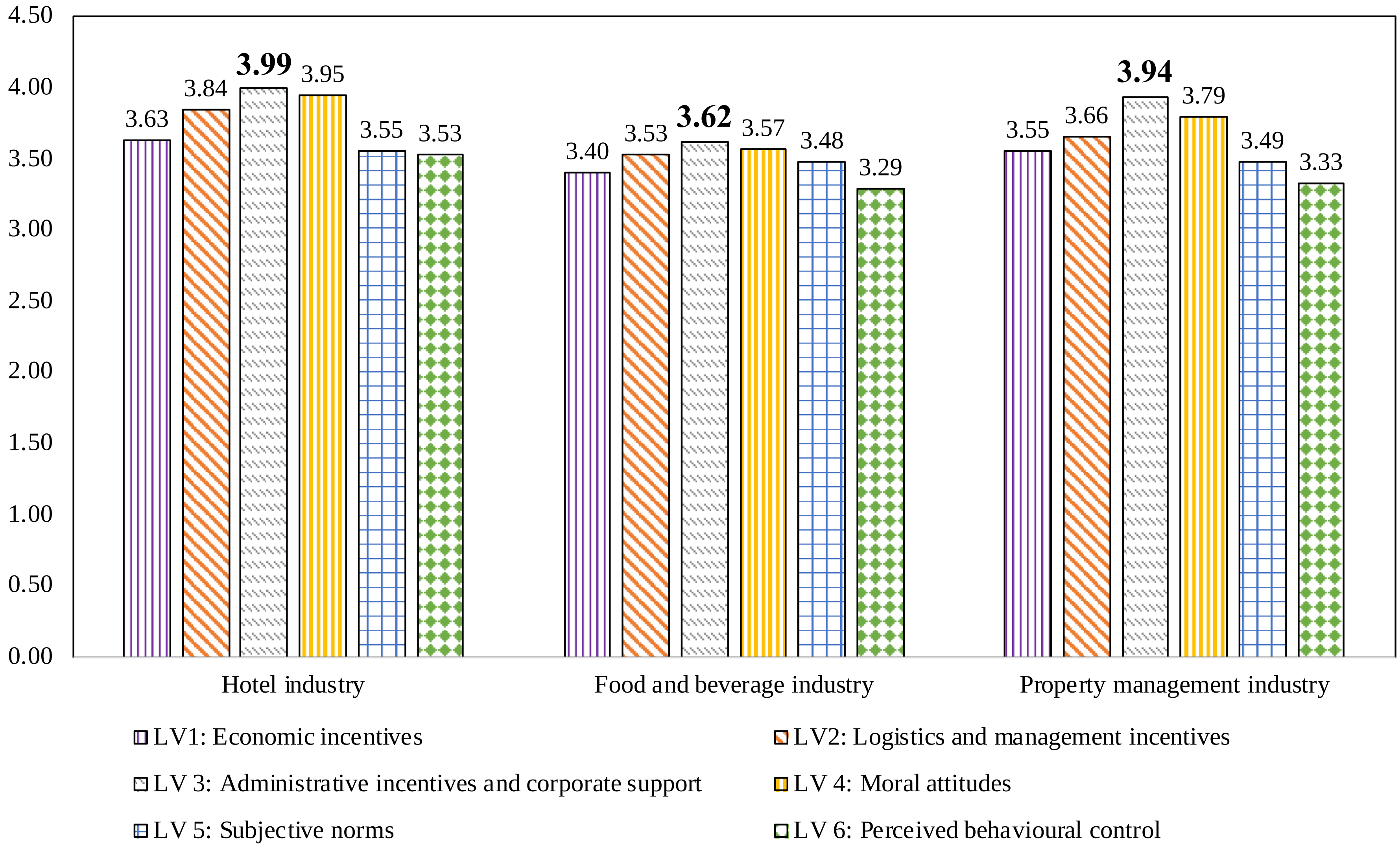


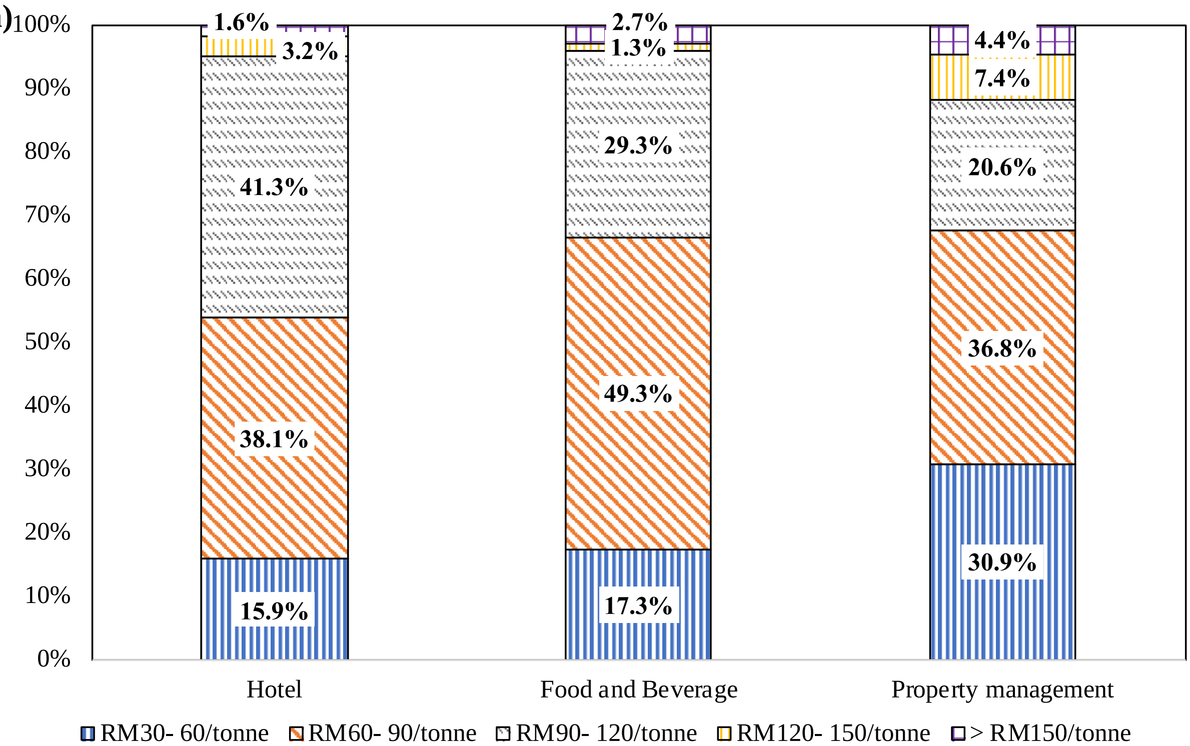
Figure 6.2 Mean score of different categories given by the three Malaysian respondent groups in the questionnaire survey.

In Malaysia, the hotel industry showed the highest acceptance level (41.3%) in recycling cost at RM90-120/tonne (US$21.7-29/t), compared to the food and beverage (49.3%) and property management (36.8%) which tended to accept RM60- 90/t (US$14.5-21.7) (**Figure 6.3a**). As compared with Hong Kong, the hotel (34.8%) and food and beverage (49.1%) industries showed the highest percentage of respondents who accepted a higher food waste recycling costs of HKD$350-500/t (US$44- 63) (Mak et al., 2018), suggesting the notable differences across the two regions. According to the World Bank Group (2018b), Malaysia is classified as upper-middle-income economies (US$3,896- $12,055), while Hong Kong is ranked as high-income economies (> US$12,056). For the former, the solid waste management cost was estimated at US$24 x 10^6, which is substantially lower than that in a high-income economy (US$159 x 10^6) (World Bank Group, 2012). Therefore, corporates in Hong Kong generally found the recycling cost more affordable than those in Malaysia did.

The hotel industry (44.4%) in Malaysia demonstrated a higher level of acceptance in arranging extra manpower in food waste handling (3-4 staff per 100 staff, i.e., 3-4% of total manpower), compared to food and beverage (42.7%) and property management (29.4%) industries who perferred one to two staff from a total of 100 (i.e., 1-2% of total manpower) (**Figure 6.3b**). At the moment, Malaysia has yet to have a policy to regulate commercial solid waste, not to mention a policy on the recycling of food waste. Corporates have their own right to outsource the waste collection and source separation schemes to any licensed contractors or manage all the solid waste themselves. Property managers, therefore, are less likely to perform recycling, unlike hoteliers or food and beverages sectors, who value the corporate social responsibilities and environmental policies and are eager to build a ‘green’ image for brand marketing and sales. This strategy is in line with the previous findings that government policy should be given a high priority to motivate commercial food waste management in Malaysia (Jereme et al., 2016).

Limitations on this kind of behavioural study include the issue of sample self-selection bias. Since the pro-environmental individuals were proactive to participate in the survey, an over-representation of that party in the sample would exist (Hage et al., 2009). Besides, self-reported behaviour of this study would lead to potential upward bias (Thøgersen, 1996), which led to an overestimation or overstatement by a statistical measure (Econterms, 2019). The reliability and validity of the self-reported items might be compromised (Chan and Bishop, 2013). Having identified limitations associated with self-selection and self-reported behaviour, a more diverse and random sample should be acquired that would be more indicative of the commercial sector. Another limitation is that TPB theory presumes that behaviour is a consequence of a static decision-making activity, which could not elucidate the change in behaviour over time (McEachan et al., 2011; Sutton, 1994). Dynamic conditions of different variables should be evaluated to study the dynamic interrelationships for projection.

(a)



(b)

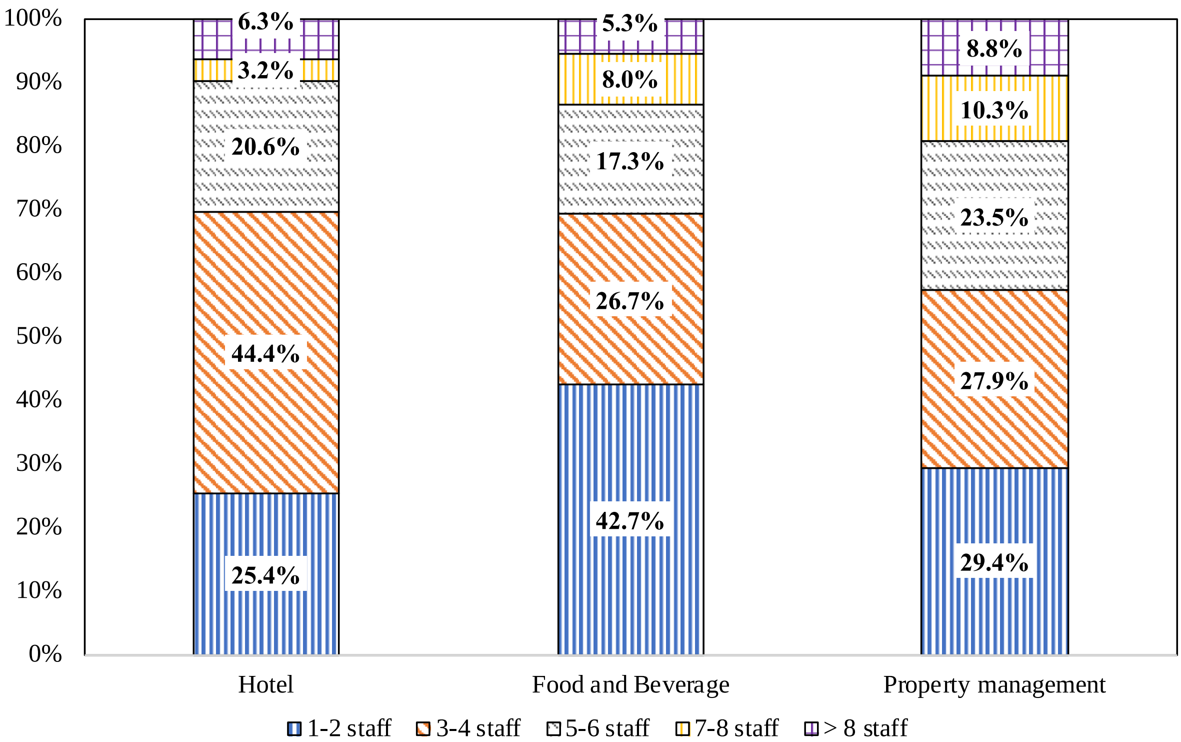


Figure 6.3 Percentage distribution of various respondents in the questionnaire survey under the category of: (a) Acceptable range of food waste recycling costs and (b) Acceptable range of extra manpower for recycling food waste.

Chapter 7- A System Dynamics Approach to Determine Construction Waste Disposal Charge in Hong Kong

7.1 Research Questions

Researchers have identified the influential operational and economic factors to improve on-site management efficiency (Wang et al., 2010; Mak et al., 2018), evaluated the importance of recycling with a dynamic material flow approach (Hu et al., 2010), and compared different recycling alternatives with a hybrid life-cycle cost-benefit approach (Lam et al., 2018a). The key to successful C&D waste minimisation is to implement waste disposal charging fee (WDCF) or landfill tax (Yuan and Wang, 2014), of which a modest charge would motivate society's behavioural change to reduce waste and realize the benefits of resources recovery for productive use (Australian Council of Recycling, 2015). The implementation of WDCF result in both political and economic implications. The success of WDCF is based on The Pigouvian Theory of Externalities that an economic activity imposes a negative effect on an unrelated third party and affects an individual who did not choose to incur the cost (Pigou, 1920). In other words, WDCF drives individual waste producer not to dispose. The key success factors for sustainable C&D waste management (Marzouk and Azab, 2013; Dace et al., 2014) and characterising waste composition (Vivekananda and Nema, 2014) have been acknowledged.

Previous studies have investigated political, social, and economic factors in managing C&D waste through various case studies, which highlighted the barriers of immature and ineffective regulatory environment for C&D waste (Tam, 2008; Yuan, 2017), assessed the negative impacts of poor awareness and behaviour of practitioners on waste management (Wu et al., 2017), and emphasised the lack of effective financial rewarding and penalising strategy (Chen, et al., 2002). Recent investigations have studied the static one-way causal relationships and revealed the advantages of WDCF on C&D waste management such as minimising waste generation and lengthening landfill life span (Lu, et al., 2015; Yuan and Wang, 2014). However, the generic system structure for determining an optimum WDCF and the the complex dynamic relationships between social/economic factors of WDCF and the reactions on waste disposal behaviours remain uncertain upon the changing social and economic environment over time. It is necessary to develop a new platform to examine the interrelationships of components in C&D waste management from a dynamic perspective catering for the future needs.

The system dynamics (SD) approach can be adopted for visualising and analysing complex dynamic feedback systems with an enhanced understanding of its underlying system behaviour and structure (Perk and Wolstenholme, 1991). The use of SD facilitates a comprehensive and quantitative simulation that allows a more robust and reliable outcomes (Wolstenholme, 2005). Two key steps are essential to develop SD model, which are describing the real system qualitatively to design a conceptual model and establishing a quantitatively formal SD model with known and proposed relationships of variables. For instance, previous research efforts have highlighted the costs and benefits of economic interaction (Naushad et al., 2010), sustainability assessment of construction projects (Yuan and Wang, 2013; Marzouk and Azab, 2014), and comparison between alternatives of C&D waste recycling facilities (Zhao et al., 2011). To cultivate favourable managerial strategies in the long run, a valid comparison with the existing policy and the optimum WDCF for future political measures should be determined.

