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Master Thesis

The power of nudging
Using reverse logistics to improve recycling behaviour in household waste management while taking the intention-action gap into account

Date of submission:
19.08.2016

Examination code and name:
GRA 19003 Master Thesis

Supervisor:
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Programme:
Master of Science in Business and Economics
Major in Logistics, Operations and Supply Chain Management

Abstract

Reverse logistics plays an important role in keeping resources in the supply chain for as long as possible through the creation of a circular waste management system. In household waste management, the success of such a system depends on the end-consumer, which supplies waste to the reverse supply chain. The aim of this thesis is therefore to examine how reverse logistics may contribute to improve the end-consumer-turned-supplier's recycling behaviour, while taking the intention-action gap into account.

A conceptual framework of recycling behaviour has been developed and tested empirically using a two-group dependent post-test quasi-experimental design following ethical guidelines. Data was collected through a pick-analysis and questionnaire. The empirical setting is a source-separation system, and the experimental and control groups were chosen from a high-rise housing cooperative in an urban residential district in Oslo municipality. Three interventions, or nudges, are designed to change behaviour through either the supplier or system dimensions. 1) Informational nudge to improve motivation through activation of social norms. 2) System nudge through reduced distance. 3) System nudge through access to equipment. The latter two aim to improve convenience. Results show improved recycling behaviour for the experimental group. 17% more food waste recycled, 29% less glass and metal disposed of in residual waste, and less contamination within recycled fractions. Control group behaviour stayed constant. Intentions to recycle are similar between the two groups.

In conclusion, targeting the end-consumer-turned-supplier through either system or supplier characteristics may improve recycling behaviour and recycling rates. This has both theoretical and practical implications for waste management system design, as this thesis contributes with an increased understanding of the role of the end-consumer-turned-supplier and how any intervention can help improve actual recycling behaviour.

Key words: reverse logistics; recycling behaviour; nudging; household waste; circular economy

Acknowledgements

In writing these words we are finalizing our studies at BI. It's been a long journey, and it would not have happened without the support of several people, whom we wish to thank.

First of all, this thesis could not have been finalised without the support and guidance of our supervisor at BI, Bente. Thank you for the "help to help ourselves", and for constructive feedback. We have valued our discussions, and we hope we have made you proud.

We would also like to thank the Agency for Waste Management in Oslo for collaborating with us, and for allowing us the use of necessary equipment and resources over the past year or so. Thank you to everyone who provided valuable insights into "real world" waste management, gave us access to data, and for the assistance with planning and solving practical issues. A warm thank you especially to John Egil, Ida, and Tale for always having time for our questions.

Mepex AS, and Sveinung especially, thank you for teaching us how to carry out a pick-analysis. Also, we could not have collected our data with the collaboration of representatives from the housing cooperative, and everyone working at Grønmo were incredibly helpful and welcoming. We would also like to thank our waste collector for letting one of us ride along at ungodly hours of the morning.

We would also like to thank our significant others, families, and friends for the support during the past two years. We have spent the better part of 2016 obsessing over waste, and look forward to spending a lot more time with you as this chapter of our lives is now closed.

Asta and Rebecka
Oslo, August 2016

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1. Introduction

There is a gigantic patch of waste floating in the Pacific Ocean. It even has a name: the *Great Pacific garbage patch* (Turgeon 2014). Its source? Mainly plastic waste. This is only one example of how human activities lead to waste generation, which poses a "crucial challenge in terms of sustainable development" (Monnot, Reniou, and Rouquet 2014). The issue of waste has two main dimensions: It is an environmental issue, but also one concerned with the efficient use of non-renewable resources. These issues are also connected: Using these non-renewable resources more efficiently will help improve the environment in the long run because the need for using so-called primary raw materials will intentionally be reduced (Rock, Hedley, and Gordon 2016). This is known as the circular economy perspective.

1.1 Background and research question

A circular economy involves shifting the economy away from the "*take-make-consume and dispose* pattern of growth", moving towards reuse and recycling of resources (European Commission 2014, 2). A circular economy may be defined as an economy where "materials from products at the end of their lifecycle [are] recovered through dismantling and recycling. Re-injecting these materials into the beginning of [a] product lifecycle reduces environmental impact and costs of production" (European Commission 2015c). This is illustrated in Figure 1-1.

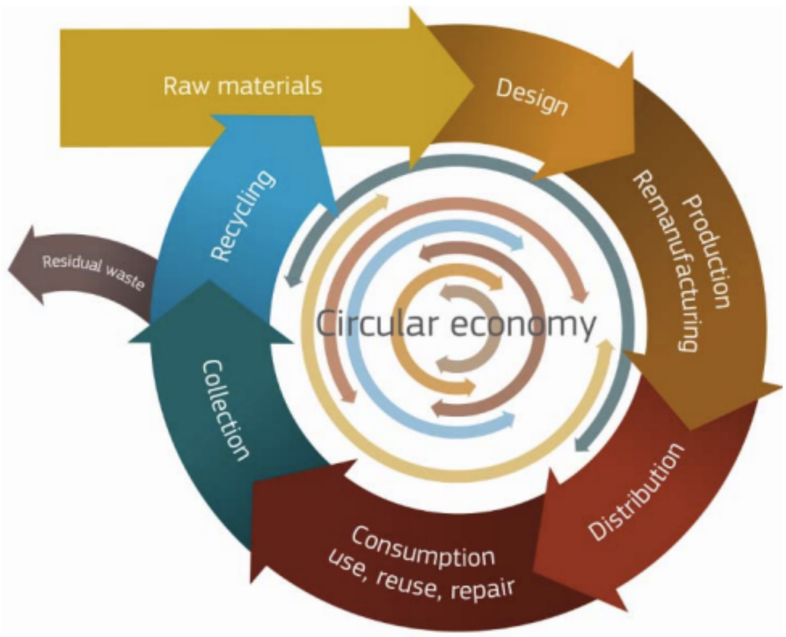


Figure 1-1: A circular economy. Source: (European Commission 2014, 5)

In a circular economy the "value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste [is] minimised" (European Commission 2015b, 1). Waste may therefore be viewed as a resource, and we argue that proper waste management is a crucial part in successfully creating a circular economy (European Commission 2015b). This is exemplified by the European Commission's ban on landfilling of recyclable materials by 2025, and the aim to achieve a minimum 65% recycling rate[1] of municipal waste by 2030 (European Commission 2014, 9, 2015a). These measures are supposed to incentivise the creation of a circular economy in Europe.

In more logistical terms, creating a circular economy involves closing the loop in the supply chain. A closed-loop supply chain (Guide and Van Wassenhove 2009) is made up of what is referred to as a forward and reverse supply chain (Govindan, Soleimani, and Kannan 2015). In a traditional forward supply chain, product flows from raw material suppliers, design, and production, and is distributed to the end-consumer for consumption (see Figure 1-1). In reverse logistics, the flow of product is in the opposite direction of traditional 'forward' logistics (Flygansvær 2006). When the end-consumer's products have reached their end-of-life, product recovery and waste management is facilitated through the reverse supply chain. We therefore argue that a waste management system may be considered a reverse logistics system, or a reverse supply chain.

The reverse waste supply chain is made up of the circular economy steps involving consumption, use, reuse and repair, collection, recycling, and residual waste (see Figure 1-1). When a product has reached its end-of-life, the end-consumer becomes a supplier of waste, and this is referred to as the end-consumer-turned-supplier pivot-point node (Jalil et al. 2016). We therefore refer to the end-consumer as the end-consumer-turned-supplier, or just supplier, in this thesis. We also consider the end-consumer-turned-supplier a passive actor in this system (Flygansvær 2006), by which we mean they do not actively "supply" waste to the system. This may be because the end-consumer-turned-suppliers do not consider waste a resource, and the implication is that the waste management

[1] This was originally 70% in 2014, but has been lowered in the revised version of the legislative proposal (European Commission 2014, 2015b).

service provider must create proper incentives for the end-consumers-turned suppliers to supply waste to the system.

Our perspective is that waste management systems are characterized by serial interdependencies, and that input therefore determines output (Thompson 1967). The waste received from the end-consumer-turned-supplier as input to the waste management system will thus affect the output, which is overall system performance. One way to define performance is the recycling rate, which is the percentage of overall amount of waste that is recycled. In this thesis we therefore argue that one way to improve system performance in waste management is to improve the rate at which the end-consumer-turned-supplier recycles, and this may be achieved through improving their recycling behaviour.

Getting the end-consumer-turned-suppliers to improve their recycling behaviour is not straightforward, and this is partly due to a psychological phenomenon called the intention-action gap (e.g. Newton and Meyer 2013). In a waste management context, this means that although people say recycling is important, an investigation into how much people *actually* recycle will tell a different story. The intention-action gap may also be an explanation for why recycling rates are lower than desired, despite the resources spent on waste management systems (Respons Analyse 2015, Mepex Consult AS 2015, 2016). This suggests that the reason people do not recycle is not that they think it is unimportant, or that they lack intentions to recycle, but that the resources spent on waste management do not improve *actual* behaviour. We therefore want to explore how we *can* affect recycling behaviour, and we must do so with the intention-action gap in mind: Any attempts to improve recycling behaviour must aim at improving actual behaviour, and not just intentions.

One explanation for the gap between intended and actual behaviour may be found in the field of climate psychology, which explains how people deny what they know, and still manage to live their lives as normal (Stoknes 2015). In order to overcome the gap and improve actual behaviour, one solution suggests that choosing environmentally friendly solutions should be made easy (Stoknes 2015). One way to make a choice easy is through something called 'nudging'. A nudge involves using indirect suggestions order to change behaviour, without prohibiting the behaviour or altering economic incentives (Thaler and Sunstein 2009).

These indirect suggestions may affect recycling behaviour, and may come in multiple forms. In this thesis we will argue that recycling behaviour may be affected through two main concepts: system characteristics and supplier characteristics. This implies that nudging may also be done through these channels, and we will argue that improved recycling behaviour may be achieved through changing the waste management system, or through affecting characteristics that are specific to the end-consumer-turned-supplier. Because we view waste management systems as reverse supply chains where the end-consumer-turned-supplier provides the input, we consider both system and supplier characteristics to be part of reverse logistics. This brings us to the research question of this thesis, which is the following:

How can reverse logistics contribute to improve recycling behaviour?

This thesis will look at how reverse logistics principles may be applied to affect recycling behaviour in a waste management context, while taking the intention-action gap into account. Our point of departure is that such a change in the end-consumer-turned-supplier's recycling behaviour may be achieved through affecting what we have termed supplier characteristics and system characteristics. The aim is to improve the recycling rate, as a higher degree of recycling will keep resources in the supply chain for longer, thus creating a circular economy.

1.2 Positioning of thesis

As we outlined in the previous section, this thesis will investigate how reverse logistics may contribute to improve recycling behaviour. This section will outline the positioning of the thesis within the context of waste management. Waste management is a broad subject area because there are several types of waste (European Commision 2016). Throughout this thesis waste is defined as municipal solid waste, which is any solid waste resulting from the operation of residential, commercial, governmental or institutional establishments (Stock 1992). The management and recycling of municipal solid waste is also what the

European Commission is concerned with (European Commission 2014). Because we are interested in looking at the recycling behaviour of the end-consumer-turned-supplier as an individual, we have further narrowed our focus to municipal solid waste from residential areas. This type of waste is also called household waste. This will also fill a gap in the existing literature, as there are only a small number of studies published in core SCM journals that co-examine recycling and reverse logistics specifically (Jalil et al. 2016, 254), and none have looked at recycling of household waste.

In addition, we have investigated the recycling behaviour of end-consumers-turned-suppliers living in high-rise buildings in an urban residential area. The reason for this is twofold: 1) Most research into actual recycling behaviour has focused on high-rise housing (e.g. Bernstad 2014, Rousta et al. 2015, Dai et al. 2015), and 2) the rate of urbanization is increasing (United Nations 2014). This means that space becomes an even more limited resource in urban areas, and we argue this will lead to the construction of more high-rise buildings. At the same time there is a lack of research that looks at how high-rise buildings affect actual recycling behaviour (e.g. due to smaller living space). This is problematic because increasing urbanization and population growth will generate more waste, and thus place increasing demands on the waste management systems in cities. When this is looked on in combination with the goal of achieving a circular economy where resources stay in the supply chain for as long as possible, it is clear that research into waste management in urban areas with high-rise buildings may provide important knowledge.

One way of dealing with increasing quantities of waste is to prevent or minimize waste generation in the first place. This is the preferred strategy according to the European Waste Directive, which provides a hierarchy of five options for waste prevention and waste management (European Commission 2008) that should be followed by all EU and EEA member states (European Union 2016, EFTA 2016). The overall goal is for waste to be managed in a way that minimizes its impact on the environment (Price and Joseph 2000), but prevention an minimization of waste will not be included in the scope of this thesis because this thesis will deal with waste that has already been generated (European Commission 2008). The focus of this thesis will therefore be the lower four options of the waste hierarchy pyramid: reuse, materials recycling, energy recycling and depot. The hierarchy is illustrated in Figure 1-2.

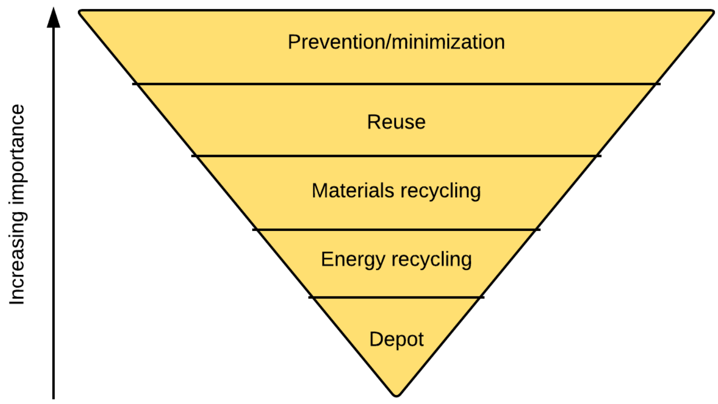


Figure 1-2: Hierarchy of options for waste prevention and management, adapted from and European Commission (2008), Price and Joseph (2000), Carter and Ellram (1998).

1.3 Outline of thesis

The rest of the thesis is structured as follows: Chapter 2 will review relevant theory, Chapter 3 outlines and discusses our conceptual framework with relevant hypotheses, Chapter 4 provides the empirical context, and Chapter 5 outlines methodology. Chapter 6 provides an overview of the results, which will be discussed in Chapter 7, and finally, Chapter 8 will conclude and provide direction for future research, as well as practical and managerial implications.

2. Theoretical background

This chapter will provide the theoretical foundation for this thesis. In order to answer our research question, we must understand how recycling behaviour can be changed. In order to achieve this we have looked at two areas of research, and placed them in the context of waste management: Psychology and consumer behaviour, and reverse logistics. Psychology and consumer behaviour literature will provide a basis for understanding role and recycling behaviour of the end-consumer-turned-supplier. Reverse logistics literature will help understand the characteristics of the waste management system itself. When combined, these two areas should provide insight into how the *actual* recycling behaviour of the end-consumer-turned-supplier may be affected through what we have identified as 'supplier characteristics' and 'system characteristics'. These two concepts form the basis of the conceptual framework that has been derived from the literature we have reviewed. Figure 2-1 provides an overview of the theoretical foundation for this thesis.

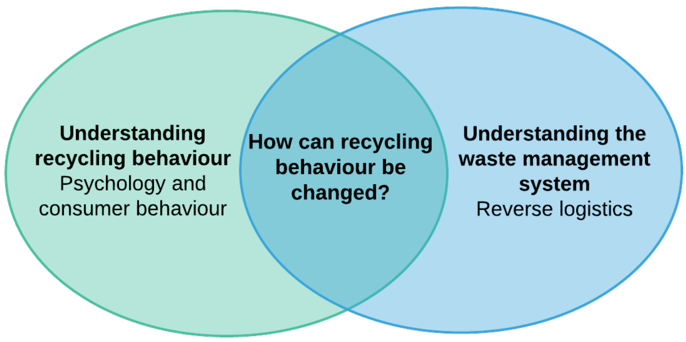


Figure 2-1: The two areas of psychology and consumer behaviour and reverse logistics form the theoretical foundation used to understand how recycling behaviour can be changed.

2.1 Understanding recycling behaviour: the role of the supplier

In order to understand recycling behaviour and how it may be improved, it is important to understand the role of the end-consumer-turned-supplier in a waste management context. We found that the intention-action gap must be taken into account, but our review of the literature also revealed that demographics, housing, and motivation and knowledge should be considered.

Recycling behaviour has not been explicitly defined in the literature (e.g. Hornik et al. 1995, Barr and Gilg 2005, Miafodzyeva and Brandt 2013), but it has been implicitly suggested that recycling behaviour means the behaviour of individuals participating in recycling activities (Hornik et al. 1995) or recycling schemes (Miafodzyeva and Brandt 2013), such as separating waste for recycling (Barr and Gilg 2005). It is also implied that the better the recycling behaviour, the more waste is recycled.

Recycling behaviour is also affected by the circular economy perspective. Because the forward and reverse supply chains are connected, this means that the same actor changes from *consumer* of goods in the forward supply chain to *supplier* of waste and products for reuse in the reverse supply chain that makes up the waste management system (Anderson and Brodin 2005). This is also why we have named this actor the end-consumer-turned-supplier. Moreover, Jalil et al. (2016) reported a symbiosis effect between the end-consumer-turned-supplier and the waste management service provider, and found that recycling behaviour must be taken into account when designing optimal waste management systems. This is due to the fact that waste management systems are characterized by serial interdependencies, which means that input determines overall system performance (Thompson 1967). The end-consumer-turned-supplier therefore plays a critical role in determining overall system performance in waste management systems where they act as both source and *separator* of waste (Jalil et al. 2016). This is because they determine whether end-of-life goods are captured by an appropriate reverse logistics system for recycling or not. If not, the resources in the end-of-life goods may not be exploited to their full extent, as they may for instance end up in a landfill (Jalil et al. 2016). This implies that the end-consumer-turned-supplier makes a *choice* in their disposal of waste, and that chosen recycling behaviour affects their individual recycling rate, as well as recycling rate or performance of the waste management system.

What may influence the choice that the end-consumer-turned-supplier makes regarding disposal of end-of-life goods? In order to understand this, we must first understand *why* the intention-action gap exists. The theory of planned behaviour states that there is a link between intentions and actions (Ajzen 1991). Intentions are formed by attitudes, subjective norms and perceived behavioural control.

However, intentions of behaviour do not always lead to actual behaviour (Kollmuss and Agyeman 2002, Barr 2007, Newton and Meyer 2013). This is called the 'intention-action gap', and it may be attributed to a set of barriers (Kollmuss and Agyeman 2002). These barriers may be understood as something that hinders the end-consumer-turned-supplier in making a choice that leaves no gap between intention and action. In order to improve actual recycling behaviour these barriers must therefore be minimized or removed. In this sense, they may also help facilitate action. The barriers to action are both 'individual constraints' related to the suppliers themselves (i.e. supplier characteristics), and 'contextual constraints' such as infrastructure (i.e. system characteristics). In this thesis, the contextual constraints are represented by the waste management system itself.

The intention-action gap may be exemplified by the fact that although most Norwegians would probably claim that food waste is bad if they were asked, they still throw away every fifth grocery bag (Aftenposten 2015, ForMat 2015). This means that although intention to prevent food waste is high, actual food waste behaviour may not be high. The cause of this gap would then be related to individual or contextual constraints that affect the choice the end-consumer-turned-supplier makes regarding proper disposal of the food waste. An illustration of the intention-action gap is provided in Figure 2-2:

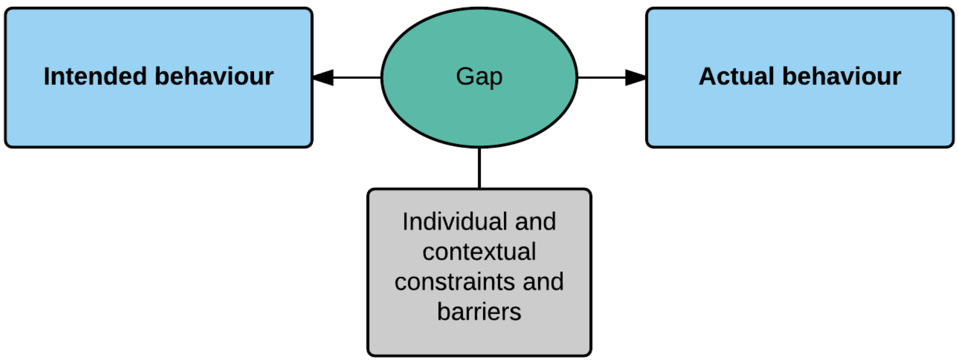


Figure 2-2: The gap between intended and actual behaviour (simplified version based on Newton and Meyer 2013).

Because of the intention-action gap, it is problematic that most research examining recycling behaviour in a waste management context has used self-assessment surveys, meaning behaviour has not been objectively observed (e.g. Granzin and Olsen 1991, Knussen et al. 2004, Meneses and Palacio 2005, Hage, Söderholm, and Berglund 2009, Timlett and Williams 2009, Klöckner and Oppedal 2011, Minton, Kahle, and Kim 2015). In recent years however, the 'gap' has been taken into consideration, as actual behaviour has been measured through waste composition analyses and pick analyses (e.g. Bernstad 2014, Rousta et al. 2015, Dai et al. 2015).

In conclusion, there seem to be two main causes for the gap between intended and actual recycling behaviour: individual and contextual. This also implies that it is possible to affect a supplier's recycling behaviour through reducing or changing these barriers (Kollmuss and Agyeman 2002, Newton and Meyer 2013). As the purpose of this section is to understand the role of the supplier, we will now outline what we have found to be the most frequently cited *individual* constraints to action. These are demographic characteristics, housing, and motivation and knowledge.

2.1.1 Demographic characteristics

The role of socio-demographics is one of the earliest areas of focus in literature about recycling behaviour (Hornik et al. 1995). Findings in terms of the role of socio-demographic characteristics (e.g. age, income, level of education and gender) have been contradicting (Shrum, Lowrey, and McCarty 1994, Rousta et al. 2015, Monnot, Reniou, and Rouquet 2014). Some studies show that older people recycle a larger amount of their waste than younger individuals (Vining and Ebreo 1990). In contrast, another study found that age as an explanation for recycling behaviour was rather marginal (Shrum, Lowrey, and McCarty 1994). Where some studies report a positive correlation between income and recycling (Vining and Ebreo 1990, Berger 1997), others find no connection at all (Granzin and Olsen 1991). When it comes to the link between level of education and recycling, no significant relationship has been identified (Vining and Ebreo 1990, Granzin and Olsen 1991). In terms of gender, women seem to participate more in the household's recycling activities than men (Granzin and Olsen 1991, Stern, Dietz, and Kalof 1993, Iyer and Kashyap 2007, Meneses and Palacio 2005).

The relationship between religion and multicultural characteristics and sustainable behaviour has also been considered (e.g. Minton, Kahle, and Kim 2015, Miafodzyeva, Brandt, and Andersson 2013). Highly religious Buddhists were found to be more likely to engage in sustainable behaviour compared to Christians and Atheists, and this was found to be consistent across the South Korean/US country-divide (Minton, Kahle, and Kim 2015). A case study investigating recycling behaviour of residents in a Swedish multicultural urban area found that attitudes towards the importance of recycling best determined recycling behaviour (Miafodzyeva, Brandt, and Andersson 2013). On the other hand, a study in an Asian-British neighbourhood found that this group's attitudes towards recycling were no different than those of the wider population, and that low participation in recycling schemes was linked to "the higher priorities imposed upon them by economic deprivation" (Martin, Williams, and Clark 2006). It is therefore unclear if what the relationship between cultural background and recycling behaviour is.

A meta-analysis synthesising results from research about recycling behaviour across a 20-year span (1990–2010) found that socio-demographic variables do not predict recycling behaviour (Miafodzyeva and Brandt 2013), and it has been found that over time, when individuals incorporate recycling into their habits, socio-demographic factors seem to correlate less with recycling behaviour (Hornik et al. 1995, Del Cimmuto et al. 2014).

In conclusion, there are mixed findings on the relationship between demographics and recycling behaviour, and when synthesised there is no evidence that demographics may be used to predict recycling behaviour (Miafodzyeva and Brandt 2013). This may suggest that there exist other factors *cause* recycling behaviour, and that demographic characteristics should only be used in a descriptive manner.

2.1.2 Housing

In conjunction with the demographic characteristics we discussed in the previous section, housing should also be considered. Housing affects recycling behaviour in the sense that it constrains the options available to the end-consumer-turned-supplier regarding how to organise recycling within the boundaries of their own home. Such constraints may for example be the type (e.g. detached house or flat), size, and number of people making up a household. These factors have been found to influence sorting activity, as well as the perceived convenience of recycling (Bernstad 2014). Convenience may for example be the availability of adequate equipment for sorting behaviour (Bernstad 2014), as well as the perception of space available to carry out the sorting activity (e.g. storage space). These factors have been found to be positively related to the recycling rate (Ando and Gosselin 2005, Bernstad 2014).

Housing also affects so-called 'consumer logistics', which are the logistical solutions used by consumers to transport their waste from their home to a collection point (Monnot, Reniou, and Rouquet 2014). Three different types of consumer logistics solutions have been identified: pooling, just in time, and stockpiling. Pooling involves disposing of the waste at the same time as some other errand is carried out (e.g. shopping). The just-in-time strategy means that waste would be regularly transported to the collection point for disposal. Stockpiling involves storing waste at home until larger quantities can be taken to the collection point at once. When choosing their consumer logistics strategy, end-consumer-turned-suppliers consider both space available, as well as aversion to smell and dirtiness of waste (Monnot, Reniou, and Rouquet 2014). This implies that people living in small flats are more likely to choose a just-in-time strategy, as they have less space for storage than people living in large, detached houses.

In summary, housing seems to affect the behaviour of the end-consumer-turned-supplier, especially when it comes to perceived space available for recycling activities. In urban areas where families live in small flats with limited space for storing waste and low perceived convenience of recycling this could lead to poorer recycling behaviour (Ando and Gosselin 2005).

2.1.3 The role of motivation and knowledge

In conjunction with housing, motivation and knowledge have been found to affect recycling behaviour. Motivation is a "process which initiates, gives direction to, maintains, and determines intensity of behaviour" (translated from Kaufmann and Kaufmann 2009, 93). This implies that motivation is a necessary component in recycling behaviour. The fact that motivation is a *process* implies that it is less 'static' than a supplier's housing or demographic characteristics. This means it may be possible to change motivation, and thus change recycling behaviour, as opposed to changing socio demographics or type of housing.

The source of motivation may be internal or external. External motivation is affected by social norms which are "sets of beliefs about the behaviour of others" Cialdini (2003, 105). External motivation may also become internal motivation: Social norms may be internalised and thus become individual values and attitudes, which then become internal motivation factors. An indirect, positive relationship between individual values and recycling behaviour has been suggested, where values influence individuals' attitudes about convenience and importance of recycling, thus affecting actual recycling behaviour (McCarty and Shrum 1994, Knussen et al. 2004).

Together with internal motivation factors, lack of knowledge about what, where, and how to sort waste for recycling can also be an important barrier to action in recycling (Schultz 1999, Barr 2007). This coincides with the finding that the most commonly used intervention to improve recycling behaviour is the "dissemination of information" (Schultz, Oskamp, and Mainieri 1995). However, results of using knowledge-deficit information interventions with the aim of *improving* recycling behaviour are mixed, and most studies show weak effects (Schultz 1999). The implied assumption that if people become more knowledgeable about recycling they will recycle more does not hold. This may be due to several social psychological phenomena, including perception, dissonance, and denial, which may prevent a people from taking action even though they know they should recycle (Stoknes 2015). To close this gap between knowledge and action, one must overcome the psychological barriers that keep people from acting on the information they have, and also understand how behaviour change happens. The traditional view of behaviour change has followed this linear model: information → awareness → concern → action (Newton and Meyer 2013, 5), but there is also evidence suggesting that change happens from behaviour to belief (Stoknes 2015, 131). Changing recycling behaviour is in other words not straightforward, but "motivation appears to be a more powerful determinant of who will and will not recycle" than information (Schultz 1999, 26).

To conclude, it appears that using informational interventions to improve knowledge have weak effects on recycling behaviour, and that it is better to influence motivation (Schultz 1999). External motivation may be internalised as individual motivation. In particular, individual values have an indirect, positive effect on recycling behaviour (McCarty and Shrum 1994, Knussen et al. 2004).

2.2 Understanding the waste management system: a reverse logistics perspective

In addition to understanding the role of the end-consumer-turned-supplier and how demographics, housing, and motivation and knowledge may both constrain and facilitate recycling behaviour, there is also a need to understand the waste management system itself. This is because the system may either enable recycling or pose as a contextual barrier to action (c.f. Figure 2-2). This section will therefore present how waste management may be understood from a reverse logistics perspective. This includes the physical dimensions of the system, as well as system design and system performance.

Reverse logistics is the concept of moving products at their end-of-life from an end-consumer back to an upstream (Rogers and Tibben-Lembke 2001) or auxiliary supplier (Carter and Ellram 1998), thus closing the loop in the supply chain (Govindan, Soleimani, and Kannan 2015), which is needed in a circular economy (European Commission 2014). Reverse supply chains are also context specific (Fleischmann and Krikke 2000), and reverse logistics research has traditionally been focused on manufacturing (Krikke, le Blanc, and van de Velde 2004, He et al. 2016). Reverse logistics has been discussed in terms of product returns (Blumberg 1999) and recovery (Insanic and Gadde 2014) in general, and more specifically the automobile (Ravi and Shankar 2005) and retail industries (Tibben-Lembke and Rogers 2002). Several studies also discuss reverse logistics as part of a closed-loop supply chain (Govindan, Soleimani, and Kannan 2015), and this life-cycle perspective is also related to the return of product packaging (Rogers and Tibben-Lembke 2001), such as reusable containers (Kroon and Vrijens 1995). Reverse logistics for plastic recycling (Pohlen and Farris 1992), hospital waste (Ritchie et al. 2000) and household electrical appliances (Shih 2001) has also been discussed.

Only a few studies that have been published in what may be denoted 'core' SCM journals have looked at *household waste* management specifically from a reverse logistics perspective (Jalil et al. 2016). These have discussed household plastics recycling (Bing, Bloemhof-Ruwaard, and Vorst 2014), and household medicines (Xie and Breen 2014). More recent reverse logistics research looks at waste management through a reverse service supply chain lens (for an overview see e.g. He et al. 2016), for example in the context of second-life retailing (Beh et al. 2016). Moreover, a classification of public service supply chain management has been provided (Esain et al. 2016). Reverse logistics has also been discussed under different names in the literature.

Literature about reverse distribution (Flygansvær 2006, Flygansvær, Gadde, and Haugland 2008), reverse channels (Jahre 1995), reverse supply chains (Govindan, Soleimani, and Kannan 2015), and reverse logistics (Stock 1992, Carter and Ellram 1998, Srivastava 2007, Jalil 2015, Dowlatshahi 2000, Fleischmann et al. 1997, Rogers and Tibben-Lembke 2001, Jalil et al. 2016, Pokharel and Mutha 2009, Mutha and Pokharel 2009) all discuss the same concept of reverse logistics, and may be defined as:

> "[…] The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Rogers and Tibben-Lembke 2001).

The required return activities may be performed by new, auxiliary actors (Carter and Ellram 1998, 86), and the products are may therefore be returned to the original 'forward' suppliers (i.e. point of origin), as well as the auxiliary actors. These actors, as well as the processes and flows make up the physical dimension of the waste management system.

2.2.1 The physical dimension of a waste management system

This section will use the definition of reverse logistics as the point of departure to outline the physical dimension of a waste management system for household waste. From a reverse logistics perspective, this will therefore include looking at flows and processes, as well as the actors that carry out the return activities (Carter and Ellram 1998, Govindan, Soleimani, and Kannan 2015). The main actors are the end-consumer-turned-supplier and the waste management service provider. Third party actors may be hired to carry out tasks on behalf of the waste management service provider (Srivastava 2007).

In the literature about flows, there is generally no agreement about the relevant number and boundaries between flows (Flygansvær, Gadde, and Haugland 2008, 6). Material, or product, flow refers to the actual physical movement of a product throughout the supply chain (Rosenbloom 2012). Promotion flow refers to the flow of persuasive communication in the form of advertising, personal selling, sales promotion, and publicity (Rosenbloom 2012). Information flow refers to the transfer of information between actors in the supply chain. Information may flow between "every possible pair of channel members" (Coughlan et al. 2014, 10), and the flow of information may be seen as a separate flow (Rosenbloom 2012) with the ability to influence the efficiency and performance of all flows (Coughlan 2014). Together, the product, promotion, and information flows tie the supply chain actors together (Rosenbloom 2012) and make products or services available (Gripsrud, Jahre, and Persson 2006). The concept of flows captures that the functions and activities may be viewed as a continuous process performed by different actors across the supply chain (Coughlan et al. 2014).

In household waste management specifically, which may be defined as a service offered by a waste management service provider to the end-consumer-turned-supplier (Sampson 2000 cited in Jalil et al. 2016), the flows may be considered bi-directional (He et al. 2016). This means that information typically flows from the waste management service provider to the end-consumer-turned-supplier, and waste flows in the opposite direction, from the end-consumer-turned-supplier to the waste management agency.

In addition, to understand how the waste management system may affect the end-consumer-turned-supplier's recycling behaviour, it is also vital to grasp how the different elements of the system are connected. A forward product supply chain and reverse waste supply chain may be combined with the waste hierarchy to create a circular waste management system. As this thesis only deals with household waste that has already been generated (c.f. section 1.2), we focus on the lower four waste hierarchy options: reuse, materials recycling, energy recycling, and disposal. Figure 2-3 therefore illustrates a circular waste management system for household waste, as well as the different actors, processes, and flows that make up a circular waste management system, which is essential to creating a circular economy (European Commission 2008, 2014, 2015b).

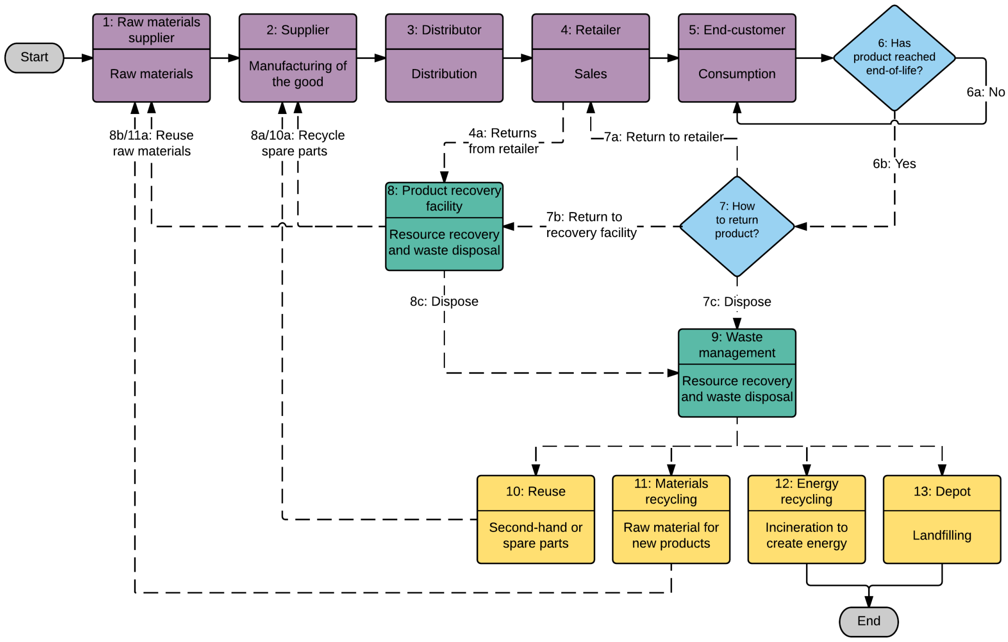


Figure 2-3: A circular waste management system combines the forward and reverse supply chain for waste management and resource recovery with the waste hierarchy. It illustrates the role of the end-consumer-turned-supplier in choosing the proper disposal of end-of-life goods (our depiction based on Tonanont et al. 2008 cited in Govindan et al. 2015, and Fleischmann et al. 1997, 12)

The forward supply chain (steps 1–5, in purple) illustrates the movement of a product from raw material supplier to the end-consumer-turned-supplier. When a product has reached its end-of-life (step 6b), the end-consumer-turned-supplier must choose how to dispose of the product (step 7), which means that the product is transferred to the reverse supply chain (green and yellow boxes). The product may for example be returned to a retailer (step 7a), to a product recovery facility (step 7b to step 8) or disposed of as waste (step 7c to step 9). Depending on the choice made, the product may either stay in the supply chain, thus contributing to a circular economy—or it may not. This is why the role and recycling behaviour of the end-consumer-turned-supplier is so important, because their decision provides the input to the system, and thus affects the performance (Jalil et al. 2016).

