Master's degree thesis

LOG950 Logistics

A consumer-oriented bio-waste recycling system. The case of household bio-waste collection at Romsdal Waste Management Company

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Preface

This MSC thesis is written as a completion of the Master's Degree Program in Logistics, with specialization Supply Chain Management at the Molde University College. The research has been collected during the period of December 2018 to May 2019. We have learned a lot from working with this thesis, and it has been exiting to look thoroughly into such a topic, which we did not know much about beforehand. The experience by doing this research and the knowledge we have gained from writing the thesis will be valuable for us in the future.

We would like to express our greatest gratitude to our supervisor, Professor Harald Martin Hjelle, for all his guidance and support through the master thesis period. Likewise, we also highly appreciate the effort by Professor Edoardo Marcucci, for helping us understand the topic and guide us through the method used in our thesis. Also, we would like to give our thanks to Mr. Valerio Gatta for great help with the analysis of the data.

Moreover, we would like to thank all the participant in the in-depth interviews, focus groups interview and questionnaire for valuable information and data needed to write this thesis. We really appreciate them taking their time. We would not have been able to write this thesis without their participation.

Last but not least, we would like to express our thanks to our friends and families for their support during our studies.

Molde 24.05.2019

Henning Hellebust
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Summary

Today, food-waste is recognized as a global environmental problem. At international level, the United Nations (UN) has adopted the 2030 Agenda for Sustainable Development along with a set of Sustainable Development Goals (SDGs). Both the European Union (EU) and Norway has committed to implement the SDGs in its internal and external policies. The Norwegian authorities and food sector made an industry agreement in 2017, where the goal is to reduce the amount of food-waste in Norway with 20% before 2020, 30% before 2025 and 50% before 2030. On the basis of this agreement, the waste management sector should have an appropriate consumer-oriented system.

This study aims to investigate consumer behaviour and propose a consumer-oriented system for Romsdal waste management company (RIR). This study use Stated Preference as the main method. Hence, the study provides an advanced and valid method to detect consumer choices. This is valuable for policy makers and the waste management sector as a contribution for further research, given that this method has not been used in the context of consumer-oriented system before.

The research, which our thesis is built upon, contains of a questionnaire with 189 respondents. In addition, in-depth and focus groups are used as supportive studies. The method used in this thesis is the Stated Preference method. By using this method, price and frequency are the chosen attributes affecting consumers recycling. Price is found to have a negative effect but where frequency is found to have a positive effect towards consumers. In addition to the Stated Preference, Factor Analysis is used to detect consumers behaviour concerning recycling.

Both qualitative and quantitative results are presented in the thesis, which is interesting for further research on the topic. The multinomial logit models are used to find the probability of choosing which frequency consumers prefer for their garbage collection. This shows that the consumers prefer to have their garbage collected every fourteen day. The results from the Factor Analysis tell that environmental concerns are the strongest attitude factor. Authorities and neighbours also have impact on consumers attitude regarding recycling.

Given the data results from the sampled population, managerial implications and a consumer-oriented system are outlined. The consumer-oriented system suggests a collection calendar and a Pay-As-You throw payment system.

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1.0 Introduction

1.1 Motivation for the thesis

Today, food-waste is recognized as a global environmental problem. At international level, the United Nations (UN) has adopted the 2030 Agenda for Sustainable Development along with a set of Sustainable Development Goals (SDGs). According to (United Nations 2015b) the 2030 Agenda is *"we are determined to protect the planet from degradation, including through sustainable consumption and production, sustainable managing its natural resources (…) so that it can support the needs for the present and future generations"*. Hence, the SDGs target number 12.3 set that by 2030 the aim is to "*halve per capita global food-waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses*" (United Nations 2015a). Both the European Union (EU) and Norway has committed to implement the SDGs in its internal and external policies (European Commision 2016, Norwegian ministry of foreign affairs 2017).