In line with the discussions above, a research question on how the C&D waste charges be decided to reduce future increase of wastes has to be answered. This study intended to develop a model to determine the WDCF that would provide sufficient incentives for market parties and advance our understanding on the behavioural dynamic relationships to guide strategic decisions in construction waste management. To this end, we (i) constructed an SD model to correlate quantitative and qualitative factors that were collected from literatures and questionnaire survey, (ii) elaborated the effects of WDCF on landfills and public fill with the newly revised charges, and (iii) suggested an optimum WDCF that could meet future increase in generated waste and relieve environmental burden of existing waste infrastructure.

7.2 Results and Discussions

7.2.1 Structural Validity of model

7.2.1.1 Structure verification test

In order to verify whether the model structure resembled the real system, three approaches were adopted. To construct the model, the specific historical data in C&D waste management in Hong Kong, available knowledge collected from previous interviews and survey (Mak et al., 2019) as well as the sub-models of the existing models in relevant studies (e.g., Yuan and Wang, 2014; Ding et al., 2016). The conceptual model of WDCF is shown in the CLD **(Figure 4.3)**. The levels of WDCF in landfill and public fill are determined by the amounts of C&D waste landfilled and public filled, respectively. The amounts of landfilled and public filled wastes depend on the generated C&D waste. The amount of generated waste would, after a delay in time, depend upon the effectiveness of regulation compliance, resulting in the increase in waste reduction incentive and completeness of waste recycling market The amount of recycled waste would depend on the completeness of waste recycling market that affects the waste recycling costs and the ratio of recycled waste, resulting in the waste recycling factors that in turn drive effective regulation compliance. In addition to these factors, other regulatory factors such as enforceability, effectiveness of supervision, and completeness of regulation would influence the effectiveness of regulation compliance. Nevertheless, when the WDCFs are implemented, the higher the costs the lesser the ratio of waste goes to landfills and public fill, which in turn imposes greater constraints in waste disposal. This also affects the effectiveness of regulation compliance. Therefore, the causal relationships constructed in this model, which were based on the specific historical data in C&D waste management in Hong Kong and available knowledge collected from semi-structured interviews and survey, could provide an empirical structural validation (Zebda, 2002). Besides, theoretical structural validation was applied by using the sub-models from the existing studies (Forrester and Senge, 1980).

7.2.1.2 Dimensional Consistency Test

Dimensional consistency test verifies if all mathematical units in all equations are dimensionally constant. For instance, the following equation represents one of the equations of WDCF: (Waste landfilling = Amount of generated waste * Ratio of waste landfilled). In order to determine whether this equation is dimensionally consistent, the dimensions of the above two factors are required. The amount of C&D waste generated is in terms of tonnes per year, and the ratio of waste landfilled is dimensionless based on its relationship with the cost of waste landfilling. Therefore, the dimensional consistency of all equations was checked and assured.

7.2.1.3 Extreme Condition Test

Extreme values were assigned to two selected parameters, which were the "Increment % of original $WDCF_1$ change" and "Increment % of original $WDCF_2$ change" **(Figure 7.2).** The main purpose was to demonstrate how the amount of landfilled waste and the amount of public filled waste would change when extreme values were assigned to $WDCF_{1,2}$. In the model, dependent variables received values greater than zero. Three scenarios were designed for simulation of scenario A (Increment % of original $WDCF_1$ and $WDCF_2$ change = 0, which was the first extreme condition test), scenario B (Increment % of original $WDCF_1$ and $WDCF_2$ change = 0.2, which was the base run simulation), and scenario C (Increment % of original $WDCF_1$ and $WDCF_2$ change = 100, which was the second extreme condition test). It is shown in scenario A that the accumulated amount of landfilled and public filled waste would grow significantly to about 45 Mt and 50 Mt by the year of 2040, respectively. This is a result of minimal recycling activities implemented by the practitioners in the construction industry when there are limited or insufficient economic or regulatory incentives. When compared to scenario C, a significant reduction on landfilled and public filled waste in scenario A is observed. By 2040, the amount of landfilled and public filled waste would be reduced by 71% and 67%, respectively, if there is 100-fold increment on the original WDCF change. In scenario B, there is an insignificant reduction on the amount of landfilled and public filled waste, which exhibits a similar trend to scenario A. Scenario B demonstrates a negative impact on the amount of landfilled waste in comparison with scenario A (*i.e.,* increase in the amount of landfilled waste) **(Figure 7.2)**. If charges remained at an increment percentage change of 20% on the original charges on waste to landfill and public fill, the amount of C&D waste landfilled, and public filled would continue to increase **(Figure 7.3)**. This suggests an urgent need to revise the present charges on landfill disposal and public fill based on further scenario analysis.

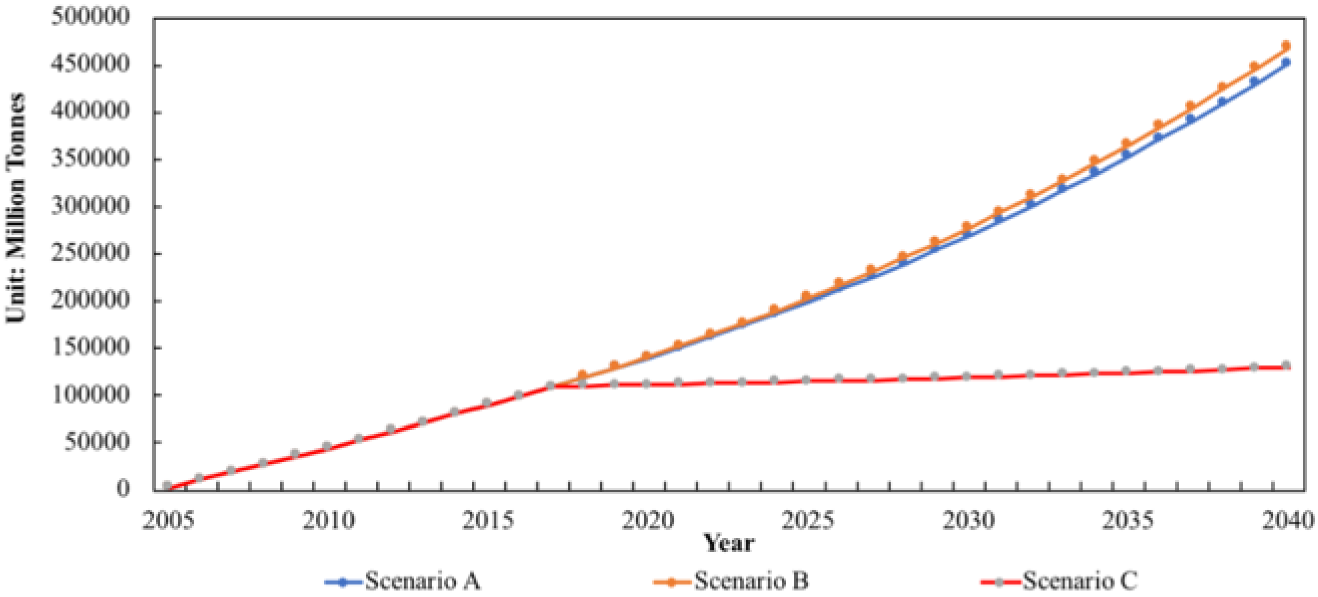


Figure 7.2 Extreme condition test on the amount of landfilled waste.

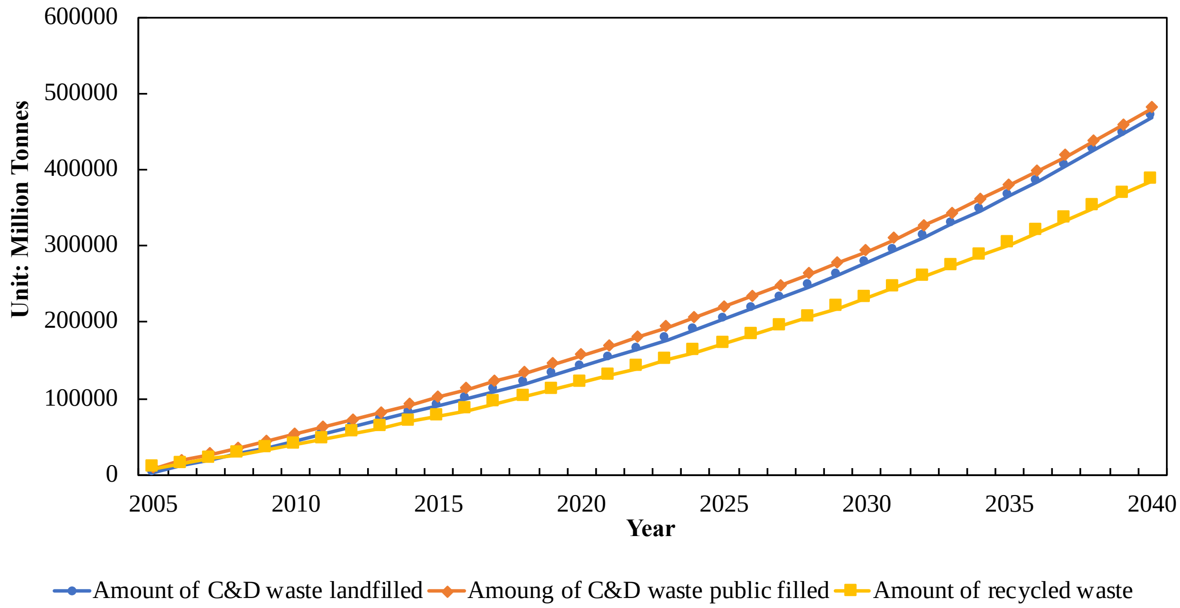


Figure 7.3 Base run simulations on the amount of C&D waste landfilled, public filled and recycled.

7.2.2 Behavioural Validity of Model

Various methods are proposed to compare the output data from the model with the corresponding historical data collected from the real world (Barlas, 1989). In this study, two methods were adopted to evaluate the historical fitness of WDCF, i.e., the error analysis and the Theil inequality statistics. Simulation results were first compared with the actual data of the annual amount of generated waste from the year of 2005 to 2015, which were collected for model testing and input as reference data **(Figure 7.4)**. 82.2% of the variance in the actual data of annual amount of generated waste is explained by the variance of the model output of annual amount of generated waste (i.e. adjusted R-squared value = 0.822). This showed a substantial goodfit between the two sets of data. It is shown that the estimation on the amount of generated waste was relatively accurate and resembled the actual trend **(Table D2)**. To quantify the error of the output data from the model, the root mean squared percent error (RMSPE) and the Theil inequality statistics were calculated **(Table 7.1)**. Considering the amount of generated waste, the RMS percent error was 1.97%, which indicated that the variables reasonably described the behaviour and enhanced confidence in this model. About 70% of the error arose from unequal variance. This indicated that the output data and the historical data matched well in general and were highly correlated but the magnitudes of variation in the two sets of data around their common mean were different. The small values of U^m (0.29) and U^c (0.01) demonstrated that errors due to bias had minimal impact and the point-to-point values of the two sets of data were consistent, respectively. Therefore, the behaviour validity of the constructed SD model was considered suitable for projecting and policy analysis. The sensitivity of the results was analysed by generating random values of uncertain parameter. It is necessary to understand the model boundary and robustness of the model. The model was subjected to sensitivity analysis by the amount of waste generation for 1000 iterations in which various probabilities are expressed as 50%, 80%, 95% and 100% confidence intervals for the amount of C&D waste landfilled. A comparative figure with waste public filling was defined **(Figure D1)**. The results demonstrated that the amount of C&D waste landfilled was very sensitive to the changing amount of waste generation. The variable of waste generation was a significant role in reducing amount of C&D waste landfilled and illustrated the robustness of the model.

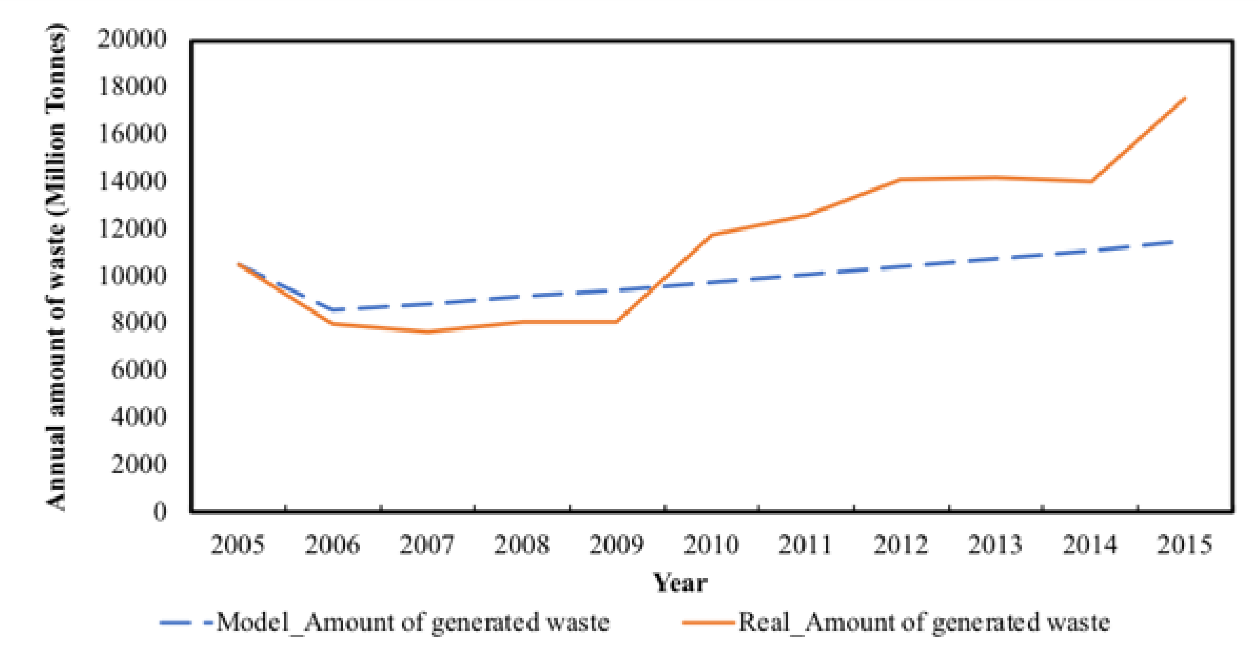


Figure 7.4 Model behaviour verification test of annual amount of generated waste and simulation results.

Table 7.1 Error analysis of model.