Furthermore, Figure 2-3 also takes the waste hierarchy into account (yellow boxes, steps 10–13). The goal is to manage waste as resources for reuse (step 10), materials recycling, and energy recycling, before resorting to the least preferred option: disposal in a landfill (European Commission 2008). The design of the waste management system itself will often influence how the waste is handled after the end-consumer-turned-supplier has made its choice, as the system itself may be set up for different combinations of reuse, materials recycling, energy recycling, or landfilling (European Commission 2014).

The product flow through the reverse supply chain also depends on the quality of the returned goods (Jahre 1995). This may be exemplified by the return of a product to a retailer (step 4). The product may either be resold again in its current state, or it may be returned to a product recovery facility (step 4a and 8). Once a product reaches the recovery facility, it may be recycled as spare parts (8a), recycled as raw materials (8b) or disposed of as waste (8c). A product disposed of as waste (steps 7c and 8c) will be channelled into a waste management facility (step 9), where it may be channelled into several flows, each representing different levels of the waste hierarchy.

When parts (8a) or raw materials (8b) are recovered, they may be resold for use in the original, similar or alternative markets for recovered products (Krikke, le Blanc, and van de Velde 2004). If the product is returned to the forward supply chain of an original or similar market, it becomes the same or a similar product. However, it may also be introduced to an alternative market, meaning the parts or raw materials will not be as the same product it originally was. One example is turning recycled plastic bottles into polyester fabric for use in fleece clothing (Patagonia 2016), as opposed to turning the bottles into new bottles. This process is an example of materials recycling (step 11). Materials recycling (step 11), as previously mentioned, involves transforming the waste into new products (step 11a). Energy recycling[2] (step 12) means using the waste as a source of energy. One example is the incineration of waste, where the heat generated is used to create electricity and hot water, which may be used for heating (European

[2] Energy recycling is shown as being an end-point to this process (step 12), but this is technically not the case. However, we have chosen to illustrate it in this way because energy itself may only be used once, and the resources are thus no longer part of the circular economy.

Commision 2010). Another example is the transformation of food waste into bio-fuels (European Commision 2010). The last step is landfilling (step 13), which does not allow for reuse of resources.

To summarize, information and product flows are bi-directional, and normally flows in opposite directions between the end-consumer-turned-supplier and the waste management service provider. We have outlined how the end-consumer-turned-supplier makes a choice regarding disposal, which affects the flow of product within the reverse supply chain of the waste management system. The waste hierarchy also plays a role in the physical dimension of the waste management system, and the level in which the waste is processed at (e.g. reuse of disposal) depends on how the system is designed.

2.2.2 Understanding waste management system design

This section will outline key elements to waste management system design, and how these may affect recycling behaviour, as the design may either constrain or enable action. Because reverse supply chains are context dependent (Fleischmann and Krikke 2000) this implies that there is no *one optimal* way to design a waste management system. Thus, there exists a different optimal network design depending on which level of the waste hierarchy is targeted (c.f. Figure 1.2). For example, a waste management system designed for waste disposal in a landfill will therefore be different from one designed for reuse and materials recycling (Carter and Ellram 1998).

If the aim is to collect waste for reuse or materials recycling, the waste will need to be separated into recyclable fractions at some point in time. This separation may either be done *by* the end-consumer-turned-supplier, or the waste may be separated post-collection (Jalil et al. 2016). Systems in which the end-consumer-turned-supplier separates the waste within the household prior to collection use the principle of 'speculation', while systems where co-mingled waste is separated post-collection use the principle of 'postponement' (Jahre 1995, Jalil et al. 2016, Bing, Bloemhof-Ruwaard, and Vorst 2014). As a consequence, the recycling rate of a system that relies on the end-consumer-turned-supplier for source separation of waste is inherently more dependent on their recycling behaviour than systems where co-mingled waste is collected (Jalil et al. 2016). Waste collection requires many-to-one transportation (Tibben-Lembke and Rogers 2002), and this creates so-called “collection complexity” (Jahre 1995), especially in systems with source separation of waste, as this means more fractions of waste need to be collected. In order to overcome this, source separated waste may be co-collected (Jahre 1995). An overview of municipal solid waste route planning problems have been reviewed by Belien, Boeck, and Ackere (2014).

Moreover, the distance from the household to the collection point is also used to classify different system designs into either kerbside or bring schemes based on the “average transport distance for the end-consumer-turned-supplier from point of consumption to point of collection and the number of households covered by one collection point” (Jahre 1995, 42). Most systems are a combination of the two. The collection points are closer to the end-consumer-turned-supplier in terms of distance in a kerbside scheme compared to collection points in a bring scheme, which is illustrated in Figure 2-4. It is also assumed that fewer people use each kerbside collection point. However, this does not apply in areas with high-rise buildings (e.g. apartment buildings and housing cooperatives), where a larger number of people will use each kerbside collection point compared to areas with single-family dwellings (detached or semi-detached houses).

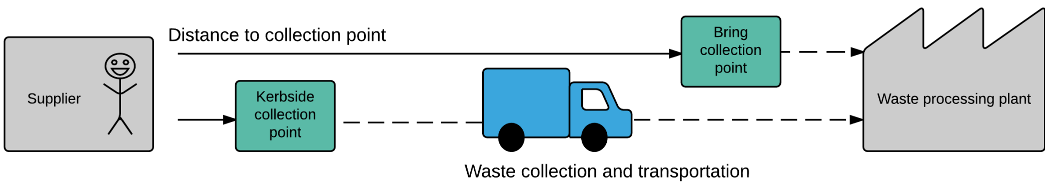


Figure 2-4: Kerbside and bring scheme illustration, where solid arrows represent distance required to travel by the end-consumer-turned-supplier and dashed arrows represent waste collection and transport by the waste management service provider.

In order to fully understand how the principles of reverse logistics and waste management system design may be used to affect recycling behaviour, one must understand how the role the end-consumer-turned-supplier affects the system. We consider the end-consumer-turned-supplier to be the input to the system. Because we also consider this actor to be a passive one, this is a cause of supply uncertainty in the system (Flygansvær 2006). There is supply uncertainty “both in terms of quantity and quality of used products returned by the [end-consumer-turned-suppliers]” (Fleischmann et al. 1997, 5). Since passive end-consumer-turned-suppliers must initiate return of a product at end-of-life, this also makes forecasting the supply of waste difficult (Tibben-Lembke and Rogers 2002). There is also seasonality in the supply patterns of different *types* of waste (Tibben-Lembke and Rogers 2002).

In addition, household waste management systems previously suffered from poor process visibility due to a lack of overview of the product entering the reverse supply chain (Hannan et al. 2015). This may be mitigated through the use of information and communication technology (see e.g. Simchi-Levi, Kaminsky, and Simchi-Levi 2009). Sensors might for example provide useful information about how full waste bins are, and RFID and barcodes may offer information about the location of waste bins and vehicles in the collection process (Hannan et al. 2015).

There is also uncertainty related to the resale of products and resources, in part due to variation in the quality of returned products (Jahre 1995). This can make negotiation with potential buyers of the returned products and resources less straightforward (Tibben-Lembke and Rogers 2002), and buyers wanting to buy the returned product may want to inspect it to ensure quality standards are satisfied. The quality of the product will also impact the pricing of the returned product, which may vary a lot, thus affecting overall system performance in terms of profitability (Tibben-Lembke and Rogers 2002, Dahlén et al. 2007). Ensuring quality of the waste will therefore be a concern for waste management service providers (European Commission 2014).

Traditionally, reverse supply chain coordination has been discussed through a commercial lens, as it involved taking product back from the original market to the original supplier (Guide, Harrison, and Van wassenhove 2003, Krikke, le Blanc, and van de Velde 2004, Mutha and Pokharel 2009). Today however, the creation of a circular economy means that the coordination of several markets is required (Srivastava 2007, European Commission 2015b). Coordination mechanisms for product flows may be related to value creation logic, which depends on the chosen level of analysis (Flygansvær, Gadde, and Haugland 2008, Thompson 1967). Coordination mechanisms, for example contracts, should align incentives to ensure both "control and motivation", and determining the correct coordination mechanism depends on heterogeneity of the end-consumer-turned-suppliers, as well as their behaviour (Flygansvær, Gadde, and Haugland 2008, 9). Contracts may be hierarchical, incentive or norm-based (Flygansvær, Gadde, and Haugland 2008), and contracts which involves revenue-sharing were found to increase overall supply chain profitability in the PC-industry (Govindan and Popiuc 2014), but did not take the end-consumer-turned-supplier into account. Efficiently managed and coordinated flows should lead to "superior system performance" in the form of increased service user satisfaction and decreased costs (Flygansvær, Gadde, and Haugland 2008, 5).

In conclusion, the method of separation and collection are central elements of waste management system design. Source separation systems depend the most on the end-consumer-turned-supplier, and their passive role is one origin of supply uncertainty. Moreover, transportation, process visibility, and coordination are possible issues that should be taken into account when designing a waste management system. Waste management system design may either create contextual barriers to action or enable good recycling behaviour, and this also affects performance.

2.2.3 System performance

There are several ways to define the performance of a waste management system. One way is to define the performance of a waste management system as the percentage of waste that is either reused or materials recycled in the system (European Commission 2014). This is the system's 'recycling rate', which is affected by supplier recycling behaviour: The higher the recycling rate, the better the system performance. In addition, waste management systems are also subject to reverse logistics performance measures such as cost and service level.

Costs in reverse logistics are related to the transportation, collection, treatment, and storage, and various optimization models in terms of reducing total reverse logistics costs have been proposed (Hu, Sheu, and Huang 2002, Dat et al. 2012, Diabat et al. 2013, Aras et al. 2015). These models have looked at material flow, number and location of collection points, and number of return centres. Waste management system cost also depends on type of system. A source separation system will have lower sorting cost for the service provider, but shifts the cost of sorting onto the end-consumer-turned-suppliers, which are not compensated for this (Yau 2010). A source-separation system will also have higher collection and transportation cost than a system that collects co-mingled waste unless the source-separated waste is co-collected (Jahre, 1995). Co-collection of source-separated waste will minimize both sorting and transportation cost for the waste management service provider (Jahre 1995).

Typically, customer service in waste management is related to frequency of collection and location of collection points. It may therefore also be considered a characteristic of the system. One study has compared different types of collection systems (i.e. kerbside vs. bring schemes), and found that kerbside schemes lead to better quality and quantity of recyclables (Dahlén et al. 2007). Increasing service levels through increasing the frequency of collection of recyclables while simultaneously decreasing the frequency of collection of residual waste has been found to improve recycling rates (Goorhuis et al. 2012, Williams and Cole 2013). Even though improved service may increase the costs of the system, this may be financed by the lower cost of waste processing (Goorhuis et al. 2012). However, it should be noted that this is only possible in systems without co-collection of recyclable waste.

To conclude, performance may either be related to cost, service level, or recycling rate. This thesis deals with performance in terms of recycling rates, and this requires a change in recycling behaviour.

2.3 Changing recycling behaviour

As we have outlined, the key to understanding recycling behaviour may be found in understanding the role of the end-consumer-turned-supplier, as well as understanding the waste management system from a reverse logistics perspective. The end-consumer-turned-supplier provides the input to the overall waste management system, and performance becomes a function of recycling behaviour. There also exists a gap between intentions and action, and the characteristics we have outlined may either facilitate or constrain recycling behaviour. So how may the actual recycling behaviour of the end-consumer-turned-supplier be changed?

Motivation is considered an influential determinant for the end-consumer-turned-supplier's participation in recycling (Schultz 1999), and our review of the literature revealed that monetary incentives, social norms, and nudging should be considered.

2.3.1 Monetary incentives

The evidence regarding whether monetary incentives, such as pay-as-you-throw and volume-based billing schemes, are effective in getting households to participate in waste recycling is contradicting (Miafodzyeva and Brandt 2013). On one hand, a household survey found respondents had a higher willingness to recycle if rewarded or penalized (Bennet, Savani, and Ali-Choudhury 2008). This is consistent with a study that found the introduction of unit-based pricing had a significant effect on recycling behaviour in the Netherlands, although this study only looked at monetary incentives, and only controlled for "environmental altruism" (Dijkgraaf and Gradus 2004). Reward schemes have also been found to have a positive influence on bring scheme site usage (Williams and Taylor 2004). There is also significant positive relationship between rewards schemes and the per-household weight of recyclables collected, holding other things constant (Yau 2010).

On the other hand, an experiment testing the usage of a reward scheme, found that only 13% of participating household cited the reward scheme as the main motivator for waste recycling (Timlett and Williams 2008). In addition, the effect of a coupon scheme on promotion of aluminium recycling found that even though the recycling frequency of those already recycling improved, monetary incentives did not convert those who did not recycle into participating (Allen, Davis, and Soskin 1993).

Relying on economic reward strategies may only produce short-lived changes in behaviour, which usually returns to baseline levels when the reward period is ended (Schultz, Oskamp, and Mainieri 1995). Rewards may also undermine internal benefit from recycling behaviour (Schultz, Oskamp, and Mainieri 1995), which is supported by a longitudinal field experiment comparing two intervention programs: one focusing on providing information versus one focusing on positive group reward incentives (Iyer and Kashyap 2007). Both programs were found to be effective, but over time the reward incentive program's effect on recycling behaviour diminished relative to that of the information program. After the reward incentive program ended the recycling rates worsened to levels that were worse than before the program was initiated, which is consistent with Schultz et al. (2007). This suggests that financial incentives do not influence internal motivational drivers of recycling behaviour, whereas information does (Iyer and Kashyap 2007).

To summarize, it appears that the use of monetary incentives has a limited, short time effect on improving recycling behaviour. When taken away, behaviour has been found to return to baseline levels–and sometime the recycling rates are even worse. It thus appears that it may be more fruitful to pursue some other motivational factors than monetary incentives in order to change recycling behaviour.

2.3.2 Activation of social norms

One other factor that may be liked to positive changes in recycling behaviour is the activation of social norms (Miafodzyeva and Brandt 2013), which we outlined was a source of motivation. According to Cialdini (2003, 105) "it is widely recognised that communicators that activate social norms can be effective in producing socially beneficial conduct". However, to avoid the 'boomerang effect' of a normative message having the opposite effect to what was intended, it is important to combine descriptive and injunctive social norms (Allcott 2011, Schultz et al. 2007). Descriptive norms describe the prevalence of something (i.e. what other people are doing), and injunctive norms convey social approval or disapproval (i.e. what other people think should be done). The two types of norms should be combined because descriptive norms alone only communicate how frequent something bad is happening. This sends the underlying message to people that already abstain from the undesirable behaviour that many people actually *are* doing this undesirable thing—so why should you continue to? For example, if someone who already recycles their waste is sent information that states that people are bad at recycling (which is a descriptive norm), this sends the message that not many other people recycle—so why should you? This is supported by Schultz (1999), who found that individuals already engaging in the desired behaviour experienced a boomerang effect when descriptive norms only were activated. Therefore, communication should not focus on messages that convey an activity as "socially disapproved, but widespread" (Cialdini 2003, 108).

When descriptive messages are aligned with injunctive norms, the message has been found to prevent the 'boomerang effect', and it has real persuasive efforts among participants not already engaging in the behaviour, (Schultz et al. 2007). Cialdini (2003) found that a combination of descriptive and injunctive norms significantly influenced intentions to recycle. However, this should not be directly interpreted to also imply an increase in actual recycling because of the intention-action gap (Newton and Meyer 2013).

Moreover, several studies have been conducted with the aim of using social norms to promote environmentally friendly behaviour, such as energy conservation (Barr 2007, 470), reuse of towels in hotel rooms (Ayres 2012, Allcott 2011), littering (Goldstein, Cialdini, and Griskevicius 2008), and household recycling (Cialdini 2003). Schultz (1999) and his team observed the recycling behaviour of 605 residents of single-family dwellings for a period of 17 weeks to investigate whether normative feedback interventions could close the intention-action gap. Messages conveying either personal norms (i.e. "feelings of obligation to act in a particular manner in specific situations" (Schultz 1999, 25) or social norms were found to have a significant effect on participation in the recycling scheme and on amount of waste recycled. On the other hand, no significant change was found in 'contamination', i.e. waste that has not been sorted correctly. In conclusion, there is evidence that supports the use of normative feedback to alter behaviour in a recycling setting (Schultz 1999).

As we have now outlined, the activation of social norms has been shown to improve recycling behaviour. A combination of descriptive and injunctive norms is needed, because this will avoid the boomerang effect. Normative feedback has been found effective in improving recycling *participation*, but in decreasing levels of contamination within fractions. The activation of social norms is normally attempted through the use of informational campaigns or written communication.

2.3.3 Nudging

Another way to activate social norms is through something called nudging. A nudge may be defined as “any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives” (Thaler and Sunstein 2009, 6). Nudges are not mandates, and for something to count as a nudge, the intervention must also be easy and cheap to avoid. For example, this means that placing fruit and vegetables at eye level in a grocery shop counts as nudge towards healthy eating, but banning unhealthy food does not (Thaler and Sunstein 2009).

Nudging builds on the principle that our choices depend not only on things like price and technical information, but even more on *how* choices are presented to us (Stoknes 2015). There are several ways to nudge: One method involves making desired choices the default option, such as organ donation consent (Johnson and Goldstein 2003) or double-sided printing (Egebark and Ekström 2016). Another way to nudge is through social influence; a social nudge appeals to peoples’ tendency to conform to what others are doing (Thaler and Sunstein 2009, 54). In this sense, written materials that seek to activate social norms may also be considered a way of nudging. In addition, peer pressure also plays a role in exerting social influence, because people take their social cues about what is considered acceptable behaviour from others. “Choice architects can [therefore] make major improvements to the lives of others by designing user-friendly environments” (Thaler and Sunstein 2009, 11).

Making the right choice should also be simple because “when life is crammed, time-demanding to-dos slip downward on our priority lists” (Stoknes 2015, 124), and most people have other things to think about than the environment. This logic may be applied to household waste recycling, and this implies that waste management systems should be designed in such a way that it makes it easy for people to recycle their waste, as “green action should not demand too much extra effort” (Stoknes 2015, 125). The design of a waste management system may thus represent a nudge toward improving recycling behaviour and recycling rates. This is especially relevant because of the passive role of the end-consumer-turned-supplier, and as a consequence the waste management systems must be designed to “compensate for the end-users lack of incentive” to correctly dispose of their waste (Flygansvær 2006). However, very little has been written about nudging in a waste management context, and this is thus a gap in the literature.

In conclusion, nudging appears to be an effective way to guide the end-consumer-turned-supplier towards improved recycling behaviour. The nudging may be done either through distribution of information, which will also activate social norms, or through system design. Using a nudge to improve recycling behaviour in a household waste management context is also a gap in the current literature.

2.4 Summary

Through this chapter we have reviewed literature with the aim of better understanding recycling behaviour. To achieve this, we aimed to understand the role of the end-consumer-turned-supplier and the waste management system itself. We identified that there is a gap in the literature in terms of research that looks at household waste management from a reverse logistics perspective. More specifically, there is a lack of research that considers the importance of the end-consumer-turned-supplier while taking the intention-action gap into account. In addition, the use of nudging as a tool to improve this behaviour is also an area in need of more research.

The theory we have revised revealed that the end-consumer-turned-supplier's intended recycling behaviour tends to be higher than actual behaviour. There are also certain characteristics of the end-consumer-turned-supplier, such as motivation, that may be influenced in order to improve recycling behaviour. These may also be called individual constraints, and these may also facilitate action. Furthermore, the end-consumer-turned-supplier has been shown to be an important actor of the household waste management system, which is part of a reverse supply chain. This system also has certain characteristics, which may be denoted as contextual constraints or enablers to behaviour. Thus, the end-consumer-turned-supplier and the system both affect recycling behaviour, and thus system performance.

The relationship between these supplier and system characteristics and their influence on recycling behaviour and performance together make up the conceptual framework used in this thesis, which will be outlined in detail in the next chapter. The conceptual framework is illustrated in Figure 2-5.

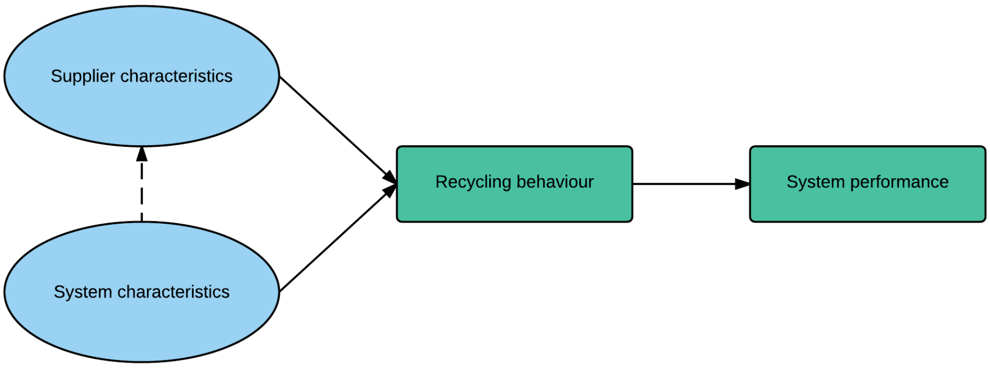


Figure 2-5: The conceptual framework, simple illustration.

3. Conceptual framework for understanding supplier behaviour

In the previous chapter we identified two main concepts that may affect recycling behaviour: 'supplier characteristics' and 'system characteristics'. These characteristics capture several dimensions that impact recycling behaviour, which determines overall system performance. The relationship between these components form the basis for the conceptual framework used to understand recycling behaviour in this thesis. This chapter will present a detailed version of the conceptual framework, which will then be used to derive the hypotheses we will test in order to answer our overall research question.

3.1 The general conceptual framework

In the theoretical background, we explored the relationship between demographics, housing, and knowledge and motivation and recycling behaviour. These are the basis for the 'supplier characteristics'. It was found that demographics could not accurately predict recycling behaviour. Nevertheless, information regarding factors such as age, gender, income, education, and cultural background should still be gathered, as new information may emerge. In addition, housing was found to affect perceived convenience and consumer logistics, which affect recycling behaviour. This may also be indirectly affected by a change in system characteristics (see dotted arrow line in Figure 3-1). It may therefore not be directly observable. Monetary incentives were found to have a weak and sometimes negative impact on actual recycling behaviour. Although knowledge seems to be a weak predictor for recycling behaviour, it may still play some role. Motivation through activation of social norms seemed to have the highest impact on recycling behaviour.

The 'system characteristics' aim to capture how the design of a waste management system may affect recycling behaviour. In particular, there is evidence to suggest that moving a fraction from the bring scheme to the kerbside scheme may improve recycling behaviour. This is in essence to reduce the distance to the collection point. Furthermore, access to equipment has been seemed to have an effect on recycling behaviour. This may be related to convenience and consumer logistics, which is why there is an indirect relationship shown in Figure 3-1. Service level in terms of pick-up frequency is also related to recycling behaviour.

Both supplier and system characteristics affect recycling behaviour, and thus system performance. Performance may either be recycling rate, cost, or service level. However, as discussed in the introduction, since the goal in a circular economy is to keep the resources in the supply chain for as long as possible, we will only look at the recycling rate. This is also in line with the goals of the European Union (European Commission 2015b). The conceptual framework is illustrated in Figure 3-1:

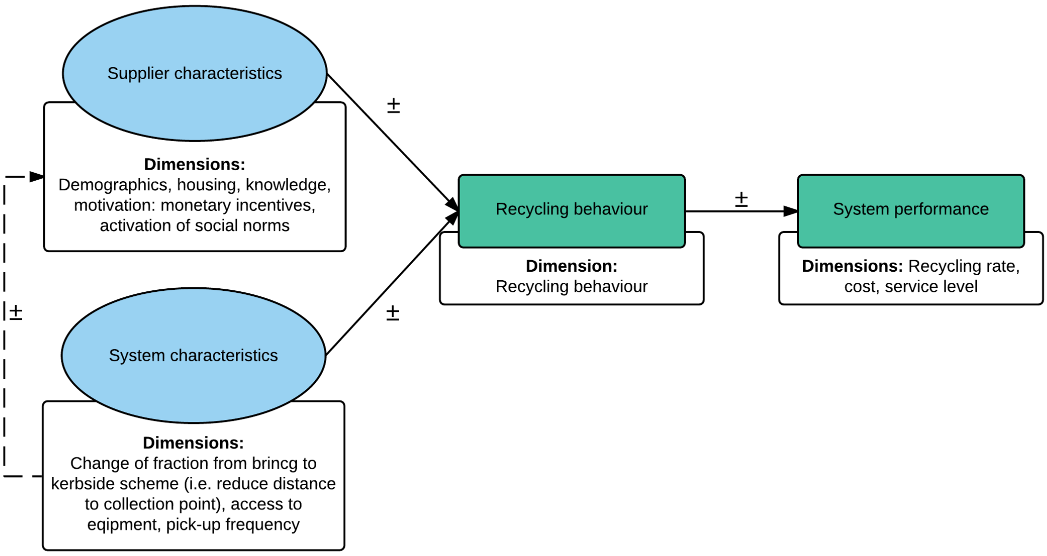


Figure 3-1: Detailed version of the analytical framework

3.2 Hypotheses

The relationship between these concepts needs to be understood in more detail. The definition of recycling rate indicates that there is a positive co-variation between recycling behaviour and recycling rate, which implies that if we want to improve the recycling rate, we need to improve recycling behaviour. To improve recycling behaviour, there are several dimensions that can be targeted. When a dimension acts as a facilitator, it improves behaviour. When it constrains it, recycling behaviour worsens. It is therefore pivotal to understand how and when the different dimensions act as facilitators, and not constraints, of recycling behaviour. This is not as straightforward as looking at the co-variation alone. For example, when monetary incentives increased this resulted in poorer recycling behaviour and lower recycling rates, meaning that an *increase* in monetary incentives *constrained* recycling behaviour (Iyer and Kashyap 2007). However, when motivation *increased*, this has been found to improve recycling behaviour, which implies an increase in this dimension facilitates recycling behaviour. We have therefore derived the following two hypotheses to test our research question:

> ***H1:*** *System performance improves when supplier characteristics facilitate recycling behaviour.*
>
> ***H2:*** *System performance improves when system characteristics facilitate recycling behaviour.*

These hypotheses will be operationalized in the methodology chapter.

3.3 Summary

The conceptual framework illustrates the relationship between supplier and system characteristics. In this thesis, assume there is a positive co-variation between recycling behaviour and recycling rate. We have derived two hypotheses that will be tested in order to answer the overall research question.

4. Empirical setting: Waste management in Oslo

This chapter will provide an overview of the empirical setting for our study in accordance with our conceptual framework. We will therefore outline the system characteristics of the waste management system in Oslo municipality, and the supplier characteristics of the households using this system. The specific empirical setting for our study will be Stovner district, and we will therefore compare the supplier characteristics of Oslo and Stovner to highlight any similarities and differences.

4.1 Supplier characteristics in Oslo

In this section, we will present an overview of the demographics, housing types, recycling behaviour and intentions that characterise the suppliers of household waste (i.e. the inhabitants) in Oslo municipality and Stovner district.

4.1.1 Demographics of Oslo

The demographics of Oslo and Stovner district are summarized in Table 4-1:

Demographics	Oslo	Stovner district
Population	658 390	32 153 (4.8% of Oslo)
Gender (male vs. female)	49.88% vs. 50.12%	50.71% vs. 49.29%
Children aged 0–18 years	19.66%	24.31%
Inhabitants > 55 years	21.75%	25.33%
Higher education ≥ 4 years	49%	23.6%
Immigrant background	33%	51%
Number of countries represented	223	142
Median income	702 000	631 800

Table 4-1: Summary of demographics in Oslo versus Stovner district.

In general, Oslo with its 658 390 inhabitants has a well-educated population being a university city (SSB 2015). Overall, almost half of the inhabitants in Oslo have higher university education, but in Stovner district this number is only 23.6%. There are also more children between 0–18 years old, and inhabitants older than 55 years old in Stovner. Inhabitants with an immigrant background make up 33% of Oslo's total population (SSB 2016), of which 25% are immigrants, and 8% are Norwegian-born with immigrant parents. Of Stovner's 31 300 inhabitants, 51%

has an immigrant background, where 65% are immigrants, and 35% are Norwegian-born with immigrant parents (Wiggen et al. 2015). The immigrants are considered well established, with half of the immigrants living in Stovner for more than 15 years.

The median income is generally lower in Stovner district compared to Oslo (Wiggen et al. 2015). In 2012, the median income in Stovner was 90% of the income level in Oslo (Wiggen et al. 2015, 87). And of the inhabitants in Stovner, those with immigrant background have an even lower median income compared to the general income level in the district.

4.1.2 Housing

The similarities and differences in housing are summarized in Table 4-2:

Housing	Oslo	Stovner district
Type of housing:		
Detached	9.7%	13.6%
Semi-detached	6.6%	8.8%
Townhouse	9.8%	15.5%
Apartment	71.8%	61.9%
1-person households	52.9%	39.3%
≥ 3 person households	23.6%	34.6%
Home ownership	69.2%	79.6%
Car disposal	48.9%	60%

Table 4-2: Summary of housing statistics in Oslo versus Stovner district.

In Oslo, 71.8% of the inhabitants live in apartments (SSB 2013). This is also most common in Stovner district (with 61.9%). Of the households in Oslo, 52.9% consist of only one person (SSB 2012a). Households consisting of three or more people constitute 23.6% of the households. In Stovner district, only 39.3% are one-person households, whereas 34.6% of the households consist of three persons or more.

Even though home-ownership is less common in Oslo compared to the rest of the country, there are still 69.2% which own their home (SSB 2012b). In Stovner district, this number is slightly higher with 79.6%. When it comes to having a car for disposal, in 2011, only half (48.9%) of the households in Oslo had a car for their disposal (SSB 2012c). In Stovner, this number is slightly higher with three out of five households (60%) having a car for their disposal.

4.1.3 Current recycling behaviour and intentions

For several years the goal of Oslo municipality has been to material recycle 50% of waste (Kommunerevisjonen 2015, Renovasjonsetaten 2016a). Since the introduction of plastic and food waste recycling in 2009–2012, there has been an increase in material recycling from 29% in 2009 to 37% in 2014. In 2015, 38% of the total food waste and 30% of the total plastic waste was sorted into green and blue bags. However, based on calculations by the Agency of Waste Management, the goal of 50% material recycling will not be reached with the current system. In residual waste, 70% of waste is waste that can be material recycled (Renovasjonsetaten 2016a). This is mostly food waste, but also paper and cardboard, plastic, glass and metal.

The Agency for Waste Management yearly performs user surveys. In the latest user survey, 8 out of 10 respondents, both in Oslo in general and Stovner district, find recycling important (Respons Analyse 2015). In addition, they also answer that they sort and recycle their waste. Depending on the type of waste fraction, the self-reported recycling behaviour is between 85–97%. The self-reported recycling behaviour in Oslo and Stovner district for the respective waste fractions, as well as attitude towards recycling, is summarized in Table 4-3.

Self-reported recycling behaviour	Oslo	Stovner district
Paper and cardboard	97%	96%
Bottles with refund	95%	92%
Glass and metal	90%	92%
Plastic	88%	94%
Food waste	87%	93%
EE waste	86%	87%
Hazardous waste	87%	85%
“Recycling is important”	8 of 10 agree	8 of 10 agree

Table 4-3: Summary of self-reported recycling behaviour in Oslo versus Stovner district.

4.2 System characteristics: Waste management in Oslo

This section we will provide an overview of how household waste management is handled in Oslo municipality. The role of the Agency for Waste Management will be outlined, before an outline of Oslo' waste management system will be presented. Oslo's proposed new strategy for waste management will then be introduced.

4.2.1 Agency for Waste Management

The Agency for Waste Management is responsible for managing and developing the waste management system in Oslo municipality (Kommunerevisjonen 2015, Oslo kommune 2016b). As an agency, they are supposed to execute the goals and strategies set by the municipality. Responsibilities include designing and developing service offerings in the waste management system, procuring and organizing services from suppliers, and promoting, providing information, and developing knowledge about service offerings to the households of Oslo.

4.2.2 Type of system

The waste management system in Oslo is a source separation system, where the end-consumer-turned-suppliers and their households are obliged to sort the waste into fractions at their homes. Different types of household waste are divided between a kerbside collection scheme and bring scheme (Renovasjonsetaten 2016a). Plastic waste, food waste, and residual waste, as well as paper and cardboard belong to the kerbside scheme, whereas textiles, glass and metal, garden waste, EE waste, hazardous waste, and bulky waste belong to the bring scheme.

All households have at least one container for paper and cardboard waste, and a residual waste container at their kerbside collection site (Renovasjonsetaten 2016a). The end-consumer-turned-supplier's dispose of three fractions in the residual waste container: Food waste sorted into green plastic bags, plastic waste sorted into blue bags, and residual waste sorted into ordinary white shopping bags. The green and blue bags can be picked up for free at grocery stores, whereas the white shopping bag usually needs to be paid for. The bags in the residual waste container are then collected and transported either Haraldrud or Klemetsrud recycling facilities for optical sorting based on their colouring. This means Oslo co-collects source separated waste for further separation. After being sorted, the residual waste will be incinerated and turned into heat for the population of Oslo, whereas the green and blue bags will be sent to material recovery (Oslo kommune 2016a). The food waste in the green bags will be transformed into environmental friendly fuel, biogas, which the busses of Oslo are using, or bio fertilizer, which is used by farmers. The plastic in the green bags are being transformed into new plastic packaging.

The bring scheme consists of both permanent and mobile collection sites (Renovasjonsetaten 2016a). The permanent sites include collection sites for glass and metal, textiles, hazardous waste, and products for reuse. Hazardous waste and products for reuse can also be collected through mobile collection sites. This also applies for EE waste and Christmas trees. Glass and metal, gardening waste, and textiles are being sent to material recycling to become new glass, metal, or soil products. EE waste, bulky waste and hazardous waste is sent to materials recycling, energy recycling through heat generation, or depot or destruction depending on the condition. Products for reuse are, rather obviously, being reused (Renovasjonsetaten 2016a).

At the end of 2015, Oslo had almost 900 permanent collection sites with glass and metal containers (Renovasjonsetaten 2016a). This means that 90% of the inhabitants in Oslo live within 300 meters of the closest glass and metal collection point. The distance to textile collection containers is a bit longer, since textile collection containers are only available at 250 collection sites. In addition, Oslo has 40 independent collection sites where households can deliver hazardous waste, and three large, eight small, and two mobile reuse sites where households can deliver bulky waste and products for reuse. The mobile collection sites where the households can deliver hazardous waste, EE waste and Christmas trees consist of over 1000 sites.

Blue, green, and white bags in the residual waste container are collected once a week (Oslo kommune 2012). The frequency of collection of paper and cardboard depends on size of container and number of households belonging to the container (Renovasjonsetaten 2012), but it is collected as often or less often than residual waste. Glass and metal containers are usually collected every fourth week. The collection of textiles is unknown, since non-governmental organizations (such as UFF and Fretex) are responsible for them. The hazardous waste, EE waste and Christmas trees collected through the mobile collection sites are collected once a year, whereas reuse products collected through the mobile reuse-sites are collected weekly.