High-level income countries such as Norway increase their waste production every year. From 1995 to 2018, household waste for consumers in Norway went up with 65 percent (Norwegian Environment Agency 2018). Food-waste on household level is connected with consumer behaviour. Problems can be related to how the consumer is planning their purchasing, and that food often must be throwed because of expiring "best-before-dates". Further, in high level income countries, consumers does often not care much about food-waste, since they can afford buying new food (Gustavsson et al. 2011). Waste production is a product of consumption; an increase in consumption will increase the production of waste. As illustrated by figure 1, the link between consumption and waste can be explained through the gross domestic product (GDP).

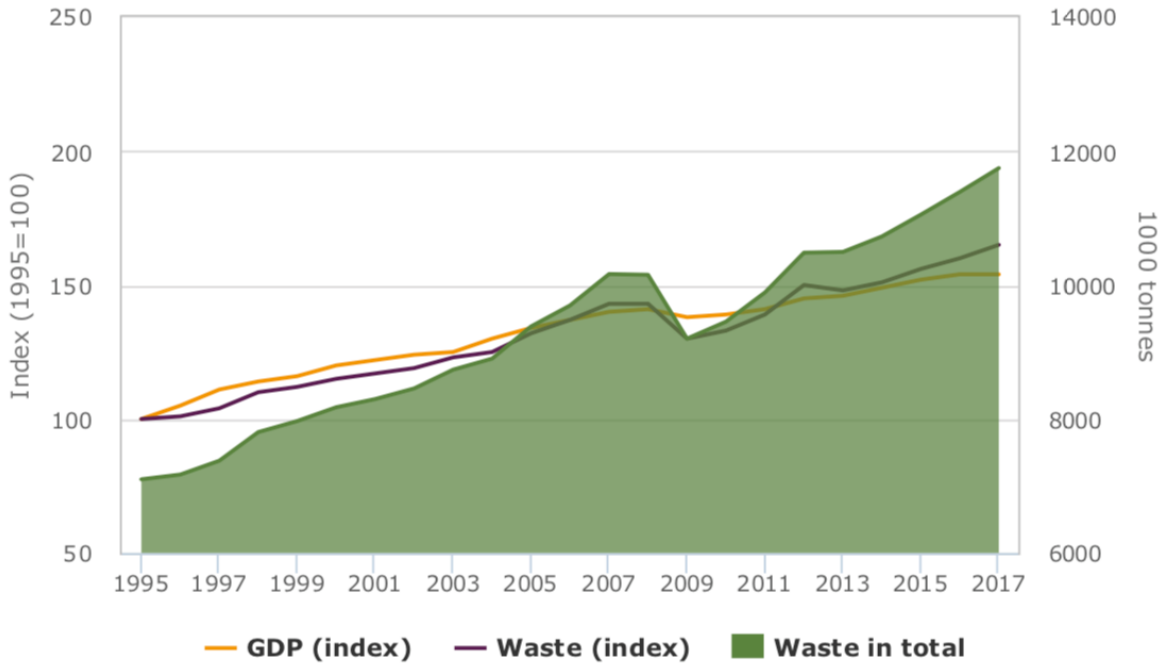

Figure 1. Growth in GDP and waste (Norwegian Environment Agency 2018) .

The focus on reduction of waste has led to increased attention in waste reuse and circular economy. Circular economy aim to use the products, and then reuse materials for additional value (Jurgilevich et al. 2016). Earlier years, food-waste was disposed at landfills. Food-waste disposed at landfills produced a lot of methane gas, which effect global warming with 25 times higher effect than Co2 emissions (Vinju 2016). In 2009, the Norwegian authorities banned food-waste disposes at landfills, but was later repealed due to inefficiency of the regulation (AvfallNorge). Waste management companies recycle food-waste through anaerobic digestion instead. Anaerobic digestion reduces the greenhouse gas emission and also supports sustainable development of energy supply since biogas can be used to replenish fossil fuels in heat and power generation, as for vehicle fuel (Weiland 2010).

The Norwegian authorities and food sector made an industry agreement in 2017, where the goal is to reduce the amount of food-waste in Norway with 20% before 2020, 30% before 2025 and 50% before 2030. Much of the food-waste happens at the households. Hence, in order to reach the goal of reducing food-waste, developing a well-functioning waste management system for collecting the waste will be important (Syversen et al. 2018). The food production sector and the retailers make one of the measures already taken to meet

the food-waste reduction goal. They have changed the marking on food products from "good before" to "not bad after" and "often good after". This is a factor to make consumers more aware of reducing their food-waste (Stensgård et al. 2018). With the initiatives from the food production sector, the waste management sector should also contribute in reducing the food-waste.