Variable	**RMSPE (%)**	**U^m**	**U^s**	**U^c**
Amount of generated waste	1.97	0.29	0.7	0.01

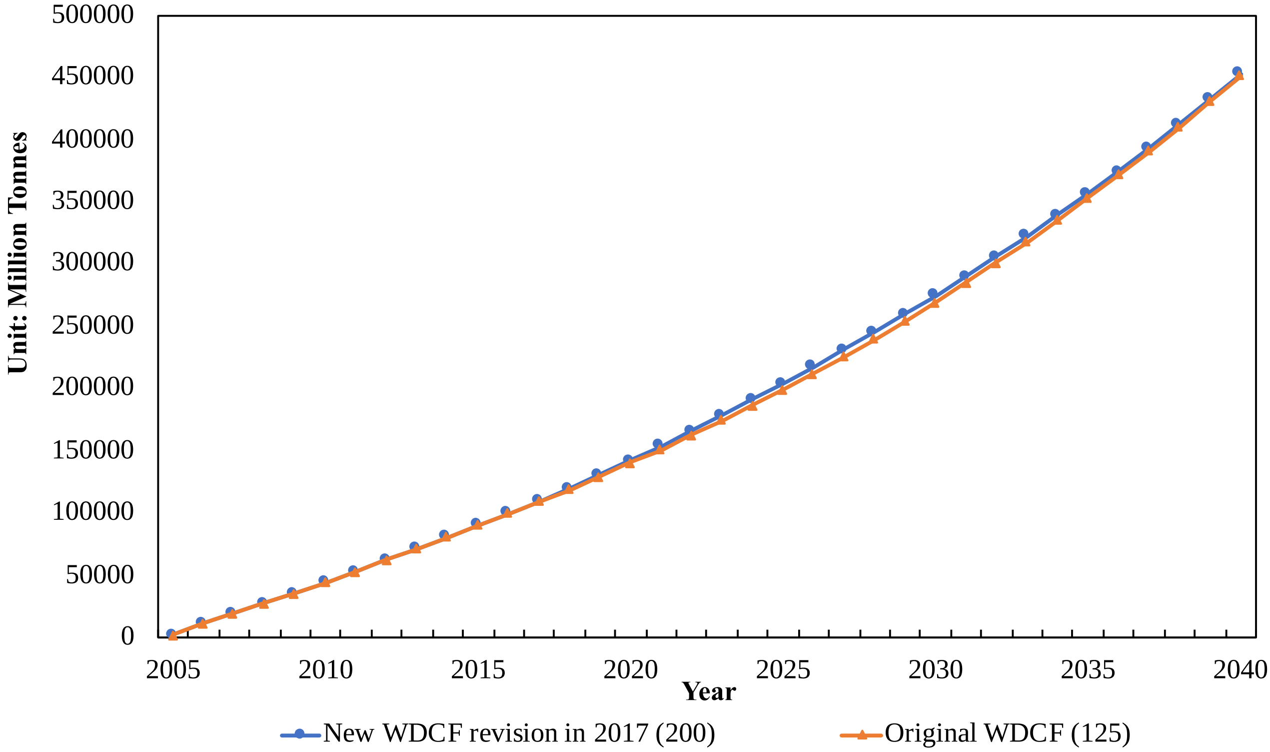
* U^m, U^s, U^c represent the fraction of mean-squared error due to bias, unequal variance and unequal covariance, respectively.

7.2.3 Policy Analysis

7.2.3.1 Effect of the newly revised waste disposal charges

After the completion of a review of the relevant charges, the Hong Kong Government in 2017 concluded the legislative process to increase the WDCF to landfill and public fill. To achieve the full-cost recovery at the current state, the landfill charge was increased from HKD$125 t to HKD$200/t and the public fill charge was increased from HKD$27/t to HKD$71/t (HKEPD, 2017a). In order to comprehend the long-term impact of the newly revised WDCF, the effects on the amount of C&D waste landfilled **(Figure 7.5a)** and the amount of C&D waste public filled **(Figure 7.5b)** were compared. When compared to the original WDCF to landfill (*i.e.* HKD$25/t), there was no obvious reduction in the amount of waste going to landfills by 2040. By the year 2022 to 2025, amount of landfilled waste would still continue increase in the range of 2.17% to 2.40% **(Figure 7.5a)**. When the WDCF was revised to HKD$71/t, it had a more positive impact on the amount of C&D waste public filled, i.e., there was 8.8% waste reduction by the year 2040 **(Figure 7.5b)**. This may suggest that there are still insufficient economic incentives to reduce waste with the newly revised WDCF. To relieve stress in landfills and public fill and promote waste reduction at source, it is indispensable for the government to propose new and continual charge increments in the future.

(a)



(b)

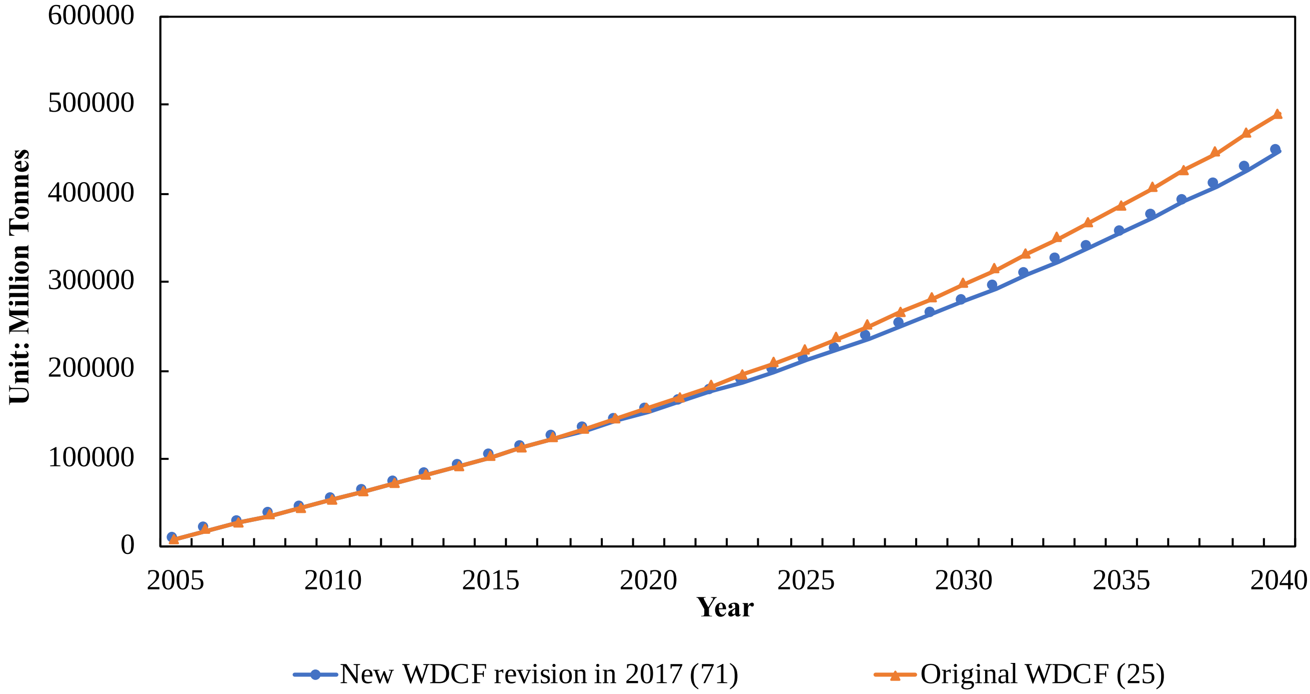


Figure 7.5 Comparison of the newly revised WDCF and original WDCF on the amount of C&D waste landfilled (a) and public filled (b).

7.2.3.2 Determining an optimum range of waste disposal charges

As discussed in section 7.2.1, the base run simulation was set at the level of 0.2. To determine the optimum range of $WDCF_1$ and $WDCF_2$, 13 additional alternatives of the increment percentage change of initial WDCF were simulated (*i.e.* 0.7, 0.9, 1.2, 1.5, 2, 2.5, 2.8, 3, 4, 4.5, 4.8, 5, and 6) **(Figure D2)**. Waste reduction in landfills and public fill diplays as a general tendency of decline **(Figure D2a)**. Particularly, when the percentage increase is 20%, there would be an average of 2.51% increase in the amount of landfilled waste over the simulation period. When the percentage increases to 70%, a slight waste reduction of 1.93% in landfilled waste would be observed by year 2040. Surprisingly, a significant average waste reduction of 12.1% is achieved when there is a 120% increase in charges from 2018 to 2040 **(Table 7.2)**. As at 2040, there would be a reduction of over 20% of landfilled waste. It is evident that there would be a dramatic decrease of landfilled waste if $WDCF_1$ falls in the range of HKD$312.5/t (*i.e.* percentage change equals to 150%) to HKD$437.5/t (*i.e.* percentage change equals to 250%) by 2040. The first peak appears at HKD$150/t, followed by a continual decrease in the amount of landfilled waste till $WDCF_1$ increases beyond HKD$375/t. In 2040, the amount of landfilled waste would level off beyond HKD$437.5/t **(Figure 7.6a)**. This reinforces and further quantifies the effectiveness of waste disposal charging scheme for the reduction of construction waste in Hong Kong (Hao et al., 2008), Denmark (Anderson, 1998), and the Netherlands (Bartelings et al., 2005). Therefore, from the perspective of landfilled C&D waste reduction, the charges should be set in the range of HKD$312.5-437.5/t (*i.e.*, USD$39.8-55.8/t).

Table 7.2 Comparison of WDCF at 0% and other scenarios on the average changes on the amount of public filled waste from 2018 to 2040.

Increment % of original WDCF change	Average changes on the amount of landfilled waste	Average changes on the amount of public filled waste
20%	2.5%	-1.3%
70%	0.13%	-3.3%
90%	-4.2%	-3.7%
120%	-12.1%	-4.3%
150%	-16.1%	-5%
200%	-29.5%	-8.5%
250%	-47.8%	-12.1%
280%	-48.8%	-13.3%
300%	-48.8%	-15.2%
400%	-48.8%	-33.8%
450%	-48.8%	-33.2%
480%	-48.8%	-25.0%
500%	-48.8%	-21.1%
600%	-48.8%	-28.2%

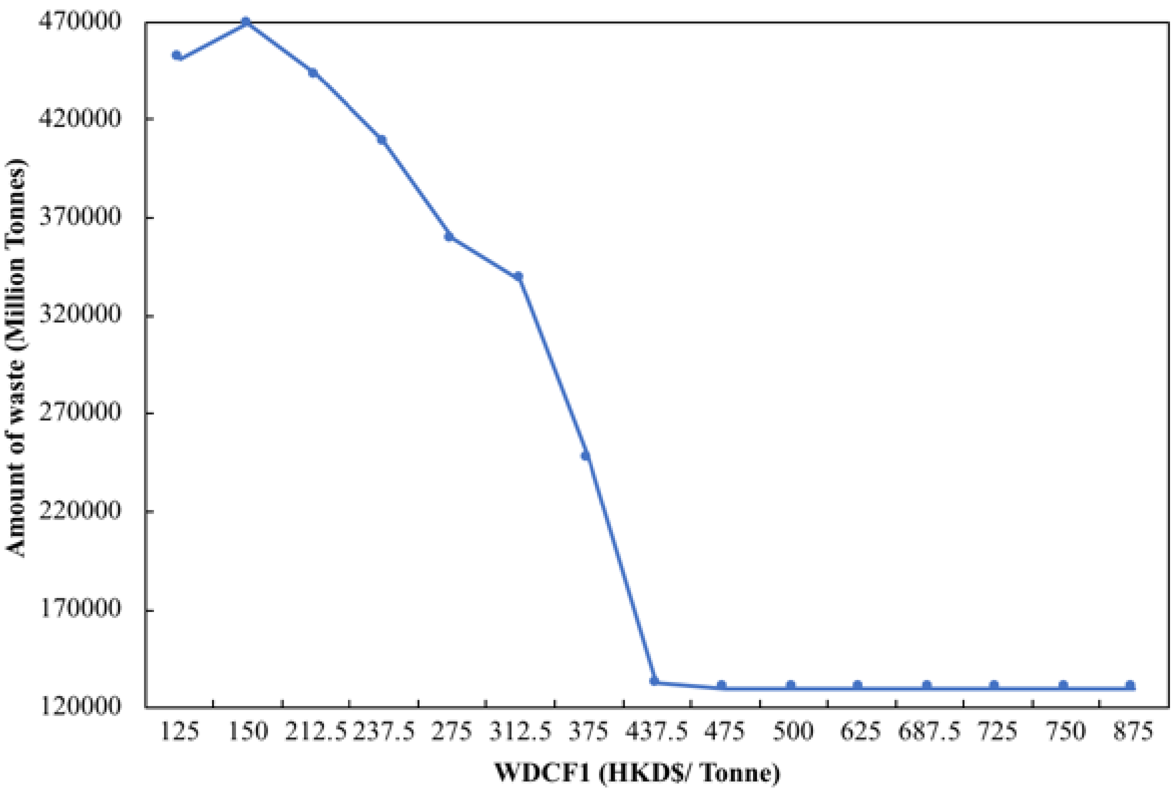


Figure 7.6a Effect of WDCF on the amount of landfilled C&D waste in year 2040.

Changes in WDCF exhibit little impact on the reduction of public filled C&D waste at a lower increment percentage **(Figure D2b)**. When percentage increases from 20% to 150%, the average public filled waste reduction would range from 1.28% to 5.0%, showing an insignificant waste reduction. When percentage increases beyond 200% till 450%, a substantial decrease of public filled waste is then achieved. As at 2040, **t**here would be a reduction of almost 20% of public filled waste when the percentage increase on WDCF is raised to 250% **(Table 7.1)**. A gradual decrease of 7.3% in the amount of public filled waste is observed when its charge increases from HKD$27/t to HKD$68/t, followed by 18% decrease of waste when the charge further elevates to HKD103/t. To determine an optimum range of WDCF on public fill, a dramatic reduction of public filled waste in 2040 can be observed when charge falls in the range of HKD$108/t (*i.e.* percentage change equals to 300%) to HKD$135/t (*i.e.,* percentage change equals to 400%). Unexpectedly, there is a negative impact on the amount of public filled waste when the charge is raised beyond HKD$149/t, and the amount of waste increases over 30% at the level of HKD$162/t (**Figure 7.6b)**. This may be due to the general public understanding that the higher the WDCF, the greater the incentives for the industry practitioners to dump waste illegally (Australian Council of Recycling, 2015).

6.2.3.3 Scenario analysis of various combinations of waste disposal charges

In order to analyse the influence of various combinations in landfill and public fill charges on waste generation and recycling, six policy scenarios were then developed. Optimum ranges of landfill charges (i.e., WDCF1) selected for further investigation are HKD$312.5, HKD$375, and HKD$437.5/t, while that of public fill charges (i.e., WDCF2) are HKD$108/t and HKD$135/t. Scenario 1 (S1) refers to WDCF1 as HKD$312.5/t and WDCF2 as HKD108/t; Scenario 2 (S2) refers to WDCF1 as HKD$312.5/t and WDCF2 as HKD135/t; Scenario 3 (S3) refers to WDCF1 as HKD$375/t and WDCF2 as HKD108/t; Scenario 4 (S4) refers to WDCF1 as HKD$375/t and WDCF2 as HKD135/t; Scenario 5 (S5) refers to WDCF1 as HKD$437.5/t and WDCF2 as HKD108/t; Scenario 6 (S6) refers to WDCF1 as HKD$437.5/t and WDCF2 as HKD135/t.