The households also have to pay a fee for the waste management service. The fees size depends on the size of the container and its location (Renovasjonsetaten 2016b). Over a 5-year period, the fees in Oslo have increased by nearly 60% (Østgårdsgjelten et al. 2015). In housing cooperatives this fee will be incorporated into the overall operating expenses, which means the fee is less explicit.

The Agency for Waste Management in Oslo attempts to influence the end-consumer-turned-suppliers to sort their waste through various promotional and informational activities, as well as quality and performance assessments at the household level (Kommunerevisjonen 2015). This includes websites, doorstepping, informational campaigns visible in the public sphere, social media campaigns, information letters distributed to households (i.e. sorting guides), educational programmes for school aged children, as well as guided tours at the sorting facilities.

4.3 New strategy: “Join the circle”

In the spring of 2016, Oslo municipality and the Agency for Waste Management proposed a new strategy called “Join the circle” (English translation of: “Bli med rundt”) for waste management in Oslo municipality towards 2025 (Renovasjonsetaten 2016a). In this strategy, the goal is for Oslo to be a world-leading environmentally friendly city, to focus strongly on sustaining resources and further develop a cycle-based waste management system, and to be a front-runner when it comes to the development of a circular economy.

In terms of household waste, the strategy aims to reduce the amount of residual waste (which goes to energy recycling and depot) by 30% within 2025 compared to 2015 levels (Renovasjonsetaten 2016a, 15-16). In addition, at least 60% of household food waste and plastic waste should be material recycled within 2025.

All hazardous and EE waste should be sorted and delivered for proper treatment. To get inhabitants of Oslo to use the waste management solutions, their goal is that 95% of inhabitants should trust that waste is recycled or reused, and a minimum of 80% of inhabitants should find it easy to sort waste in Oslo.

To achieve these goals, a strategy with a focus on the needs of the end-consumer-turned-supplier, as well as adjustment to housing type as part of their service provisioning is enhanced (Renovasjonsetaten 2016a, 62). This strategy aims to address the diversity of the city in terms of people and housing types. Glass and metal collection services are explicitly mentioned as services that may be adapted to housing type and the needs of end-consumer-turned-suppliers.

4.4 Summary

This chapter has presented the empirical setting of this thesis: the household waste management system in Oslo municipality and Stovner district. The end-consumer-turned-suppliers in Stovner district distinguish themselves demographically from the suppliers in Oslo municipality. However, the self-assessed recycling behaviour is similar in Stovner and Oslo, with 85%–97% claiming that they sort and recycle the various waste fractions.

The household waste management system in Oslo is a source-separation system with both a kerbside and bring scheme, where some waste is co-collected. The distance to bring scheme collection points varies, but most households have glass and metal containers within 300 meters of their home. The Agency for Waste Management in Oslo Municipality has proposed a new strategy towards 2025 where meeting the needs of the end-consumer-turned-suppliers and adaptation to housing types is enhanced as possible strategies to achieve a higher recycling rate.

5. Methodology

This chapter presents the methodology of this thesis. We will first outline our philosophical views, as this has influenced our choice of research strategy and design, along with the unit of analysis. The research design will then be discussed in more detail, before we outline the data collection methods used. We will then discuss the quality of the research, before we end with a discussion of ethical issues.

5.1 Philosophical view of the researchers

In this study, the waste management system is considered something tangible that can be designed and re-designed to influence the recycling behaviour of the end-consumer-turned-suppliers. This is in line with an objectivist ontological view that "asserts that social phenomena have an existence that is independent of social actors" (Bryman and Bell 2011, 21). The waste management system is a social phenomenon in the sense that it was created by a social actor (i.e. the waste management service provider), and it acts upon other social actors (e.g. the end-consumer-turned-suppliers). At the same time, the system also exists independently of the actors, and we argue the system acts both as a constraint and as a facilitator on recycling behaviour (the system also affects the suppliers, not just the other way around).

We also view supplier characteristics as something tangible, and we argue that the identified supplier characteristics of demographics, housing and knowledge may easily be measured in objective terms. We argue that it is possible to observe the supplier characteristic of motivation through the end-consumer-turned-supplier's recycling behaviour, and that recycling behaviour can be objectively measured through our senses with the recycling rate. We thus take a positivist epistemological position, which supports the usage of natural science principles to the study of social reality (Bryman and Bell 2011, 15), and that we can use our senses to confirm or reject our hypotheses, and to arrive at knowledge.

5.2 Research strategy and choice of design

As the overall aim of this thesis is to investigate how reverse logistics can contribute to improve recycling behaviour, we needed a research strategy that allowed us to test this. In line with our philosophical view, we found a deductive strategy fitting to answer this research question. A deductive strategy allows us to assess existing theory regarding end-consumer-turned-supplier behaviour and reverse logistics in a waste management context, and to examine whether these hold in an empirical setting.

When choosing an appropriate research design, we had to take the research question, conceptual framework and hypotheses, as well as the empirical setting into account. Because we wanted to investigate the *effect* a change in either system or supplier characteristics may have on actual recycling behaviour, we found that an experimental design was fitting. Due to the empirical setting available, we had to use a quasi-experimental design. A quasi-experiment is similar to a classical experiment in the sense that it allows of exploration of causality, but it fails to satisfy all the internal validity requirements of a true experiment (Bryman and Bell 2011).

Furthermore, it is worth mentioning that in practice our research was not strictly linear in its deductive approach. This was mostly due to practical concerns, especially in terms of operationalization. We sometimes found that even though theory recommended some interventions to improve recycling behaviour, they were not feasible in practice (e.g. due to funding restraints or regulatory concerns). In sum, both the theoretical and empirical setting imposed some constraints on our research design, and it also influenced the unit of analysis.

5.3 Unit of analysis

In terms of unit of analysis, the norm in business logistics, which may also be assumed valid for reverse logistics, is to frame the study within a managerial perspective or that of a focal organisation (Gripsrud, Jahre, and Persson 2006), which in this case would lead to employing the waste management service provider as the unit of analysis.

In our thesis, such a narrow focus would lead to suboptimal solutions, as this ignores the importance of designing a waste management system with *both* the service provider and end-consumer-turned-supplier's preferences in mind (Jalil et al. 2016). Because the end-consumer-turned-supplier also provides the input to the system, this further underpins the logic of simultaneously looking at both the individual and the system. The consequence is a two-dimensional unit of analysis in this thesis: The individual and the system. This is also reflected in the use of supplier and system characteristics in the conceptual framework, and this was also why we used an experimental design in this thesis.

5.4 Designing a quasi-experiment

This section will outline the quasi-experimental design of this thesis in more detail, which was influenced by both the theoretical background and empirical setting. A quasi-experiment is similar to a classical experiment in the sense that it allows for exploration of causality, which is important to understand how supplier and system characteristics influence recycling behaviour. However, it does not afford the same level of control over variables due to the context in which such experiments are carried out (Shadish, Cook, and Campbell 2002). One example is the lack of random sampling. This threatens internal validity, which creates ambiguity in the source and direction of causality (Bryman and Bell 2011). This means that we must carefully design our experiment to allow us to infer if the supplier and system characteristics we wish to influence are the source of any observed changes in recycling behaviour.

We therefore carried out a quasi-experiment that used an untreated control group along with dependent pre-test and post-test samples (Shadish, Cook, and Campbell 2002, Chapter 5). The design is illustrated in Table 5-1.

	Pre-test	**Intervention**	**Post-test 1**	**Post-test 2**
Experimental group	Waste analysis	*Intervention*	Waste analysis	Questionnaire
Control group	Waste analysis	*No intervention*	Waste analysis	Questionnaire
Investigating	Action			Intention

Table 5-1: Quasi-experimental design

The design enabled us to measure both actual and intended recycling behaviour. The pre-test and post-test analyses of waste allowed for comparison of actual recycling behaviour both between and across the groups to see if the intervention had any effect. In addition, we administered a questionnaire to both groups, as this would allow us to investigate intentions, as well as rule out potential sources of variation other than the intervention. Before we elaborate on the design and data collection methods used to analyse waste and collect data about intentions, it is important to understand how our design was constrained by the waste management system in Oslo, as well as by the chosen sample. These aspects, known as 'sampling' and 'operationalization', will therefore be discussed in more detail in the following sections.

5.4.1 Sampling

One feature of a quasi-experiment is that samples are non-random, thus making the experimental and control groups non-equivalent by definition. It may therefore be assumed that some selection bias will be present in the sample (Shadish, Cook, and Campbell 2002, 138). In order to mitigate selection bias, the sample must be carefully selected. Otherwise, any observed change may be due to some pre-existing difference in the samples, and not due to our intervention. We therefore had to carefully identify sampling criteria, which were related to demographics and housing, cross-contamination of waste between groups, and recycling behaviour. We have summarized the possible sources of sampling bias and ways to mitigate the bias in Table 5-2.

Selection bias dimension	Sampling selection criteria
Demographics and housing different between groups	Demographics and housing is similar from start
Cross-contamination between groups	Ensure cross-contamination not likely by choosing sample with beneficial configuration of collection points
Recycling behaviour different from start	Pre-test waste analysis to enable baseline comparison

Table 5-2: Sampling criteria

A large housing cooperative was identified as a suitable sample. The housing cooperative happened to be located in Stovner district in Oslo municipality, and we found that the overall demographic characteristics of the housing cooperative appear to be similar to those of Stovner. Using a housing cooperative would also ensure that demographics and housing were similar for the experimental and control groups. In the housing cooperative, there is a mix of one-person households, families with and without children, and retired persons. Approximately 50% have an immigrant background, and most households own their flat (as opposed to renting).

Furthermore, we had to take into account the lack of research looking at actual recycling behaviour in urban areas, particularly in areas with high-rise buildings (c.f. Chapter 2). The housing cooperative in our sample comprises 17 four-story buildings with 328 apartments. The high-rise buildings consist of four floors with an equal division between two-bedroom and three-bedroom apartments, housing approximately 1000 people in total. The experimental group consisted of 96 households, compared to 80 in the control group, which is 53% of all households in the housing cooperative. The layout of the housing cooperative is illustrated in Figure 5-1.

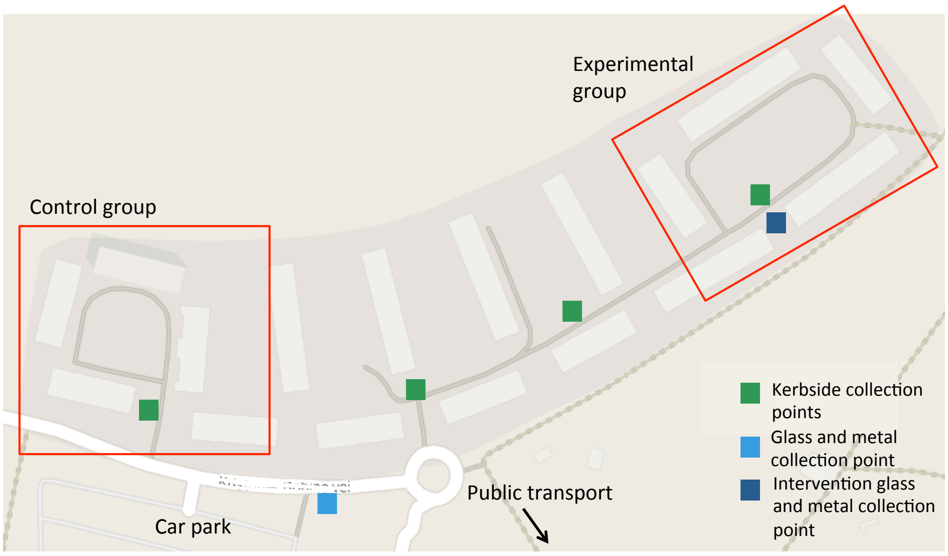


Figure 5-1: Overview of control group and experimental group, as well as distribution of collection points, including intervention glass and metal collection point.

As illustrated in Figure 5-1, the housing cooperative has four kerbside collection points. Each collection point consists of one waste container for paper and cardboard, and two for residual waste in white bags, food waste in green bags and plastic waste in blue bags. Each container has a volume of 5000 litres. Waste is collected once a week, with residual waste collection on Thursdays, and paper and cardboard on Tuesdays. The existing bring scheme glass and metal collection point was placed next to the car park (pale blue box, Figure 5-1). Glass and metal is collected monthly on Tuesdays. The housing cooperative also has an agreement with a private waste collection company about annual "spring cleaning". This company collects and sorts bulky waste, EE-waste, textiles, and hazardous waste, which the end-consumer-turned-suppliers place on their kerbside.

In order to ensure the validity of our results, we needed to make sure we could claim with relative certainty that the waste we would analyse actually came from the households within the experimental and control groups, respectively. We therefore had to choose the control and experimental group in such a way that the risk of cross-contamination between groups was low. Observation of the inhabitants also revealed that a common consumer logistics strategy appeared to be pooling waste disposal in with other errands. This meant that we had to locate the groups so that the risk of households using other collection points than the closest one for disposal of waste was low. We therefore located the control and experimental groups on opposite ends of the housing cooperative to ensure that participants used 'their' collection point, and that the risk of cross-contamination was minimized.

We also needed to identify any pre-existing differences in recycling behaviour between the two groups. The pre-test waste analysis made it possible to investigate the magnitude of such a bias, and allowed us to establish a baseline. Despite taking all these measures, it should also be noted that the "absence of pre-test differences in a quasi-experiment is never proof that selection bias is absent" (Shadish, Cook, and Campbell 2002, 138). This means that any pre-test differences may be caused by some other unmeasured variable(s) unrelated to selection bias. The sample we chose also influenced the operationalization of our conceptual framework.

5.4.2 Operationalization: Making concepts measurable

In order to test our hypotheses through our quasi-experiment, we had to devise ways to *measure* the concepts in these hypotheses in real-life. The first step was to identify the dimensions that would best represent the system and supplier characteristics, recycling behaviour and performance in the given empirical setting.

We started by identifying *what* to measure, meaning the dependent variables: Recycling behaviour and performance. We did not use cost or service as an indicator of performance, because recycling rate is the performance indicator consistent with the circular economy perspective. In Chapter 2, the recycling behaviour of the end-consumer-turned-supplier was also defined as the recycling rate of the individual, which means that recycling rate may measure both individual and system performance. The independent variables were chosen based on the empirical setting and theoretical findings, and are: Housing, activation of social norms, change in fractions from bring to kerbside scheme, and access to equipment. The rest of the supplier and system dimensions remained fixed in this experiment. This is illustrated in Figure 5-2.

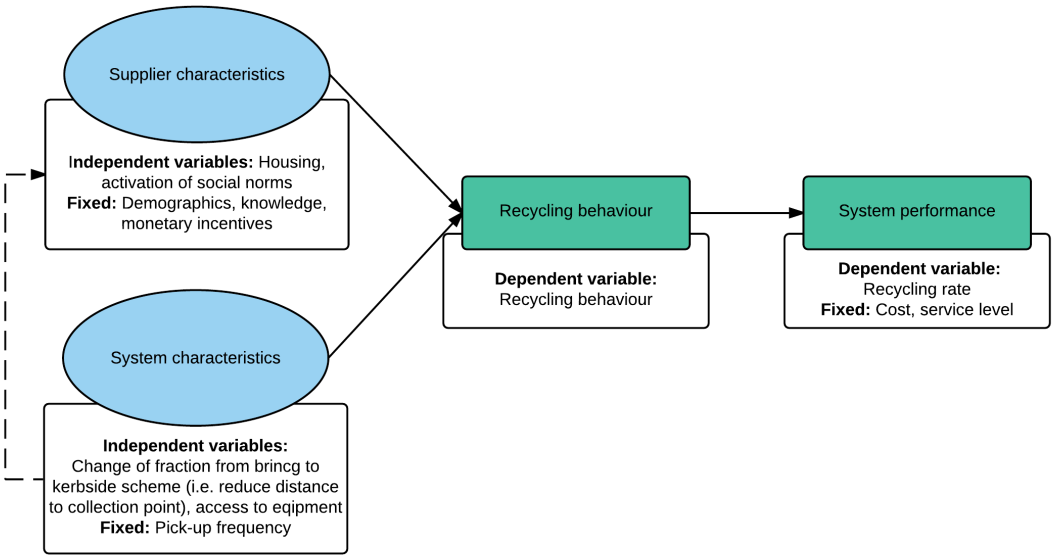


Figure 5-2: The conceptual framework (Figure 3-1) showing independent and dependent variables, along with fixed dimensions of supplier and system characteristics.

The experimental group interventions had to affect the independent variables, thus affecting the recycling behaviour and recycling rate. Previously, we found that nudging appears to be an efficient way of achieving this. In combination, this lead to the following operationalization, which is summarized in Table 5-3.

Variable	Characteristic	Dimension and sub-dimensions		Indicator/measurement
Dependent variable	**System performance**	Recycling rate		Weight of a sorted fraction as a percentage of weight of total waste. Measured as wt.% (weight-percentage).
	Recycling behaviour			
Independent variables	**Supplier characteristic**	Housing	Consumer logistics	Lag in fill-rate of glass and metal container due to change in consumer logistics strategy
			Convenience	Indirectly affected by access to equipment
		Motivati on	Activation of social norms	Willingness to sort different fractions, measured through self-reported recycling behaviour. Observation of food waste in residual waste and in green bags
	System characteristic	Change of fraction from bring to kerbside scheme	Move glass and metal fraction from bring to kerbside scheme (Reduce distance)	Measure glass and metal in residual waste and fill-rate of new collection point
		Access to equipme nt	Hand out blue, green, and red bags for residual waste. Hand out reusable bag for glass and metal.	Count number of red bags used, as well as contaminated blue and green bags. Indirect effect: see Convenience
Fixed	**System performance**	Cost		Total system cost
		Service level		Pick-up frequency
	Supplier characteristic	Demo-graphics	Age, income, education, ethic background etc.	See section 5.5.2 for details
		Housing		Type, size, number of residents in each household
		Knowledge		What households think happen to the waste they sort
		Motivation	Monetary incentives	Size of recycling fee (in NOK per year)
	System characteristic	Pick-up frequency		Number of pick-ups per week per fraction

Table 5-3: Operationalization indicators and measurements for the chosen independent, dependent and fixed dimensions of supplier and system characteristics in the conceptual framework (Figure 5-3). Some dimensions have several sub-dimensions, such as motivation (activation of social norms, monetary incentives).

The interventions that the experimental group was subjected to were the following:

1. Informational letter containing a nudge to activate social norms that target food waste recycling behaviour
2. System nudge through reduced distance to glass and metal collection point
3. System nudge through access to free waste bags for food, plastic and residual waste, and reusable glass and metal bag

The purpose of the first intervention was to **test H1**. As outlined in the theoretical background, an informational nudge appears to be one way to affect motivation through the activation of social norms. Food waste was chosen as the fraction to target because it was an area with room for improvement, according to prior waste analyses (Mepex Consult AS 2015). Additionally, as food waste already belonged to the kerbside scheme, it was not possible to further optimize the system design by reducing the distance in this case. We combined a descriptive and injunctive norms (Cialdini 2003) into the following statement:

> *Did you know that 8 out of 10 of your neighbours separate their food waste into green bags?* **(Descriptive norm)** *Food waste is an important resource that is used to produce biogas and bio fertilizer. Even if you only have a small amount of food waste, it is important to use a green bag.* **(Injunctive norm)**

The second and third nudge was designed to **test H2**. The second intervention involved moving glass and metal from the bring scheme to the kerbside scheme. This fraction was also chosen on the basis of prior analyses, and also because glass and metal in the residual waste could destroy the waste bags—thus making the recycling effort of other end-consumer-turned-suppliers pointless. Prior to the intervention, both groups used a glass and metal collection point that was next to the car park. The intervention involved placing a new glass and metal collection point near the experimental group’s existing kerbside collection point. The distance between the groups’ respective kerbside collection points and the glass and metal container is listed in Table 5-4.

	Pre-test distance	Post-test distance	Change
Experimental group	230 m	6 m	−224 m
Control group	120 m	120 m	No change

Table 5-4: Distance to glass and metal collection point(s) before and after the intervention.

The third intervention was a consequence of the first two. As lack of equipment was identified in the literature as a potential barrier to action we had to ensure all participants in the experimental group had access to equipment needed to recycle food waste and glass and metal. We therefore wanted to distribute green bags and reusable bags for glass and metal. Prior analyses also revealed a certain degree of residual waste contamination in the blue and green bags (Mepex Consult AS 2015), and we therefore distributed both blue and green bags, as well as new red bags for residual waste. The purpose was to reduce contamination through improving access to bags, and thus improving perceived convenience among the end-consumer-turned-suppliers. This was also the purpose of distributing the reusable glass and metal bags. Together, the second and third interventions may count as system nudges (Stoknes 2015) that will increase the convenience for the consumers (see e.g. Perrin and Barton 2001, Miafodzyeva and Brandt 2013).

Through doorstepping, we distributed the intervention as a bundle to the end-consumer-turned-suppliers in the experimental group. An informational letter stated the purpose of the study, and also briefly explained the three interventions (Appendix A). The letter also contained the food waste nudge. It was distributed along with the waste bags and a standard sorting guide. All households in Oslo should already know of this sorting guide. Figure 5-3 illustrates this.

Figure 5-3: Material that was distributed to the experimental group during the intervention. Reusable glass and metal bag (left), and informational letter, sorting guide, and waste bags, (right).

In sum, this thesis used a quasi-experimental design with an experimental and control group chosen from the same housing cooperative. We have described how the sample was selected, as well as how the empirical setting and theoretical findings affected the operationalization of the conceptual framework. We also described the interventions that were designed to test the two hypotheses we derived to test our research question. The quasi-experimental design used a pre-test and post-test waste analysis to investigate actual recycling behaviour through the use of recycling rates, and additional data regarding intention and demographics was gathered using a second post-test questionnaire. The waste analysis was conducted through the use of a pick-analysis, which will be described in more detail—as a pick analysis is also a method for data collection.

5.5 Data collection methods

The quasi-experimental design we outlined in the previous section required two main sources of primary data: 1) Data regarding actual recycling behaviour from a pick analysis, and 2) Data regarding intentions and demographics from a questionnaire. This section will therefore first describe the methods used to obtain this data, before outlining sources and methods used to collect supportive primary data and secondary data. This data was used to validate and support our design.

5.5.1 Waste analysis: Conducting a pick analysis

The purpose of the waste analysis was to investigate actual recycling behaviour, and we conducted a pre-test and post-test pick-analysis to obtain the data required. A pick-analysis involves manually sorting waste into separate fractions (e.g. residual waste into recyclable and non-recyclable fractions) (Mepex Consult AS 2015). The recycling rate is most measured as weight-percentage (wt.%), which is the weight of the different fractions relative to the overall amount of waste collected (Mepex Consult AS 2015). This is an indicator of recycling behaviour. Two pick-analyses were conducted in this study, and the timeline followed the experimental design (c.f. Table 5-1). For both groups, waste was picked up from the same collection point container at the same time on both occasions. This was verified by one of the researchers who participated in the waste collection. The timeline is illustrated in Table 5-5.

Week	Experiment timeline						
	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
1			Pre-test pick analysis: Collect and sort waste from experimental and control group				
2			**Intervention**				
3	Week 3 to allow for intervention to be absorbed						
	Picked up unclaimed materials left at door			Waste collection outside experiment			
4			Post-test pick analysis: Collect and sort waste from experimental and control group				

Table 5-5: Overview of experiment timeline. The collection for pre- and post-test pick analyses occurred on the same weekday from the same collection points.

As the intervention targeted food waste, glass and metal, as well as access to equipment, we had to carry out an analysis of the residual waste bags to separate the mixed waste into fractions. In addition we performed a simpler analysis of the content in the green and blue waste bags to check for level of contamination. This is the waste that is co-collected from the residual waste containers.

To ensure the quality of our pick-analysis and gain experience, we spent one day observing and participating in the annual pick analysis conducted by the Agency for Waste Management (Figure 5-4). During this day, we learned how to set up a pick-analysis to analyse residual waste, and blue and green bags, and what kind of equipment was needed for the analysis. We learnt the processes involved in performing a pick analysis, from types of analysis needed, how to cut up the residual waste bags and separate them into waste fractions, how to weigh the waste fractions, and also how to document the waste composition with pictures. This was later used to perform the simpler analysis of the blue and green bags. We also gained an understanding of the time and effort it would take to perform a pick-analysis, and thus how much waste we would be able to analyse given our timeframe.

Figure 5-4: Observation and participation of Agency for Waste Management's annual pick-analysis. Waste load analysed (left), waste separation activities (middle), and set-up (right).

In the detailed residual waste analysis, waste fractions were separated into the same fractions the households in Oslo are obliged to sort their waste into. The fractions we used also allowed the effect of the interventions to be measured. Waste was sorted into the following 12 fractions: usable food waste, non-usable food waste, recyclable plastic, paper and cardboard, textiles, gardening waste, glass and metal, plastic bags used for waste disposal, bulky waste (other glass and metal, polystyrene, wood, other plastic), hazardous waste, EE-waste, and residual waste (See Appendix B for details). The purpose of the fraction called "plastic bags used for waste disposal" was to make sure the weight-numbers added up. Due to time constraints, the fractions we were not going to target were grouped into larger fractions than those used in the pick-analysis we observed. One example is the "bulky waste" fraction, which is more detailed in Oslo's annual pick-analysis. During analysis of the data, we looked at change within the respective waste fractions, instead of the change in share of overall amount of waste (e.g. change within the food waste fraction, not change in food waste as a percentage of overall waste). This was because we were interested in the change over time *between* the two groups, as this result would not be affected by pre-test differences.

In sum, the set-up and methodology of the residual waste pick-analysis (see Appendix C) followed that of the Agency for Waste Management. When the **waste was collected (Step 0),** we followed the same approach for both analyses of the control and experimental groups, which was as follows:

Step 1: Initial sorting. Blue and green bags were separated from residual waste bags, and all waste was stored in 660-litre containers according to fraction (Figure 5-5). The containers were then weighed to measure the starting quantities of waste. These containers had also been weighed while empty, which allowed us to measure the net weight of waste, so that we could be sure we had analysed all the waste when comparing the combined weight of the different fractions with the starting weight. All 660-litre containers were marked with numbers and group identifier.

Figure 5-5: The waste load before initial sorting (left) and after initial sorting (right) where blue and green bags are separated from the residual waste bags. In the background, we can see the 660l containers used for storage of the waste.

Step 2: Residual waste analysis. Each residual waste bag was cut open, and the contents were sorted into the different fractions, before we weighed each fraction separately (Figure 5-6). The scales we rented were the same scales that were used in the annual pick analysis performed for the Agency of Waste Management, and it was calibrated annually. The buckets and containers used during sorting of the waste were marked with name of the waste fraction, so that waste would not accidentally be sorted into the wrong fraction. Both the Agency for Waste Management's sorting guide (Appendix D) and a more comprehensive list of waste fraction examples (Appendix B) were available for crosschecking if we were uncertain about which fraction the waste should be sorted as. Waste was swept up from the sorting table and floor regularly, to ensure all waste was sorted. The weight of sorted fractions was written down immediately after weighing, and both researches were present when waste was weighed to ensure the correct number was written down.

Figure 5-6: Example of a residual waste bag cut open during the residual waste analysis (left). All of the residual waste bags where sorted into their respective waste fractions (right).

<u>**Step 3: Analysis of blue and green bags.**</u> Because we were interested in the degree of contamination of the waste in these bags, we performed a simpler analysis. The blue and green bags were inspected visually, and each bags was "squeezed" to feel if they contained anything other than plastic waste or food waste, as this was easy to feel without cutting the bags open. Bags were separated into "clean" and "contaminated" bags, and these fractions were then weighed separately (Figure 5-7). The bags that we believed to be contaminated due to containing heavier or harder material than food or plastic were then set aside and cut open. If they proved to consist of material not belonging to the waste fraction, they were taken picture of and counted.

Figure 5-7: Contaminated blue (left) and green (right) bags lined up on table. This is from the pre-test pick-analysis of the experimental group.

It should also be mentioned that during the first pick analysis we experienced a discrepancy between the starting and ending net weight of residual waste, which was due to placing the scales on a non-level surface. The discrepancies were still within acceptable levels (Mepex Consult AS 2015), but to correct this in the second pick-analysis, a levelling tool was used to ensure that the scales were horizontal.

5.5.2 Questionnaire design and distribution

As the pick-analysis investigated actual recycling behaviour, we had to use a different method of data collection to investigate intention and collect additional data. This would allow for comparison between the experimental and control groups. We therefore handed out a postal questionnaire (Appendix E) to the households in the experimental and control groups, and the following section will outline the questionnaire was designed and administered.

The purpose of the questionnaire was to obtain additional primary data to improve internal validity of the quasi-experiment. The questionnaire consisted of eleven questions about recycling behaviour, and eleven demographic questions, and was designed with an easily comprehensible and understandable language to encourage participation. The language was of special concern, since we knew that 50% of housing cooperative households had an immigrant background and might not understand Norwegian that well. To ensure the questionnaire was easy to understand, it was successfully piloted on a sample of bachelor and graduate students.

We measured satisfaction with overall and home system satisfaction, and respondents were welcome to add qualitative comments. The purpose was to identify possible barriers to convenience. We also assessed the level of knowledge to make sure a knowledge deficit could not be the reason for lack of recycling. The knowledge question was derived from a study with similar methodology (Milford, Øvrum, and Helgesen 2015).

Self-reported actual recycling behaviour and motivation for recycling behaviour were derived from (Barr 2007). Ten items were selected from the items listed in the sorting guide that the Agency for Waste Management sends out to households in Oslo. To measure self-reported action, the respondents were asked *how often* they recycled the items. Motivation for recycling was measured by asking respondents *how willing* they were to recycle these items. The purpose of these questions was to investigate if there existed a self-reported intention-action gap, which may indicate the existence of some barrier to recycling. To avoid respondents observing the similarity of these questions and thus repeating their responses, the order of the items were different in the two questions, and the questions were also placed on different pages.

To assess the effect of the informational nudge about food waste, we tapped into two constructs: The first asked the respondents whether they believed their neighbours were better at sorting their waste. The second question asked the respondent to assess how much of the waste they believed their neighbour was sorting. We also asked about the quantity of food waste sorted, and barriers of not sorting all food waste.

The respondents were also asked to assess their usage of the glass and metal container over the last six weeks. The purpose of this question was to reveal if a possible observed change in glass and metal recycling behaviour could have other potential causes than the reduced distance to the collection point.

The second part of the questionnaire gathered demographic information about the respondents. The categories chosen for the variables were based on official statistics from Statistics Norway and a survey administered to waste management service users in Oslo (Respons Analyse 2015). We collected information about gender, age, level of education, income, and country origin. Public transport and car access was also asked about. To identify possible barriers related to the household inhabitants, two sub-questions were asked: Number of household members, and number of children in the household. For example, several children in a small apartment may indicate that the focus of that household is something other than recycling (Stoknes 2015). This logic also underpins the other demographic questions.

The questionnaires were distributed directly in the respondents' post boxes, as this would save time. Each questionnaire had a unique number, which allowed us to trace the door-stepping interaction with the experimental group. Collection was done through return-envelopes on site. The timeline for distribution and collection is illustrated in Table 5-6.

Week	**Experiment timeline - continued**						
	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
6				Distribute questionnaire			
7					**Collection and reminder**		
8				Final collection			

Table 5-6: Distribution and collection of questionnaires, and weeks denote the continued timeline of overall experiment, as the questionnaire is the second post-test.

5.5.3 Supportive primary data and secondary data

This section will briefly outline how semi-structured interviews, meetings with expert informants, and site visits and observation were used to validate the design and understanding of the empirical setting. Qualitative research was therefore used to facilitate our quantitative research (Bryman and Bell 2011, 634).

When a suitable housing cooperative had been identified, this was confirmed through a site visit and meeting with a representative from the housing cooperative. We were informed of the demographic composition of the household, issues with collection points. Afterwards we walked around to get a visual picture of the housing cooperative, its waste containers and location.

We also met with representatives for the Agency for Waste Management several times. The first meeting in autumn 2016 provided us with an overview of the flows and characteristics of the waste management system in Oslo. The final choice of schedule and interventions also had to be agreed upon. During a meeting to explain and validate our design from a practical perspective, the type of interventions became a heavily discussed topic. It should therefore be mentioned that there were some politics involved that lead to the focus on food waste: As it is the fraction that weighs the most, it thus has the greatest impact on recycling rate KPIs that are based on weight percentages, and any improvement in food waste recycling rate will lead to performance improvement. Some interventions were also deemed unfeasible in the empirical setting, either because of legal or technical constraints.

The final step taken to ensure the quality of the quasi-experimental design was the have it validated by a PhD student. The conceptual framework, the choice of interventions and group location was discussed, as well as the choice to conduct the questionnaire as a second post-test to avoid the Hawthorne effect (Bryman and Bell 2011).

Furthermore, secondary data was used to gain an understanding of the empirical setting. These sources were both internal and public company reports. Public documents and official statistics were studied to give an in-depth overview of the experimental context we outlined in Chapter 4.

A summary of the all data sources and collection methods used is provided in Table 5-7.

Type of data	Data collection method
Primary data	Pick analysis
	Questionnaire
Supportive primary data	Semi-structured interviews, meetings with expert informants, site visits
Secondary data	Internal company reports - Survey of Oslo households' attitudes towards recycling 2015 - Pick analysis report 2015 - Pick analysis raw data and preliminary report 2016
	Public company reports - "Join us around" – proposal for new waste management strategy for Oslo towards 2025
	Official statistics (SSB)

Table 5-7: Source of data and collection methods

5.6 Quality of the research

The previous sections have outlined the design and data collection methods used in this thesis. This section will describe and discuss how quality of the research can be ensured in terms of validity, reliability and replication.

5.6.1 Validity

Validity refers to the "approximate truth of an inference" (Shadish, Cook, and Campbell 2002, 34), and it is common to distinguish between internal and external validity (Ghauri and Grønhaug 2010). For experimental designs, construct validity should also be considered (Shadish, Cook, and Campbell 2002).

Internal validity refers to whether the *cause* of a change that occurred during an experiment was the experimental intervention or some confounding variable. It may be defined as: "the validity of inferences about whether observed co-variation between A (the presumed treatment) and B (the presumed outcome) reflects a causal relationship from A to B as those variables were manipulated or measured" (Shadish, Cook, and Campbell 2002, 38). Causality is hard to prove due to the empirical setting of quasi-experiments, but internal validity may be improved with careful design (Shadish, Cook, and Campbell 2002, 61-62).

One issue is the previously mentioned lack of random sampling, which leads to the presence of selection bias (c.f. Table 5-2). The pre-test pick analysis was conducted to identify pre-test differences in recycling behaviour. Demographic characteristics were assessed through the questionnaire. The risk of cross-contamination was minimized by the use to a housing cooperative with a favourable location of collection points. However, as Shadish, Cook, and Campbell (2002, 40;62) point out, many threats towards validity cannot be prevented by design features alone as it is impossible to control every variable in real life.

As a result, the identification and assessment of threats to internal validity to rule out alternative interpretations and explanation of causal relationships, the focus was on identifying *possible* threats that are *plausible*. Plausible threats depend on the empirical setting of an experiment, as well as the observed experimental outcome (Shadish, Cook, and Campbell 2002, 139). The experimental outcome may typically be biased by selection-maturation, selection-instrumentation, and selection-history (Shadish, Cook, and Campbell 2002, 142-143).

If respondents in “one group are growing more experienced, tired, or bored than respondents in another group” (Shadish, Cook, and Campbell 2002, 138), this is known as selection-maturation. To avoid this, we kept our interactions with the experimental group brief during the doorstepping, and we also kept any information as brief as possible without omitting details. Selection-instrumentation threat is present when “groups begin at different points on the pre-test” (Shadish, Cook, and Campbell 2002, 138), and selection-history is the possibility that an event occurred between pre-test and post-test that affected on group more than the other (Shadish, Cook, and Campbell 2002, 139). The pre-test pick analysis helped identify these biases.