This thesis presents a case study of Romsdal waste management company (RIR) and the current waste collection system with fixed prices and fixed frequency. The existing system does not give the consumers any strong incentives to recycle, except to contribute to recycle because they have to. A consumer-oriented system based on the consumers' incentive to recycle food-waste, increase consumers' participation in recycling. This relates to the individual's behaviour in a consumption act. The output from consumer orientation is the motivation and value components (Pons, Mourali, and Nyeck 2006). To understand the consumer orientation of individuals' Stated Preference is a suitable method to detect both motivation and value. Stated Preference uses both a qualitative and quantitative approach. Motivation is found through qualitative study from in-depth and focus groups. Value can be found from utility and quantitative research.

At present, Stated Preference method has not been used to suitable fit a consumer-oriented system for food-waste. The research of this thesis is motivated by the goal to reduce the amount of food-waste by 50 percent before 2030. The objective is to give the waste management sector, RIR and policy makers an example of how they can apply Stated Preference methods to detect both motivation and value for their consumers to increase their awareness towards recycling.

1.2 Research problem and questions

The goal of the thesis is to give an example of how Stated Preference methods can be used to obtain a consumer-oriented system for bio-waste recycling. So, the research problem for this master thesis is:

A consumer-oriented bio-waste recycling system. The case of household bio-waste collection at Romsdal Waste Management Company.

To understand how a new consumer-oriented system can be applied, two additional research questions about behaviour and motivation need to be answered sequentially.

RQ1: What factors affect the behaviour of people to recycle?

To investigate the factors affecting the behaviour to recycle, the key attributes are first identified through literature review, focus groups and interviews to set up the utility function through Stated Preference choice modelling. In addition to Stated Preference choice modelling, Factor Analysis is used to group respondents. To understand the factors for recycling behaviour, Stated Preference techniques is helpful to collect and analyse data. With the factors identified, the willingness-to-pay analysis will investigate how the key factors influence recycling behaviour.

RQ2: What can motivate consumers to increase their food-waste recycling?

Today, consumers can influence price and frequency to a small degree, by choosing between fixed prices and fixed frequency. The current system does not give consumers the ability to influence when the garbage is collected and which price they want to pay. With the current system, consumers do not have any personal interest and incentives to participate in the recycling, except to be a good citizen. Discrete choice modelling can assess how the utility for consumers change if the frequency differs from as it is today. Different price systems can also be used to motivate consumers through economic incentives.

1.3 Structure of the thesis

The master thesis is structured in the same way as a Stated Preference project, starting to define the study objective as this chapter has described. The following chapter describes the waste management sector and a part of how RIR operates. This chapter includes what legislations the waste management sector has. The third chapter presents a brief review of the literature and the theoretical framework used later in the study. The fourth chapter describes the methodology and framework conducting a Stated Preference experiment as the main data collection method. The fifth chapter describe the questionnaire in detail. Chapter six contains data results. Chapter eight outline policy implications and the consumer-oriented system, before chapter nine conclude the main result and answer the two research questions presented in section 1.2.

2.0 Description of the Norwegian waste management sector and RIR

This chapter starts to cover the Norwegian waste management sector and a description of RIR in more detail regarding private household's food-waste system. Statistics Norway (SSB) are responsible for the Norwegian national statistics for waste (AvfallNorge 2014). Most of the statistics in this section are from SSB and are cited if not.

2.1 Norwegian waste management sector

The waste management sector in Norway is an expanding sector. There are about 8000 employees and an annual turnover of 23billion NOK. The sector operates in two different markets, the private and competitive market. The private market is monopoly where one firm has the responsibility to collect garbage from private households. Responsibility for the private market is delegated from municipalities who is also the owners. The competitive market collects garbage from commercial firms and competes about contracts with other actors. Over the last 30 years, the idea of waste has gone from disposable pollutant to deliver recycled raw materials for the manufactory industry. This is an important part of the circular economy, for the purpose to minimize waste and make the most out of the materials. In addition, to deliver recycled raw materials, the focus is also to mitigate waste and use landfill disposals as a final outcome (industri 2019).