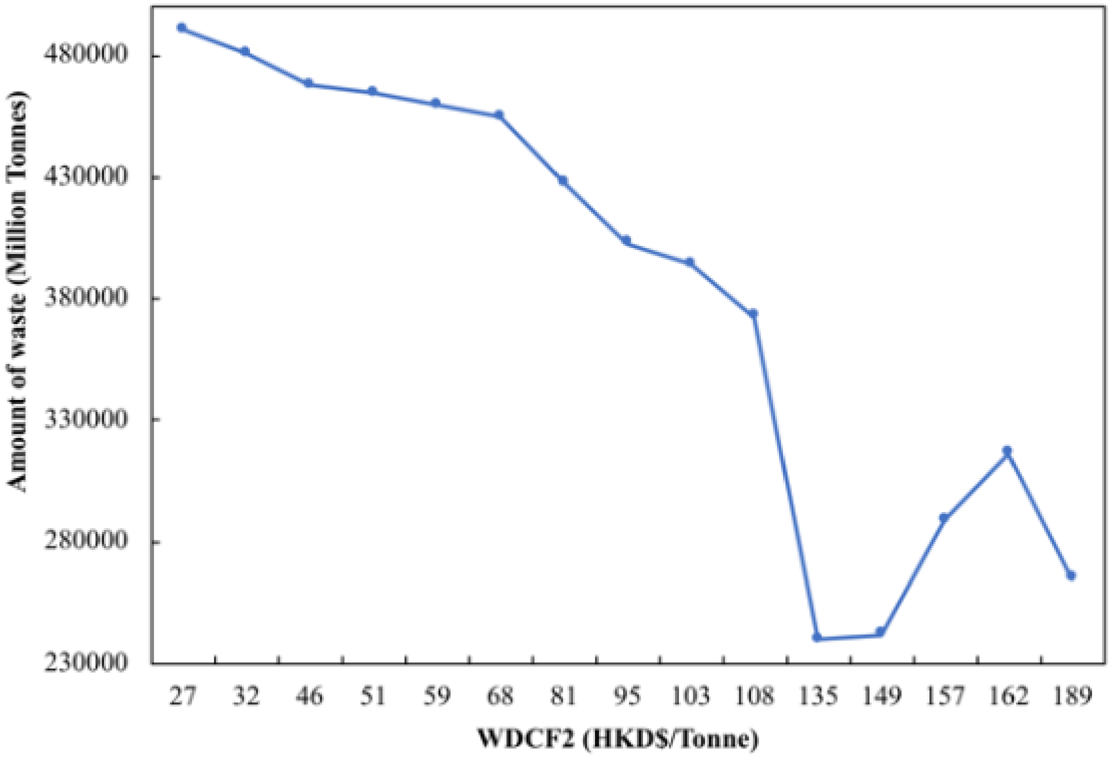
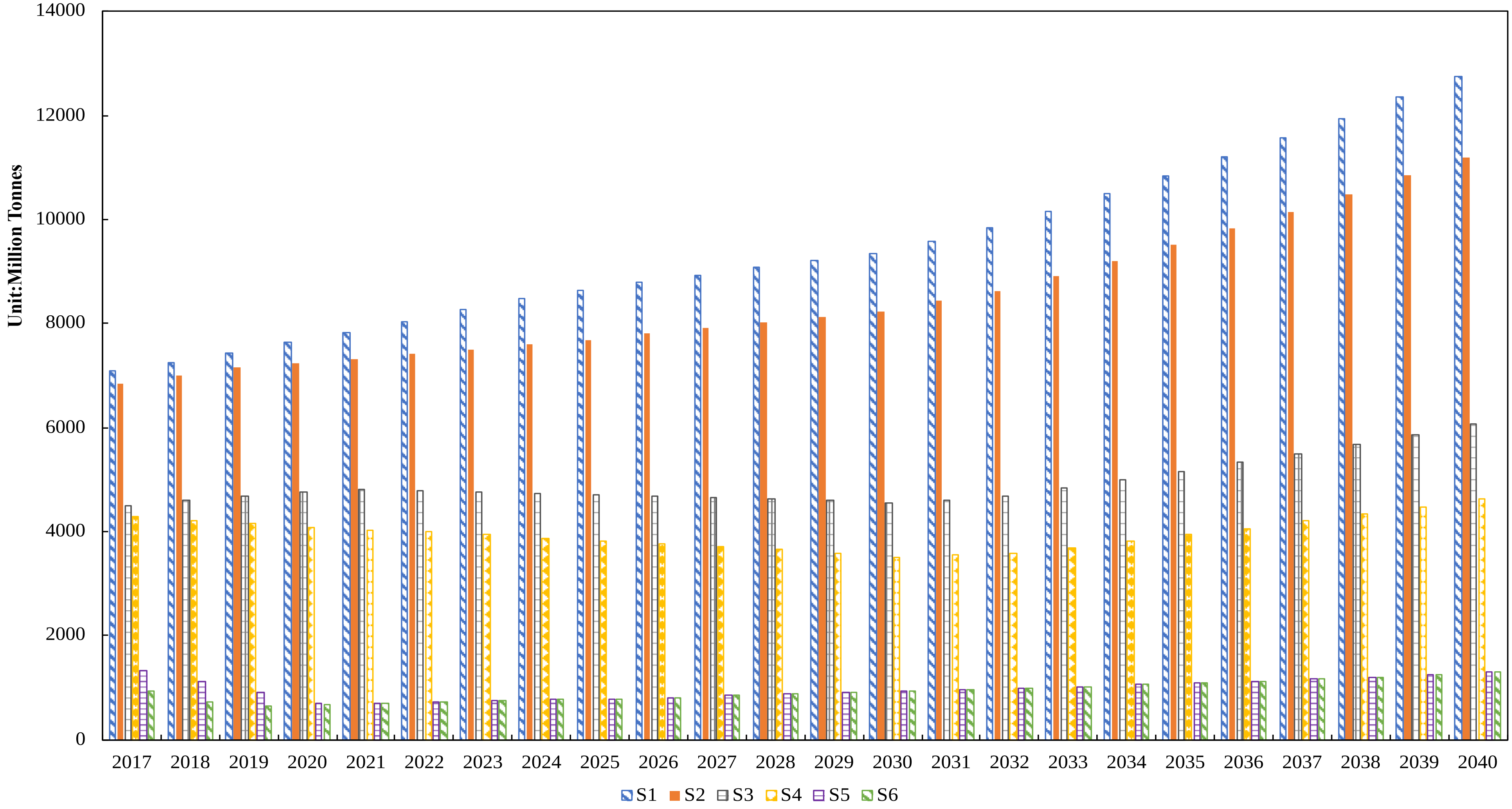


Figure 7.6b Effect of WDCF on the amount of public filled C&D waste in year 2040.

Waste flows to landfills and public fill were compared to identify the optimum charge combinations in Hong Kong. It is obvious that S1 and S2 both demonstrate minimal reduction impact on the waste flows to landfills and public fill **(Figure 7.7).** Steady waste flow is maintained till the year 2030 if S1 or S2 is implemented. Upon the implementation of S1 and S2, waste flows to landfills **(Figure 7.7a)** and public fill **(Figure 7.7b)** display an average of 36.2% and 36.7% increase from 2030 to 2040, respectively. Significant reduction in waste flow to landfill can be observed when either S5 or S6 is implemented. Average waste flow from 2017 to 2040 would decrease by one-fourth when comparing S4 and S5 **(Figure 7.7a).** Similarly, waste flow to public fill under S1, S2, S3, and S5 remains at a high level over 10 Mt.

Significantly lower level of waste flow is observed upon the implementation of S4 and S6, with only an average increase of 26.7% and 30.7% from 2017 to 2040 **(Figure 7.7b).** Based on the above discussion, S6 is considered as the optimum scenario to minimize the landfilled and public filled waste. It is recommended that the increment percentage on original landfill charges should not exceed 250% (*i.e.*, HKD$437.5/t), while that on public fill charges should be below 400% (*i.e.*, HKD$135/t) to improve practitioners' awareness and waste minimization at source.

(a)


Unit:Million Tonnes
14000
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2017
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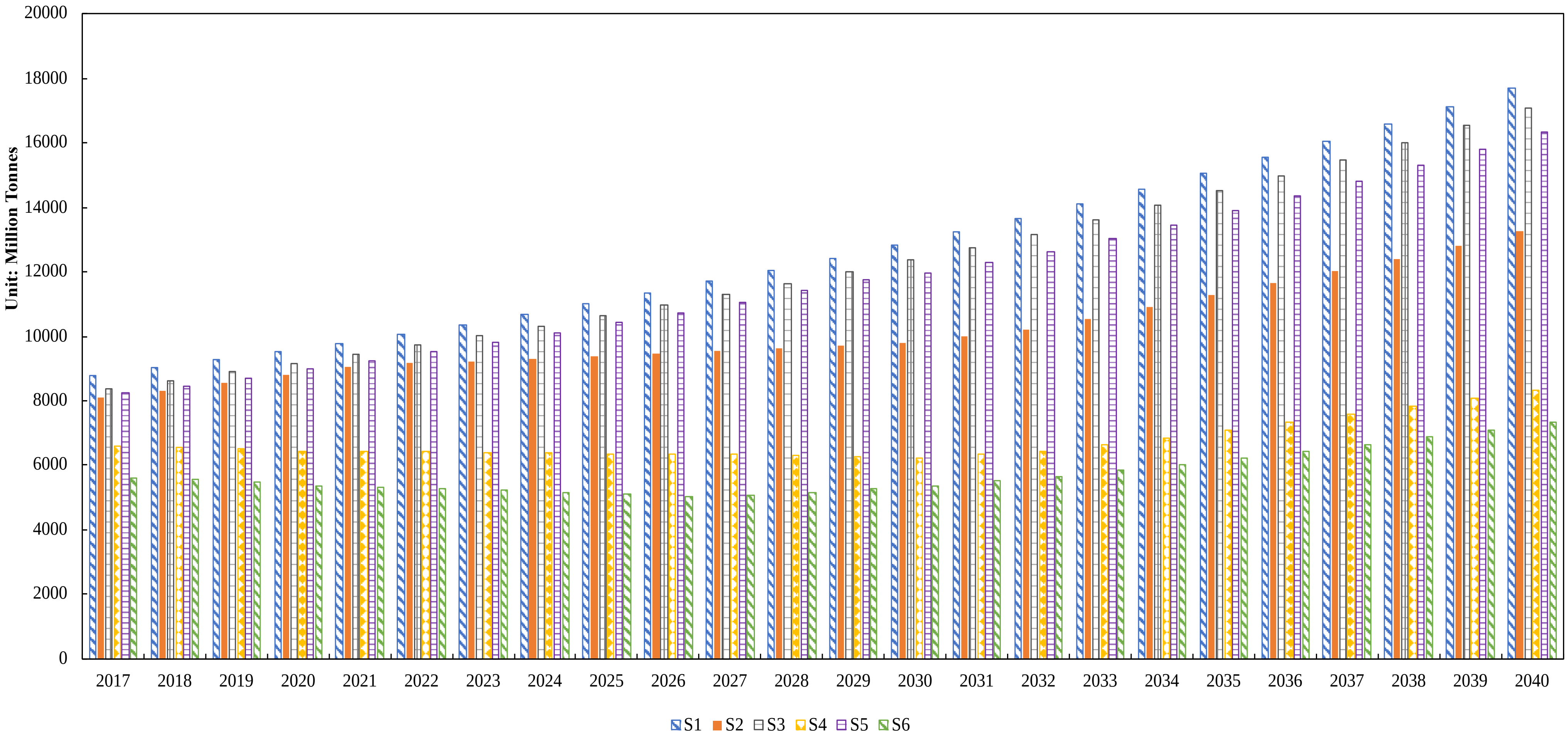

Figure 7.7 Comparison on the waste flow to landfill (a) and public fill (b) of six policy scenarios.

Chapter 8- Conclusions and Recommendations

8.1 Conclusions

This thesis first identifies prioritizes, and quantify the key factors and relationship among key latent variables that affect food waste recycling behaviour of relevant industries and C&D waste recycling behaviour of various stakeholders in Hong Kong. Quantitative outputs from the TPB study of both food waste in commercial sector and C&D waste are subsequently utilized for regional comparison with Malaysia and system dynamics simulation to obtain optimum waste disposal charging fee, respectively.

The actual situation of food waste recycling in the commercial sector in Hong Kong is first considered as an example. Results demonstrate that food waste recycling behaviour is mainly determined by three LVs, of which Administrative incentives and corporate support showed significant indirect effect on recycling behaviour, whereas Logistics and management incentives negatively and directly influenced recycling behaviour. There were strong positive correlations between Moral attitudes and Administrative incentives and corporate support, and between Moral attitudes and Logistics and management incentives. In other words, it would be more effective to enhance food waste recycling among corporates if policies put an emphasis on providing sufficient Administrative incentives and corporate support as well as Logistics and management incentives to affect attitudes of individuals. Different perceptions and levels of acceptance on recycling costs and manpower are revealed in different industries. Representatives from hotel and food and beverage industries share similar consideration on Administrative incentives and corporate support over other LVs. In comparison, nearly 40% of property management representatives have higher concern on Logistics and management incentives and a higher acceptance on food waste recycling costs as HKD$500-650/t (*i.e.*

USD$64- 83/t) than the other two industries during food waste handling. Yet, about half of respondents from food and beverage industry preferred to arrange fewer number of staff for on-site handling of food waste **(Chapter 4)**.

(Malaysia_FW) Regional comparison on food waste recycling in commercial sector is further elucidated under different economies by extending the convention TPB model with the identified key LVs from the previous study conducted in Hong Kong **(Chapter 4)**. It further consummates the understanding and promotes 6Rs principle within corporates. In particular, rethinking is of utmost importance when it comes to waste management, and it should be well-considered before recycling. A survey-based SEM referred to the environmental psychology theory and analysed the actual situation of both Malaysia and Hong Kong as a cross-region example. The results demonstrated that food waste recycling behaviour in Malaysia was mainly influenced by perceived behavioural control, logistics and management incentives and economic incentives and had substantial indirect effects on recycling behaviour. Significant differences were observed as commercial industries in Hong Kong emphasised administrative incentives and corporate support as the most critical variable, while perceived behavioural control had a less critical impact. Strong positive correlations were discovered between moral attitudes and administrative incentives and corporate support, and between administrative incentives and corporate support and logistics and management incentives. Representatives from the hotel, food and beverages and property management industries shared similar perceptions over administrative incentives and corporate support, demonstrating the highest importance than other LVs. Over 40% of hotel representatives had a higher acceptance level on food waste recycling costs, which was RM90-120/tonne (US$21.7-29/t) and preferred to designate 3-4% of total human resources for on-site handling of food waste. With known determinants and stakeholders' perceptions identified in this study, a region-specific tailor-made waste policy can encourage food waste recycling behaviour of the corporates and enhance the culture of rethink and refuse before consumption **(Chapter 6)**.