However, when internal validity improves, this may involve lowering external validity (Shadish, Cook, and Campbell 2002). External validity concerns generalization of persons, experiment setting and time to other persons, settings and times (Shadish, Cook, and Campbell 2002, 37). External validity therefore concerns inferences of whether a causal relationship holds over variations (but this is not synonymous with *broader* application). When internal validity is improved, this therefore means that the ability to generalize the results is weakened. Such generalization is normally done through statistical application, and this is difficult with quasi-experiments, since situations with random selection and assignments are rare (Shadish, Cook, and Campbell 2002). The measures taken to improve external validity included reviewing existing theory to provide reasoning as to the why and how of causal relationships, which resulted in the conceptual framework. In addition, the use of official statistics showed surface similarity between the city, district and housing cooperative.

Another aspect related to generalization is construct validity. Construct validity may be defined as “whether or not a measure that is devised of a concept really does reflect the concept that it is supposed to be denoting” (Bryman and Bell 2011, 42). Examples of concepts used in this thesis are ‘supplier characteristics’, ‘system characteristics’, ‘recycling behaviour’ and ‘performance’. The operationalization was underpinned by theory, and the measures had been used in prior studies (c.f. Table 5-3). This approach also helped ensure that the indicators and measurements used in the specific empirical setting reflected the higher order concepts they were supposed to represent (Shadish, Cook, and Campbell 2002, 20).

Moreover, construct validity is not limited to the measurement of experimental outcomes, but also include measurement and characterization of features such as persons, settings and interventions (Shadish, Cook, and Campbell 2002, 65). We therefore had avoid being to general or too specific in our descriptions, and when we also used respondent validation to make sure our understanding of an expert opinion or explanation of a setting was accurate. Another threat is not identifying all constructs or identifying the wrong ones, which was why all articles were read by both researchers. Lastly, construct validity may be threatened by using only one construct operationalization or only one method (Shadish, Cook, and Campbell 2002, 73). This was mitigated by the use of several methods for data collection. One weakness may the use of recycling rate as an indicator of performance. Cost or service level may also indicate performance, but the singular focus is justified by the circular economy and recycling behaviour approach used in this thesis. Measuring the recycling rate as weight-percentage (wt.%) also has its limitations, despite being the most common way to measure recycling rate and recycling behaviour (see e.g. Bernstad 2014, Rousta et al. 2015, Dai et al. 2015). This is because the weight-percentage does not take into account the volume of the waste, and the measurement may therefore be biased because some fractions weigh more than others.

In addition, the experiment situation in itself may be a threat to construct validity as it may influence participants to “provide results the researchers want to see” (Shadish, Cook, and Campbell 2002, 78). Participants may be influenced by for example altruism or obedience to comply, or they may also be apprehensive about being evaluated. This had to be taken into account when doorstepping, and the hit rate and response rate were tracked and analysed to reveal possible bias in the results. Moreover, the experimenter may unintentionally convey cues about “desirable responses” which may influence the participants (Shadish, Cook, and Campbell 2002, 73). To mitigate this effect, the pick analysis was carried out at one of the Agency of Waste Management’s reuse sites, located far away from the housing cooperative. This meant that the end-consumer-turned-supplier would not know that we were measuring actual recycling behaviour, as participants may have altered their behaviour if they had known. We also limited researcher-participant interaction in general, and any information provided was standardized across groups.

5.6.2 Reliability

In the previous section it was described how construct validity refers to whether or not a concept or measure actually measures what it is supposed to measure. Reliability is related to the consistency of said measurements and indicators, and includes both stability of the measure over time, as well as inter-observer consistency (Bryman and Bell 2011, 155-157).

Stability refers to whether there is a change in responses over time (Bryman and Bell 2011, 155-156). To ensure stability in “responses”, which in this quasi-experiment means recycling behaviour, we conducted the post-test pick analysis a short while after the intervention took place. In this way, we were able to limit possible external sources of variation that could impact the response.

Inter-observer consistency concerns research in which the observer is required to make subjective decisions regarding the categories in which data are going to be translated into (Bryman and Bell 2011, 158-159). This is especially an issue if multiple observers are involved in this decision-making, and the pick-analysis posed the greatest threat to inter-observer consistency in this thesis.

This was because two researchers had to make decisions in terms of which fraction to categorise waste into (e.g. if slightly wet/dirty plastic should go in plastic or residual waste—was it wet/dirty *before* it went into the residual waste, or was it wet due to being in the residual waste?). To ensure these decisions were consistent, three precautionary measures were taken: 1) Both researchers observed and participated in the annual Agency for Waste Management pick analysis. 2) We had access to a list of waste fraction examples to crosscheck the proper fraction if we were uncertain or disagreed (see Appendix B), and 3) It was agreed beforehand that waste that was difficult to separate would be classified as the fraction towards which the item contributed the most. For example, ketchup bottles full of ketchup would be classified as useable food waste, whereas a ketchup bottle almost empty would be classified as plastic packaging. We also limited researcher-participant interaction, and any information provided was standardized across groups to avoid self-fulfilling prophecies.

Lastly, the post-coding of open-ended questionnaire responses into broader classifications was also a possible threat to inter-observer consistency, as well as construct validity. In order to mitigate this, both researchers did the post-coding.

5.6.3 Replicability

Replication is very similar to the concept of reliability, but where reliability refers to the possibility of achieving the same *result* in another study, replicability concerns the possibility of carrying out the study on a *different occasion* (Bryman and Bell 2011, 41). To make it possible to replicate our study, we have therefore documented our design and data collection methods to the best of our ability. Documentation was done through the writing down of procedures and by taking pictures during data collection.

The quality of the research, including threats to validity, reliability and replicability has now been discussed. Because a quasi-experiment was carried out, it is important to outline and discuss possible ethical concerns.

5.7 Ethical issues

There are some ethical concerns that need to be discussed and mitigated with regards to the proper conduct of the quasi-experiment in this thesis. This section will outline how we dealt with concerns regarding potential harm to participants, lack of informed consent, privacy, and deception, as well as data management.

5.7.1 Potential harm to participants

Researchers are required to minimize potential harm to participants (Shadish, Cook, and Campbell 2002, 281, Bryman and Bell 2011, 128). This also includes harm to participants' self-esteem (Diener and Crandall, 1978 cited in Bryman and Bell 2011).

One potential source of harm to participants is that participants in the experimental group may experience feelings of embarrassment if they feel they are 'caught' not recycling because of the nudge we used in our communication. This may harm their self-esteem. In reality, we expect the risk of this happening to be quite low, as all participants should *already* know they are *required* to recycle their waste. Another important point is that the idea using activation of social norms to change behaviour is to induce a feeling of 'unpleasantness' because the established norms are not followed. We therefore believe the end (i.e. improving recycling behaviour by encouraging people to do what is already required of them through conducting our study) justifies the means (i.e. taking the risk that the 'nudged' participants may be embarrassed when they feel 'caught' not recycling). In order to further minimize this risk, we also avoided asking participants if they recycle or not when we handed out equipment as part of our intervention.

5.7.2 Informed consent

Informed consent could not be obtained from the experimental and control group prior to the pick-analysis because this could severely skew our results due awareness of being tested (Bryman and Bell 2011, 281). Such an effect would damage the results, as we did not want respondents to recycle more than they normally would just because they knew they were being observed. We did get consent to perform the analysis from the director of the housing cooperative.

Informed consent *was* obtained from questionnaire respondents. The questionnaire was prefaced with an information sheet based on the Norwegian Social Science Data Services' guidelines, which stated the purpose of the study, that anonymity would be ensured in the final study, and that participation was voluntary and could be withdrawn at all times. Each participant was assigned a sheet number so that they were able to withdraw even after they had handed in their responses.

5.7.3 Privacy

Some participants may feel like their privacy had been invaded if they knew we had analysed their waste. We also knew we would find personal information in the waste. Because of this we were careful not to include any personal information in illustrative pictures we took of the waste. The only other data noted in the pick analysis was the weight of each fraction.

When collecting the questionnaires from the respondents, we chose to collect them through an envelope hanging the entrance hall of building. This was chosen as a compromise, because we knew we would not get the responses required in a postal questionnaire and it was not possible to obtain email addresses of the respondents. During the time the sheets were in this envelope it was technically possible for the participant's neighbours to look at the questionnaire and work out who filled it out based on the background information. However, we believe it reasonable to assume little harm would come from this, as it may be assumed that neighbours already know personal information such as number of children, ethic origin about each other. Income information is also possible to obtain through official sources. If the participants still felt this was too great an invasion of privacy, it was made clear they could refrain from answering the questionnaire.
In terms of data management, the study is approved by and conducted in accordance with the Norwegian Social Science Data Services guidelines and requirements.

5.7.4 Deception

The informational nudge regarding food waste was a modified version of the truth because we used data from the control group pre-test as basis for this number. This wording may be considered a form of deception, as we twisted the number a bit. The number ‘8 of 10’ reflects the percentage ‘uncontaminated’ green bags (i.e. food waste bags not containing other waste), and does not take into account the food waste that was thrown into residual waste. Despite this, we argue that the wording was appropriate, as the control group correctly sorted 50% of bags. We wrote ‘of your neighbours’ to be more general, as it would be an invasion of the control group’s privacy to claim that 8 of 10 of your neighbours living in ”those specific apartments” recycle their food waste.

5.7.5 Funding of the study and conflict of interest

This study was written with the support of Oslo Municipality’s Agency for Waste Management. They have covered operational costs that were incurred during the study, such as rent of equipment, vaccines, protective clothing, and paper and printing costs. No other funding was received.

Other costs (e.g. taxi trips, miscellaneous operating costs) were covered by the researches themselves. No grants besides a universal scholarship from the State Educational Loan Fund were received during the writing of this study.

It should also be mentioned that our supervisor at BI Norwegian Business School was the project manager for the design and implementation of the waste management system in Oslo, and is currently employed there at a part-time basis in addition to her academic work at BI.

5.8 Summary

To summarize, this thesis followed a deductive strategy and a mainly quantitative approach, which allowed possible causal relationships to be inferred. A quasi-experiment was designed to test the two hypotheses (c.f. Chapter 3), through the use of a waste analysis and questionnaire to investigate actual and intended recycling behaviour. Primary data was collected through conducting a pick analysis before and after the experiment intervention, as well as through a postal questionnaire. Other sources of supportive primary data and secondary data were also described.

The study was carefully designed to ensure the quality of research in terms of internal and external validity, reliability, and replicability. The measures taken to mitigate any threats to the quality of the study, as well as any ethical issues encountered, have been discussed.

6. Results

This chapter will first present the results from the pick-analysis, which represents actual recycling behaviour, and any changes related to the hypotheses (c.f. Chapter 3) and overall research question (c.f. Chapter 1). We will then present the questionnaire results, including demographic characteristics for the experimental and control groups, as well as insight into intended recycling behaviour.

6.1 Pick-analysis: waste composition and trends in recycling behaviour

This section will present the results from the pre-test and post-test pick analyses, and present trends in recycling behaviour. First, an overview of the overall quantities and composition of waste, including any pre-test differences will be outlined, before reporting results regarding food waste, and glass and metal recycling behaviour. We then discuss how the quality of sorted fractions has changed, before outlining results regarding access to equipment.

In total, we collected 1.335 metric tonnes of household waste divided across four samples. After removing blue and green bags for later analysis, this left 946 tonnes of residual waste for the more detailed waste composition pick-analysis. There were positive discrepancies between waste amounts before and after the pre-test pick-analysis, and this was caused by the scales being placed on an uneven surface. This was corrected during the second analysis. The margins of error were within the expected range (±≤ 2%) (Mepex Consult AS 2015, 2016). It should also be mentioned that 6.68 kg of loose waste was removed during the post-test experimental group analysis because this waste was clearly related to a resident moving in. We could easily see this, as all paper was from the same newspaper, and was formed as plates, mugs and cups (Appendix F). The negative discrepancies in waste amounts before and after the post-test analysis were expected, and may be explained by some loss of waste (e.g. sand, water vapour, small bits falling on floor) during analysis. The overall quantity of waste that was collected is summarized in Table 6-1.

All numbers in kilograms, rounded to closest whole number	**Experimental group**		**Control Group**	
	Before (pre-test)	**After (post-test)**	**Before (pre-test)**	**After (post-test)**
Total amount of waste received	311	343	335	347
– Weight of blue and green bags received	66	95	113	108
= Total amount of residual waste received, waste before in pick-analysis	*245*	*241*	*222*	*238*
– Total amount of residual waste after analysis	246	239	225	237
= Discrepancy in residual waste after pick-analysis	***0.6%***	***-1.0%***	***1.4%***	***-0.5%***
Comments	Increase in amount due to scales placed on a non-horizontal surface	Loose waste omitted from analysis: 6.68 kg. Decrease due to some loss of waste during analysis.	Increase in amount due to scales placed on a non-horizontal surface	Decrease due to some loss of waste during analysis.

Table 6-1: Overall waste quantities and weight discrepancies.

6.1.1 Overall results from the residual waste analysis

At first glance, the overall distribution of waste fractions from the residual waste analysis looks rather similar for all samples: It appears that most of the waste is food waste in green bags, food waste from the residual waste, and non-recyclable waste (i.e. actual residual waste in the residual waste bags). Bulky waste, garden waste, textiles, and hazardous and EE waste have the lowest amount of waste, and it seems that there is a good amount of glass and metal in the residual waste. In addition, there is a lot of paper and cardboard, as well as plastic waste in the residual waste and plastic waste in blue bags. The amount of bags used for disposal is stable across all samples. The overall distribution of waste fractions with corresponding waste amounts in kilograms, and change within and across samples is illustrated in Figure 6-1.

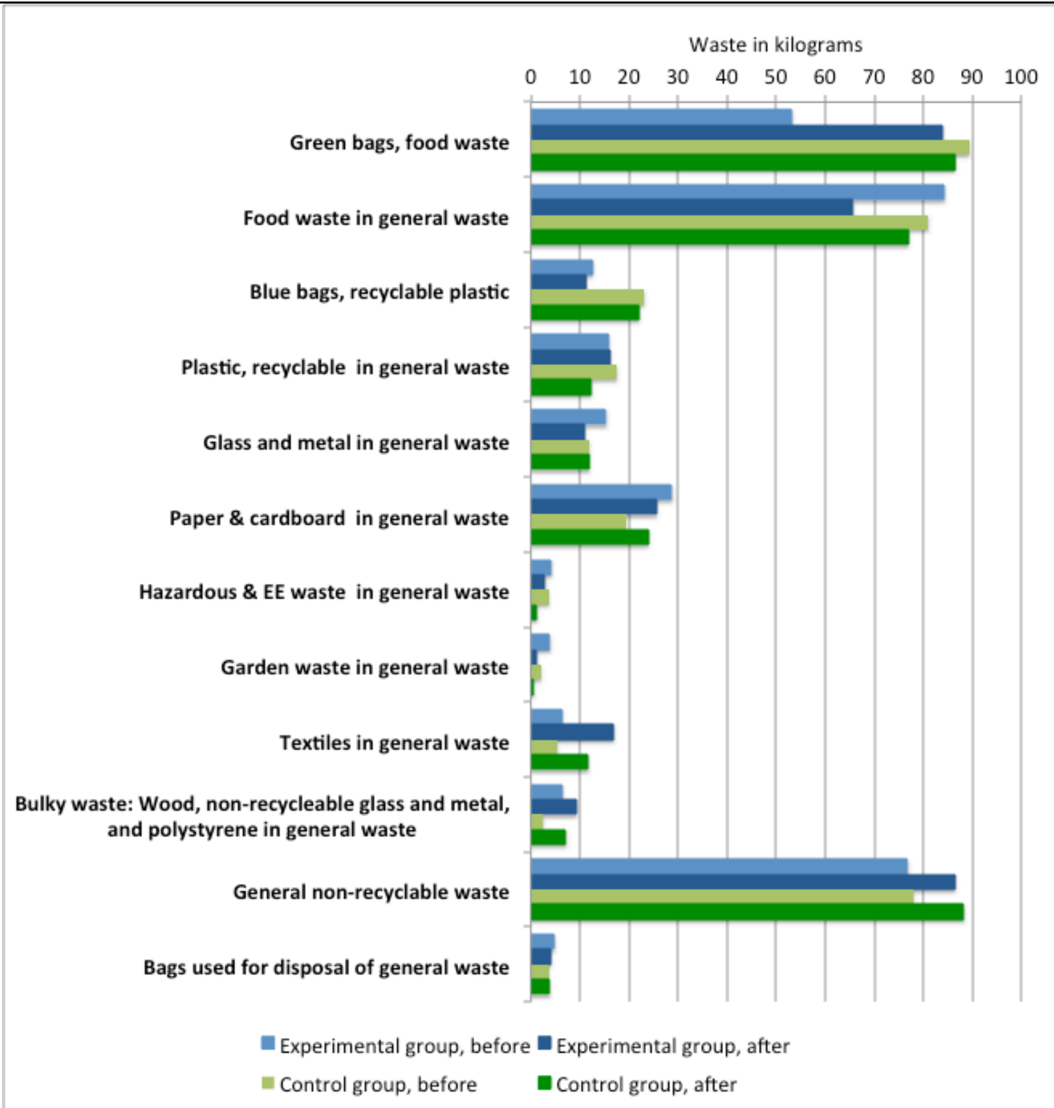
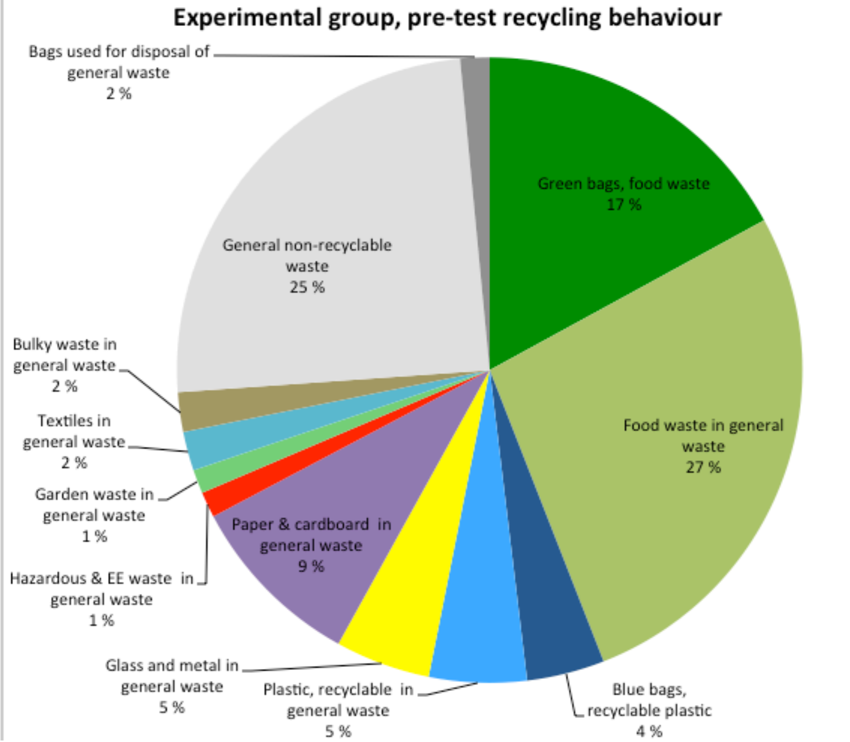


Figure 6-1: Change in waste fractions over time between and across experimental (blues) and control (greens) groups. Waste quantities in kilograms.

When taking a closer look, further analysis reveals some interesting patterns, including pre-test differences in recycling behaviour.

6.1.1.1 Pre-test differences in recycling behaviour

Pre-test differences indicate that the control group's recycling rates were higher than those of the experimental group from the start. This is shown in Figure 6-2.



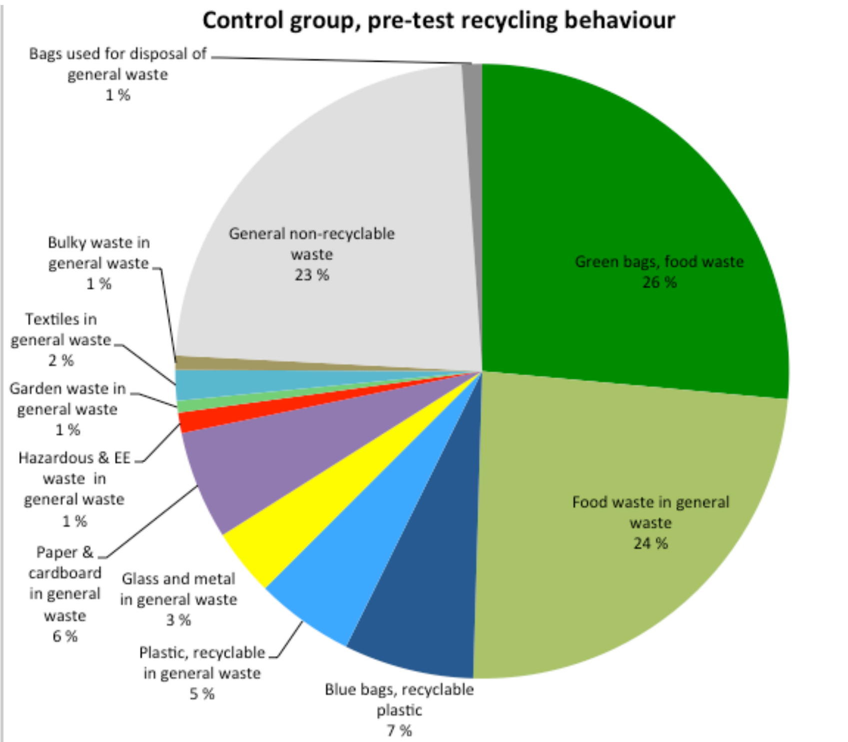


Figure 6-2: Pre-test recycling behaviour for the experimental group (above) compared to the control group (below).

As shown in Figure 6-2, the control group recycled more food waste in green bags (26% vs. 17%) and threw less food waste in residual waste (24% vs. 27%). The control group also has a higher percentage of food waste overall. If the control group had been bigger than the experimental group, this may have been explained by the fact that food waste weighs relatively more compared to other waste, and thus it would skew the data. However, as the control group consists of 80 households compared to 96 in the experimental group, this seems an unlikely explanation.

There are also pre-test differences in recycling behaviour related to plastic waste, paper and cardboard, and glass and metal. Both groups throw the same amount of plastic in residual waste (5%), but the control group recycles almost twice as much plastic in blue bags (7% vs. 4%). The control group recycles more paper and cardboard (6% vs 9%), and throws less glass and metal in residual waste (3% vs. 5%). Recycling behaviour within the bring scheme fractions (bulky, textiles, garden, and hazardous and EE waste) is similar, but it should be noted that the amount of waste in these fractions is very small (1-2% of total waste), which makes any change appear very large percentage wise. This will be outlined in the following section, where we report each group's relative change in fractions.

6.1.1.2 Relative change in waste fractions

The overall relative change in waste quantities showed a -3% decrease and 5% difference in the experimental and control group respectively. This change is negligible on a macro level. The changes are shown below in Table 6-2.

Waste fractions, % change in kilograms	**Experimental group**	**Control group**	**Comments**
Food waste in green bags	58%	-3%	See 6.1.2 for details
Total food waste in residual waste, of which:	-22%	-5%	
Non-usable food waste	*-26%*	*-10%*	
Usable food waste	*-14%*	*9%*	
Plastic waste in blue bags	-12%	-5%	See 6.1.4
Plastic waste in residual waste	2%	-30%	
Other fractions in residual waste:			
Glass and metal	-29%	-2%	See 6.1.3
Paper and cardboard	-11%	24%	
Table 6-2, cont. next page			

Table 6-2, cont.			
Hazardous and EE waste, of which:	-31%	- 68%	Small quantities
Hazardous waste	*-9%*	*-38%*	
EE waste	*-36%*	*-73%*	
Garden waste	-70%	-74%	Small quantities, Seasonality
Textiles	168%	114%	
Bulky waste (wood, non-recyclable glass and metal, polystyrene)	44%	180%	
General non-recyclable waste	12%	13%	See 6.1.4
Bags used for waste disposal	-17%	3%	Small quantities
Overall percentage change	**-3%**	**5%**	

Table 6-2: Pre-test to post-test percentage change within the different fractions, a comparison between experimental and control groups.

On a more detailed level, further analysis of the relative change in fractions for the experimental group versus the control group (e.g. the percentage change in the amount of pre-test and post-test food waste in the experimental group vs. the same percentage change in the control group) revealed some similarities and differences between the groups:

For instance, there are large reductions in hazardous and EE waste, but this is mostly a measurement related issue, as the overall quantities themselves are very small: - 31% represents a 1.27 kilogram decrease for the experimental group, and -68% represents a 2.45 kilogram decrease for the control group (see Appendix G). Although it looks like there is an improvement in the control group's hazardous and EE waste recycling behaviour, the absolute changes reveal that this is probably not the case. Moreover, there are large negative changes within garden waste, and this is also related to small quantities, as the -70% and -74% represent 2.7 and 1.55 kilogram decreases for the experimental and control group respectively, which is similar for both groups.

In addition, there is an increase in the amount of textiles found in the residual waste, with increases of 186% (10.55 kilograms) and 114% (6.8 kilograms) for the experimental and control group. The increase may be due to seasonality, by which we mean expected variations in waste amounts (Chopra and Meindl 2013,

193) which are often related to the time of year when many people tend to clean out their closets when one season transfers into another. This is a probable cause, as the data was collected in April-May. The larger increase for the experimental group compared to the control group may simply be due to more people in that group cleaning out their closets, and not an actual change in recycling behaviour (meaning people throw clothes in the residual waste all the time, they just do not do it every week). The textiles found seemed to be of poor quality (i.e. dirty or very well worn), and it seems likely that the clothing was deemed unfit for reuse by the person who disposed of it. This could also indicate a lack of knowledge, as all textiles may now be recycled—no matter the quality.

For bulky waste (wood, non-recyclable glass and metal, and polystyrene), an increase of 44% (2.83 kilograms) and 180% (4.58 kilograms) was observed for the experimental and control group respectively. These are also rather small quantities, and the increase may be due to seasonality as well, especially tied to waste resulting from spring-cleaning of peoples' storage rooms (e.g. old furniture, lamps), as well as activities related to moving or home renovation. The former was observed in the housing cooperative, as they had scheduled a day for kerbside collection of bulky waste via a third-party company. This happened a week before the post-test pick-analysis, and we were unable to stop it form happening. We find it plausible that the increase in bulky waste may be due to the fact that some people did not clear out their storage rooms during the scheduled collection time, and they instead disposed of bulky waste in the residual waste because they did not want to wait for next year's collection or drive to a bring collection site for bulky waste. The bulky waste collection could also explain the increase in clothing in residual waste.

Overall, the percentage change in hazardous and EE waste, garden waste, textiles, and bulky waste follow the same direction (i.e. increase *or* decrease within fractions both groups). This may be interpreted as naturally occurring seasonality in supply of waste, and it suggests that the recycling behaviour in fractions not targeted by the interventions are similar for both groups. The change within food waste, plastic waste, glass and metal, and paper and cardboard—fractions targeted by the interventions—vary within the groups, and will thus be discussed in more detail in the following sections of this chapter.

6.1.2 Changes in food waste recycling behaviour

This section will present results regarding food waste recycling behaviour. Table 6-2, presented in the previous section, indicates that there has been a positive shift in food waste recycling behaviour for the experimental group compared to the control group. As Table 6-2 only looks at change within fractions, it does not take into account the total quantity of food waste (i.e. green bags and food waste in residual waste combined). When this is taken into account, results indicate that the **experimental group sorted 17% more of their total food waste into green bags, while the control group's recycling behaviour is shown as being relatively constant in comparison** (1% increase). The increase was also found in the clean green bags (20% pre-test to 39% post-test), which is an indication that **the quality of sorting has also increased for the experimental group**. This is illustrated in Figure 6-3.

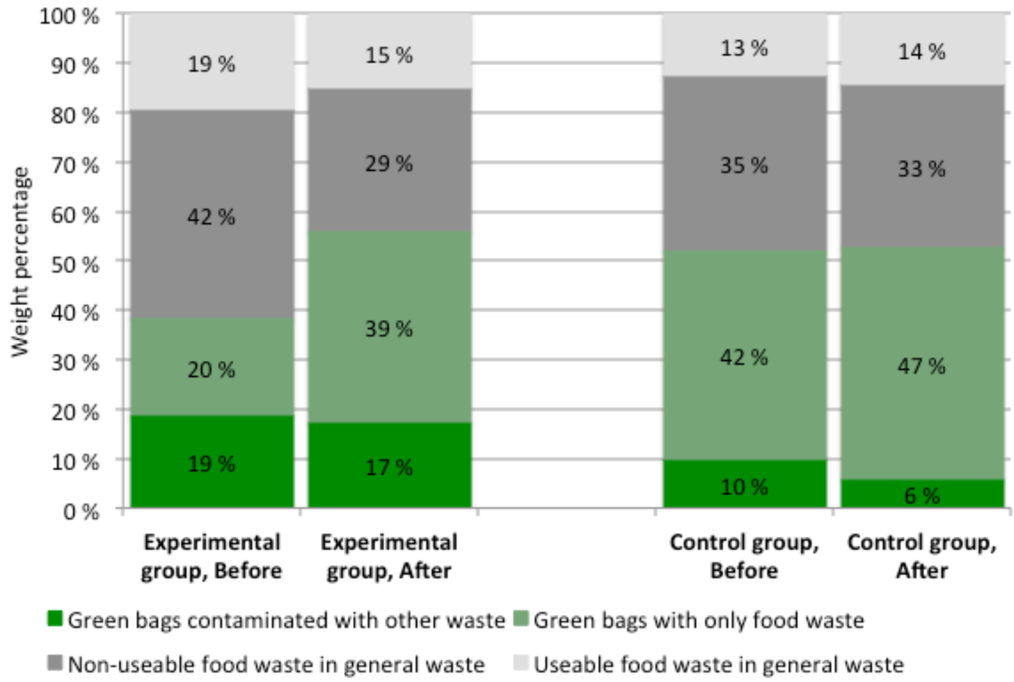


Figure 6-3: Experimental group (left) indicates increase in food waste recycling behaviour compared to control group (right). Waste sorted by origin, percentage of total food waste amounts.

One important thing to notice is the pre-test difference in the food waste recycling rate. Figure 6-3 shows that the control group sorted 52% of food waste into green bags compared to 39% for the experimental group. This indicates that the control group sorted more food waste into green bags from the start. The post-test shows a food waste recycling rate of 53% for the control group, compared with 56% for the experimental group. In conclusion, the food waste recycling rate of the experimental group has improved, while the control group's has remained at the same level.

Moreover, the data that suggested the quality of green bags had improved for the experimental group was further explored. The ratio of correctly sorted versus contaminated green bags was therefore examined. Contaminated bags are green bags with waste other than food waste in them (c.f. Chapter 4, and Appendix H). Figure 6-4 shows a 10% increase in the number of clean green bags for the experimental group, while the control group showed no change. The mean weight of green bags for the experimental group also *increased* from 1.11 kg to 1.25 kg, which is a 13% increase. In comparison, for the control group the mean weight of green bags *decreased* from 1.24 kg to 1.17 kg for the control group, which is a 6% decrease. As food waste is the heaviest fraction, this may indicate that the green bags of the experimental groups contain more food waste and less contamination from other fractions, which means that the quality of green bags improved.

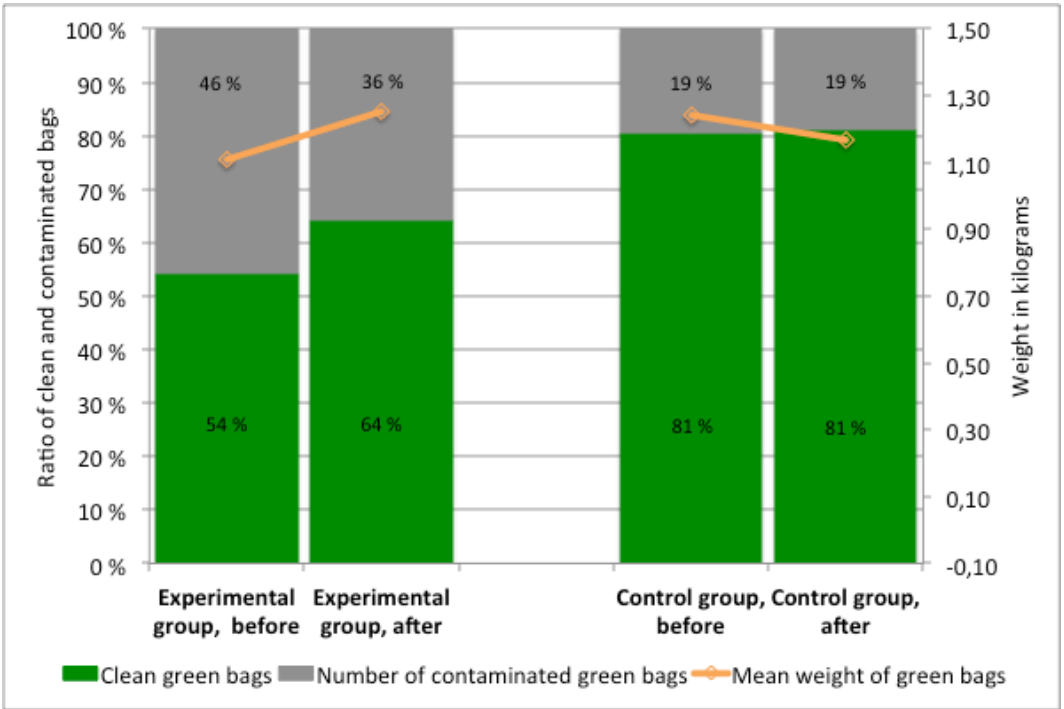


Figure 6-4: Experimental group (left) shows an increase in mean weight of green bags, and a higher ratio of correctly sorted green bags compared to control group (right). Food waste sorted by origin and number of green bags.

In general, we observed that the type of food waste found in residual waste bags was mostly peels and other inedible parts of food (i.e. bones, apple cores). This is non-usable food waste. We observed some edible food, and this was mostly thrown away in packaging, which is usable food waste. We also noticed that contaminated green bags were either used in place of residual waste bags, or we found full glass or metal cans which contained food, as people had not bothered to separate the fractions. Another general observation was that if we found food waste in the residual waste, we also found plastic and paper.

In sum, our results suggest that there has been an improvement in the experimental group's food waste recycling behaviour, while the control group's behaviour remained constant in comparison.

6.1.3 Changes in glass and metal recycling behaviour

This section will outline results related to glass and metal recycling behaviour. For the experimental group, **after the distance to the collection point had been reduced from 230 to 6 metres, we observed 29% less (-4.39 kilograms) glass and metal in the residual waste.** In comparison we found 2% (-0.19 kilograms) less glass and metal in the residual waste from the control group, where the distance was not changed. This is illustrated in Figure 6-5.

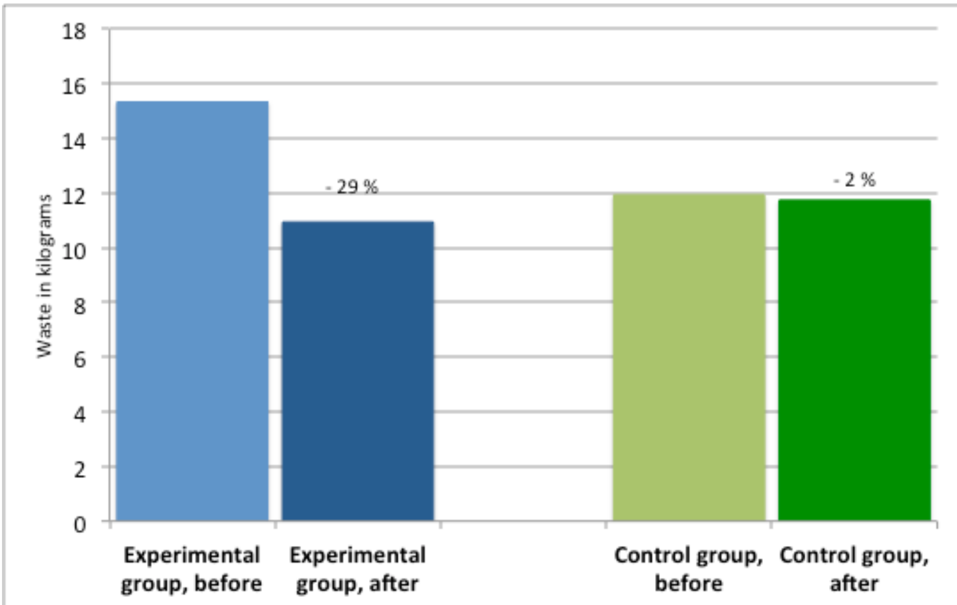


Figure 6-5: Glass and metal in residual waste analysis indicates improved recycling behaviour for experimental group (left) compared to control group (right). Waste in kilograms.