Norwegian waste management and recycling association is the umbrella organization for public services and private companies. The members of this association are responsible for 95 percent of household waste in Norway and they offer advice and guidance to develop the waste management sector. Norwegian waste management and recycling association task is to coordinate and maintain interests in the sector. One of the important activities is to map the waste sector operations with benchmarks every other year to determine the status, best practice and projections within the sector (AvfallNorge 2014).

2.2 Waste management laws and regulations

Norway is not a part of the European Union (EU) but have a close relationship to the environmental policies through the European economic Area (EEA). Norway has implemented most of the environmental legislation from the EU and support the EU in international environmental- and climate negotiations. Most of the regulations are to mitigate pollution and ESTA surveillance authority (ESA) are responsible to control that the commitments in the EEA is adhered (Regjeringen 2015).

The waste management sector in Norway is bounded by the law of pollution and regulations. This law regulates who is responsible for household waste and definition of waste from households in Norway. This law says that each municipality is responsible for household waste and guidelines for consumers. Each municipality has its own regulations and decides the price (Lovdata 1983, 2004).

Møre and Romsdal county council have regulations for household waste for each of the municipality related to RIR. These regulations include where households can deliver their waste and that all households are bound to pay their annual charge to RIR. The regulations also contribute to what RIR should do and what they are responsible to do (Lovdata 2013).

2.3 Romsdal waste management company (RIR)

Romsdal waste management company (RIR) is one of three waste management firms in Møre and Romsdal county. The social mission for RIR is to collect waste and do tasks that the member municipalities have after the pollution law. The member municipalities RIR are responsible for is Aukra, Eide, Fræna, Gjemnes, Midsund, Molde, and Nesset. RIR operates in the monopoly market, collecting waste from households and the competitive market collecting waste from commercial firms. RIR have the responsibility to collect waste from a total of 51 290 citizens and this equals 26 859 households, cabins and residences (RIR 2019a).

Households related to RIR generated 21 262 tons of garbage in 2018, of this 2870 tons (13%) was bio-waste. From 2017 to 2018, the household consumption increased by 1,4 percent from 20 969 tons to 21 262 tons. The bio-waste increased from 2862 tons to 2870 tons (0,3%).

RIR offers three different waste collection methods. These are kerbside collection, drop-off sites and recycling facilities. For private households, kerbside collection system is used, where the customers need to set out the garbage bins for collection. When the collection take place is based on a collection calendar that the customers is offered, the frequency of collection is differing between type of fraction. Customers that lives in shared apartments is it common to share garbage bins with the entire block. Most of them has garbage rooms, where collection takes place. Drop-off sites are located nearby grocery stores and consumers can deliver glass and metal. From 2018, RIR decided to have the glass and metal fraction at the kerbside instead, which has led to reduced number of drop-off sites. There is one recycling facility in each municipality where households can deliver different kinds of fractions, such as dangerous waste, wood, electrical waste, etc (RIR 2019a). RIR have installed RFID tags on all their garbage bins and sensors on the trucks. These tags registrate the location, kilograms and which type it is (RIR 2019d).

Customers at RIR is charged for a fixed price of 2078 NOK yearly and with variable charge which depends on the size of the bins and the frequency of collection as summarized in table 1 below. The customers aren't charged for paper-, glass/metal- and plastic waste. To illustrate an example, where the customer has the combination of residual waste of 140 litre and bio-waste bin of 80 litre with collection every fourteen day will give a total charge of 3694 NOK. Consumers can choose additional different size, frequency and price, but the thesis look at the most typical 80 or 140 litres (Molde Municipality 2019).