Apart from conducting regional comparison on food waste recycling determinants in commercial sector, TPB study on C&D waste recycling identifies key factors of various operative levels from both public and private organizations. Results show that C&D waste recycling intention is determined by perceived benefits and costs, social values, and behaviour control beliefs. Four major factors affect individuals' decision-making in waste recycling: "Regulatory compliance", "Economic incentives", "Accreditation scheme", and "Logistics and management incentives", of which Regulatory compliance is the most determining factor. Different perceptions and considerations of various groups of operative levels are revealed. Representatives from construction-waste-related organizations and government officials share similar consideration on Regulatory compliance over other factors in both semi-structured interviews and questionnaire. In comparison, the public put Economic incentives as the major drive for waste recycling. There is a positive correlation between disposal costs and collection and sorting costs, thus it is desirable to increase the cost margin by waste disposal charging to promote recycling behaviour. Moreover, greater recognition of Accreditation scheme and clearer specifications of recyclables can facilitate a closed-loop material flow **(Chapter 5)**.

To further incorporate our understanding on the determining factors of recycling behaviour to develop a generic solid waste system structure over time to cater future needs, system structure with a SD model considering the actual situations of Hong Kong as a case study is visualized. It advances our understanding on the behavioural dynamics of the complex system in WDCF and C&D waste generation, C&D waste landfilled, C&D waste public filled, and recycled C&D waste. Results compared the effect of newly revised WDCF in 2017 with the initial charges in 2005, and revealed little impact on landfilled waste reduction by year 2040. A higher WDCF would be crucial to achieving effective minization of waste going to landfills and public fill. By 2040, over 20% reduction of landfilled and public filled waste could be achieved, which WDCF was at the range of HKD$312.5 to HKD$437.5/t (*i.e.* USD$40- 56/t) and HKD$108 to HKD$135/t (*i.e.* USD$14-17/t), respectively. The comparison of six policy scenarios revealed that the optimum increment percentage on original landfill and public fill charges should not exceed 250% and 400%, respectively **(Chapter 7)**.

8.2 Recommendations and Future Research Works

These research efforts elucidate the significance of understanding recycling behaviour and its importance in formulating long-term waste management policies. It is noted that the TPB theory may be unable to explain change of behaviour over time and predict future behaviour because it assumes that behaviour is a result of linear decision-making process (McEachan et al., 2011; Sutton, 1994). Further research should consider the dynamic condition of different variables. Studies conducted on food waste and C&D waste collected data on a voluntary basis and from employees across various industries, while future studies could conduct quesionnaire for targeted interviewees with even portion of different operative levels in each industry to ensure the diversity of results and balanced expression of perspectives. More objective measures of recycling behaviour of employees and corporates could be introduced, such as measurement of money spent on initiatives, such that strategies and outcomes of food waste policy implementation of different jurisdictions could be compared to develop nationwide strategies. Since the pro-environmental individuals were proactive to participate in the survery, an over-representation of that party in the sample would exist (Hage et al., 2009). Besides, self-reported behaviour of this study would lead to potential upward bias (Thøgersen, 1996), which showed an overestimation or overstatement by a statistical measure (Econterms, 2019). The reliability and validity of the self-reported items might be compromised (Chan and Bishop, 2013). Having identified limitations associated with self-selection and self-reported behaviour, a more diversed and random sample should be acquired that would be more indicative of the commercial sector.

SD approach has tried to be adopted in determining optimum food waste charging fee. However, reliability of model is in doubt due to insufficient historical data on the amount of food waste generation, food waste recycling and food wsate disposing to landfills. As a long-term study, limitations in adopting SD approach in determining optimum WDCF are recognized. Firstly, the study scope focused on the impact of WDCF by the four major components in C&D waste management. Other driving factors such as the elasticity of charges and the availability of waste recycling infrastructure should be further investigated in a broadened scope. Secondly, inevitable assumptions were made to investigate the relationships between some social economic factors and the charging fee in this study. Further studies can be conducted to expand the study scope. Thirdly, the situation of illegal dumping could not be precisely modelled as such data were not reported by the government. The amount was assumed to be negligible upon proper enforcement of trip-ticket sysem (TTS) in Hong Kong, which was adopted in 1999 and further enhanced in 2004 (HK DevB, 2010). With TTS, a standard trip-ticket form must be filled in by construction contractors with information including transportation vehicle, type, and approximate volume of C&D waste, and the designated disposal facilities approved by the Public Fill Committee or the Director of HK EPD. The implementation of TTS offers a timely record and good track of C&D waste, which helps to minimize improper or illegal dumping and enhance the effectiveness of off-site C&D waste management (Lu and Yuan, 2012). The impact of illegal dumping could be taken into account in future models when quantitative data become available. Besides, additional analysis should be conducted on life-cycle assessment (Lam et al., 2018b) as well as technical and economic assessment (Wang et al., 2018) for the establishment of recycling infractructure so that the feedback loops in the SD model can be further improved with quantitative data input.