Figure 6-5 indicates that the experimental group's recycling behaviour has improved. To further investigate this, we also collected data on the fill-rate of the new glass and metal collection point, which came from a sensor inside the collection point. The starting point on the graph illustrates the start of the intervention. The reason the fill-rate is at 0 the first week is that the households first filled up a sub-smaller compartment with a separate access point, and this compartment did not have a sensor (see Appendix I). Figure 6-6 shows two periods of collection, with collection happening on May 23, and the trend lines indicate that the recycling behaviour happens at the same rate (i.e. the trend line slopes are the same, 0.087 vs. 0.089). This also shows that the households actually started to use the collection point, which is further supported by the fact that **the Agency for Waste Management made the collection point a permanent one after the experiment conducted in this thesis ended.** The fill-rate is illustrated in Figure 6-6.

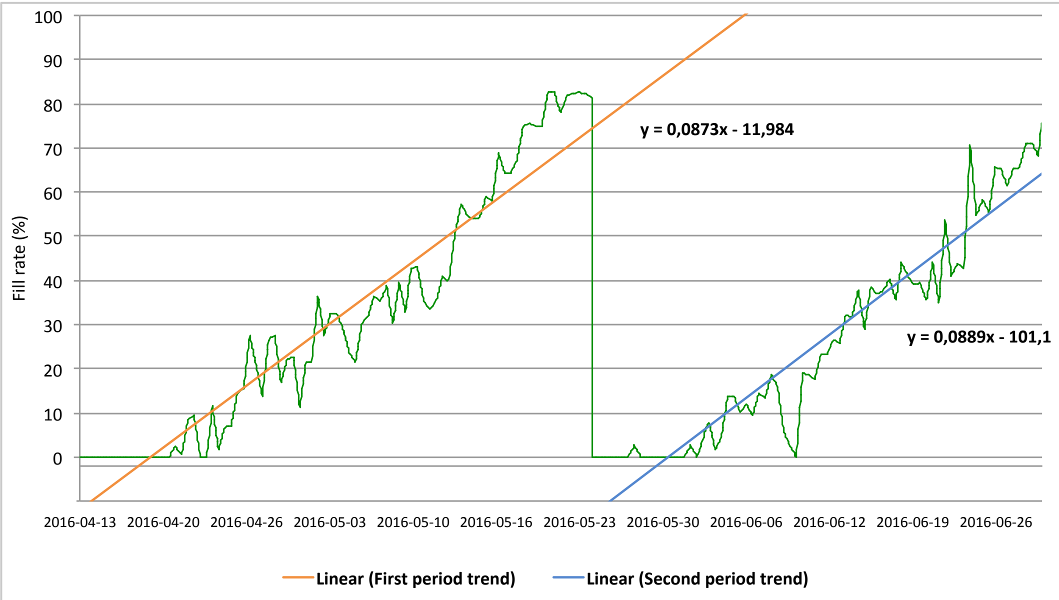


Figure 6-6: Fill-rate of glass and metal thrown in the experimental group's new glass and metal collection point from 13 April to 26 June 2016.

In general, we noticed that the contents of the residual waste bags included recyclable bottles and bottles and cans with return ("panteflasker"). In addition, class and tin cans were often not emptied or cleaned.

In sum, the results show that the experimental group has disposed of less glass and metal in the residual waste since the placement of the new glass and metal container. The fill-rate of this container is also constant, which shows it has been used over time.

6.1.4 Change in plastic waste recycling behaviour

When it comes to change in plastic waste recycling behaviour, no large changes were observed for either group. In terms of blue bags with plastic waste, a -3% decrease was found in the experimental group, and a 5% increase in the control group. However, an increase in clean blue bags for the experimental group (from 11% to 25%) was observed, while this ratio stayed relatively constant (23% vs. 25%) for the control group. This suggests that the quality of sorted plastic waste improved (i.e. less contamination, see Appendix J), but none of the groups became *better* at recycling plastic waste. This is illustrated in figure 6-7.

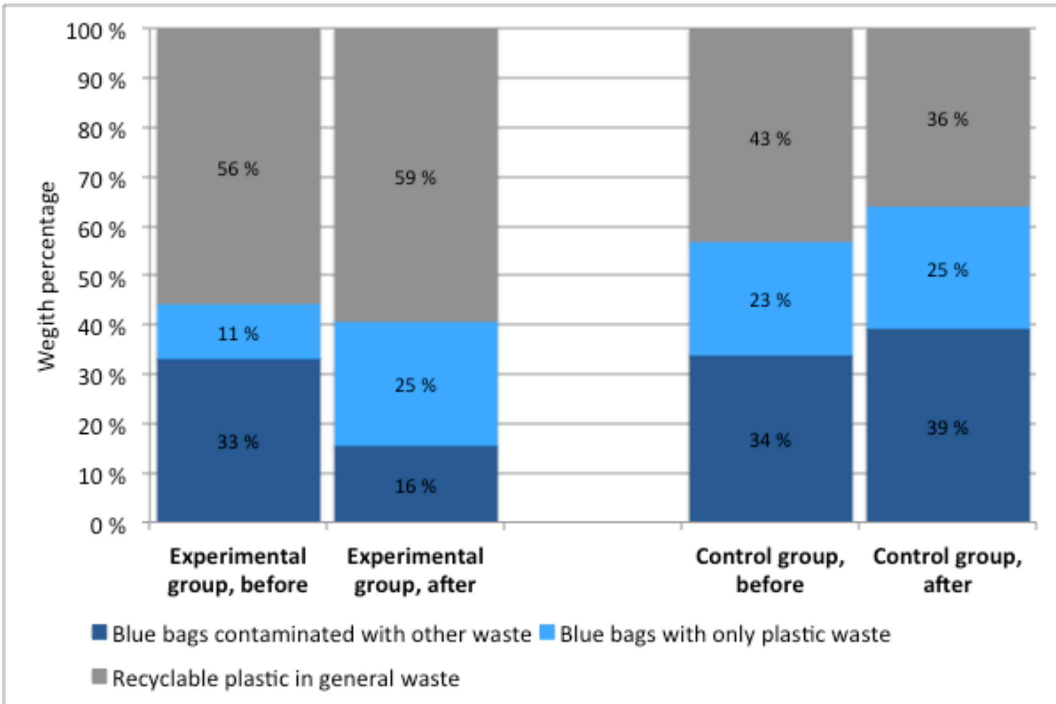


Figure 6-7: Indication of slightly improved quality of plastic waste in experimental group (left) compared to control group (right).

To further investigate the quality of blue bags, we looked further into the ratio of clean and contaminated blue bags. Results show that clean blue bags from the experimental group had increased by 9%, while there was a 2% decrease in the number of blue bags for the control group. Also, the decrease in the mean weight of blue bags was larger for the experimental group than for the control group. This also suggests that the quality of sorted plastic waste improved for the experimental group, and these results are shown in Figure 6-8.

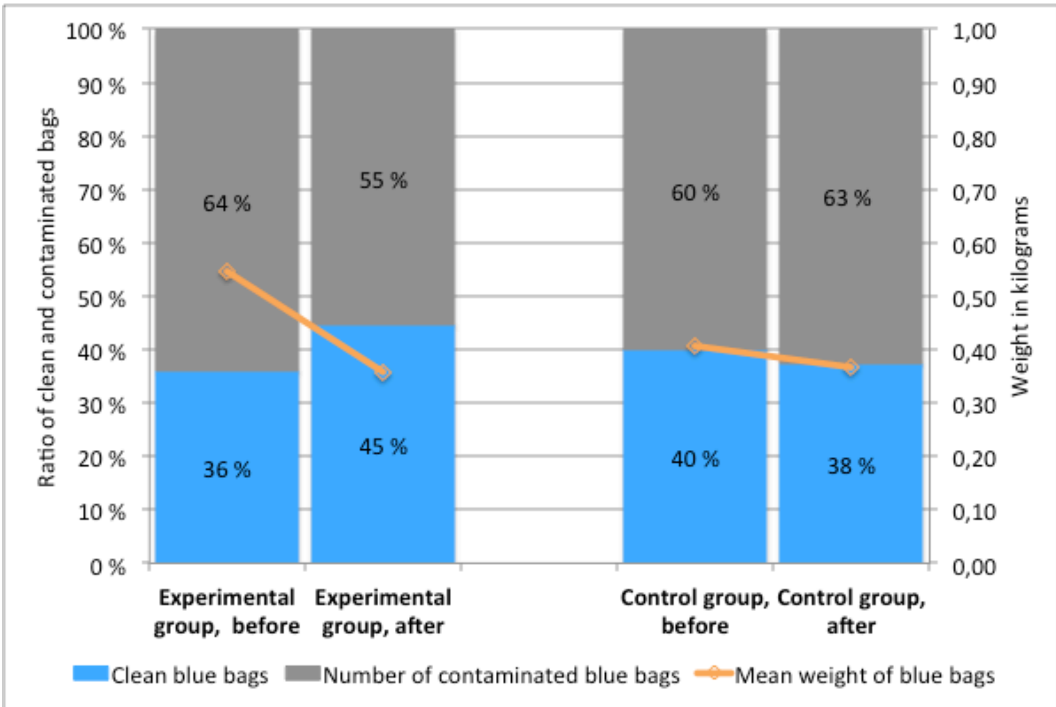


Figure 6-8: Experimental group (left) shows bigger decrease in mean weight of blue bags, and a slightly higher ratio of correctly sorted blue bags compared to control group (right). Waste sorted by origin and number of blue bags.

In terms of quality of waste, we mainly observed packaging and plastic bags in the residual waste, most of which was dirty. We also frequently observed the use of small plastic bags to peel vegetables in, resulting in plastic and food waste thrown in the residual waste together. In addition, some residual waste bags contained only plastic that was both clean and dry. This could be an indicator of lack of knowledge regarding how the system works. Moreover, the contaminated blue bags had often been used to dispose of waste from the bathroom, or used in place of residual waste bags.

In sum, overall amount of plastic waste was unchanged, but the number of clean blue bags increased for the experimental group. This indicates that the quality of blue bags containing plastic waste improved for the experimental group.

6.1.5 Paper and cardboard recycling behaviour

This section will describe paper and cardboard recycling behaviour. We observed an 11% decrease in paper and cardboard waste in the experimental group, and a

24% increase in the control group. The type of paper and cardboard observed was often drinking containers (i.e. juice and milk cartons) that were not cleaned, and advertisements and old mail, including torn up letters and bills with personal information. The latter may indicate that people deliberately throw some paper waste in the residual waste because they believe the waste will get incinerated, and feel this is a “safer” option. The change in recycling behaviour is illustrated in Figure 6-9.

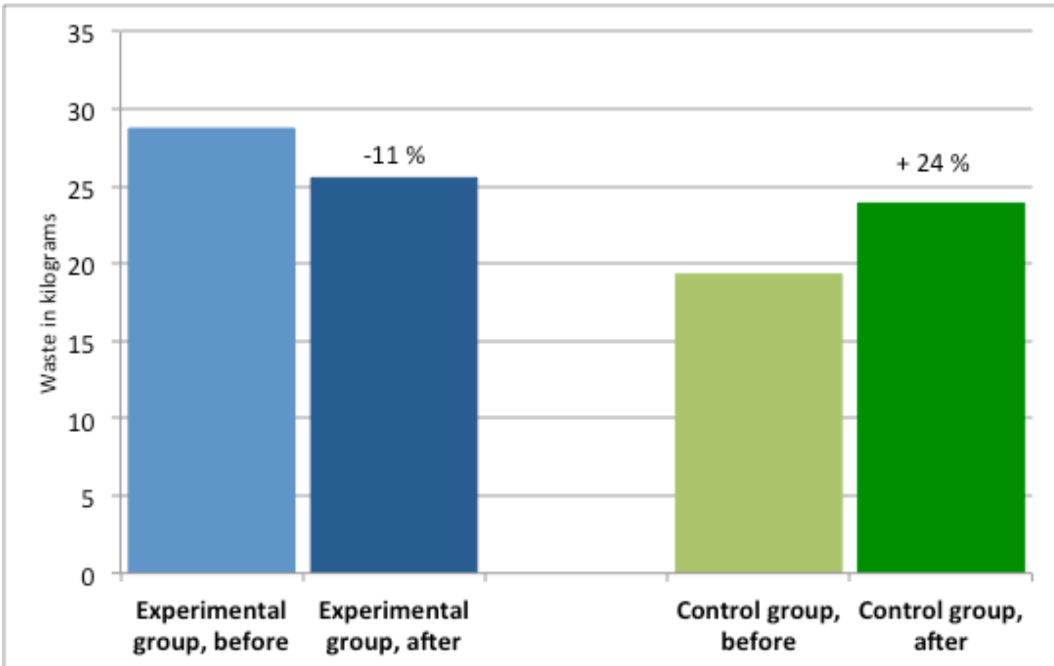


Figure 6-9: Experimental group (left) shows a decrease while control group shows a 24% increase in amount of paper and cardboard in residual waste.

There is no clear trend or explanation for the change in recycling behaviour for paper and cardboard. We did not correct for any wet paper waste, as this was consistent across all four samples.

6.1.6 Red residual waste bags

We distributed red bags to the experimental group for them to use for residual waste. We collected a total number of 16 red bags, with a mean weight of 1.07 kilograms. The total weight of red bags was 17.1 kilograms, which is only 7% of overall residual waste collected from the experimental group. The lack of use may be due to wrong size of bags, as some comments show, or that the colour was associated with hazardous waste.

6.2 Results from questionnaire

The previous section outlined results from the pick-analysis, which reflects the actual recycling behaviour in the housing cooperative. In order to gain an understanding of the housing cooperative's intended recycling behaviour and demographic characteristics, this section will outline the results from the questionnaire. We first describe how the data was processed and analysed, before describing demographic characteristics, satisfaction with waste management system, the end-consumer-turned-supplier's beliefs about their neighbours' recycling behaviour, and self-reported recycling behaviour.

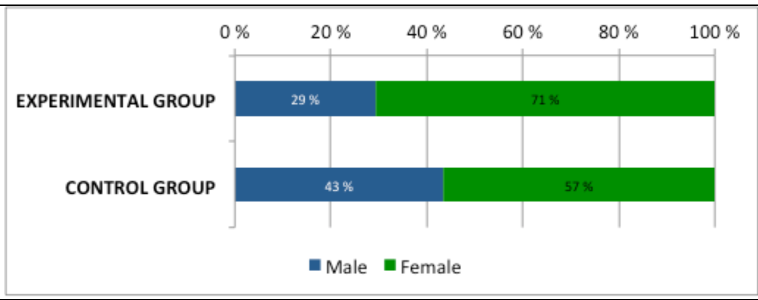
In line with the methodology, doorstepping was used as the method of distribution for the part of the intervention consisting of the informational letter and equipment. Because the researcher interaction, we needed to look at the hit rate. Any hit rate lower than 100% means that all participants did not get the same treatment, and this interaction may have lead to bias in the questionnaire (c.f. Chapter 5). During the doorstepping we interacted with 59% (57 of 96) of experimental group households, which means we talked to the respondent when they answered the door. The remaining 38% of households did not answer their door, and we therefore placed the required equipment outside their door and checked if they had taken it in a day later. In combination, this yields a hit rate of 97%, by which we mean we delivered the equipment to 97% of experimental group households.

After removing 12 non-useable questionnaires, the overall response rate was 33%, with a slightly lower response rate for the control group (30% vs. 35% in the experimental group). Even though this is below 50% and therefore not acceptable (Mangione 1995 cited in Bryman and Bell 2011, 234), this is mostly an issue with probabilistic samples (Bryman and Bell 2011, 236), which is not the case in this thesis. When further examining the response rate, results showed that we had interacted with 74% of experimental group respondents. These respondents may have felt more compelled to respond to the questionnaire than the respondents we had no interaction with. However, it may also reflect that the respondents we did interact with during the doorstepping were the ones who were actually *at home*, and therefore they also had time to respond to the questionnaire. The respondents who interacted with us and responded to the questionnaire may also be the ones who care more about recycling. We have no sure way of knowing this, as we only have 10 non-interaction experimental group responses, meaning we cannot assume a normal distribution for the responses in this subgroup (Løvås 2004). When further analysing the questionnaire data to uncover possible trends we examined the relative frequency of responses. This is because we used categorical variables, and coupled with the small sample size and low response rate any statistical conclusions would be misleading at best (Løvås 2004).

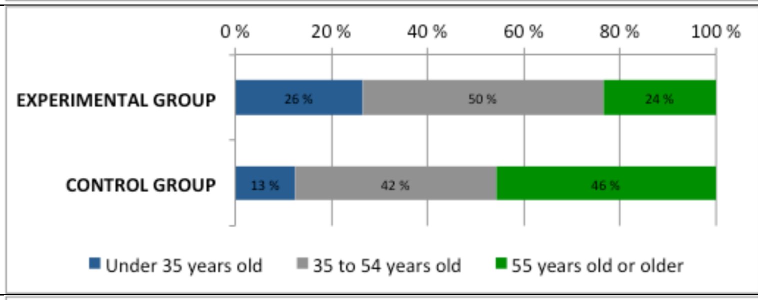
6.2.1 Demographic characteristics

We have summarized the demographic characteristics of the respondents in the experimental and control groups in Figure 6-10.

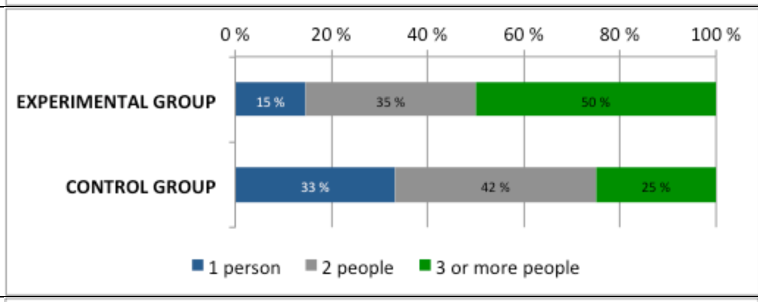
1: Gender



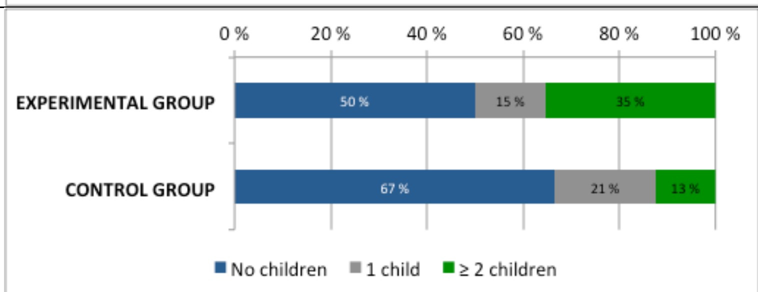
2: Age



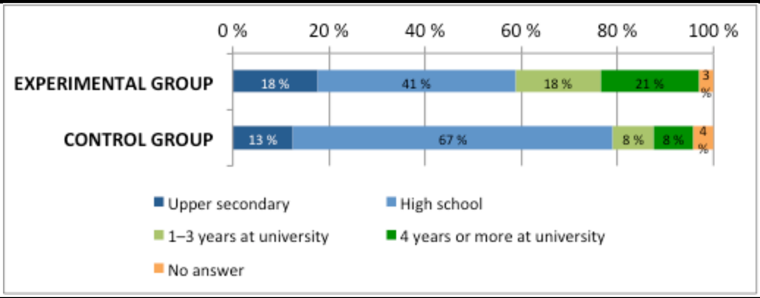
3: Number of people in apartment



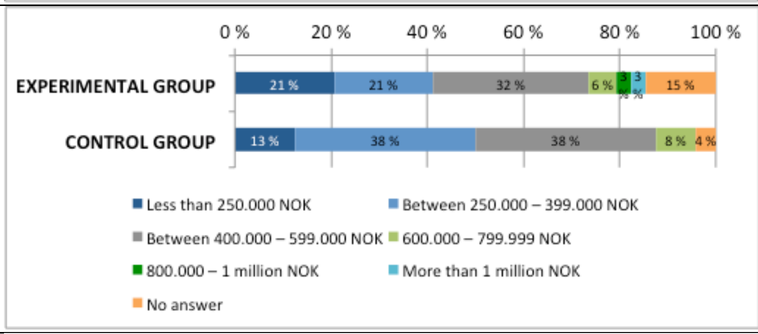
4: Number of children in apartment



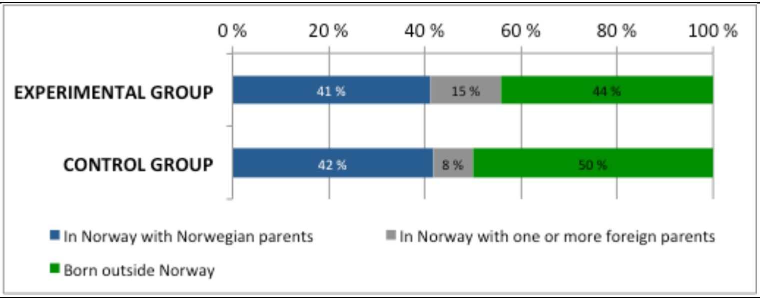
5: Education



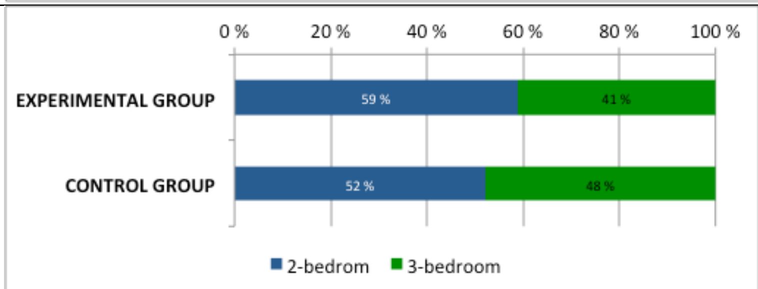
6: Income



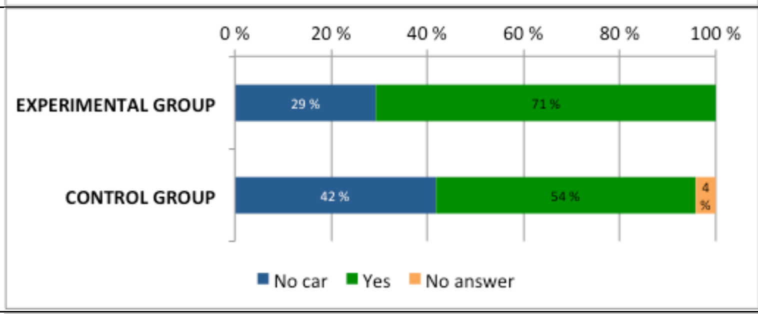
7: Birth place



8: Size of apartment



9: Car access



10: Public transportation usage

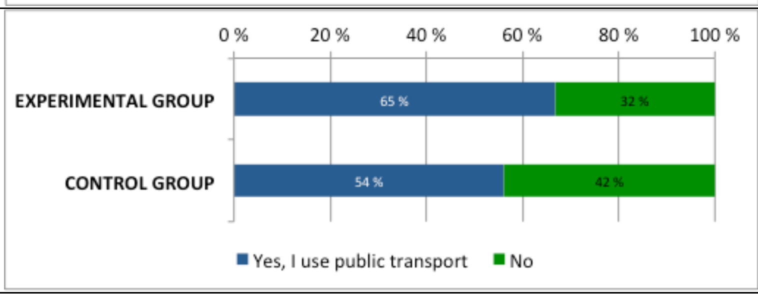


Figure 6-10: The 10 figures provide an overview of demographic characteristics, with a comparison between the experimental and control group. Graphs show relative frequency of questionnaire responses.

In terms of gender, 71% of experimental group respondents were female, compared to 57% in the control group. This difference between groups may be due to researcher interaction, as 74% of experimental group responses came from women, which is similar to the gender distribution of the interaction: 76% of the people we interacted with during doorstepping were women, while only 24% were men.

The median age bracket is 35–55 years for both groups, and approximately half the respondents in both groups belong in this category. When comparing the two groups, the experimental group is "younger", as fewer respondents are elderly people (24% older than 55 years old vs. 46%), and more respondents are under 35 years old (26% vs. 13%). Results also showed that there are fewer one-person households in the experimental group (15% vs. 33%), and more households with three or more people (50% vs. 25%). Results also show that 50% of experimental group respondents live in households with children, compared to 33% in the control group. This may explain why the experimental group is "younger".

When it comes to education, results show that 38% of experimental group respondents have higher education (at least one year of university), compared to 17% in the control group. We would expect higher levels of education to positively covariate with reported levels of income, and this was reflected in the fact that those reporting a high income (≥ 600.000) did have higher education. However, we found no general link between education and income in either group, as the lower incomes (≤ 400.000) were distributed evenly across all education levels and was similar in both the experimental and control group. Nevertheless, we did discover a trend that suggests those with an immigrant background (59% in experimental groups and 58% in control group) reported a higher level of education in general. However, there is no link between immigrant background and reported level of income in either group. In sum, this indicates that although those with an immigrant background have a higher level of education, they do not have higher incomes (see Appendix K).

In terms of size of apartments, 59% of experimental group respondents report living in two-bedroom apartments and 40% in three-bedroom apartments. The control group shows an even 50-50 distribution.

Reported car access is higher in the experimental group than the control group (71% vs. 54%). Public transportation usage is also higher for the experimental group (65% vs. 54%). Further analysis revealed similar behaviour in both groups, as those without car access are the ones who use public transport. In addition, we found a higher percentage of those *with* car access in the experimental group *also* used public transportation, which may explain why both numbers are higher for the experimental group (see Appendix L).

6.2.2 Satisfaction with waste management system

In general, our results indicate a high level of satisfaction with the waste management system in Oslo. Results show that overall system satisfaction is slightly higher for the experimental group than the control group, as 94% of the experimental group respondents reported they are *very satisfied* or *satisfied* with the overall services offered by the Agency for Waste Management in Oslo, compared to 79% in the control group. None of the respondents in either group reported being dissatisfied with the overall system. Moreover, we investigated satisfaction with the home system, and results show that overall satisfaction levels are similar for both groups: 76% of experimental group and 75% of control group respondents reported being *very satisfied* or *satisfied* with their waste management solutions at home. These results are illustrated in Figure 6-11.

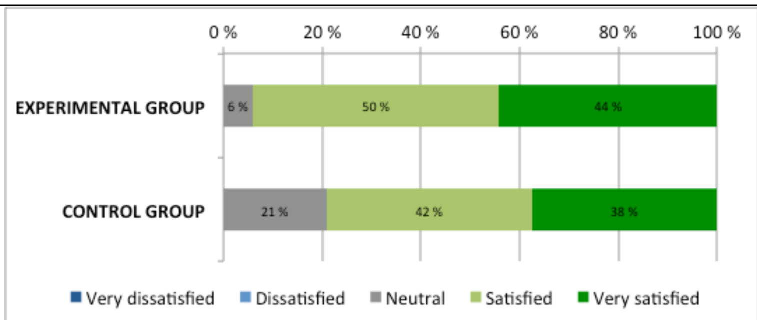
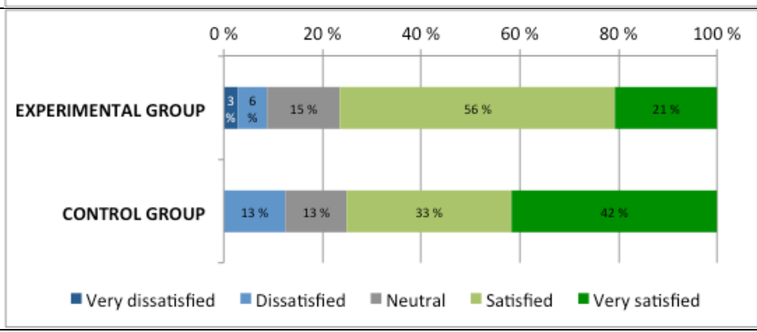
1: Overall system satisfaction	
2: Home system satisfaction	

Figure 6-11: Relative frequency in responses categorizing overall system satisfaction (1) and home system satisfaction (2) in experimental group versus control group.

When comparing respondents' home system satisfaction level *given* their overall system satisfaction, a higher percentage of control group respondents seem to be more satisfied with both the overall system *and* their system at home. Results also show that the respondents who are dissatisfied with their home system are satisfied with the overall system, which is contradictory. Our data is not able to tell us why, but it may be a sign that these respondents have not been able to find a home system they deem optimal. These results are summarized in Figure 6-12.

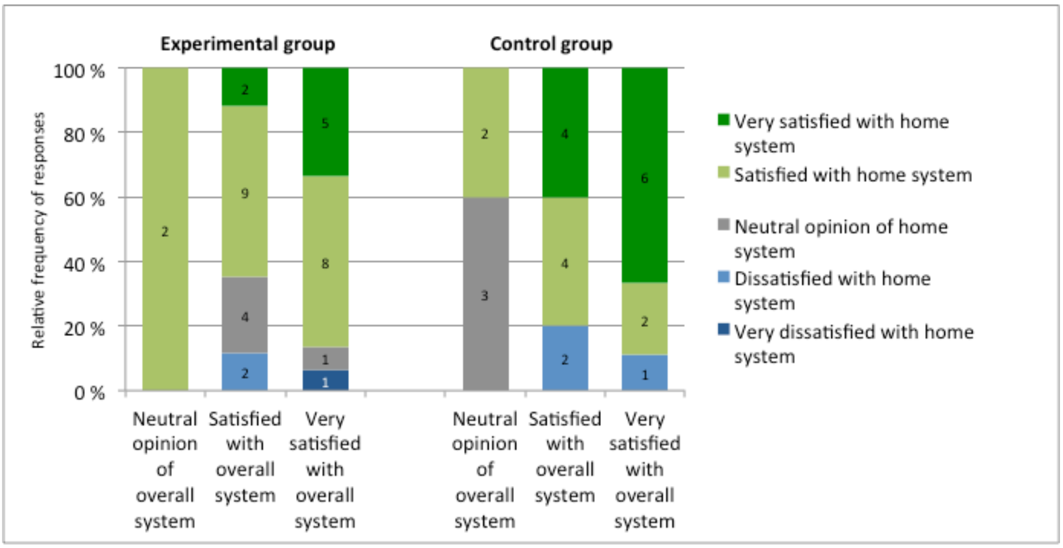


Figure 6-12: Relative frequency of respondents' home system satisfaction given their overall system satisfaction.

The qualitative comments received regarding the overall and home system are listed in Table 6-3 and 6-4. In general, it seems that frequency and convenience is something respondents care about in the overall system. In the home system, lack of space is cited as the primary reason for not recycling.

Comments regarding overall system (C=control, E=experimental group)	**Category**
More frequent waste collection than today **C**	Frequency
Better at sorting glass and metal. Sometimes things get thrown into the residual waste bin **C**	Convenience
Nothing **C**	
Metal and glass closer to the ordinary waste containers **C**	Convenience
More frequent collection of bulky waste **C**	Frequency
Bigger waste bags than now, especially the green bags. Where are we supposed to throw kitchen equipment such as frying pans and pans etc.? **C**	Convenience, knowledge
Nothing **E**	
Would love to have more space at home to sort waste, but my kitchen does not have room for more than three waste bins. It means that I do not sort paper and cardboard well enough. **E**	Space
A way to dispose cooking oil would be beneficial in residential areas. **E**	Knowledge, convenience

Table 6-3: Qualitative comments regarding overall waste management system

Comments regarding home system (C=control, E=experimental group)	Category
More space in the cupboards **C**	Space
Own bin for glass and metal. I have three different waste bins under the sink, which works well. **C**	Convenience
I think today's solution works well **C**	
Better system **C**	
Lack of space, do not have room for three waste bins in the kitchen **C**	Space
It could take up less space **C**	Space
Nothing **E**	
I would like to sort paper/cardboard better, but now I throw it in the residual waste due to shortage of space. **E**	Space
Have a good system for food, plastic and residual waste. Glass and metal takes up too much space, have not found a good placement or system. **E**	Space
Recycling takes too much space in the kitchen. Many waste bins. **E**	Space
The red bags could have been bigger. **E**	Convenience
More cupboard space for the waste bins **E**	Space
Sometimes insufficient supply of bags for residual waste **E**	Lack of equipment
Not enough space, plan to refurbish the kitchen and then this will be taken care of. **E**	Space
A tray with various bins for the different fractions **E**	Convenience
Think it's too much with a bin for food waste, plastic waste, paper/cardboard, tin cans/bottles and a bin with other waste **E**	Convenience

Table 6-4: Qualitative comments regarding home system

6.2.3 Beliefs about neighbours' recycling behaviour

The informational nudge we distributed to the experimental group claimed that "8 of 10 of your neighbours recycle their food waste". In order to test if the nudge was the likely cause of the increase in food waste recycling behaviour we observed in the experimental group, and not some other confounding variable, we had designed two questions. The first measured the perceived diligence of neighbours, and the second perceived quantity recycled.

Results show how diligent they though their neighbours were *given* how much they thought their neighbours recycled. In both groups, results show that most respondents believe their neighbours recycle about the same amount of waste as them, no matter how much waste they believe their neighbours recycle. In the control group, 17% believe their neighbours do not recycle any of their waste, and in the experimental group more respondents believe their neighbours recycle half or more of their waste (91% vs. 71%). **Results also indicate that a higher share of experimental group respondents who believe their neighbours recycle half or more of their waste, also believe their neighbours are about the same or better than them in terms of diligence. These results may indicate that the**

informational nudge has had an effect, as we do not find the same reported tendencies in the control group. However, it should be noted that there is a weakness in asking the questions this way. The assessment of diligence is subjective, as the respondents have compared their neighbours' perceived recycling behaviour against *their own* perceived behaviour. Also, it was not possible to tie the perceived behaviour of neighbours to objectively observed behaviour on the respondent level, so we had to rely on the devised measure. Figure 6-13 illustrates these results.

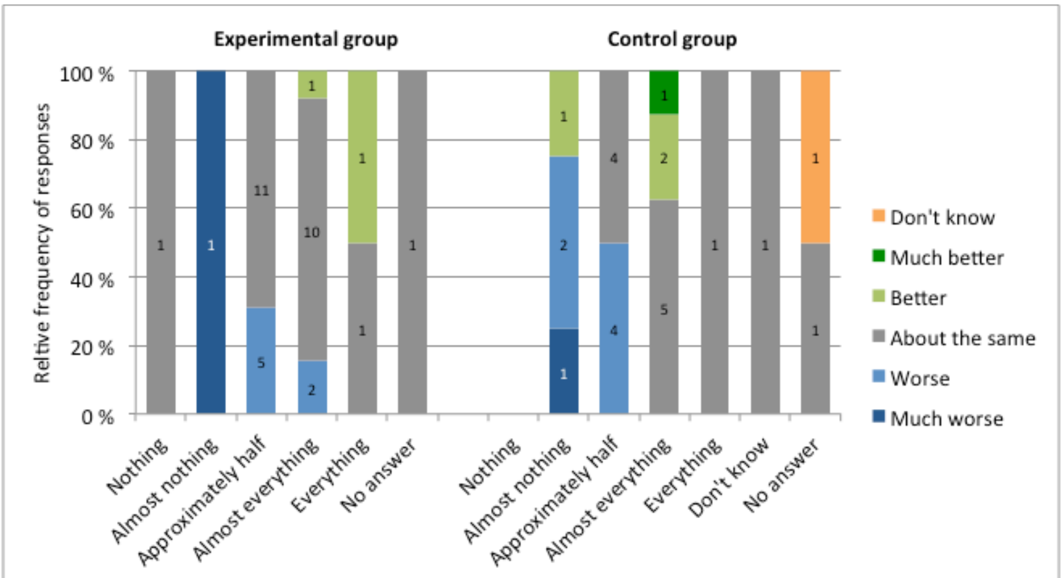


Figure 6-13: Figure shows relative frequency of responses of perceived diligence of neighbour given how much they believe said neighbours recycle.