Appendix A

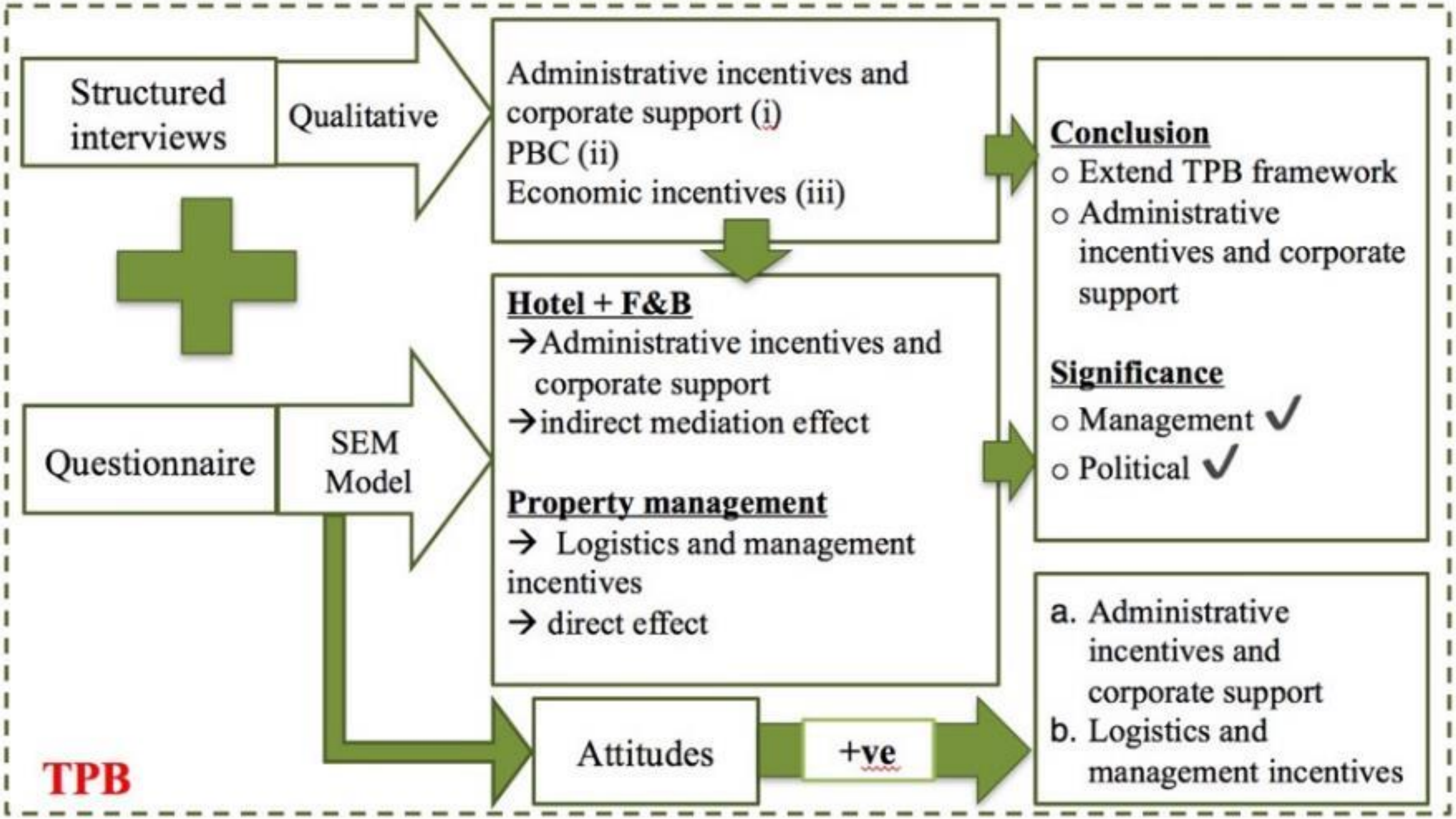

Figure A1. Graphical abstract of Chapter 4

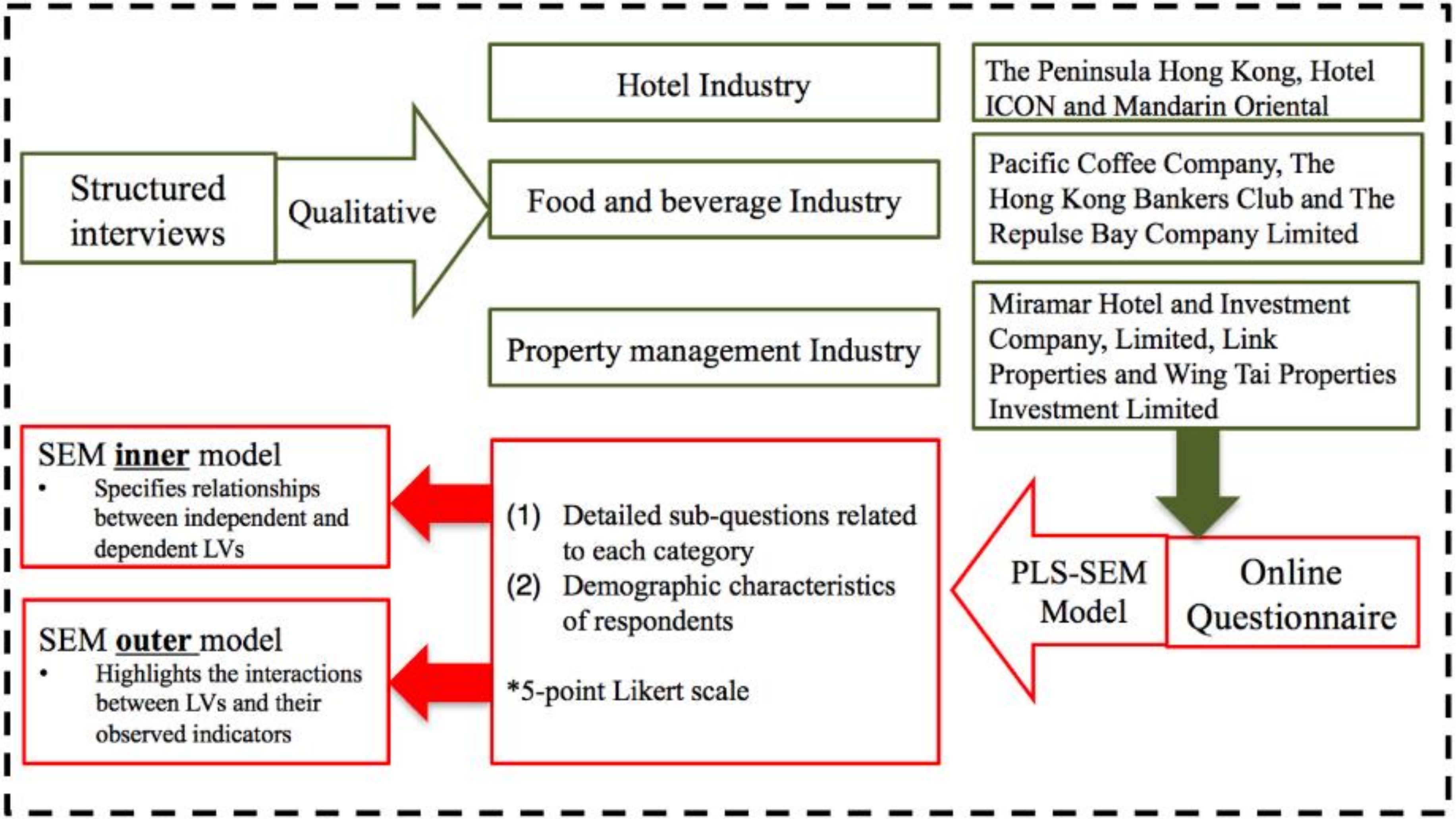

Figure A2. Methodology flow of study

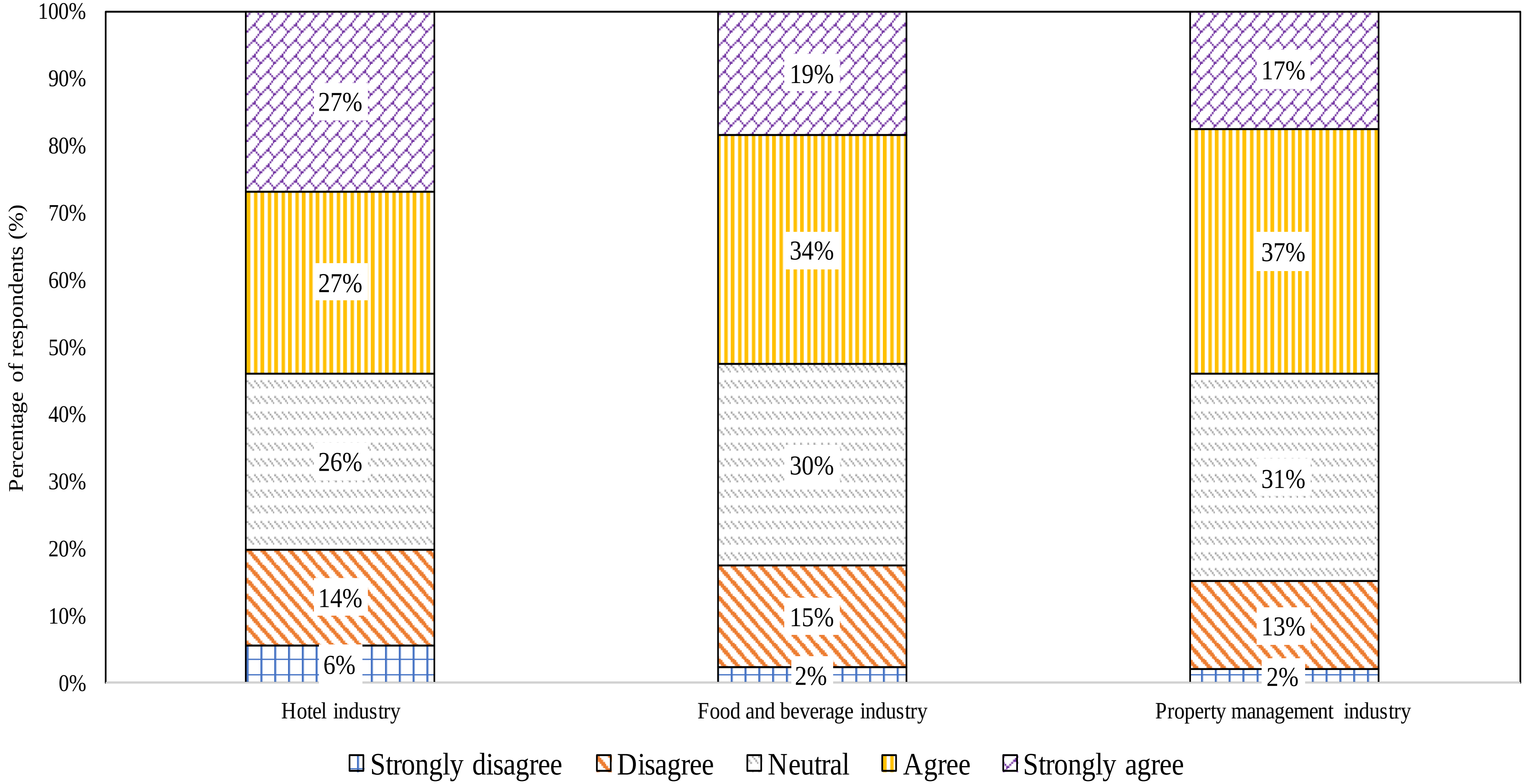

Figure A3. Score distribution of various respondents in the questionnaire survey

Table A1. Semi-structured interviewees profile

Interviewees	Interview category	Organization	Position
R1	Hotel Industry	The Peninsula Hong Kong	Chief Steward
R2		Hotel ICON	Hygiene Manager
R3		Mandarin Oriental, Hong Kong	Executive Chief Steward
R4	Food and beverage industry	Pacific Coffee Company	Chief Executive Officer
R5		The Hong Kong Bankers Club	General Manager
R6		The Repulse Bay Company Limited	Operations Manager/Executive Chef
R7	Property management industry	Miramar Hotel and Investment Company, Limited	Area Manager
R8		Link Properties Limited.	Property Manager
R9		Wing Tai Properties Investment Limited	Associate Director- Estate Management

Table A2. Questionnaire responses profile

Demographic attribute		Percentage (%)
Gender	Female	41.3
	Male	58.7
Education level	Primary and secondary education	11.6
	University level	36.1
	Professional training	29.7
	Postgraduate level	22.6
Age group	18-25	8.4
	26-35	32.3
	36-45	32.9
	46-60	24.5
	Above 60	1.9
Industry	Hotel	29.7
	Food and beverage	35.5
	Property management	34.8
Role	Operation division	24.5
	Management division	20
	Green/ Sustainability division	11.6
	Human resources division	11.6
	Marketing division	12.3
	Property management/ leasing division	12.3
	Engineering division	2.4
	Maintenance division	0.6
	Procurement division	1.8
	Surveying division	0.6
	Accounting division	1.2
Experience in industry	1-5 years	32.9
	6-15 years	37.4
	16-30 years	21.9
	Over 30 years	6.5
	None	1.3
Food waste recycling schemes in corporates	Yes	28.4
	No	71.6

Table A3. Latent variable correlations of model

	LV 2: Logistics & management incentives	LV 3: Administrative incentives & corporate support	LV 4: Moral attitudes	LV 5: Subjective norms	LV 6: Perceived behavioural control	LV 7: Recycling intention	LV 8: Recycling behaviour	LV1: Economic incentives
LV 2: Logistics & management incentives	1	0.801	0.852	0.594	0.571	0.606	0.207	0.699
LV 3: Administrative incentives & corporate support	0.801	1	0.849	0.758	0.517	0.704	0.175	0.768
LV 4: Moral attitudes	0.852	0.849	1	0.692	0.612	0.693	0.197	0.771
LV 5: Subjective norms	0.594	0.758	0.692	1	0.63	0.625	0.301	0.694
LV 6: Perceived behavioural control	0.571	0.517	0.612	0.63	1	0.604	0.403	0.579
LV 7: Recycling intention	0.606	0.704	0.693	0.625	0.604	1	0.196	0.698
LV 8: Recycling behaviour	0.207	0.175	0.197	0.301	0.403	0.196	1	0.171
LV1: Economic incentives	0.699	0.768	0.771	0.694	0.579	0.698	0.171	1

Table A4. Measurement scales and breakdown of mean score of indicators in the formal online questionnaire

Construct/ Latent variable	Indicators	Mean
LV 1: Economic incentives	ECON_1A	3.68
	ECON_1B	3.53
	ECON_1C	3.57
	ECON_1D	3.24
LV 2: Logistics & management incentives	LOGIS_2A	3.78
	LOGIS_2B	4.05
	LOGIS_2C	3.81
	LOGIS_2D	3.73
	LOGIS_2E	3.87
LV 3: Administrative incentives & corporate support	ADMIN_3A	3.76
	ADMIN_3B	3.77
	ADMIN_3C	3.76
	ADMIN_3D	3.71
	ADMIN_3E	3.94
	ADMIN_3F	3.89
LV 4: Moral attitudes	MORAL_4A	3.79
	MORAL_4B	3.58
	MORAL_4C	3.83
	MORAL_4D	3.70
	MORAL_4E	4.12
LV 5: Subjective norms	SUB_5A	3.95
	SUB_5B	2.66
	SUB_5C	3.36
LV 6: Perceived behavioural control	PBC_6A	3.10
	PBC_6B	3.37
	PBC_6C	3.54

Appendix B

Elaboration of extended theory of planned behaviour (TPB) in Figure 5.1

The interviewees suggested six types of ***perceived benefits*** from promoting C&D waste recycling perceived by the industrial practitioners, which included maintaining good company image; gaining environmental benefits; lengthening lifetime of landfill; being more sustainable individually; gaining commercial benefits such as increasing attractiveness of flat from developers' perspective; and achieving higher recognition grade in various green building assessments such as BEAM Plus or gaining higher marks in tendering process of construction projects.

For ***perceived costs***, five tangible and intangible costs in total were considered by the interviewees during decision-making process. The tangible costs included the costs of collection, sorting, and transportation of C&D waste; cost of operation and maintenance of equipment; logistics arrangement; and costs on quality control and assurance for applying recycled materials in the construction projects. The intangible cost was referred to the time cost on recyclables delivery and training.

Considering the ***social and moral values***, interviewees suggested that fulfilling corporate social responsibility (CSR) was one of the social pressure encountered by the industry. Comparatively, all interviewees remarked that the public had low awareness on the application of construction waste recycling materials in Hong Kong due to the insufficient education. In addition, the local green groups paid little attention to the promotion of recycling materials, of which most efforts were placed on addressing the environmental pollution issues.

For ***behaviour control beliefs***, the interviewees suggested some considerations held by the industry over the use of construction recyclables, which were time, cost, available legislative framework, industry-recognized accreditation scheme, sufficient quality control and assurance, supply and demand of recyclables, safety concern, and available credible reference in tendering process.

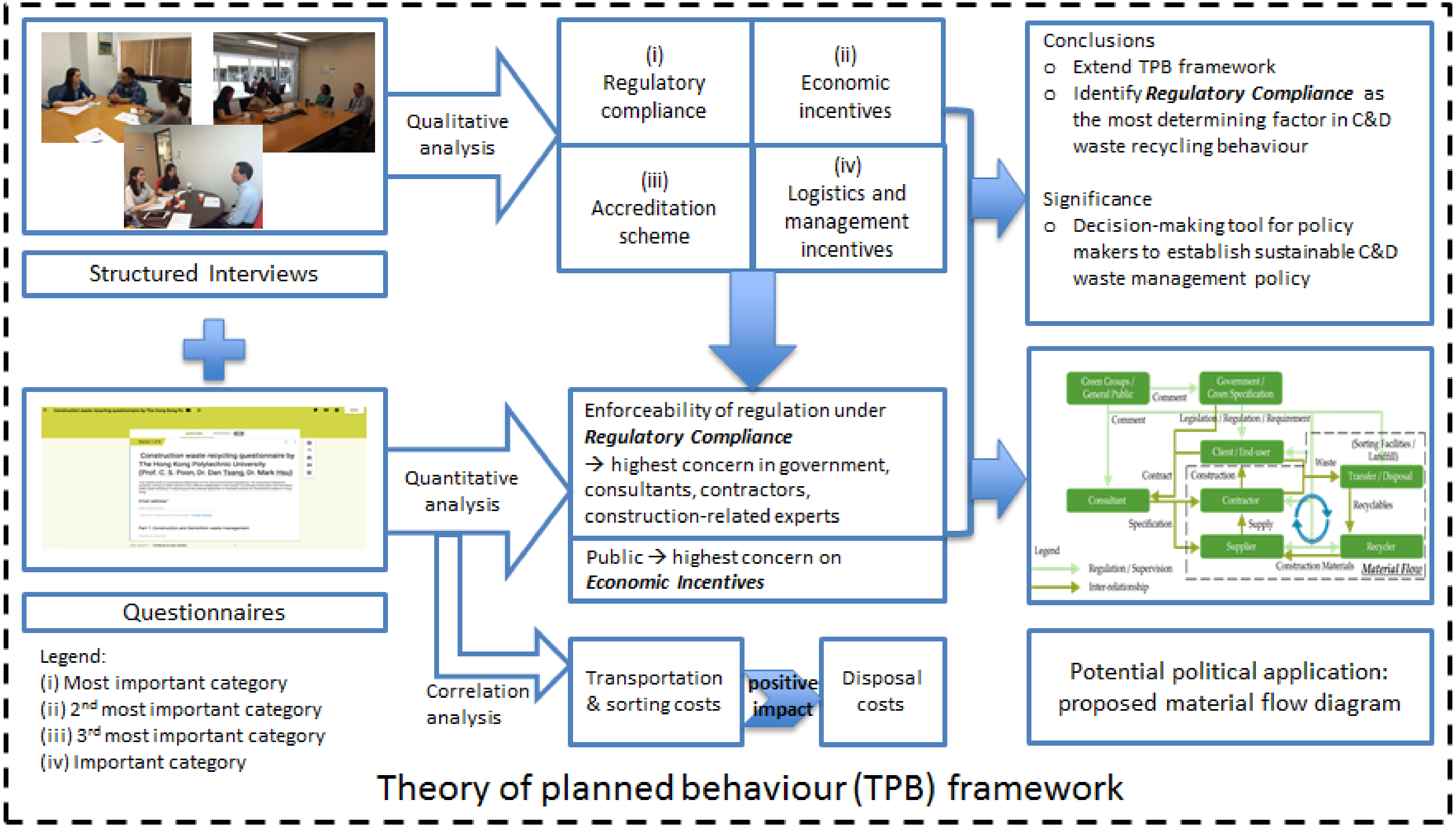

Figure B1 Graphical abstract of **Chapter 5**

Table B1. Cronbach's alpha if item deleted of each item in questionnaire

Item	**Cronbach's alpha if item deleted**
A1 Regulatory compliance	0.824
A2 Logistics and management incentives	0.820
A3 Economic incentives	0.823
A4 Accreditation scheme of recycled products	0.820
A5 Innovative recycling technology or products available	0.822
B1 Enforceability of regulation	0.824
B2 Coverage of regulation	0.821
B3 Effectiveness of regulation	0.824
C1 Comparable quality of recycled products with virgin products that meet statutory requirements	0.822
C2 Constant supply of recycled products	0.821
C3 Health and safety concerns of users	0.816
C4 Statutory product labelling of recycled products	0.817
C5 Wide applicability of recycled products	0.820
C6 Uniformity of recycled products (QA/QC)	0.817
C7 Corporate social responsibility (CSR)	0.816
D1 Collection and sorting costs (on-site/ off-site)	0.815
D2 Transportation costs to disposal sites	0.821
D3 Disposal costs of waste/ recycled materials	0.819
D4 Recycling value of waste/ recycled materials	0.818
D5 Disposal charging fee implementation by Government	0.823
D6 Government subsidies and corporates funding	0.823
Ea1 Hong Kong BEAM Plus certification scheme by HKGBC	0.821
Ea2 Green Product Accreditation and Standards (G- PASS) by HKGBC	0.828
Ea3 Hong Kong Awards for Environmental Excellence (HKAEE) by ECC	0.824
Eb1 I think an accreditation scheme for recycled products should be made statutory	0.822
Eb2 I think an accreditation scheme for recycled products should be established by government bodies	0.818
Eb3 I think an accreditation scheme for recycled products should be a minimum requirement for bidding government contracts	0.820
Eb4 I think an accreditation scheme for recycled products should be statutorily specified in construction contracts with private companies	0.820
Eb5 I think an accreditation scheme for recycled products should be used as a credible reference provided by the government	0.819

Table B2. Respondent profile

Variable	Category	Frequency	Percentage (%)	Cumulative percentage (%)
Age	"18-25"	66	34.6%	34.6%
	"26-35"	56	29.3%	63.9%
	"36-45"	41	21.5%	85.3%
	"46-60"	25	13.1%	98.4%
	"Above 60"	3	1.6%	100.0%
Work experience	"1-5 years"	85	44.5%	44.5%
	"6- 15 years"	36	18.9%	63.4%
	"16- 30 years"	36	18.9%	82.2%
	"Over 30 years"	5	2.6%	84.8%
	"None"	29	15.2%	100.0%
Position	"Contractor"	47	24.6%	24.6%
	"Consultants"	70	36.6%	61.3%
	"Construction- related experts"	17	8.9%	70.2%
	"Government officials"	20	10.5%	80.6%
	"General public"	37	19.4%	100.0%

Table B3. Measurement scales and breakdown of mean score of factors in the formal online questionnaire

Category		Measurement scales	Mean score
A	General view	**A1** Regulatory compliance	4.32
		A2 Logistics and management incentives	3.89
		A3 Economic incentives	4.16
		A4 Accreditation scheme of recycled products	3.41
		A5 Innovative recycling technology or products available	3.57
B	Regulatory compliance	**B1** Enforceability of regulation	4.41
		B2 Coverage of regulation	3.94
		B3 Effectiveness of regulation	4.16
C	Logistics and management incentives	**C1** Comparable quality of recycled products with virgin products that meet statutory requirements	4.01
		C2 Constant supply of recycled products	3.93
		C3 Health and safety concerns of users	4.00
		C4 Statutory product labelling of recycled products	3.81
		C5 Wide applicability of recycled products	3.95
		C6 Uniformity of recycled products (QA/QC)	3.90
		C7 Corporate social responsibility (CSR)	3.73
D	Economic incentives	**D1** Collection and sorting costs (on-site/ off-site)	4.15
		D2 Transportation costs to disposal sites	3.89
		D3 Disposal costs of waste/ recycled materials	4.07
		D4 Recycling value of waste/ recycled materials	4.04
		D5 Disposal charging fee implementation by Government	4.15
		D6 Government subsidies and corporates funding	4.10
E	**(a)** Understanding of accreditation scheme	**Ea1** Hong Kong BEAM Plus certification scheme by HKGBC	3.44
		Ea2 Green Product Accreditation and Standards (G- PASS) by HKGBC	2.57
		Ea3 Hong Kong Awards for Environmental Excellence (HKAEE) by ECC	2.73
	(b) Importance of accreditation scheme	**Eb1** I think an accreditation scheme for recycled products should be made statutory	3.83
		Eb2 I think an accreditation scheme for recycled products should be established by government bodies	3.95
		Eb3 I think an accreditation scheme for recycled products should be a minimum requirement for bidding government contracts	3.98
		Eb4 I think an accreditation scheme for recycled products should be statutorily specified in construction contracts with private companies	3.81
		Eb5 I think an accreditation scheme for recycled products should be used as a credible reference provided by the government	3.92