6.2.4 Self-reported recycling behaviour

This section will outline results regarding self-reported recycling behaviour in general, before presenting a more detailed analysis regarding food waste and glass and metal. Due to the intention-action gap, any self-reported recycling behaviour should be viewed as a measure of the respondent's self-perceived action. This means that the responses reflect *intention* to recycle. In order to investigate this intention, we measured two things: 1) Self-reported willingness, or intention, to recycle and 2) self-reported action for ten different waste items. As expected, we found that both of these measures on average were high for both groups, and self-reported intention was higher than self-reported action. On a scale of 1–5, the experimental group reported an average intention of 4.3, and an average action of 4.0. The control group reported an average intention of 4.5, and average action of 4.2. This means that both groups on average are *willing* or *very willing* to recycle the ten items, and that they on average recycle the same ten items *almost every time* or *every time*. Results also show that self-reported plastic packaging intention and action is higher than the reported behaviour for soiled plastic. In addition, the experimental group reports a larger gap between reported intention and action for the bring scheme fractions batteries, electrical products, potted plants, and textiles. The control group also reports such a gap for textiles. These results are summarized in Figure 6-14.

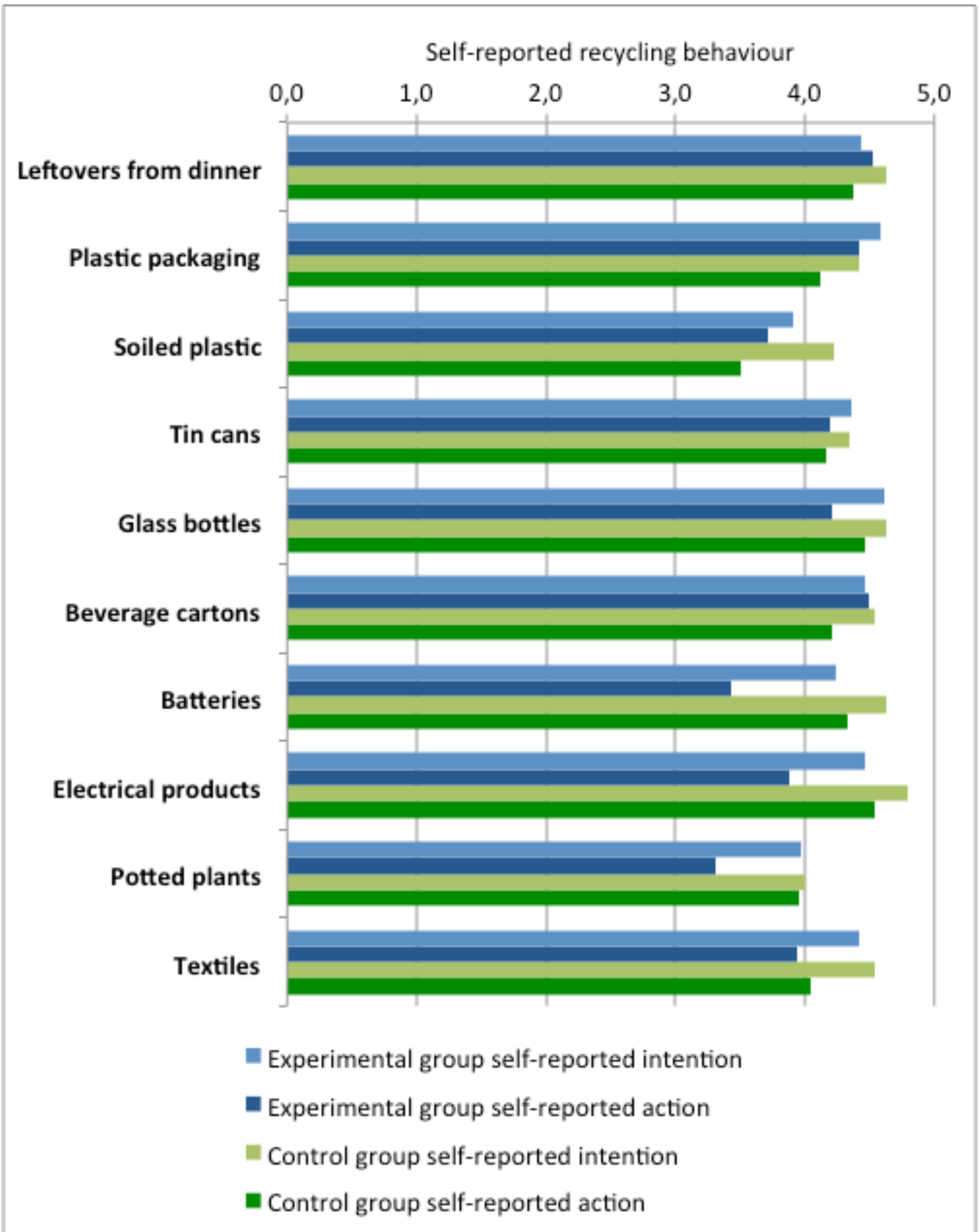


Figure 6-14: Self-reported intention and action for the experimental group (blues) and control group (greens), calculated as arithmetic mean of scores measured on 5-point scale.

6.2.4.1 Self-reported food waste recycling behaviour

We have investigated self-reported food waste recycling behaviour in more detail, as this is one of the fractions specifically targeted by the interventions used in the experiment. The results regarding food waste recycling behaviour are shown in Figure 6-15.

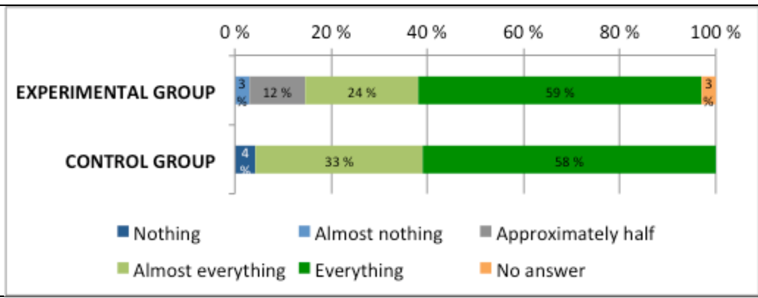
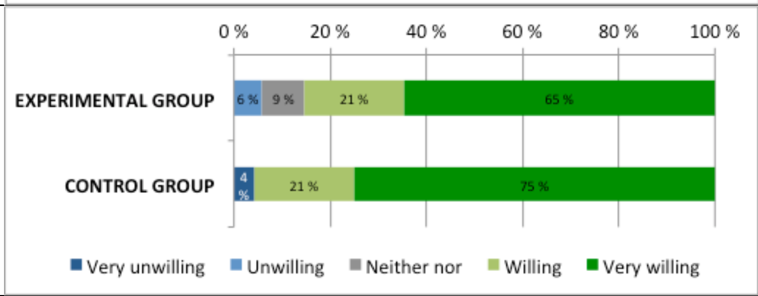
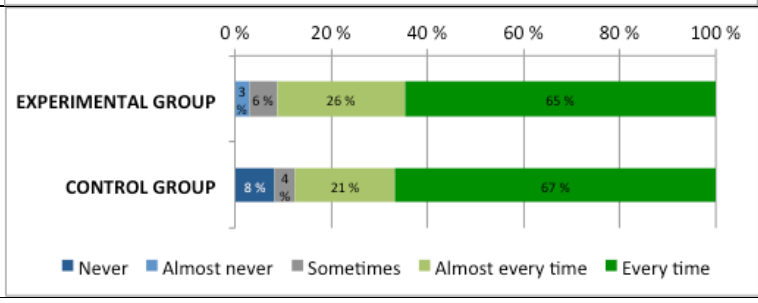
1: Portion of food waste sorted in green bag	
2: Self-reported intention to sort leftovers from dinner	
3: Self-reported recycling behaviour (action) of leftovers from dinner	

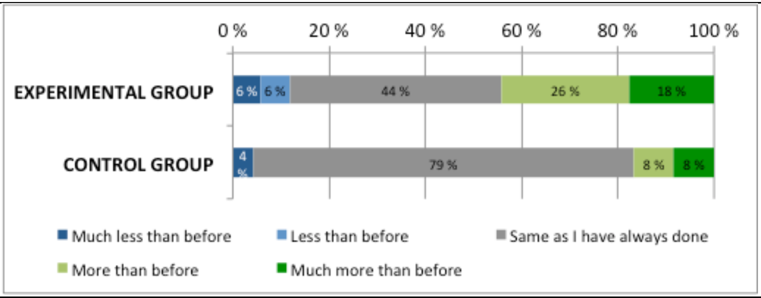
Figure 6-15: Summary of self-reported food waste recycling behaviour, with portion of food waste sorted into green bags (1), intention (2) and action (3) regarding recycling of leftovers from dinner.

We found that 83% of the experimental group report that *almost everything* or *everything* of their food waste is sorted into green bags, versus 92% in the control group. In order to measure self-reported intention and action regarding food waste, the behaviour is measured *leftovers from dinner*, as this should be more relatable to the respondents (see Figure 6-14). Results show that self-reported intention was lower for the experimental group (83% were *willing* or *very willing*), than for the control group (96%). Self reported recycling behaviour (action) was also high for both groups, but the experimental group claims to be better at recycling leftovers from dinner (91% recycle leftovers from dinner *almost every time* or *every time*, vs. 88%). In summary, overall intention to recycle food waste is very high for both groups.

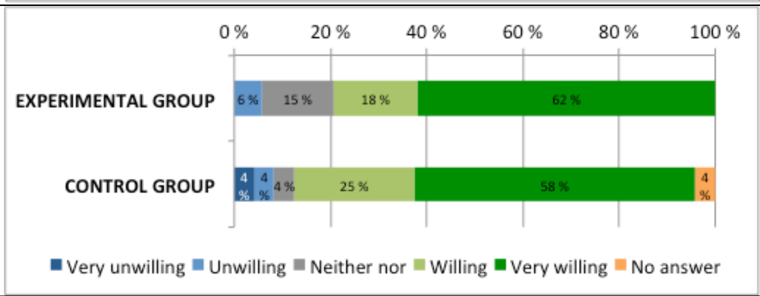
6.2.4.2 Self-reported glass and metal recycling behaviour

We also investigated glass and metal recycling behaviour in more detail, and the results are illustrated in Figure 6-16.

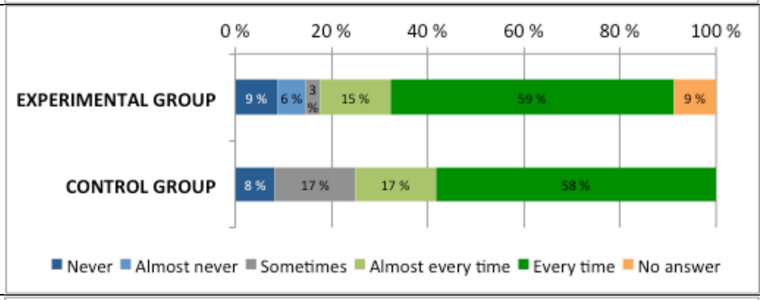
1: Quantity of glass and metal sorted last six weeks



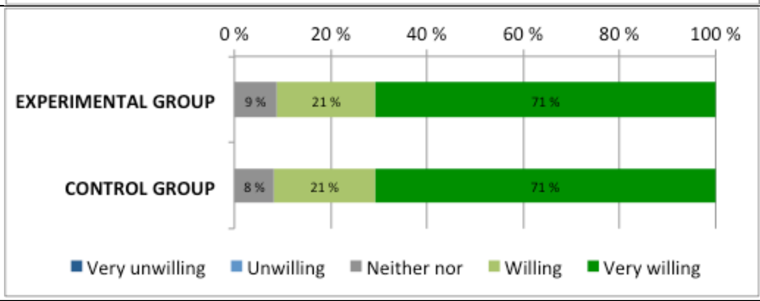
2: Self-reported intention to sort tin cans



3: Self-reported recycling behaviour (action) of tin cans



4: Self-reported intention to glass bottles



5: Self-reported recycling behaviour (action) of glass bottles

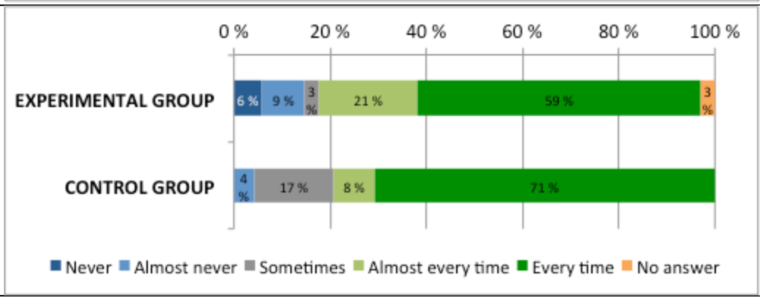


Figure 6-16: Summary of glass and metal recycling behaviour, including perceived glass and metal recycling behaviour (1), intention (2) and action (3) to recycle tin cans, and intention (4) and action (5) to recycle glass bottles.

The reason respondents were asked to indicate how much glass and metal they had recycled *during the last six weeks* was to identify a change in perceived behaviour since the start of our intervention. **Results show a clear difference in the reported quantities of glass and metal recycled in the last six weeks, where the experimental group reported that they had sorted *more* or *much more* glass and metal than before (44% vs. 16% in control group).** In comparison, 79% of control group respondents reported sorting the same amount as before. This indicates a clear improvement in glass and metal self-reported recycling behaviour for the experimental group.

We also investigated self-reported intention and action regarding tin cans and glass bottles. Intention to sort tin cans was lower for the experimental group compared to the control group (79% vs. 83% *willing* or *very willing*), but reported action was about the same (74% vs. 75% *almost every time* or *every time*). Intention to recycle glass bottles was similar for both groups (91% vs. 92%), and action was also similar (79% for both groups). In sum, results show similar recycling intention and self-reported behaviour for is similar for both groups regarding glass and metal, but there is a difference in how much the groups believed they had sorted in the past six weeks.

6.3 Summary

In this chapter we have described the results from the pick-analyses and questionnaire. The pick-analysis shows there are pre-test differences in recycling behaviour. The control group recycled more plastic, food waste, and disposed of less glass and metal in the residual waste compared to the experimental group. The recycling rate of waste fractions in the bring scheme was the same for both groups.

After the intervention, the experimental group's recycling behaviour for the targeted fractions changed. The experimental group sorted 17% more of overall food waste into green bags after intervention, and results show a 10% increase in the number of clean green bags. We also observed 29% less glass and metal in the residual waste after we reduced the distance to the collection point for the experimental group. The intervention glass and metal collection was actively used, and made permanent at the end of the experiment. Additionally, there was a 9% increase in clean bags with plastic. In comparison, control group's recycling rate for these waste fractions was unchanged.

When it comes to the questionnaire, there were demographic differences between the respondents belonging to the experimental and control group. The respondents in the experimental group consisted of more women, was younger, and with higher level of education. There were fewer households in the experimental group with one-person households, and households with three or more people, as well as more households with children compared to the control group. Access to and use of cars and public transport is similar in both groups.

In general, results show a high level of satisfaction with the waste management system in Oslo, and at home. At home, lack of space and convenience was cited as the main reasons for not recycling. Self-reported intentions and action for recycling are also high for all waste fractions. And as expected, self-reported intentions are higher than self-reported action. When it comes to perceived behaviour related to recycling of glass and metal, 44% of the experimental group reported that they had sorted *more* or *much more* glass and metal than before during the last six weeks. In comparison, 79% of control group respondents reported sorting the same amount as before. When it comes to beliefs about neighbours recycling behaviour, most respondents believe their neighbours recycle about the same amount of waste as them, no matter how much waste they believe their neighbours recycle. However, more respondents in the experimental group believe their neighbours are better than them at sorting their waste, which may indicate that the informational nudge has had an effect.

7. Discussion

This chapter will discuss the results of this thesis, and its structure will follow that of the conceptual framework. There is indeed a gap between intended and actual recycling behaviour, with intentions in general being higher than action. Our aim has been to design interventions that targeted actual recycling behaviour, and our results indicate that actual behaviour has changed. This discussion will focus on whether or not those changes were caused by the interventions we designed to test our hypotheses, or if sample selection bias may explain some of the variation.

We first discuss if the intervention related to supplier characteristics has changed recycling behaviour, before discussing how the interventions related to system characteristics appear affected recycling behaviour. Recycling behaviour will have affected recycling rates, which is how system performance has been defined in this thesis. Because recycling behaviour has been *measured* by the recycling rate, this discussion will treat them as one and the same, meaning if recycling behaviour has improved, recycling rates have increased.

7.1 Supplier characteristics and changes in recycling behaviour

The following hypothesis was designed to test how supplier characteristics and recycling behaviour are related:

> ***H1:*** *System performance improves when supplier characteristics facilitate recycling behaviour.*

The intervention that was designed to test this was an informational letter containing a nudge with the purpose to activate social norms that target food waste recycling behaviour. This was because motivation was the supplier characteristic that showed the most promise in its ability to affect actual recycling behaviour, and nudging appeared to be the best way to affect the motivation of end-consumer-turned-suppliers. The reasoning behind this choice was that if motivation could be increased, it would become a facilitator of recycling behaviour, as opposed to a lack of motivation, which would instead act as a barrier.

As expected, intentions to recycle food waste are higher than actual recycling behaviour. Our results show that 83% of the experimental group report that *almost everything* or *everything* of their food waste is sorted into green bags, versus 92% in the control group, with around 60% of respondents in both groups claiming they sort all their food waste into green bags. This means that almost all respondents in both groups claim to sort ~75% or more of their food waste, if *almost everything* is interpreted as being in the middle of *approximately half* (50%) and *everything* (100%).

In contrast, the pick-analysis showed that actual recycling behaviour is not as high as intentions. The control group sorted 52% of total food waste in the pre-test, meaning the control group actually recycle *approximately half* their waste. For the experimental group however, the pre-test showed that 39% of total food waste was sorted into green bags, which is less than half. This means that there was a large gap between intention and action for both groups prior to our interventions.

Post-test results showed that the control group sorted 53% of food waste. For the experimental group, recycling behaviour improved, as 17% more food waste (56%) was sorted into green bags after the intervention. This increase in green bags was also without contamination. There is still a gap between intention and action for both groups, but the gap has become smaller for the experimental group, whereas the control group's behaviour remained constant. It therefore appears that using an informational nudge to improve food waste recycling worked, and that we did manage to activate a norm regarding recycling. Our results are in line with other studies that have successfully used social norms to improve environmental friendly behaviour such as littering, and energy conservation (Barr 2007, 470, Goldstein, Cialdini, and Griskevicius 2008, Allcott 2011, Ayres 2012). The results also support the observational study of Schultz (1999), in which messages activating social norms were found to have an effect on participation in recycling schemes, and on amount of waste recycled. As we used a combination of descriptive and injunctive norms, our results seem to support evidence that suggests these messages are effective in changing behaviour (Schultz et al. 2007, Cialdini 2003).

However, because the intention-action gap is present in both groups, and as both groups only recycle a little over half their food waste, it is worth discussing to what degree a social norm regarding recycling has been internalised in the housing cooperative. If a social norm is internalised, it becomes a personal norm and source of internal motivation (Schultz 1999). We do not know to what degree each person actually recycles their waste due to the way the collection points are configured. We do not know if some end-consumer-turned-supplier recycle nothing, and some everything, as our numbers reveal average recycling behaviour. If we for example assume that the questionnaire respondents who reported high intentions also recycle all their food waste, and that the people who did not respond to it recycle nothing, the overall recycling rate will still be approximately 50%, and there is likely a smaller intention action gap. This also means that our intervention may only have succeeded to re-activate a latent personal norm about recycling present in the experimental group, and not established a new norm for those who previously did not recycle.

To further explore this, we asked respondents how they perceived their neighbours' food waste recycling behaviour, as this was what the informational nudge had targeted. We found that a higher share of the respondents in the experimental group both believed that their neighbour sorted their waste, and that their neighbours were better than themselves at sorting their waste. The questionnaire response rate of 33% means we can only use this data to support the findings from the pick-analysis. Taken together, these results indicate that the observed change in food waste recycling behaviour probably was caused by the informational nudge and an activation of a social norm.

This also controlled for the change in distribution method, as the experimental group was also provided with green bags for food waste disposal when the nudge was distributed. This change in distribution method may partially have caused the increase in food waste recycling because end-consumer-turned-suppliers simply had not recycled because they lacked the equipment to do so, and this may confound our results.

In conclusion, it appears plausible that the informational nudge did in fact activate a social norm, which successfully increased the recycling rate of food waste.

7.2 System characteristics and change in recycling behaviour

The hypothesis that was derived to test how system characteristics may improve recycling behaviour was the following:

> ***H2:*** *System performance improves when system characteristics facilitate recycling behaviour.*

We derived two interventions in the form of system nudges to test this hypothesis: The first involved reducing the distance to glass and metal collection point, the second was to ensure access to free waste bags for food, plastic and residual waste, and to distribute a reusable glass and metal bag. Recall that the logic behind these interventions was that theory suggested that a waste management system with shorter distance to the collection point and access to necessary equipment would facilitate, and not constrain, recycling behaviour.

Overall, the intention to recycle glass and metal was high, and quite similar for both groups. Around 80% of respondents reporting they were *willing* or *very willing* to sort glass and metal, and that they did this *almost every time* or *every time*. As we still found glass and metal in the residual waste, it is clear that there is also a gap between intention and action for glass and metal. However, the gap between intention and action was larger for the experimental group than the control group, as the pre-test revealed that the experimental group disposed of more glass and metal in the residual waste.

After the intervention, glass and metal recycling behaviour improved for the experimental group, as 29% less glass and metal in was observed in the residual waste in the post-test pick analysis. In addition, the fill-rate of the intervention glass and metal container increased at a steady rate. This container was also made permanent due to its frequent and continued use. The fact that this was an actual change in recycling behaviour, and not some seasonal change, is supported by the fact that 44% of experimental group questionnaire respondents reported that they had sorted *more* or *much more* glass and metal than before during the last six weeks. There were not such patterns among the control group.

Overall, these findings indicate that the reduced distance to the collection point did result in a change in recycling behaviour, and thus a higher recycling rate for glass and metal. Our findings support previous studies which have found that kerbside schemes (compared to bring schemes) increases recycling quantities (Dahlén et al. 2007), and that reduced distance to collection point may be a tool to increase sorting and recycling (Rousta et al. 2015). Improved recycling rates for metal, which contains a lot of aluminium, is also beneficial to the environment. This is because reusing aluminium for new products requires only 5% of the energy compared to primary aluminium production (Hydro 2012).

The second intervention looked at how access to equipment affected recycling behaviour. This was measured by looking how contamination of bags changed after the end-consumer-turned-suppliers were provided with free waste bags for food, plastic and residual waste, as well as a reusable bag for glass and metal. Our results indicate that for the experimental group, there is less contamination in both green and blue bags after the intervention. For food waste, we observed a 10% decrease in the number of contaminated bags, while the behaviour of the control group did not change. For plastic waste, the number of correctly sorted blue bags increased by 9% for the experimental group, compared to a 2% decrease for the control group. As previously stated, we do not know how much of the increase in the food waste recycling rate was caused by the nudge or by access to waste bags, but as the change also happened for the blue bags this may suggest that overall recycling behaviour has improved. More importantly, the post-test pick analysis showed a decrease in the number of blue and green bags used for residual waste bags, which is an improvement, and in sum these findings indicate that convenience is a determinant in recycling behaviour, which is in line with Miafodzyeva and Brandt (2013). This thesis also corroborates Perrin and Barton (2001), who found that participation or non-participation in recycling schemes were linked to the level of inconvenience it poses to the end-consumer-turned-supplier.

On the other hand, we did not observe a reduction in contamination for paper and cardboard. Although we observed an 11% decrease in paper and cardboard in the residual waste for the experimental group, results indicate a 24% *increase* for the control group. It thus appears that the decrease observed for the experimental group was due to seasonality, and not improved recycling behaviour, as the control group's behaviour also changed. This is in line with Schultz (1999), who found that interventions did not lead to lower rate of contamination. However, as none of our interventions specifically targeted paper and cardboard waste, and we therefore did not improve convenience for this fraction, this finding is not surprising. This is supported by the qualitative statements from some of the experimental group respondents stating that they do not recycle paper waste due to lack of space. Moreover, the red bags for residual waste were not used by many end-consumer-turned-suppliers (7% of overall residual waste), and this intervention was not used. This may be because the bags were too small, and this did not make it more convenient for the end-consumer-turned-supplier.

The way the glass and metal bag was thought to influence convenience was through a possible change the consumer logistics strategies used to recycle glass and metal. If the bag increased convenience for the end-consumer-turned-supplier, they would start to use it, thus changing their consumer logistics strategy. The lag in fill-rate for glass and metal which we observed the first week could indicate that the end-consumer-turned-supplier changed from not recycling glass and metal to a strategy that involved stockpiling the glass and metal waste in the bag we distributed. Since this bag has room for quite a lot of waste, it could therefore take a while to fill this bag up. This is in line with the stockpiling strategy as defined by Monnot, Reniou, and Rouquet (2014).

Correspondingly, consumer logistics patterns could also be influenced by car access and the use of public transport across the groups. If the end-consumer-turned-suppliers used pooling as a strategy, they may have disposed of glass and metal in on their way to their mode of transportation (Monnot, Reniou, and Rouquet 2014). However, it is unlikely that this is relevant in this thesis, as both these measures are higher for the experimental group, yet they still had lower pre-test recycling rates for glass and metal.

In general, intentions to recycle are high for both groups. The presence of pre-test differences in actual recycling behaviour may thus be illuminated by looking into aspects related to housing, as these affect level of perceived convenience (Bernstad 2014). The data shows that more people in the experimental group live in households with three or more people, and more respondents live in households with children. Raising children require time and effort, and if the end-consumer-turned-supplier perceived the current waste management system as requiring too much time and effort in an already demanding everyday life, it is plausible to assume that recycling is not on top of people's priority lists. This in in line with Stoknes (2015), and supports the design of a waste management system that makes recycling convenient for the end-consumer-turned-suppliers.

This claim is further supported by the qualitative statements regarding system and home satisfaction from both groups, which identified a lack of space and equipment as reasons for not recycling. As we only got 16 comments regarding home system satisfaction, and nine regarding overall satisfaction, we cannot generalize these within the groups or to the whole sample. However, we find that the themes of space, knowledge, convenience, pick-up frequency and lack of equipment are relevant to both groups, and thus appears to be a general concerns for the end-consumer-turned-suppliers.

Overall, it thus appears that system nudges such as reducing the distance to the glass and metal collection point, and increasing access to equipment, helps increase level of convenience, thus improving recycling behaviour.

7.3 Summary

It appears that both the nudges related to supplier characteristics and the interventions related to system characteristics have lead to an improvement in the end-consumer-turned-suppliers' recycling behaviour for the targeted waste fractions. We therefore find support for the hypotheses we have tested, and our results also align with findings of previous studies.

8. Conclusion

The aim of this thesis is to answer the following research question: *How can reverse logistics contribute to improve household waste recycling behaviour?* This thesis has specifically looked at waste management in a circular economy perspective, and it has been shown how this system may be considered a reverse logistics system characterized by serial interdependencies. Our main area of focus has been to understand how the end-consumer-turned-supplier both affects—and is affected by—the waste management system. A conceptual framework for understanding how supplier characteristics and system characteristics affect recycling behaviour, and thus system performance, was developed and tested through the use of a quasi-experimental design.

The quasi-experiment, which was set up to take into account the intention-action gap, used a pick-analysis to analyse waste composition to measure actual recycling behaviour in a housing cooperative consisting of high-rise buildings. To test whether or not the end-consumer-turned-supplier's recycling behaviour could be affected through affecting supplier characteristics directly, we identified motivation to be a promising way of improving behaviour in the long run. We tested if an informational nudge could increase motivation through the activation of social norms and thus lead to an improved recycling behaviour. Results indicate that the informational nudge did work, as an increase in recycling behaviour for the targeted fraction did improve.

In order to test if the end-consumer-turned-supplier could be affected through changing the system, we identified a change in fractions from bring schemes to kerbside schemes (reducing distance to the collection point), as well as access to equipment. Moving a fraction from the bring scheme to the kerbside scheme significantly improved recycling for that fraction, and the new system configuration was made permanent. Access to equipment also contributed to improved convenience, and thus improved recycling behaviour for the fractions that were specifically targeted by the interventions.

In sum, it appears that there is empirical support for the conceptual framework, which is illustrated below.

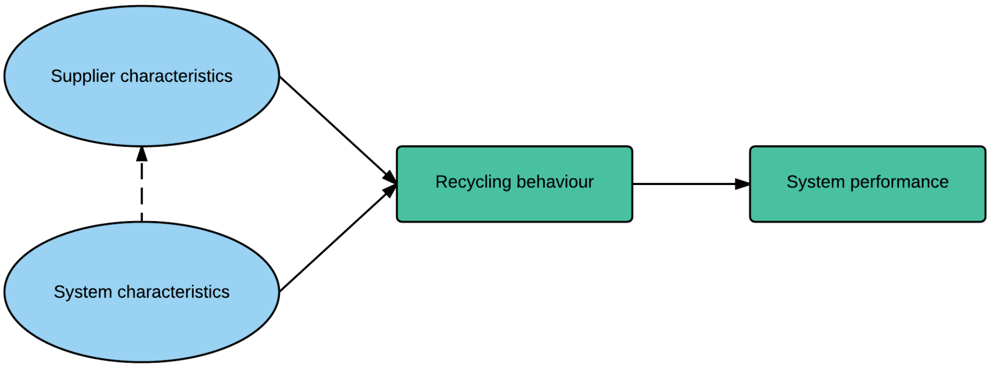


Figure 7-1: Conceptual framework, simple illustration

It thus seems that reverse logistics has the potential to contribute a great deal to improve recycling behaviour. The interventions were designed as nudges, and this thesis has shown their efficiency in improving behaviour by making choices simple for the end-consumer-turned-suppliers. In a world where people are constantly running from one thing to the next, it appears that nudging is a powerful tool that is able to cut through the noise and make people behave in the way that is needed to create a circular economy—designing waste management systems that work for the environment, the waste management service providers, *and* the end-consumer-turned-suppliers means we are one step closer to creating a sustainable economy.

8.1 Implications

This thesis naturally has some implications, and we have separated these into theoretical and practical implications.

8.1.1 Theoretical implications

We previously identified a lack of literature looking at household waste management from a reverse logistics perspective. More specifically, there was very little written about the role of the end-consumer-turned-supplier. We therefore derived a conceptual framework with the purpose to better understand how the end-consumer-turned-supplier and the waste management system were connected, and how these actors affected each other.

The framework was then tested in an empirical setting. Our findings suggest that both supplier and system characteristics may impact recycling behaviour, and thus system performance. Due to the central role of the end-consumer-turned-supplier, it appears that new insight into waste management issues may be gained from combining the fields of reverse logistics and psychology and consumer behaviour in the future. This is especially relevant within the fields of nudging and behavioural economics.

The thesis also looked at household waste recycling in an urban residential area, with high-rise buildings. Waste management in these areas often require many end-consumer-turned-suppliers to use each kerbside collection point, and small apartments also harm perceived convenience. This thesis may thus contribute to increased knowledge of how waste management may be improved in areas with increasing urbanization and thus often a lack of space to store waste.

8.1.2 Practical implications

The findings from this thesis may have practical implications for waste management actors trying to achieve higher recycling rates, especially in systems with source separation. Waste management service providers can benefit from understanding the importance of the end-consumer-turned-supplier in the reverse logistics systems, as this actor ultimately determines the input to the system. This thesis also offers practical insight when it comes to the design of waste management systems. Our thesis suggests that recycling rates improve when recycling is made easy for people. Thus, taking the insights gained from this thesis into account may help the waste management system to serve as a facilitator for recycling behaviour.

In redesigning or evaluating the effect of specific design elements, such as distance to collection points or pick-up frequency, waste management service providers can also benefit from understanding the intention-action gap. This means that actual behaviour would need to be assessed instead of self-reported behaviour.

In addition, the current knowledge base indicates that monetary incentives are not effective in changing motivation. Waste management service providers are therefore encouraged to spend their resources wisely, and to investigate interventions that have been shown to have an impact on actual recycling behaviour before spending resources on interventions that may potentially harm recycling rates in the long run. This is not conductive to creating a circular economy in which resources need to be higher up in the waste hierarchy to be fully utilized in a closed-loop supply chain—thus such a system depends on higher recycling rates.

The researchers also note that by only measuring recycling rate as weight percentage (wt.%), this may lead to emphasis on the heaviest waste fractions on the expense of those waste fractions that are not that heavy, such as plastic waste. If only "what is measured gets done", as the saying goes, important fractions may be ignored.

8.2 Limitations

Despite its contribution, the present thesis is not without limitations. As this thesis has had a circular economy perspective, in which system performance has been defined as the recycling rate. Thus system performance in terms of cost and service level has not been covered.

It is also important to note that the time between the interventions and the post-test pick-analysis might have been too short to say something about the possibility of long term effects of the initial increase in recycling behaviour. To evaluate potential persisting changes in recycling behaviour, new pick-analysis would have to be performed at later points in time. Moreover, a focus group could have been used instead of the questionnaire, as this would have allowed us to talk to those end-consumer-turned-suppliers who did not recycle their waste.

In addition, the small sample of this thesis is also a concern. Even with examining the waste of 176 households, the co-collection of made it impossible to isolate every individual's waste and carry out statistical testing. Statistical testing would allow for statistical conclusion validity which would strengthen internal validity (Shadish, Cook, and Campbell 2002). The result of this thesis may therefore only be interpreted as indications, since no statistical valid inferences may be drawn about the existence or size of covariation between the variables. However, this does not mean that our results are not internally valid, as we used several methods to infer the results of this study.

In terms of generalizability, there is surface similarity between the demographic characteristics of the housing cooperative and those of Stovner, so we assume the results are valid for Stovner district. Because demographic characteristics cannot accurately predict recycling behaviour, this is not necessarily an indicator of generalizability to other areas. However, we believe these results may be valid for similar waste management systems and similar housing types as the one in this thesis, as these appear to be more powerful indicators of recycling behaviour.

8.3 Further research

This thesis has developed a conceptual framework (c.f. Figure 3-1), which of course needs further testing. The present study should be replicated with a larger sample size in order to allow for the use of statistical methods to control for confounding effects, and researchers are encouraged to conduct longitudinal research to test if the change in recycling behaviour holds over a longer period of time.

Moreover, this thesis could not explore all dimensions of supplier and system characteristics that were identified in the conceptual framework, and future research may therefore be designed to investigate the effect of these unexplored dimensions.

Since system performance has been defined as recycling rate in this thesis, further research should expand the performance measure to include cost and service level, as a change in recycling rates could influence both these dimensions. This would allow for a holistic perspective on performance in a reverse logistics waste management system.

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Appendix A: Informational letter

Oslo kommune
Renovasjonsetaten

INFORMATION FOR THE HOUSEHOLDS IN [name] HOUSING COOPERATIVE

Hello! We are testing out several solutions for recycling of household waste

You are chosen to test these solutions, and for that reason you receive this letter. The board in your Housing Cooperative has been informed about the test, and has approved it.