Table B4. Correlation analysis between four major categories

Correlation on general view				
	Regulatory compliance	*Logistics and management incentives*	*Economic incentives*	*Accreditation scheme of recycled products*
Regulatory compliance	1			
Logistics and management incentives	0.03	1		
Economic incentives	0.02	0.05	1	
Accreditation scheme of recycled products	-0.05	0.41	0.14	1

Table B5. Correlation analysis between factors under **Regulatory compliance** category

Correlation on regulatory compliance			
	Enforceability of regulation	*Coverage of regulation*	*Effectiveness of supervision*
Enforceability of regulation	1		
Coverage of regulation	0.15	1	
Effectiveness of supervision	0.07	0.13	1

Table B6. Correlation analysis between factors under **Logistics and management incentives** category

Correlation on logistics and management incentives							
	Comparable quality of recycled products with virgin products that meet statutory requirements	*Constant supply of recycled products*	*Health and safety concern of users*	*Statutory product labelling of recycled products*	*Wide applicability of recycled products*	*Uniformity of recycled products (QC/QA)*	*Corporate social responsibility (CSR)*
Comparable quality of recycled products with virgin products that meet statutory requirements	1						
Constant supply of recycled products	0.27	1					
Health and safety concerns of users	0.14	0.21	1				
Statutory product labelling of recycled products	0.18	0.21	0.36	1			
Wide applicability of recycled products	0.07	0.13	0.21	0.35	1		
Uniformity of recycled products (QC/QA)	0.37	0.23	0.29	0.27	0.30	1	
Corporate social responsibility (CSR)	0	0.23	0.45	0.37	0.27	0.28	1

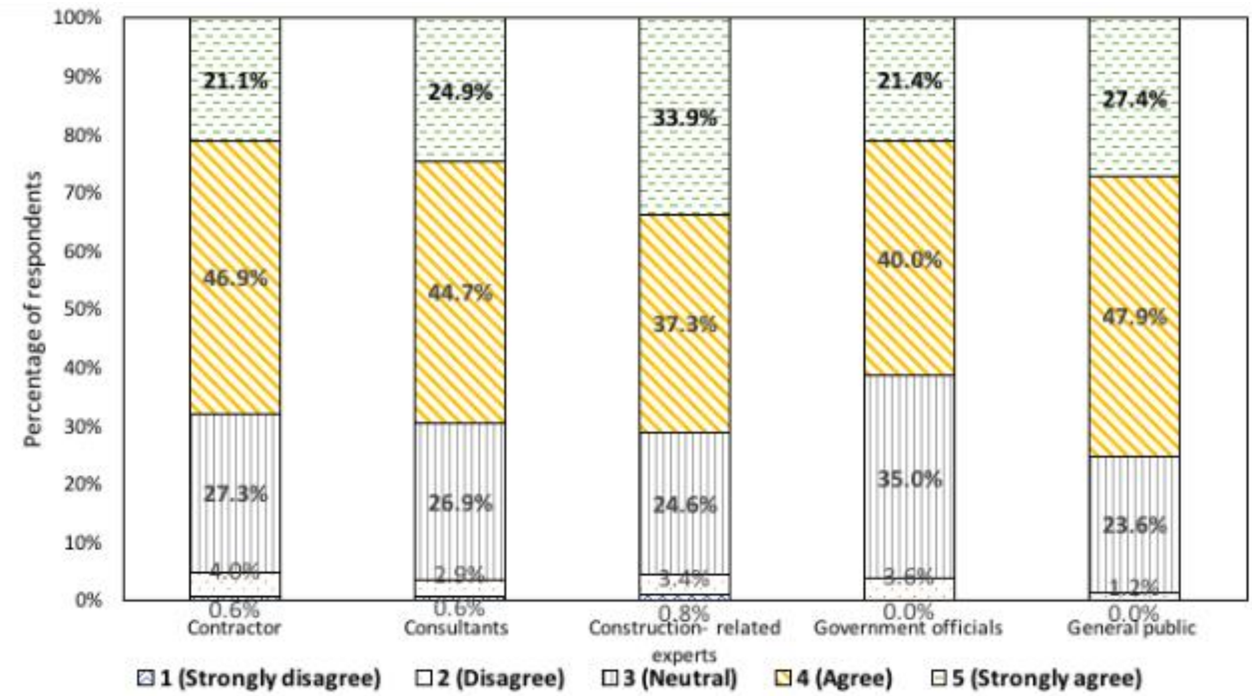

Figure B1. Comparison of percentage of respondents under the category of logistics and management incentives.

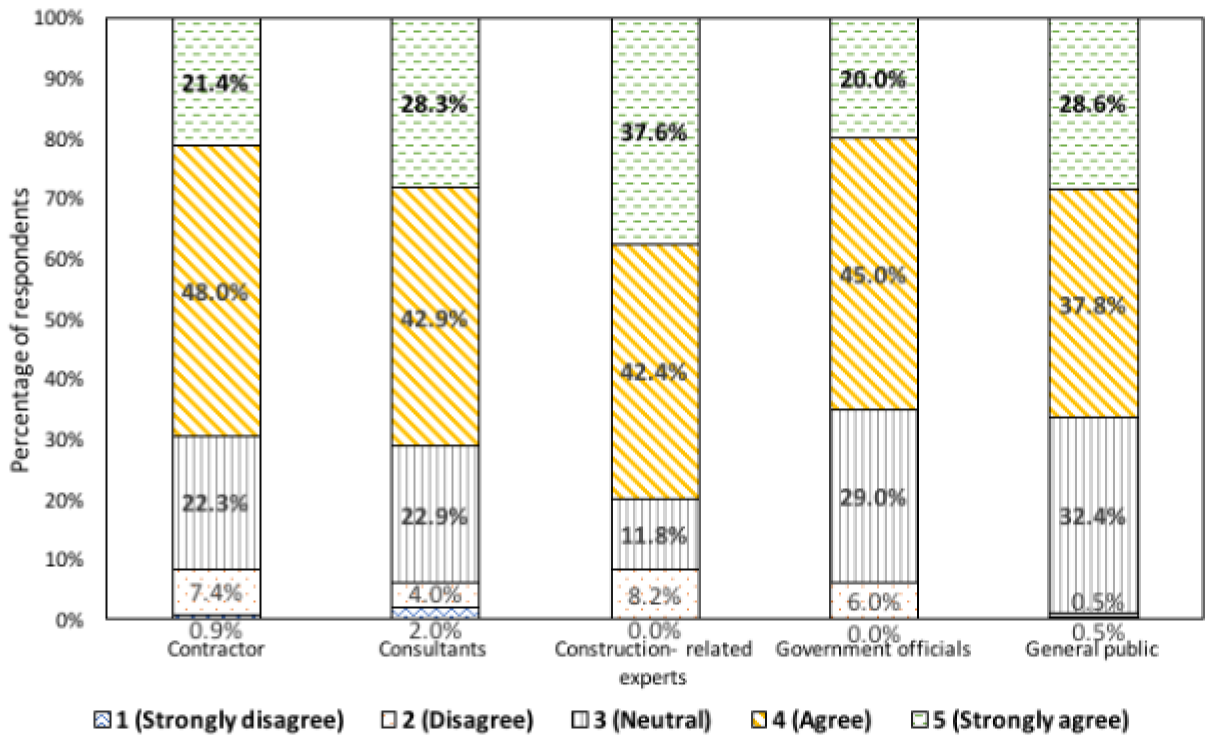

Figure B2. Comparison of percentage of respondents under the category of accreditation scheme.

Appendix C

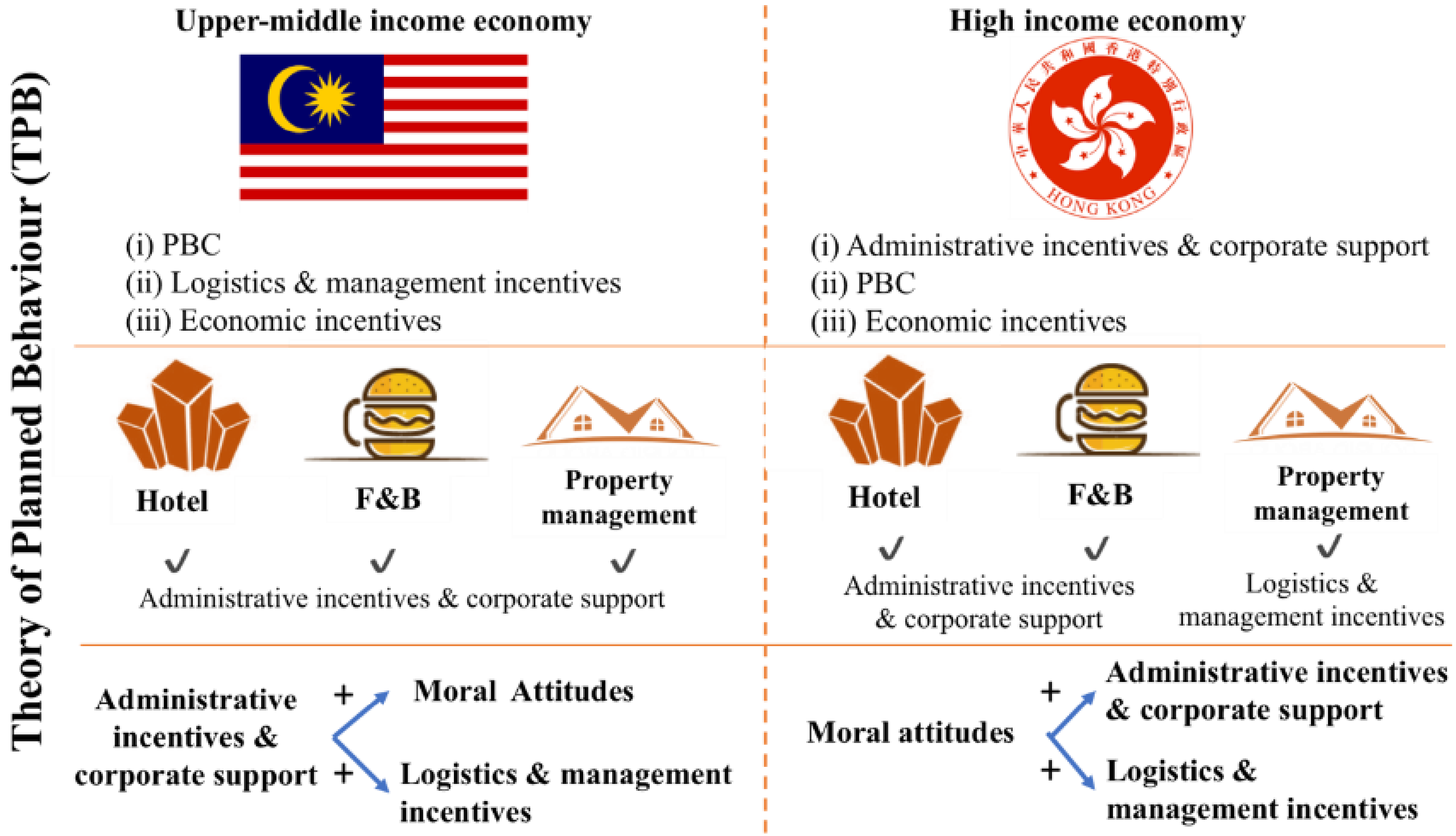

Figure C.1 Graphical abstract of **Chapter 6.**

Table C1. Descriptive statistics of Malaysian respondents

Demograpgrphic statistics	**Items**	**Percentage**
Gender	Female	49.0%
	Male	51.0%
Education level	Primary and secondary education	49.5%
	University level	42.2%
	Professional training	6.8%
	Postgraduate level	1.5%
Age group	18-25	32.5%
	26-35	31.1%
	36-45	30.1%
	46-60	0.0%
	Above 60	6.3%
Industry	Hotel	30.6%
	Food and beverage	36.4%
	Property management	33.0%
Role	Operation division	27.2%
	Management division	43.2%
	Green/ Sustainability division	2.9%
	Human resources division	5.8%
	Marketing division	2.4%
	Others	18.4%
Experience in industry	1-5 years	46.6%
	6-15 years	33.0%
	16-30 years	17.5%
	Over 30 years	1.5%
	None	1.5%
Food waste recycling schemes in corporates	Yes.	29.1%
	No.	70.9%
Total responses		206

Table C2. Measurement scales and breakdown of mean score of indicators in the questionnaire

Construct/ Latent variable	Indicators	Mean
LV 1: Economic incentives	ECON_1A	3.73
	ECON_1B	3.65
	ECON_1C	3.55
LV 2: Logistics & management incentives	LOGIS_2A	3.79
	LOGIS_2B	3.66
	LOGIS_2C	3.63
	LOGIS_2D	3.65
	LOGIS_2E	3.60
LV 3: Administrative incentives & corporate support	ADMIN_3A	3.81
	ADMIN_3B	3.93
	ADMIN_3C	3.86
	ADMIN_3D	3.67
	ADMIN_3E	3.98
	ADMIN_3F	3.81
LV 4: Moral attitudes	MORAL_4A	3.76
	MORAL_4B	3.68
	MORAL_4E	3.78
LV 5: Subjective norms	SUB_5A	4.06
	SUB_5C	3.83
LV 6: Perceived behavioural control	PBC_6A	3.43
	PBC_6B	3.26

Table C3. Latent variable correlations of model

	LV1: Economic incentives	**LV2: Logistics & management incentives**	**LV3: Administrative incentives & corporate support**	**LV4: Moral attitudes**	**LV5: Subjective norms**	**LV6: Perceived behaviour control**	**LV7: Recycling intention**	**LV8: Recycling behaviour**
LV1: Economic incentives	1	0.513	0.539	0.477	0.378	0.3	0.248	-0.058
LV2: Logistics & management incentives	0.513	1	**0.608**	0.566	0.48	0.216	0.214	-0.029
LV3: Administrative incentives & corporate support_	0.539	0.608	1	0.622	0.512	0.34	0.173	-0.098
LV4: Moral attitudes	0.477	0.566	**0.622**	1	0.591	0.329	0.199	-0.138
LV5: Subjective norms	0.378	0.48	0.512	0.591	1	0.243	0.054	-0.289
LV6: Perceived behaviour control	0.3	0.216	0.34	0.329	0.243	1	0.384	0.171
LV7: Recycling intention	0.248	0.214	0.173	0.199	0.054	0.384	1	0.155
LV8: Recycling behaviour	-0.058	-0.029	-0.098	-0.138	-0.289	0.171	0.155	1