Recycling is given high priority in Oslo municipality, but we are dependent on your contribution. To make the sorting of waste easier for you, we are testing out **two new practical solutions** for a period:

1. **An extra container for glass and metal can be found together with your ordinary paper/packaging and residual waste containers.**
   - You will find the new container next to entrance number [x].
   - You will also get *a bag for glass and metal*

   It is important to recycle glass and metal, since glass and metal tear up and destroys the bags used for waste disposal.

2. **Three types of bags: Green, blue and red (new bag in test)**
   - Green – food waste
   - Blue – plastic waste
   - *Red – residual waste*

   All of these bags can be thrown in the ordinary residual waste container. Use the red bag until you do not have any left. Then you can continue using ordinary shopping bags. You will find the green and blue bags at the grocery store as usual.
   - Paper and cardboard – remember that this are still going in a separate container.

Did you know that 8 out of 10 of your neighbours separate their food waste into green bags? Food waste is an important resource that is used to produce biogas and bio fertilizer. Even if you only have a small amount of food waste, it is important to always use a green bag.

For sorting of other types of waste, see the sorting guide which we have handed out to you.

The test is being executed as a project between master students at the Norwegian Business School BI and the Agency for Waste Management during the spring of 2016.

For any questions, please contact Agency of Waste Management's customer service at phone number 23 48 36 50 between 08.00 a.m. and 03.30 p.m.

Thank you for recycling!

Kind regards,
Master students at BI and Agency for Waste Management

: Sammen gjør vi Oslos viktigste jobb

Renovasjonsetaten Postadresse: Postboks 14 Vollebekk 0516 OSLO
Besøksadresse: Haraldrudveien 20
E-post: postmottak@ren.oslo.kommune.no
Organisasjonsnr.: NO 976 820 088
Sentralbord: 02 180
Kundetorg: 23 48 36 50
Telefaks: 23 48 36 01

Appendix B: Waste fractions into categories and descriptions

No.	Category	Sub-category		Description
1	Paper and cardboard	1.1	Beverage carton	Packaging for non-carbonated beverages and packaging for sauces. For example: milk cartons, juice cartons, vanilla sauces.
		1.2	Corrugated cardboard and brown paper	Corrugated cardboard and solid board, bags and packaging made of brown paper.
		1.3	Other carton and paper packaging	Packaging from sugar, flour and bread etc. Paper bags. Boxes and cartons, for example pizza boxes, shoe boxes, egg cartons, cereal cartons, and boxes for toys etc. Toilet paper and paper towel cores.
		1.4	Reading material and other paper	Newspapers, magazines, advertisements, paperback books, and catalogues without rigid cover. Sheets for notes, envelopes, ordinary copy and printer paper, note books and posters.
2	Food waste	2.1	Usable food waste	Bread and pastries, cheese, jam, butter etc. used for sandwiches, left over from dinner, snacks, dairy products.
		2.2	Non-usable food waste	Peels from fruit and vegetables; bones; eggshells, coffee grounds; etc.
		2.3	Paper towels from kitchen	Paper towels, and napkins (only from kitchen activities; not form bathroom); coffee filters.
3	Garden waste	3.1	Garden waste	Branches, twigs, leaves, grass. Fruit and growths grown in own garden.
		3.2	Indoor plants	Herbs, indoor pot plants, cut flowers etc.
4	Bags for waste disposal	4	Bags for waste disposal	Bags used for disposal of waste.
5	Plastic waste	5.1	Hard plastic packaging	Moulded hard plastic packaging. Trays, bottles, cups, flower pots etc.
		5.2	Plastic foil packaging	Foils used for packaging of products.
		5.3	Plastic bottles with refund	All bottles with refund made of plastic, both Norwegian and non-Norwegian.
6	Other plastic	6	Other plastic	All plastic which is not packaging. Plastic baskets, garden furniture, buckets, containers, toys, CD covers, cutlery of plastic, tooth brushes, flooring, foam, garden hoses, dishwashing brushes.
7	Glass and metal	7.1	Beverage packaging of glass	Bottles of glass. Juice bottles, lemonade bottles, wine bottles, beer bottles, soda bottles. Not items such as cod liver oil bottles, cough syrup bottles etc.
		7.2	Other glass packaging	Glass packaging which is not beverage packaging. Glass used for jam, sauces, baby porridge, etc.
		7.3	Metal packaging	Tin cans, jam lids, metal caps etc. Aluminium foil, -boxes and – containers.
		7.4	Beverage packaging of	All aluminium boxes with refund, and Swedish and other imported boxes.

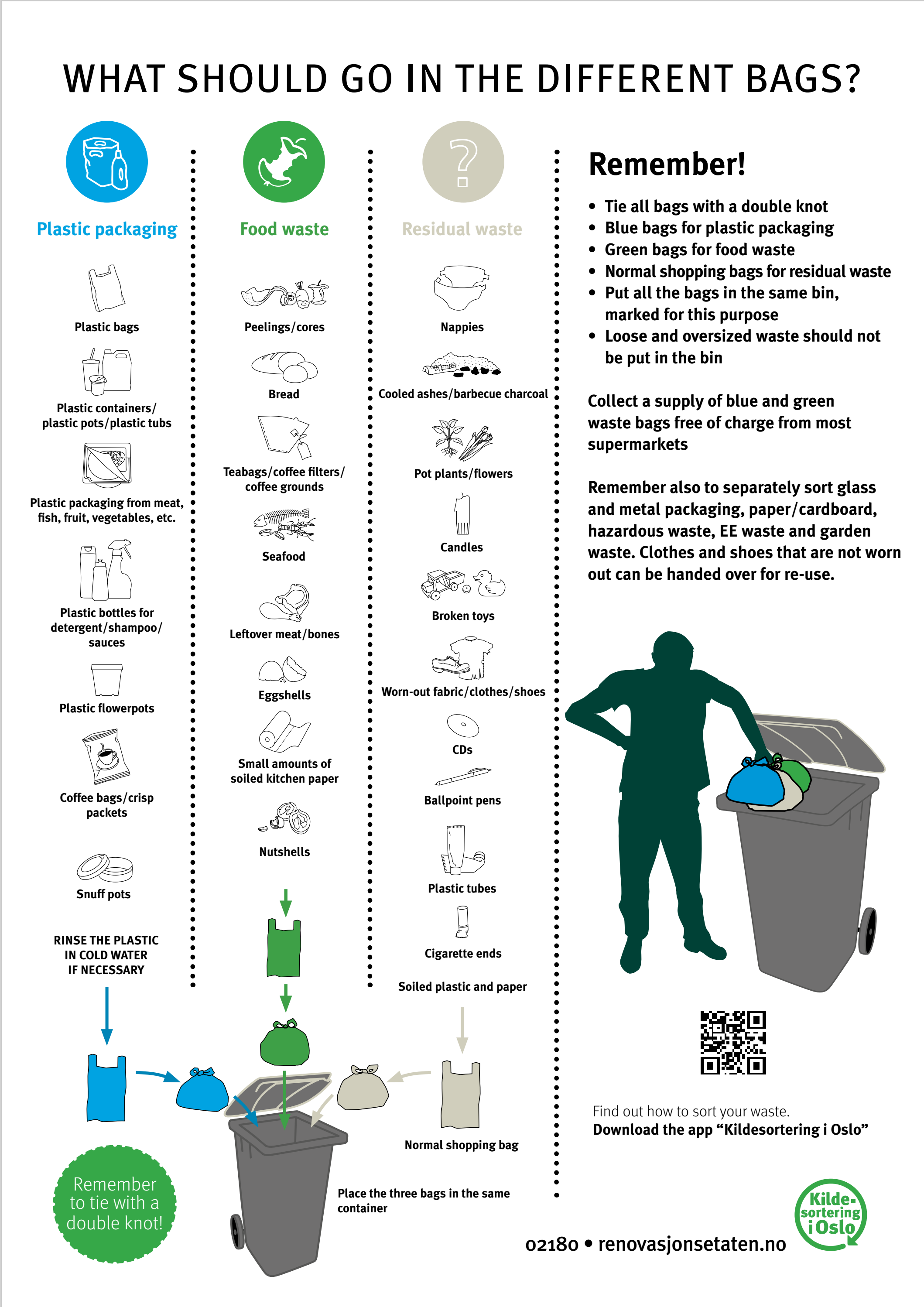
			aluminium	
8	Other glass, metal and EPS/EPP	8.1	Other glass	Glass which is not packaging. Kitchen items and ornaments made by glass, windows, mirrors, drinking glasses.
		8.2	Other metal	Metal which is not packaging. Tools such as hammers, screws, nails, crowbars etc. Iron rods, metal plates, bread forms. Umbrellas.
		8.3	EPS/EPP (styrofoam etc.)	3D packaging for electronics and furniture, and other cushioning packaging (not for food products).
9	Textiles	9.1	Textiles for reuse	Shoes, clothing, and other textiles.
		9.2	Textiles for recycling	Clothes, curtains, linen, towels, blankets, shoes, socks, underwear fit for material recycling.
10	Hazardous waste	10	Hazardous waste	Painting, lacquer, danger highlighted spray cans, solvents, and cleaning detergents, grease, inorganic bases, lighters, and other gas containers. XPS, treated wood, vinyl flooring, and skirting etc.
11	Electric or electronic waste (EE-waste)	11	Electric or electronic waste	Electronic products, light bulbs, wires (everything with current or batteries, including shoes, toys etc.), and also batteries.
12	Residual waste	12.1	Other waste	Waste which does not belong to any other waste fraction. Diapers/sanitary napkins, wood, vacuum cleaner bags, candles, corks, paper not suited for recycling (paper cups, paper plates, greaseproof paper, laminated paper etc.), pet litter bags, paper towels/cotton pads from bath room, medicines. Cement, stone, cat litter, ceramics, plaster, and insulation material.
		12.2	Textiles not suited for recycling	Textiles which are splashed or destroyed with paint etc., and which have not been clean or dry when disposed. Wore out shoes or boots (not rubber boots).

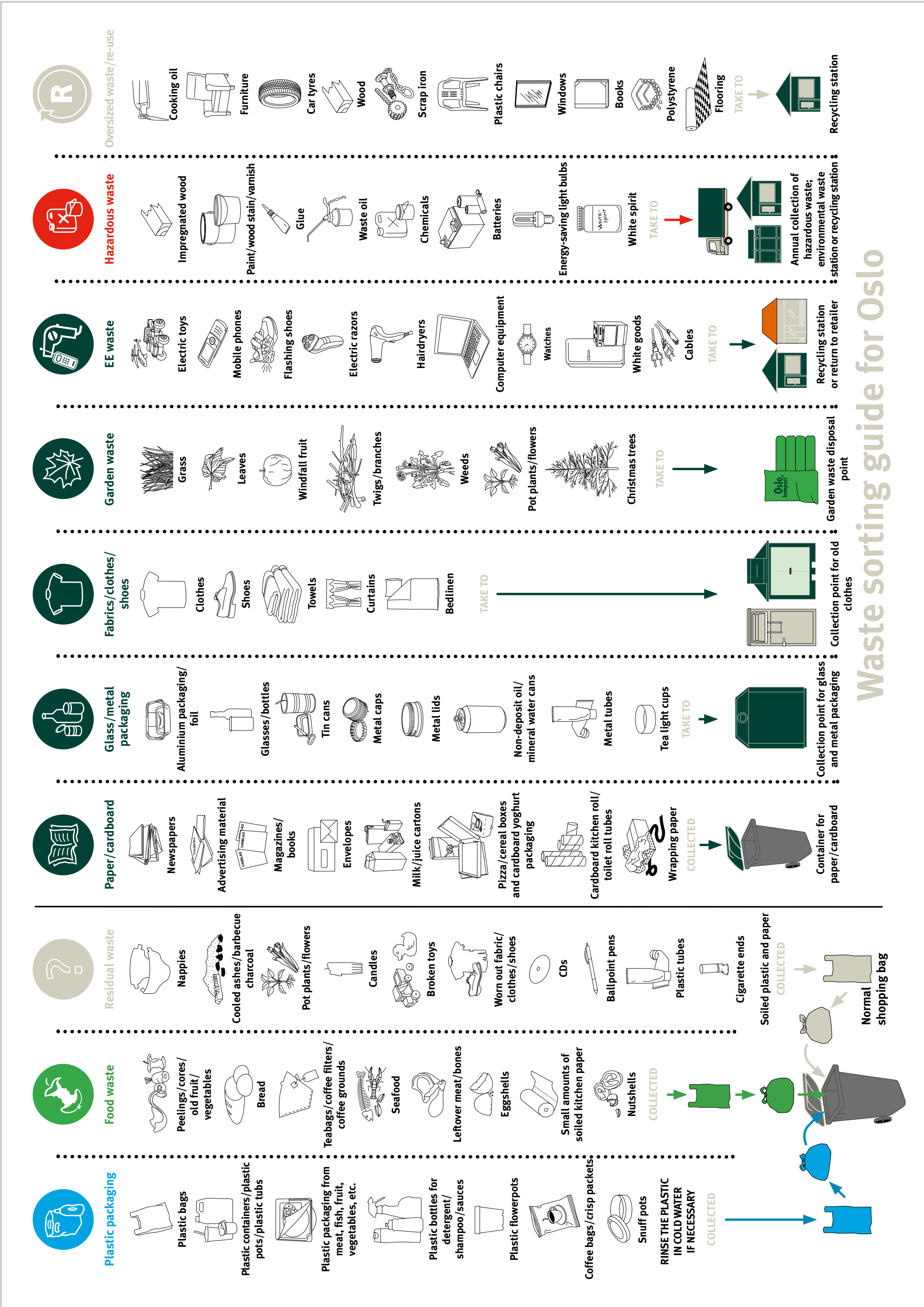
Appendix C: Pick-analysis set up

Picture 1: Pick-analysis set-up with sorting table, buckets and 240l containers lined up around.

Picture 2: Pick-analysis set up showing sorting table in the foreground, shuffles, brooms and weight at the right side, waste loads for the experimental and control group in the middle, and 660l containers used for storage of waste in the background.

Appendix D: Sorting guide




Waste sorting guide for Oslo
Plastic packaging
Plastic bags
Plastic containers/plastic pots/plastic tubs
Plastic packaging from meat, fish, fruit, vegetables, etc.
Plastic bottles for detergent/shampoo/sauces
Plastic flowerpots
Coffee bags/crisp packets
Snuff pots
RINSE THE PLASTIC IN COLD WATER IF NECESSARY
COLLECTED
Food waste
Peelings/cores/old fruit/vegetables
Bread
Teabags/coffee filters/coffee grounds
Seafood
Leftover meat/bones
Eggshells
Small amounts of soiled kitchen paper
Nutshells
COLLECTED
Residual waste
Nappies
Cooled ashes/barbecue charcoal
Pot plants/flowers
Candles
Broken toys
Worn out fabric/clothes/shoes
CDs
Ballpoint pens
Plastic tubes
Cigarette ends
Soiled plastic and paper
COLLECTED
Normal shopping bag
Paper/cardboard
Newspapers
Advertising material
Magazines/books
Envelopes
Milk/juice cartons
Pizza/cereal boxes and cardboard yoghurt packaging
Cardboard kitchen roll/toilet roll tubes
Wrapping paper
COLLECTED
Container for paper/cardboard
Glass/metal packaging
Aluminium packaging/foil
Glasses/bottles
Tin cans
Metal caps
Metal lids
Non-deposit oil/mineral water cans
Metal tubes
Tea light cups
TAKE TO
Collection point for glass and metal packaging
Fabrics/clothes/shoes
Clothes
Shoes
Towels
Curtains
Bedlinen
TAKE TO
Collection point for old clothes
Garden waste
Grass
Leaves
Windfall fruit
Twigs/branches
Weeds
Pot plants/flowers
Christmas trees
TAKE TO
Garden waste disposal point
EE waste
Electric toys
Mobile phones
Flashing shoes
Electric razors
Hairdryers
Computer equipment
Watches
White goods
Cables
TAKE TO
Recycling station or return to retailer
Hazardous waste
Impregnated wood
Paint/wood stain/varnish
Glue
Waste oil
Chemicals
Batteries
Energy-saving light bulbs
White spirit
TAKE TO
Annual collection of hazardous waste; environmental waste station or recycling station
Oversized waste/re-use
Cooking oil
Furniture
Car tyres
Wood
Scrap iron
Plastic chairs
Windows
Books
Polystyrene
Flooring
TAKE TO
Recycling station

Appendix E: Questionnaire

Form number:

Questionnaire about recycling in Oslo

Purpose

The questionnaire is about recycling, and we wish to ask you some questions. Your responses will be an important contribution to research which will give us more knowledge about recycling. The questionnaire is conducted by two master students, and is a part of our master degree at the Norwegian Business School BI, and is performed in cooperation with the Agency for Waste Management in Oslo municipality.

What does participation in the study entails?

You have to answer the questionnaire form, and it takes approximately 5-7 minutes. The questionnaire consists of 22 questions.

What happens with the information about you?

All personal information will be handled confidentially, and the answer sheet will be shredded afterwards. It will not be possible to identify your responses in the final master thesis. It is only two students and our supervisor at BI which will have access to the information.

Participation is voluntary

It is voluntary to participate in the study. If you wish to withdraw from the study after you have delivered the questionnaire form, you have to contact us and specify your form number.

The study is reported to the official for data protection for research NSD – Norwegian Centre for Research Data AS.

If you have any questions related to the study, contact [name student] at phone number [x], or e-mail adress [x], or our supervisor Bente Flygansvær on phone number [x] .

How to hand in filled out form?

Put the filled out questionnaire in the marked envelop which you will find on the wall at the entrance (first floor).

Deadline: We need your form by [date]

Part 1 – About recycling in your housing cooperative

We are now going to ask you some questions about your recycling habits, and about recycling in your housing cooperative. It is important that you answer as honest as possible, and after best efforts. This part will consist of 11 questions, and will take ca. 3-4 minutes to complete.

1) Have you received something on your door by the Agency for Waste Management Oslo municipality during the last 6 weeks?

Yes	
No	

1.1) **If yes:** When you received something on your door from the Agency for Waste Management in Oslo, did you speak to those who handed out the equipment?

Yes	
No, they just put it outside my door.	

You need to answer all the following questions.

How satisfied are you, in general, with the ways you can deliver waste in Oslo? We are now thinking about both the waste you have to deliver yourself, and also the waste which is collected outside your housing. Only tick one box.

Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied

If you could change anything with the way you can deliver waste, what would that be? If you need more space to answer the question, you can use the back of the sheet.

2) Think about how you have organised recycling in your household. How satisfied are you with your solutions? We are now thinking about the way you store your waste and containers you use for this purpose. Only tick one box.

Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied

If you could change something with your solutions in your house, what would that be? If you need more space to answer the question, you can use the back of the sheet.

3) When you dispose any of these items, how often do you sort them? Tick off.

	Never	Almost never	Sometimes	Almost every time	Every time
Plastic packaging					
Leftovers from dinner					
Soiled plastic					
Beverage cartons					
Tin cans					
Textiles					
Pot plants					
Electrical products					
Batteries					
Glass bottles					

5) During the last six weeks, how much glass- and metal packaging (for example tin cans and glass bottles without refund) would you say you recycle? Only tick one box.

Much less than before	Less than before	Same as I have always done	More than before	Much more than before

6) Do you think your neighbours are better or worse than you when it comes to recycling? Only tick one box.

Much worse	Worse	About the same	Better	Much better

7) Which of the following statements would you say reflect how waste in the blue and green bags are handled in Oslo? Only tick one box.

	Tick off
Everything in the blue and green bags will be recycled, and turned into new material for new products	
Some of the blue and green bags will be recycled, but some will also be combusted	
Everything in the blue and green bags will be combusted together with the residual waste	

8) How much of their waste do you think your neighbours recycle? Tick off.

Nothing	Almost nothing	Approximately half	Almost everything	Everything

9) How willing are you to recycle the following items?

	Very unwilling	Unwilling	Neither nor	Willing	Very willing
Batteries					
Soiled plastic					
Glass bottles					
Beverage cartons					
Leftovers from dinner					
Electrical products					
Pot plants					
Tin cans					
Plastic packaging					
Textiles					

10) How much of your food waste do you sort in green bag? Only tick one box. If you do not sort food waste in the green bag, tick the box for "nothing".

Nothing	Almost nothing	Half approximately	Almost everything	Everything

11) What are the four most important reasons why you do not sort your food waste in green bag? Only choose 4 reasons, and range these from 1-4, where 1 is most important and 4 is least important. If you sort everything, you do not need to answer.

	Ranger
Have not received any information about how to sort my waste	
Do not have enough food waste to bother	
It is nasty/smells bad	
Do not have green bags/do not know where to find green bags	
It is useless to sort food waste	
It attracts bugs	
Use food waste for compost/ have a pet that eat it	
To busy/ easier to put it in together with the residual waste	
Worried about hygiene and/or children close to it	
Do not have a food waste container	
I fell that I contribute my part	
It is more important to recycle other items	
Food rot, so it is not necessary to recycle it	
Have not been informed about why it is important to recycle food waste	

Part 2 – General information about you and the other members of the households
We are now going to ask you some questions about you and the other member of the household. This part consists of 11 questions, and it will take ca. 2-3 minutes to answer them.

1) What gender do you identify with?

Female	
Male	

2) How old are you?

Under 35 years old	
35 to 54 years old	
55 years old or older	

3) How many people live in the apartment? If you are living alone, tick off for 1 person.

1 person	
2 people	
3 or more people	

4) How many children live in the apartment?

No children	
1 child	
2 or more children	

5) How old are the children living with you? If you are living with two (2) children between the ages of 5-8 years, you write the number 2 in the associated box.

0–4 years old	
5–8 years old	
9–12 years old	
13–17 years old	
18 years or older	

6) Which type of apartment do you live in? 3-rooms means 1 living room + 2 bed rooms, 4-rooms means 1 living room + 3 bed rooms.

3-rooms	
4-rooms	

7) What is your highest accomplished education? If you have taken your education abroad, choose the one which fits best. Only tick off one box.

Upper secondary	
High school	
1–3 years at university	
4 years or more at university	

8) How much did you earn per year, before taxes? Only tick of one box.

Less than 250.000 NOK	
Between 250.000 – 399.000 NOK	
Between 400.000 – 599.000 NOK	
600.000 – 799.999 NOK	
800.000 – 1 million NOK	
More than 1 million NOK	

9) Where are you born? Only tick of one box.

In Norway with Norwegian parents	
In Norway with one or more foreign parents	
Born outside Norway	

10) Have you or anyone you live with a car? Only tick off one box.

Yes	
No	

11) Do you use train or bus more than two times a week? Only tick off one box.

Yes, both bus and train	
Yes, but only train	
Yes, but only bus	
No, neither	

Thank you for the time you put into participating in this questionnaire!

Put the filled out form in the marked envelope you will find in your hallway **Deadline: We need the form by [Date].**

Appendix F: Pictures of loose waste removed during the post-test experimental group analysis

Picture 1: Loose waste before removal of waste belonging to a resident moving into the housing cooperative

Picture 2: Loose waste after removal of waste belonging to a resident moving into the housing cooperative

Appendix G: Pictures hazardous and EE-waste

Picture 1 Hazardous waste intervention group pick analysis 1

Picture 2 Hazardous waste control group pick analysis 1

Picture 3 EE-waste intervention group pick analysis 1

Picture 4 EE-waste control group pick analysis 1

Picture 5 Hazardous waste intervention group pick analysis 2

Picture 6 Hazardous waste control group pick-analysis 2

Picture 7 EE-waste intervention group pick analysis 2

Picture 8 EE-waste control group pick analysis 2

Appendix H: Pictures contaminated green bags

Picture 1 Contaminated green bags experimental group pre-test analysis

Picture 2 Contaminated green bags experimental group post-test analysis

Picture 3 Contaminated green bags control group pre-test analysis

Picture 4 Contaminated green bags control group post-test analysis

Appendix I: Intervention collection point glass and metal

Appendix J: Pictures of contaminated blue bags

Picture 1 Contaminated blue bags experimental group pre-test analysis

Picture 2 Contaminated blue bags experimental group post-test analysis

Picture 3 Contaminated blue bags control group pre-test analysis

Picture 4 Contaminated blue bags control group post-test analysis

Appendix K: Analysis of income, education and birth place

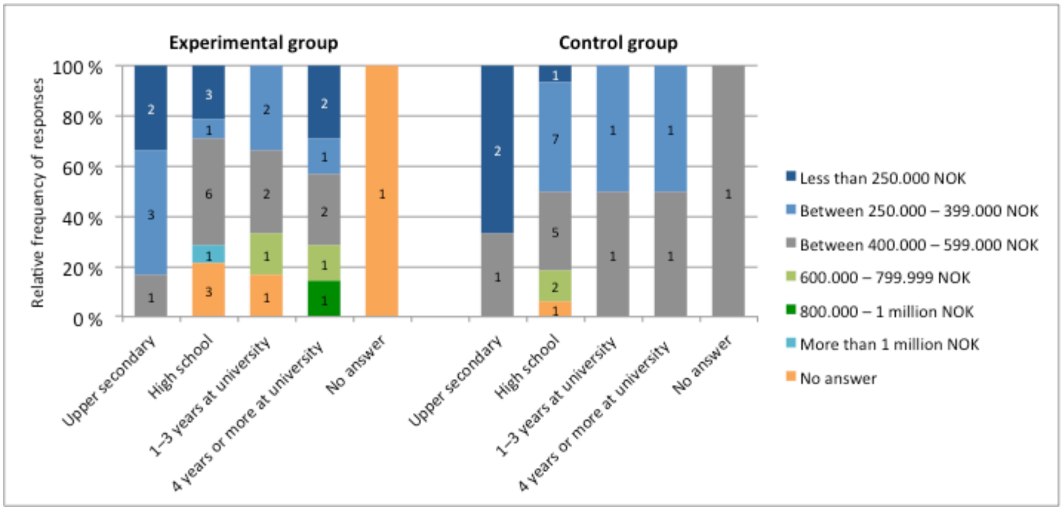


Figure 1: Reported income given level of education

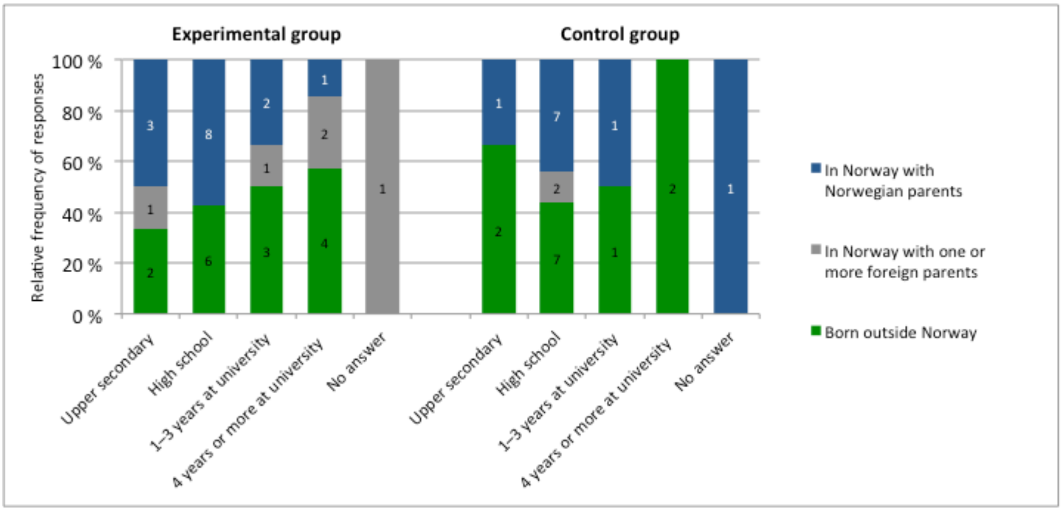


Figure 2: Reported birth place given level of education

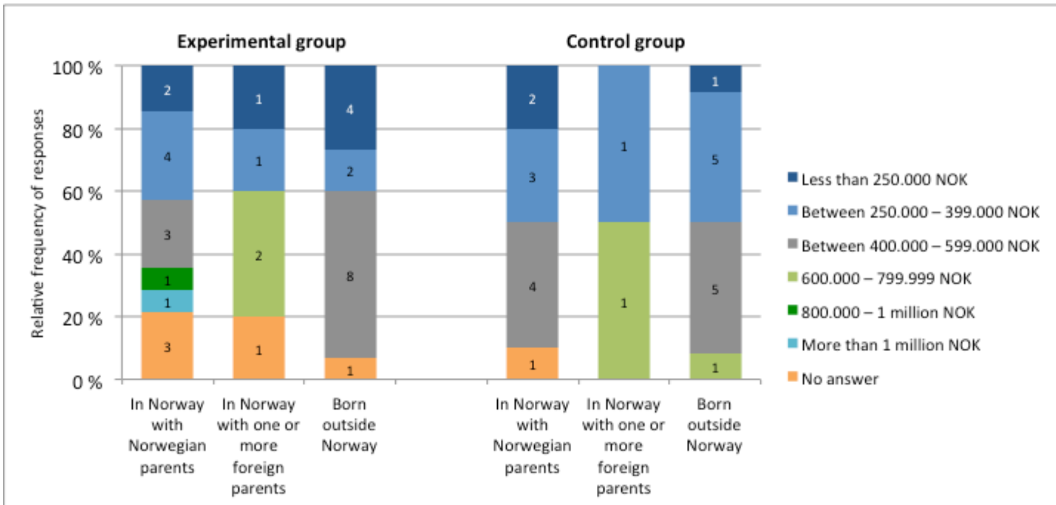


Figure 3: Reported level of income given birth place

Appendix L: Detailed analysis transportation usage

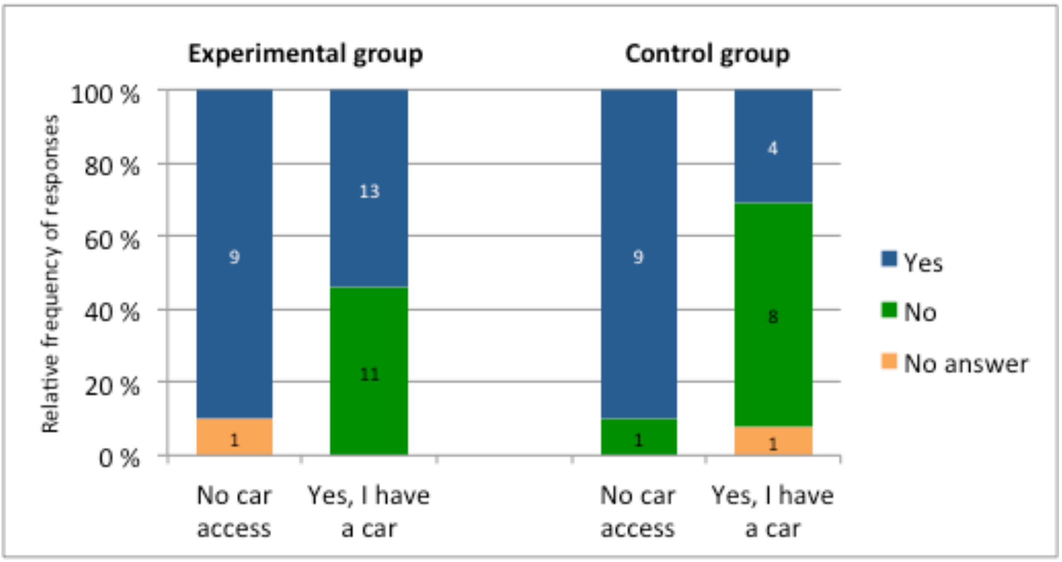


Figure 1: Reported public transport usage given car access

0966743
0932646

Preliminary Thesis Report

- How can reverse logistics contribute to close the intention/action gap in recycling of household waste? -

Hand-in date:
15.01.2016

Campus:
BI Oslo

Examination code and name:
GRA 19003 Preliminary Thesis Report

Supervisor:

Bente M. Flygansvær

Programme:
Master of Science in Business and Economics
Major in Logistics, Operations and Supply Chain Management

Table of contents

Abstract

When asked, most people say that the environment is important to them. However, Norwegians still throw away food equivalent to every fifth grocery bag, which leads to a substantial amount of food waste. The same behaviour also applies to other forms of recycling, and this phenomenon is called the intention-action gap (e.g. Newton and Meyer 2013).

We want to explore why this is the case, and in particular we want to investigate the interface between systems and suppliers. Our research question is: *How can reverse logistics contribute to close the intention/action gap in recycling of household waste?* We view waste management systems as reverse logistics systems, and this is further outlined in our literature review. The literature review also discusses human behaviour and motivation, and we use the revised theory to propose a research model. We then briefly outline methodological ideas, and provide a short description of our chosen case. A project plan is also included, as well as a chapter outline for the final thesis.

1. Introduction

1.1 Research area and significance of study

There is a gigantic patch of trash floating in the Pacific Ocean. It even has a name: the *Great Pacific garbage patch*. Its source? Mainly plastic waste. This is only one example of how human activities lead to waste generation and causes a "crucial challenge in terms of sustainable development" (Monnot, Reniou, and Rouquet 2014). It is also an example of resources leaking from waste supply chains. To prevent this leak, the European Commission has proposed a to move towards a circular economy, or in more logistical terms: to close the loop in the supply chain. To do this, the economy must move away from what the EU called the "*take-make-consume and dispose* pattern of growth", and move towards reuse and recycling of resources (European Commission 2014, 2). The European Commission has therefore banned the landfilling of recyclable materials by 2525, and aims to achieve a minimum 70 % recycling rate of municipal waste by 2030 (European Commission 2014, 9). In order to reach these goals, European (and Norwegian through the EEA) municipal waste management systems must be state of the art. Reaching these goals will also require a substantial effort from consumers in terms of behaviour change.

This change will not be easy, partly due to the intention-action gap (e.g. Newton and Meyer 2013). This means that although people say recycling is important, their actions imply otherwise. This can be exemplified by the fact that although most Norwegians probably would claim that food waste is bad if they were asked, they still throw away every fifth grocery bag, amounting to 46.3 kilograms of food every year (Aftenposten 2015, ForMat 2015). This has promoted us to ask "*Why?*" in our Thesis. How come people do not recycle if they know they should? Research in the field of climate psychology shows how we deny what we know, and still manage to live our lives as normal (Stoknes 2015). The same body of research has shown that messages that use social norms as motivation has a bigger effect on behaviour change (Cialdini 2003). We will also examine the influence the reverse logistics systems in waste management affects the consumer, because we believe in making in easy for people to choose environmentally friendly solutions (Stoknes 2015).

1.2 Research question

The research question of this Thesis is the following:

> *How can reverse logistics contribute to close the intention/action gap in recycling of household waste?*

1.3 Novelty of study

The novelty in this study lies in merging the theory on reverse logistics systems and behavioural aspects of recycling behaviour to understand how the intention-action gap may be closed. It will also examine recycling a multicultural urban area with high-rise buildings, which has not been examined in this context before. The study will have both academic and practical implications.

1.4 Scope and limitations

This thesis will focus on the consumer level of a reverse supply chain in a waste management context. This is because the end-consumer becomes the supplier in reverse logistics. Consumers' behaviour when recycling will thus impact the whole system. We will also look at how the logistics system impacts recycling behaviour, and thus the overall recycling rate in a waste management system. Recycling rate in this context means 'materials recycling'. The study will only look at recycling in a kerbside speculation system, and only in high-rise residential buildings in an urban area in Norway.

2. Theoretical background

Our thesis aims to examine the interface between a reverse logistics system and supplier behaviour in a waste management context (Figure 1).

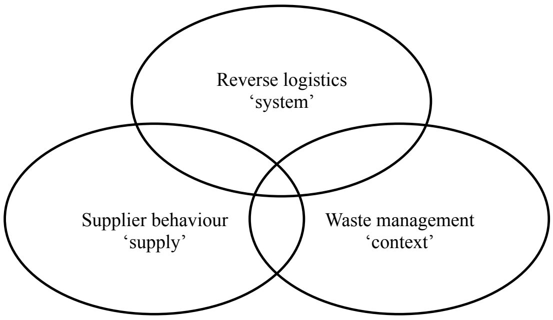


Figure 1: Conceptual framing of literature review.