Appendix D

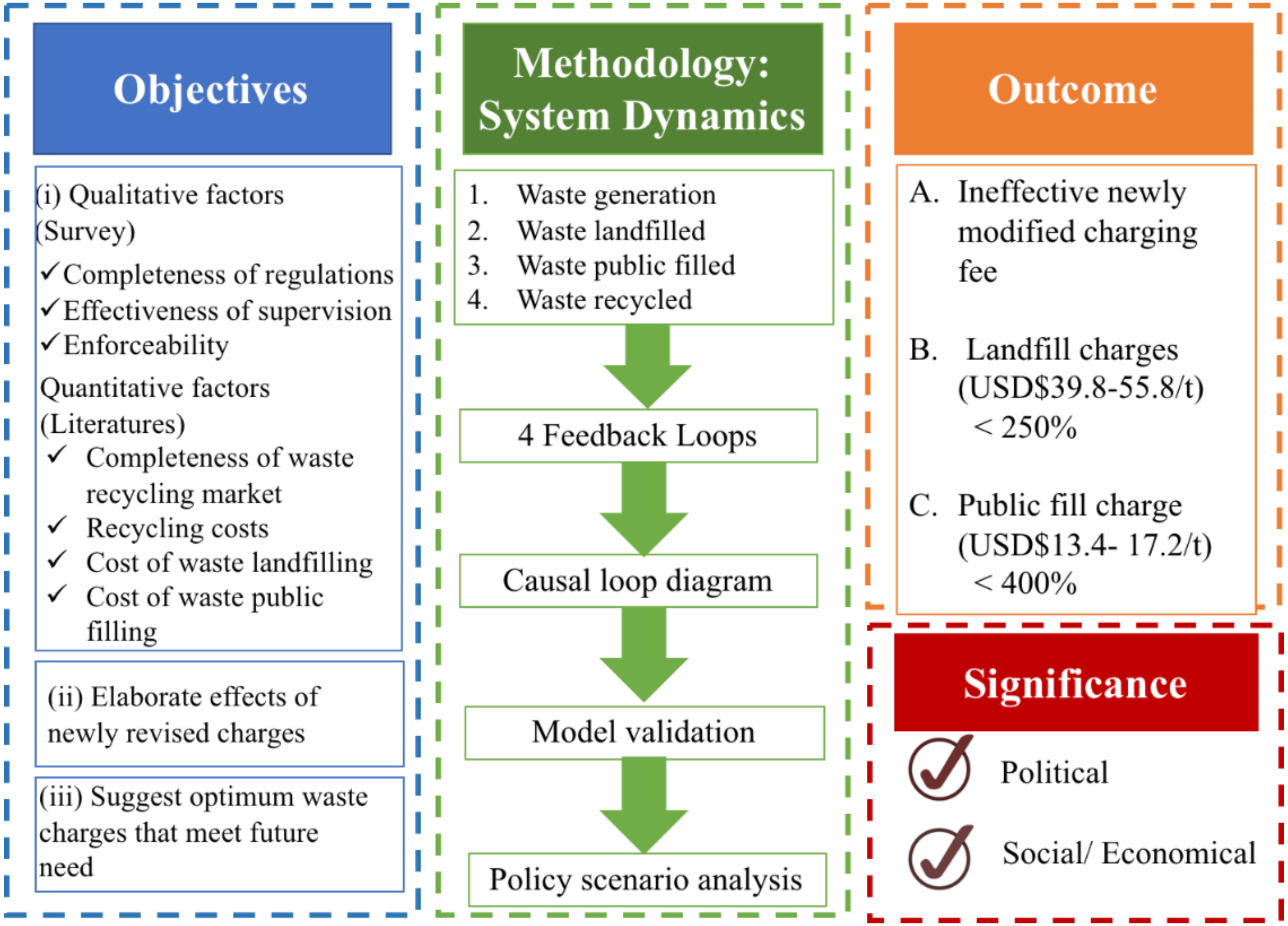

Figure D1 Graphical abstract of **Chapter 7.**

Table D1. Functions table of SD equations.

Equation	Waste decreasing rate = LOOKUP (Incentive of waste reduction)											
X	Incentive of waste reduction	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Y	Waste decreasing rate	0.092	0.223	0.321	0.478	0.603	0.696	0.734	0.766	0.793	0.799	0.799
Equation	Incentive of waste reduction = LOOKUP (Effectiveness of regulation execution)											
X	Effectiveness of regulation execution	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Y	Incentive of waste reduction	0	0.2	0.231	0.25	0.35	0.45	0.6	0.72	0.75	0.04	0
Equation	Ratio of waste recycled = LOOKUP (Cost of waste recycling)											
X	Cost of waste recycling (HKD/t)	0	60	120	180	240	300	360	420	480	540	600
Y	Ratio of waste recycled	0.918	0.88	0.815	0.788	0.783	0.685	0.163	0.103	0.071	0.06	0.06
Equation	Cost of waste recycling = LOOKUP (Maturation of waste recycling market)											
X	Maturation of waste recycling market	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Y	Cost of waste recycling (HKD/t)	92.4	85.3	74.5	71.7	69	60.9	51.6	45.7	42.4	42.4	40
Equation	Maturation of waste recycling market = LOOKUP (Effectiveness of regulation execution)											
X	Effectiveness of regulation execution	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Y	Maturation of waste recycling market	0.147	0.277	0.408	0.511	0.625	0.75	0.793	0.81	0.842	0.853	0.853
Equation	Ratio of waste landfilled = LOOKUP (Cost of waste landfilling)											
X	Cost of waste landfilling (HKD/t)	0	150	300	450	600	750	900	1050	1200	1350	1500
Y	Ratio of waste landfilled	1	0.91	0.81	0.7	0.48	0.35	0.24	0.23	0.22	0.21	0.1

Equation	Waste recycling driving factor = LOOKUP (Amount of recycled waste)											
X	Amount of recycled waste (1000 Tonnes)	8600	10740	12880	15020	17160	19300	21440	23580	25720	27860	30000
Y	Waste recycling driving factor	1.027	1.033	1.087	1.12	1.152	1.168	1.413	1.69	1.788	1.821	1.842
Equation	Ratio of public filled waste = LOOKUP (Cost of waste public filled)											
X	Cost of waste public filled (HKD/t)	0	100	200	300	400	500	600	700	800	900	1000
Y	Ratio of public filled waste	1	0.85	0.8	0.7	0.65	0.3	0.2	0.15	0.15	0.125	0.1

Table D2. Amount of generated waste from real statistics and output from model.

Time	Real_Amount of generated waste (Mt)	Model_Amount of generated waste (Mt)
2005	10504.94	10505
2006	7989.625	8570
2007	7664.98942	8852
2008	8092.14644	9144
2009	8065.51666	9446
2010	11768.59566	9758
2011	12589.80348	10080
2012	14088.70958	10413
2013	14239.16408	10756
2014	13995.25291	11111
2015	17539.69937	11478

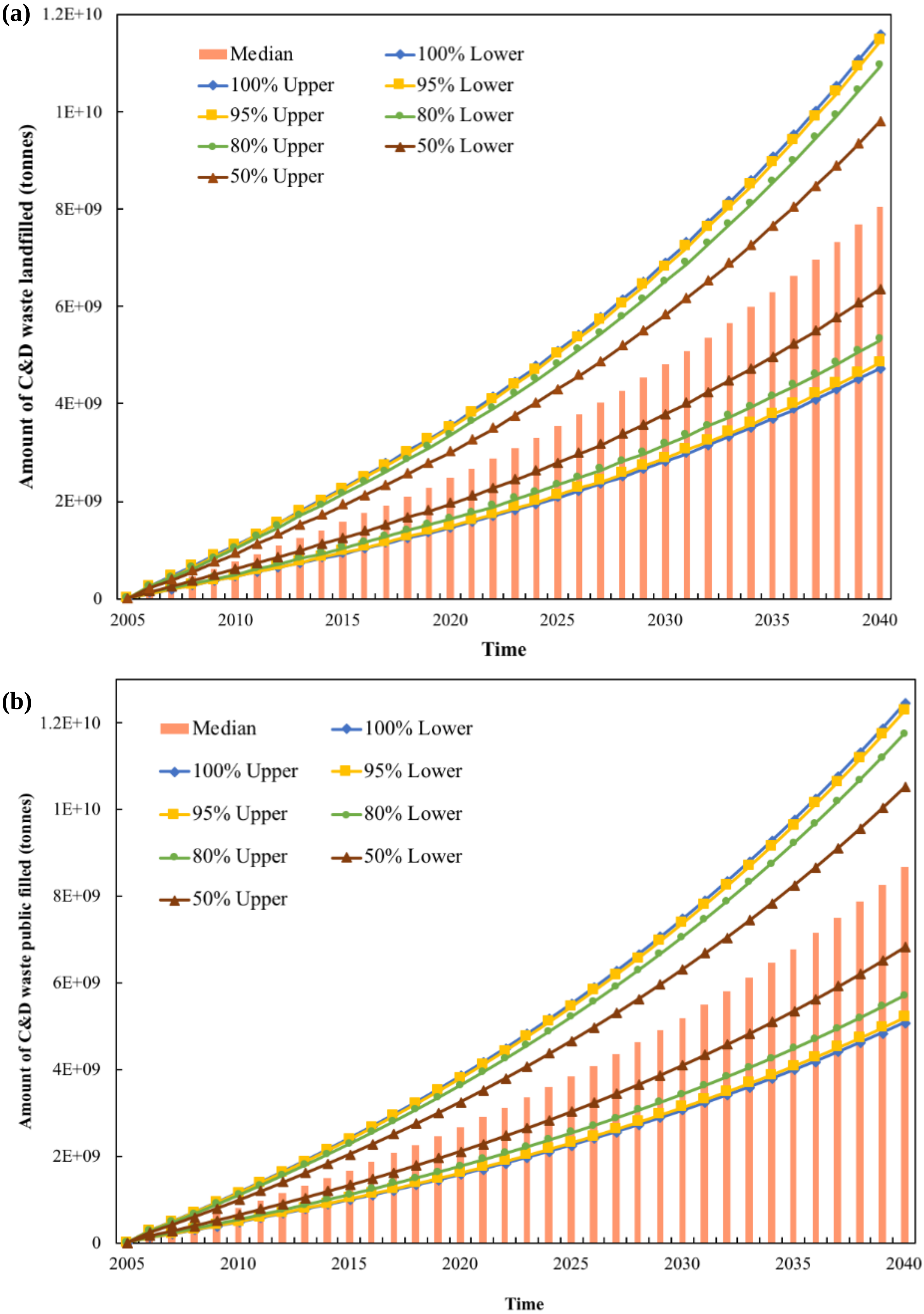

Figure D1. Variation of (a) amount of C&D waste landfilled and (b) public filled due to amount of waste generation variation (2005-2040).

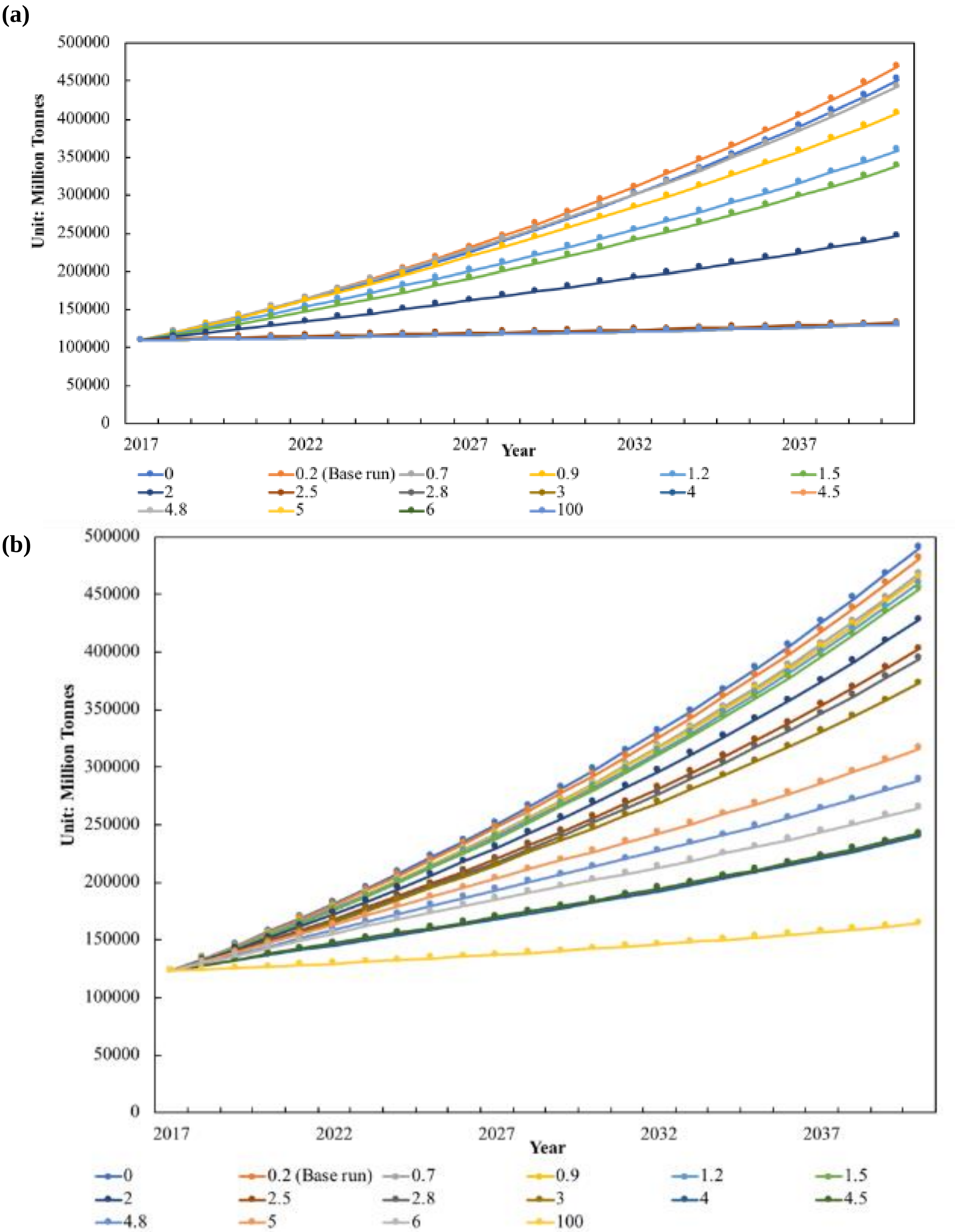

Figure D2. Effect of increment percentage change of WDCF on the amount of landfilled (a) and public filled (b) C&D waste from 2005 to 2040.

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