2.1 Reverse logistics in a waste management context

<u>2.2.1 Defining 'reverse logistics'</u>

The concept of 'reverse logistics' is discussed under several names in the academic literature. Literature on reverse distribution (Flygansvaer 2006, Flygansvaer, Gadde, and Haugland 2008), reverse channels (Jahre 1995), reverse supply chains (Govindan, Soleimani, and Kannan 2015), reverse logistics (Stock 1992, Carter and Ellram 1998, Srivastava 2007, Jalil 2015, Dowlatshahi 2000, Fleischmann et al. 1997, Rogers and Tibben-Lembke 2001) and closed-loop supply chains (CLSCs) (Guide, Harrison, and Van wassenhove 2003, Pokharel and Mutha 2009, Krikke, le Blanc, and van de Velde 2004) discusses the same concept. We have therefore chosen to use the term 'reverse logistics' (RL) to refer to these concepts in this Thesis, as it seems to be the most widely used term.

The 'reverse' part in reverse logistics refers to the flow of goods, which is the opposite direction of traditional 'forward' logistics (Flygansvaer 2006). Reverse logistics can be defined as "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Rogers and Tibben-Lembke 2001).

Srivastava (2007) outlines some generic characteristics of a reverse logistics network (Figure 1), which illustrated how the combination of a forward and reverse supply chain will make up a CLSC (Govindan, Soleimani, and Kannan 2015).

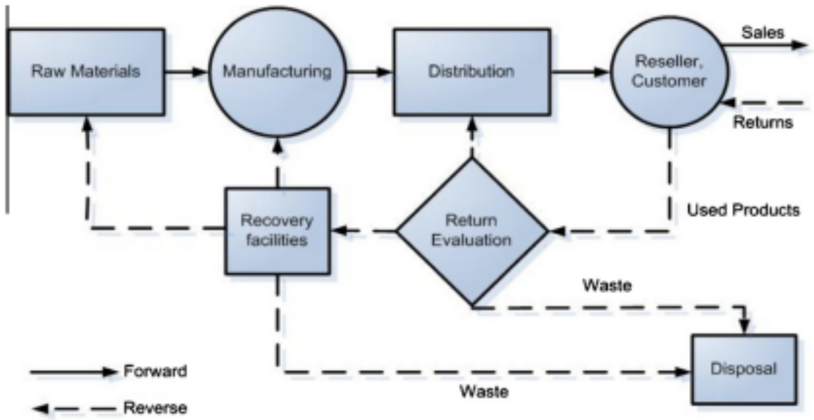


Figure 2: Forward/reverse logistics (from Tonanont et. al. 2008 cited in Govindan et. al 2015)

<u>2.1.2 Characteristics of a reverse supply chain</u>

The main characteristics that make 'reverse logistics' activities different from traditional 'forward' logistics (Pokharel and Mutha 2009, Carter and Ellram 1998) relate to the "coordination requirement of two markets, supply uncertainty, returns dispositions decisions, postponement and speculation" (Srivastava 2007).

The supply uncertainty is related to the fact that the supplier in a reverse supply chain is the original end-consumer in the forward chain. The supplier is 'passive', i.e. not an active seller of their goods as in a traditional supply chain (Flygansvaer 2006). There is supply uncertainty "both in terms of quantity and quality of used products returned by the consumers" (Fleischmann et al. 1997, 5).

A high level of coordinated action in a distribution system is found to decrease overall cost and increase service levels (Flygansvaer 2006, Flygansvaer, Gadde, and Haugland 2008). To achieve this coordinated action, the actors in the supply chain must have aligned incentives. In traditional logistics this incentive alignment can be achieved through contracts, but in a reverse logistics chain the consumer must use different measures to secure the supply. One challenge with this is pointed out by Guide, Harrison, and Van wassenhove (2003). They argue that most companies do not actively manage the returns they receive from system.

A combination of a passive supplier and passive consumer is not conducive to an optimized system.

Reverse logistics is quite often discussed in a practical way (Carter and Ellram 1998), such as a product recovery (Insanic and Gadde 2014) or CLSC context (Govindan, Soleimani, and Kannan 2015). This paper will focus on reverse logistics in a waste management context.

Ravi and Shankar (2005) analysed the interaction among barriers in reverse logistics in the automobile industry. They identified 11 barriers: Lack of information and technological systems, problems with product quality, company policies, resistance to change to reverse logistics, lack of appropriate performance metrics, lack of trained and educated personnel, financial constraints, lack of top management commitment, lack of awareness about reverse logistics, lack of strategic planning, and a lack of support of other supply chain actors. A dependency diagram is made to identify interdependencies between barriers, and they are all found to affect each other. These factors may be applied in a waste management setting (will be explained in the Chapter 5: Case).

2.1.3 The waste management supply chain

The reverse supply chain has different stages or functions (Figures 2 and 3). In a waste management context, these stages are identified as collection, transportation, incineration, composting, recycling, and disposal by Caruso, Colorni, and Paruccini (1993). The last four stages may be combined into the waste processing level. Jahre (1995) describes the levels of a reverse distribution system as the consumer, collection, transfer, processing and end market levels.

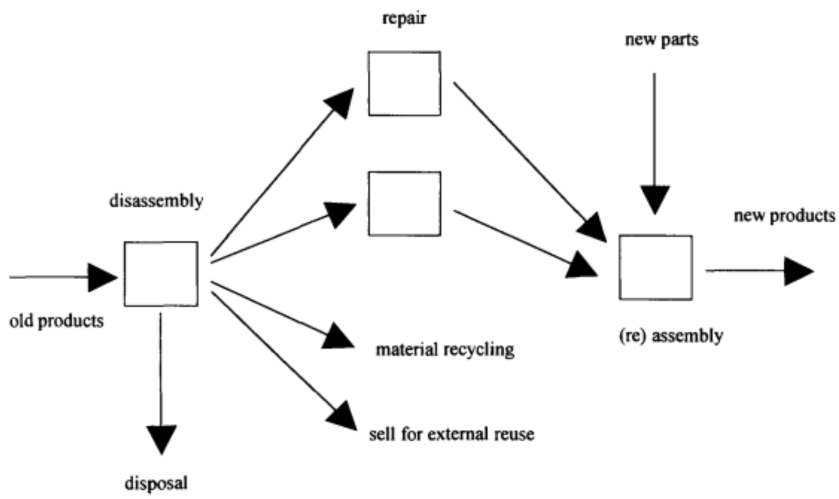


Figure 3: Framework for reverse logistics from Fleischmann et al. (1997, 12)

Traditionally, waste management systems used to he classified as kerbside or bring schemes based on who performed the initial transport (consumer or waste manager) (Jahre 1995). However, Jahre points out that this view is too simplistic, and that the classifications must reflect the existing types of collection schemes. More precise criteria are the “average transport distance for the consumer [i.e. supplier] from point of consumption to point of collection and the number of households covered by one collection point” (1995, 42). A kerbside system has a more complex material flow due to the number of distribution points (e.g. pick-up points in each household), but a bring scheme may have more levels in the system (e.g. drop-off centres and retailers).

2.1.4 Waste hierarchy

In this Thesis, waste is defined as municipal solid waste (MSW), whish is any solid waste resulting from the operation of residential, commercial, governmental or institutional establishments (Stock 1992). This paper will focus on waste from residential areas, i.e. household waste. A conceptual way of illustrating the different stages of waste recovery is the waste hierarchy (Figure 4). The aim is to be as high up in the pyramid as possible.

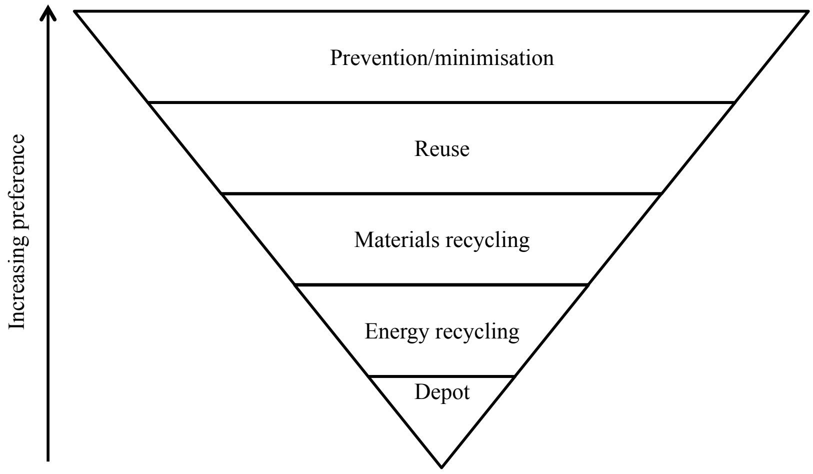


Figure 4: Waste hierarchy, adapted from (Price and Joseph (2000), Carter and Ellram (1998)).

2.1.5 Cost depends on system configuration

Two concepts that are relevant to household waste collection are postponement and speculation (Jahre 1995). Speculation in a kerbside system means that the consumer does the initial sorting of waste at home. This leads to what Jahre calls 'collection complexity', as it may require multiple transports to the same household, which increases transportation costs. A speculation system shifts the sorting cost to the consumer/supplier, which means the waste management company will not have to pay this cost. However, the consumer will incur the cost of recycling (from the separation of waste and waste delivery), which in most cases is not financially remunerative, and the consumer is not properly compensated for this (Yau 2010). The consumer's cost of recycling should be considered when designing an optimal reverse logistics system for waste management, as the consumer is responsible for product quality in a speculation system. This is because a waste management system is characterised by serial interdependencies, which means that the succeeding steps in the system depend on the previous steps (Stabell and Fjeldstad 1998).

The opposite of speculation is postponement, which means that the waste is sorted at the waste processing level. Such a system uses co-collection at the household level, but the sorting is more costly. Combining the two strategies into a system that may also be done with speculation and co-collection. This will minimize both sorting and transportation cost for the waste management agency, but this might be a suboptimal solution to the system if the consumer's cost of recycling is too great. This is the kind of system our Thesis will investigate (will be outlined in Chapter 5).

Customer service, or customer service level, in reverse logistics is the frequency of collection at the household level and the location of pick-up points. This however, increases cost in the system for the collector. Performance of the system will be understood to mean recycling rate, i.e. how much of total waste is recycled and not sent to landfill (See Figure 4). There will always be a trade-off between cost and service-level in such a system. We need to include more theory on this in the final edition of this chapter.

In this paper we assume that the consumer's cost of recycling will affect their recycling behaviour, i.e. whether or not they choose to recycle their waste. This recycling behaviour is also dependent on what Monnot, Reniou, and Rouquet (2014) call 'consumer logistics'. They identify three types of logistical solutions used by consumers when they recycle their waste: pooling, just in time, and stockpiling. They find that consumers consider aversion to smell and dirtiness of waste, in addition to space available, when choosing to recycle or not. This is especially relevant in urban areas, where residents live in small flats with limited space for storage.

A Dutch study by Goorhuis et al. (2012) discusses how waste management systems may be improved to "enhance separate collection and recycling of household waste" to increase the recycling rate. This study is relevant because it looks uses three different cases to examine how kerbside systems that allows for separate collection of more types of waste (e.g. garden waste, glass and metal, textiles, bulky waste) contributes to reducing amounts of residual waste (which is normally incinerated or landfilled). The principles were based on offering enhanced service for collection of recyclable waste, while at the same time decreasing service for residual waste, as well as rewarding source separation of waste. The results were preliminary, but they found a significant reduction in residual waste, but participants were resistant to change, and it is challenging to implement such systems without rising costs. However, the authors note that "it is possible to implement the system of 'reverse collection' without extra cost to citizens […]. The higher service is financed by the lower cost on the processing of waste" (Goorhuis et al. 2012, 75). They also underline the importance of good communication to consumers.

2.1.6 Intention-action gap

As we have previously touched upon, the reverse logistics supplier is passive. Another important aspect when trying to improve recycling behaviour is the intention-action gap (Figure 5) (Newton and Meyer 2013, Barr 2007). "Individuals are not behaving in a manner that is congruent with their stated attitudes and intentions" (Newton and Meyer 2013, 5), i.e. their consumption was not congruent with their stated beliefs about environmental concerns. In a waste management context this means that even though people say recycling is important, the recycling rates tell a different story. The gap between intentions and actions can be attributed to a set of barriers (Kollmuss and Agyeman 2002). These barriers include 'contextual constraints' such as infrastructure, which may be viewed as the reverse logistics system in the context of this Thesis, and 'actual consumption behaviour' is referred to a recycling behaviour.

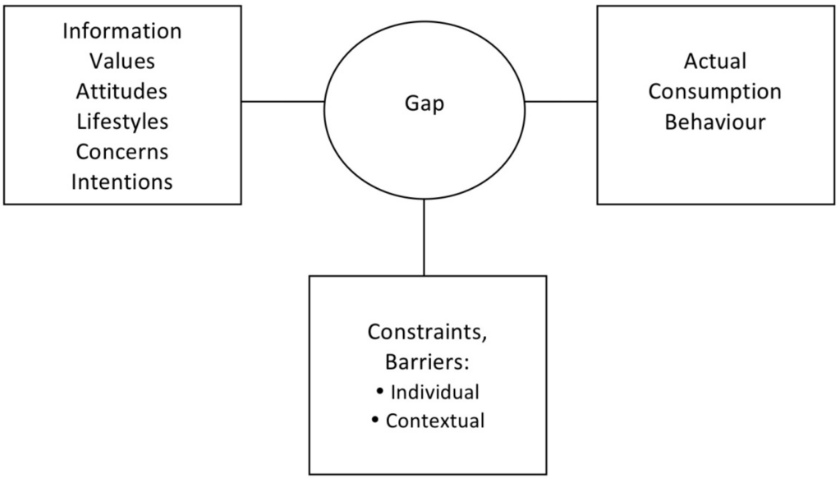


Figure 5: The gap between subjective indicators of intent and actual consumption behaviours (Newton and Meyer 2013)

To close the intention-action gap, one must understand how behaviour change happens, which has traditionally followed this linear model: information → awareness → concern → action (Newton and Meyer, 5). However, Stoknes (2015) describes several social psychological phenomena, including perception, dissonance, and denial, which may prevent a consumer from taking action even though the information is there. This will be further discussed in Chapter 2.2 – Supplier behaviour.

Jalil (2015) refers to the reverse distribution system as 'situational factors' and recycling behaviour as 'personal factors', and examines what he calls a 'symbiosis effect' between these factors. This is an attempt to explain the interface of the system and supplier, but our Thesis takes a slightly different approach.

2.2 Supplier behaviour

The gap between intentions and actions can be contributed to both individual and contextual explanations (Kollmuss and Agyeman 2002). Several researchers have investigated determinants and factors influencing the passive suppliers' recycling behaviour. These determinants and factors range from demographic characteristics of the individual, internal and external motivation factors, the role of the logistic system, to the interaction between the logistic system and the individual (Barr 2007, Monnot, Reniou, and Rouquet 2014)

<u>2.2.1 Role of demographic characteristics</u>

The role of socio-demographic is one of the most frequent studied topics in literature about recycling behaviour (Hornik et al. 1995). Findings in terms of the role of socio-demographic characteristics (e.g. age, income, level of education and gender) have been contradicting (Shrum, Lowrey, and McCarty 1994, Rousta et al. 2015, Monnot, Reniou, and Rouquet 2014). Some studies show that older people recycle a larger amount of their waste than younger individuals (Vining and Ebreo 1990). However, another study found that ages as an explanation for recycling behaviour was rather marginal (Shrum, Lowrey, and McCarty 1994). Where some studies report about a positive correlation between income and recycling (Vining and Ebreo 1990, Berger 1997), others find no connection at all (Granzin and Olsen 1991). Research about the role of education and gender are more unison. When it comes to the link between level of education and recycling, there is not found a significant relationship (Vining and Ebreo 1990, Granzin and Olsen 1991). And women seem to participate more in the household's recycling activities than men (Granzin and Olsen 1991, Stern, Dietz, and Kalof 1993, Iyer and Kashyap 2007, Meneses and Palacio 2005).

A recent meta-analysis synthesising result from research about recycling behaviour in a 20 year span (1990-2010) found that socio-demographic variables do not predict recycling behaviour (Miafodzyeva and Brandt 2013). Over time, when individuals incorporate recycling into their habits, the socio-demographic factors seem to correlate less with recycling behaviour (Hornik et al. 1995, Del Cimmuto et al. 2014). Recycling behaviour is rather found to be influenced by information, convenience, moral norms and pro-environmental attitudes (Miafodzyeva and Brandt 2013).

Newer research contributions have evolved into considering demographic elements of religion and multicultural characteristics such as ethnicity (Miafodzyeva, Brandt, and Andersson 2013, Minton, Kahle, and Kim 2015). The relationship between religion and sustainable behaviour such as recycling is investigated in a cross-cultural comparison of South Korean and US suppliers in relation to their religious background (Minton, Kahle, and Kim 2015). Findings indicate that highly religious Buddhists are more likely to engage in sustainable behaviour compared to Christians and Atheists. These findings were largely consistent across the country-divide.

In a case study about recycling behaviour among householders living in multicultural urban areas in Sweden, it was found that attitudes towards the importance of recycling were the main determiner for recycling (Miafodzyeva, Brandt, and Andersson 2013). In addition to this finding, the study calls for the importance of further investigation into several aspects of the multicultural households recycling behaviour and addressing an identified gap in the literature in this area.

2.2.2 Role of System

Several studies have shown that accessibility and convenience of the system may be influential in both ensuring participation in recycling behaviour and increasing the recycling rate (Barr and Gilg 2005, Ando and Gosselin 2005, Timlett and Williams 2008, Hage, Söderholm, and Berglund 2009, Best and Kneip 2011, Klöckner and Oppedal 2011, Barr et al. 2012, Bernstad 2014).

In 1995, the ABC-theory (Attitude, Behaviour and Conditions), was outlined by Guagnano, Stern, and Dietz (cited in Hage, Söderholm, and Berglund 2009). According to this theory, to ensure high participation in recycling, high access to the system needs to be provided. Ensuring participation is then considered independent of pro-recycling attitudes and environmental awareness. In recent empirical research, this hypothesis have gained support (Barr et al. 2012). Performing factor analysis of individual's self-reported responses of attitudes and behaviour towards recycling when confronting a municipal recycle scheme, Barr (2012) found that for some supplier segments low levels of recycling do not necessarily reflect negative attitudes towards recycling, but can be related to structural constraints.

Some studies have related convenience to the presence of kerbside collection system and distance to collection points. Comparing the alternative of kerbside collection schemes with the alternative of bring-side schemes, suppliers prefer kerbside collections (Barr and Gilg 2005). In a study comparing kerbside with pro-recycling attitudes on participation in recycling, the existence of kerbside collection points were found to contribute more to recycling participation then pro-recycling attitudes (Best and Kneip 2011). The distance to the kerbside's recycling containers might be a moderating effect when it comes to participation. However, one case study investigating Norwegian students living in student housing found that perceived behavioural control (perceived ability to perform the recycling task) might moderate the influence the distance impact on recycling behaviour (Klöckner and Oppedal 2011).

Other studies have related convenience to the sorting activity and the physical infrastructure in housing (Ando and Gosselin 2005, Bernstad 2014). In a case study of multifamily dwellings, the perception of space to perform the sorting activity was found to be strongly related to the recycling rate (Ando and Gosselin 2005). Another case study looking into the recycling behaviour in a residential area in Sweden, found that written information about why and how to recycle did not contribute to an increase in sorting and separating household waste (Bernstad 2014). Instead an increase in sorting activities was found when adequate physical infrastructure in terms of instalment of sorting equipment such as metal hangers and vessels for paper waste was in place.

The interaction between the convenience of housings internal infrastructure and the convenience of outer kerbside collection points might also influence recycling behaviour. In kerbside collection schemes, it is found that if the capacity of the kerbside collection point is inadequate, recycling participation has a tendency to decrease (Timlett and Williams 2009). This has been related to availability of inner storage space to store recycling items in the time the kerbside collection point is full. Semi-detached households have then larger spaces available compared to apartments in medium-rise and high-rise housing which offers an explanation for the tendency of having a higher participation rate in such housing.

2.2.3 Role of Internal Motivation

Both individual values and attitudes have been discussed in the literature in terms of internal motivation factors when it comes to recycling participation and behaviour (McCarty and Shrum 1994, Knussen et al. 2004). McCarty and Shrum (1994) supported earlier work which had suggested that the relationship between values and recycling behaviour is indirect, where values influence individuals' attitudes about convenience and importance of recycling. It is further found that pro-recycling attitudes influence recycling behaviour positively (Knussen et al. 2004).

2.2.4 Role of External Motivation

In addition to internal motivation factors, knowledge about what, where and how to sort waste for recycling have been considered an important factor impacting recycling behaviour (Barr and Gilg 2005). However, they acknowledge the limitations in informational campaigns following the AIDA model (Awareness → Information→Decision→ Action, which is slightly different than the model used by Newton and Meyer (2013)) and calls for a shift towards policies reflecting other motivation factors to influence recycling behaviour.

According to Cialdini (2003, 105) "it is widely recognised that communicators that activate social norms can be effective in producing socially beneficial conduct". Social norms are "sets of beliefs about the behaviour of others" (Schultz 1998, 26). However, to avoid the 'boomerang effect' of the normative message having the opposite effect to what was intended, it is important to combine the use of both descriptive and injunctive social norms. This is because descriptive norms alone, which describe the prevalence of something (i.e. what other people are doing), can communicate how frequent something bad is happening. This sends the underlying message that many people actually *are* doing this – so why should you not? Communication should not focus on messages that convey an activity as "socially disapproved, but widespread" (Cialdini 2003, 108). The same study also found that a combination of descriptive and injunctive norms significantly influenced recycling intentions. It may however be worth noting that this may not imply an increase in actual recycling.

If these descriptive messages are aligned with injunctive norms, which convey social approval or disapproval (i.e. what other people think should be done), the message has been found to have real persuasive efforts, and even eliminating the 'boomerang effect' (Schultz et al. 2007).

When discussing factors that influence environmental behaviour, Barr (2007, 468) found that access to recycling facilities is the situational factor (i.e. system) has the strongest impact on recycling behaviour. In terms of psychological factors, recycling is affected by normative and convenience-based factors. However, one concern with the study is that dependent measures were collected using self-reporting, which may have resulted in an intention inflation (Barr 2007, 470).

Several studies have been conducted with the aim of using social norms to promote environmentally friendly behaviour, such as energy conservation (Ayres 2012, Allcott 2011), reuse of towels in hotel rooms (Goldstein, Cialdini, and Griskevicius 2008), littering (Cialdini 2003), and household recycling (Schultz 1998). Schultz (1998, 25) and his team observed the recycling behaviour of 605 residents of single-family dwellings for a period of 17 weeks to investigate whether normative feedback interventions could close the intention-action gap. He found that messages conveying either personal norms ("feelings of obligation to act in a particular manner in specific situations" (Schultz 1998, 26)" or social norms has a significant effect on participation in the recycling scheme and on amount of waste recycled. However, he found no significant change in 'contamination', i.e. waste that has not been sorted correctly. In conclusion, this study indicates that normative feedback may be used to alter behaviour in a recycling setting, which is relevant for this Thesis.

Nudging is also a useful phenomenon to discuss, as this may be used to construct a reverse logistics network that makes it simple for the consumer to choose right (Stoknes 2015). We will need to expand on this phenomenon in the final edition of this chapter.

One study examined the effects of why doorstepping of household waste recycling (Dai et al. 2015), and found that the activity increased food waste separation rates by 12.5 %. This may be relevant to our study in terms of methodology.

3. Research model

Based on the literature review, we have identified two main concepts that may explain recycling behaviour: ‘system characteristics’ and ‘supplier characteristics’ (Figure 6). ‘System characteristics’ aim to capture the structure of the reverse logistics supply chain that make up the waste management system. We have illustrated that there are two main configurations to this system: kerbside schemes and bring schemes.

Because the suppliers in a reverse logistics system are passive, we propose that there is a relationship between the system and supplier characteristics. This makes sense, because convenience and service level affect the supplier. Consumer logistics also play a role here.

‘Supplier characteristics’ also include demographics, such as age, income and household type, as well as motivational factors. Internal motivation to recycle is affected by values and attitudes, and external motivation is impacted by social norms and knowledge.

We propose that these two concepts are central to explain supplier recycling behaviour, i.e. the degree to which people choose to recycle. Because consumers act as suppliers, and thus provide the inputs to the entire waste management system, this will in turn affect overall system performance, i.e. recycling rates. The model is illustrated in Figure 6.

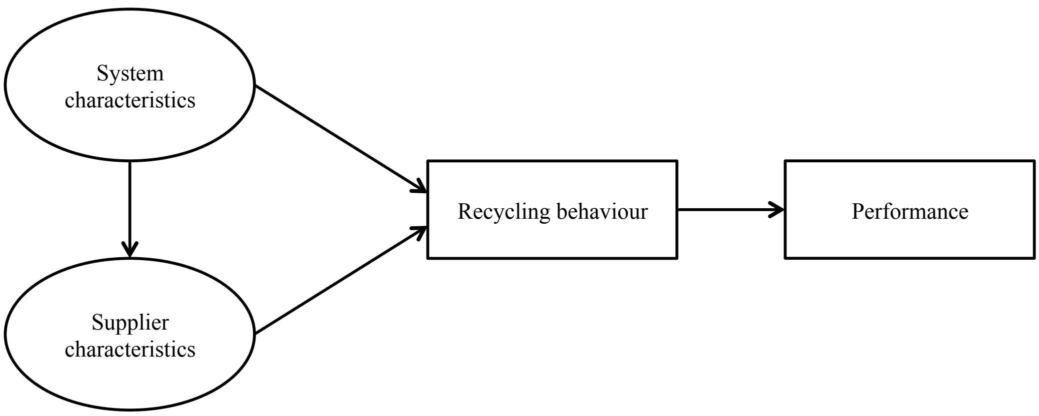


Figure 6: The research model, illustrated

4. Research methodology

Following our research strategy, design and method for data collection and analysis will be outlined.

4.1 Research strategy

To answer our research question we have chosen a mixed quantitative/qualitative strategy. Our main strategy will be quantitative; however it will precede or follow a qualitative one (cf. Bryman and Bell 2011, 634-638). Up to this point, we are unsure if it is best to let the qualitative research strategy facilitate or be facilitated by the quantitative research. If the qualitative research strategy will be used to guide quantitative research it will help in providing a hypothesis, whereas if the qualitative research strategy is applied after the qualitative strategy it would be to provide contextual information.

Quantitative research often entails a deductive approach towards the relationship between theory and research (Bryman and Bell 2011, 11–13). We will aim to follow this deductive approach by developing a hypothesis based on theory and what is known in the field of reversed logistics, waste management and theories of human behaviour and then test it by collecting data about recycling behaviour.

4.2 Research design: field experiment

To compare actual recycling behaviour with the introduction of an incentive, we will conduct a field experiment in a real-life setting, at home where people live. An example of a possible experimental design would be a design where a treatment group is compared to a control group. The experimental group will be given an incentive to recycle, whereas the control group will not. The recycling behaviour will be measured both before and after the introduction of the incentive. The difference between the each group's pre and post recycling behaviour is then computed to establish whether or not the incentive has made a difference. The independent variable which will be manipulated will be the incentive the supplier receives, whereas the dependent variable will be recycling behaviour measured in terms of recycling rate.

4.3 Sampling

We aim to select a representative sample of the population we are going to study as this would ensure generalisability of the study.

4.4 Data collection

Primary data will be collected through a pick-analysis (avfallsanalyse) and through interviews of relevant people. Secondary data will consist of data from internal company reports and official documents.

4.5 Data analysis

The data will be analysed by comparing recycling rate between the groups from the pick-analysis

4.6 Quality of research

To ensure quality of our research, we need to ensure that it follows the criteria of reliability, replication and validity.

4.6.1 Reliability

Especially quantitative research emphasise the importance of the study being reliable. A reliable study would mean that it is possible to repeat the study and gain the same findings (Bryman and Bell 2011, 41). Concerns about the measure would then need to be addressed in order for it to be stable so that it would be consistent.

4.6.2 Replication

To make sure that it is possible to replicate our study; our procedures must be accounted for in great detail. The importance of replicability allows for other researchers to reproduce the study to see if there might be other evidence that might be relevant for the original result (Bryman and Bell 2011, 41)

4.6.3 Validity

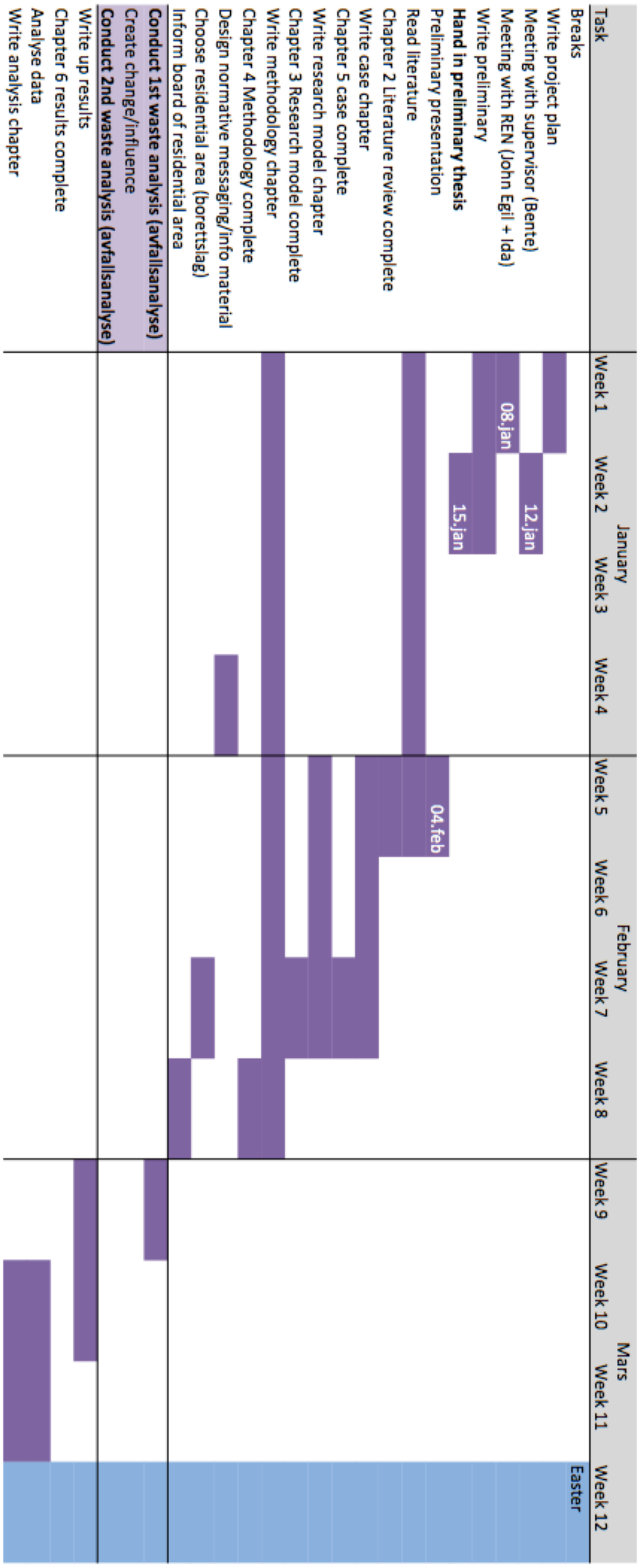
Validity concerns the integrity of the result of the study conducted (Bryman and Bell 2011, 42). Ecological validity is usually strong when the research is a field experiment compared to a lab experiment (Bryman and Bell 2011, 48). However, experiments can be exposed to various threats towards internal validity such as participants becoming aware of the purpose of the experiment, events unrelated to the manipulation might have caused the change, and differences between the groups might impact the result (Bryman and Bell 2011, 47). Internal validity relates to the issue of whether the causal relation between different variables hold (Bryman and Bell 2011, 42) This threat can be mitigated by having a control group and allocate participants to the different groups on a random basis (Bryman and Bell 2011, 47). In addition, experiments may also be subjected to threats against external validity such as whether the result can be extended to other settings. To ensure external validity, the samples need to be representative of the population studied. (Bryman and Bell 2011, 43)

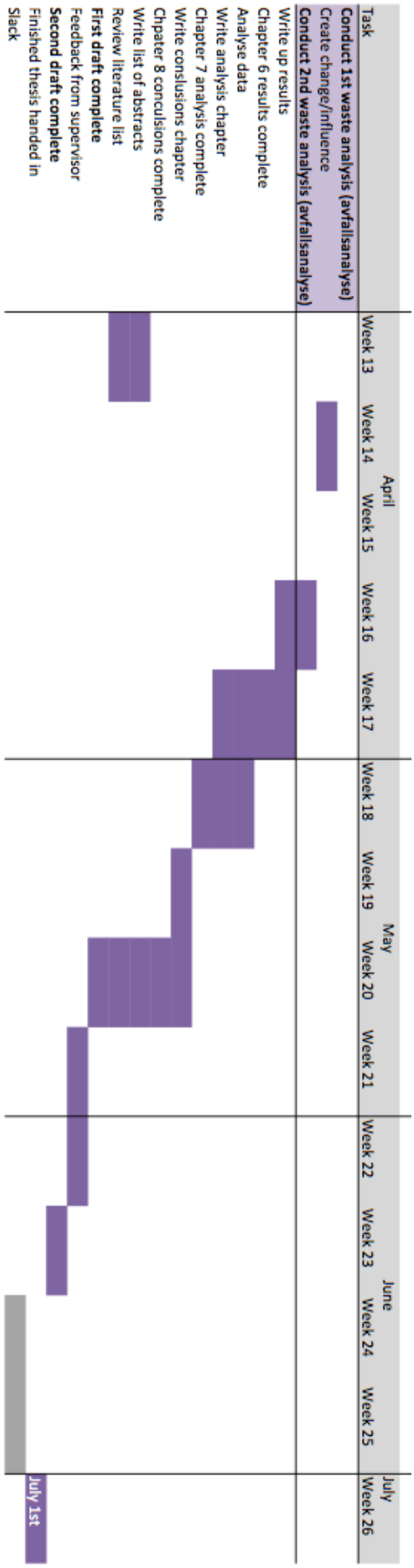
5. Case – Waste management in Oslo

The case will be written based on the waste management system for MSW in Oslo, with a focus on household waste. We will provide an outline of the waste management network (Oslo Kommune Kommunerevisjonen 2015) based on information we receive from the Agency for Waste Management in Oslo Municipality. The system is a kerbside and bring combination scheme depending on the type of waste. Kerbside collection includes separation food waste, plastic and residual waste into separate bags. These are then co-collected using the same trucks, and separated by a waste-sorting robot. Paper is also included in the kerbside system, but is collected separate from the other waste. Bulky waste, glass and metal, EEE waste, dangerous waste, textiles, and garden waste is part of the bring scheme.

Oslo Municipality aim to have a 50 % materials recycling rate by 2018, but with the current system setup, this goal will not be reached. To shed light over the demographics of Oslo, which consists of high-rise buildings with multicultural residents we will use data from the Oslo Statistics Bank.

6. Project time schedule




Task
Conduct 1st waste analysis (avfallsanalyse)
Create change/influence
Conduct 2nd waste analysis (avfallsanalyse)
Write up results
Chapter 6 results complete
Analyse data
Write analysis chapter
Chapter 7 analysis complete
Write conslusions chapter
Chpater 8 conculsions complete
Write list of abstracts
Review literature list
First draft complete
Feedback from supervisor
Second draft complete
Finished thesis handed in
Slack
April
Week 13
Week 14
Week 15
Week 16
Week 17
May
Week 18
Week 19
Week 20
Week 21
June
Week 22
Week 23
Week 24
Week 25
July
Week 26
July 1st

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Final thesis chapter outline