Fraction	Collection frequency	80 litres	140 litres	240 litres
Residual waste	Every 14 days	not offered	818 NOK	1325 NOK
Bio-waste	Every 7 days	1726 NOK	2978 NOK	4828 NOK
Bio-waste	Every 14 days	798 NOK	1391 NOK	2349 NOK
Paper	Every fourth week	Not offered	Free	Free
Plastic	Every fourth week	Not offered	Free	Free
Glass/metal	Every eight week	Not offered	Free	Free

Table 1. Pricing system for customers at RIR (Molde Municipality 2019)

2.4 Norwegian consumer waste

Consumer waste is defined as waste from private households, including larger object such as inventory and similarities. This can be delivered at drop-off sites, recycling facilites or kerbside for recycling. The annual person in Norway consumed 426 kilograms of waste in 2017. Residual waste had the highest share with 42% and bio-waste had a share of 9% in 2017. Figure 2 illustrates the shares of waste from Norwegian households in 2017. Other include garbage such as wood, garden waste, electrical waste, etc.

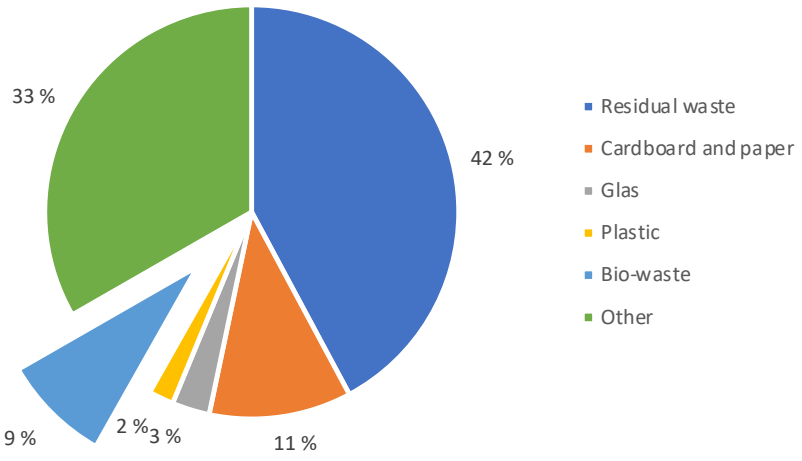

Figure 2. Shares of fraction from Norwegian households - 2017

The pie chart is divided into the kerbside bins delivered by RIR. Bio-waste stands for 9% of the total amount of garbage in Norway from households in 2017. After the garbage is collected from the households, it is distributed for further reuse. From the total of 170 000 tons of bio-waste collected (figure 3), 108 000 tons (64%) goes to energy and biogas production. 56 000 tons (33%) is composted and used as fertilizer. 4 500 (3%) is recycled and under one percent is combusted or landfilled.

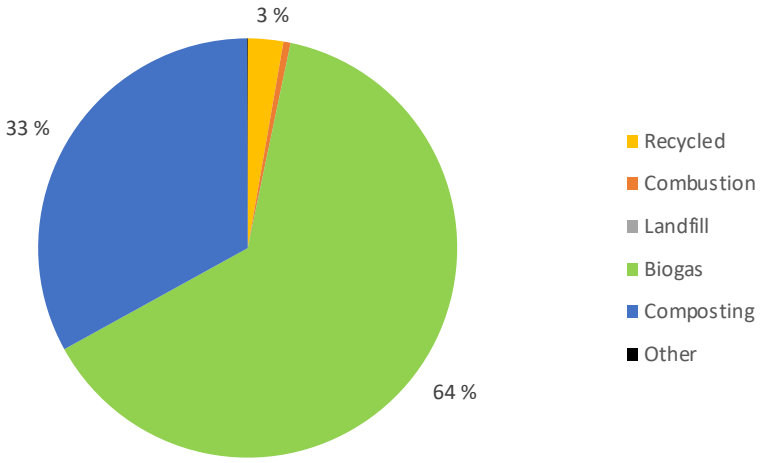

Figure 3. Distribution of bio-waste after it is collected

2.5 Norwegian waste management- and payment system

In Bergen is Bergen waste management company (BIR) responsible for the collection of waste. BIR does not separate bio-waste, this is collected together with residual waste. Instead of producing biogas of the bio-waste is residual waste sent to incineration where bio-waste is turned in to heat and power (BIR 2019a). BIR is using pay-as-you-throw (PAYT) system where the customers is charged for amount of residual waste delivered by themselves, based on how often the garbage is collected. There is a minimum charge for collection, which indicates frequency collection once a month of a 140 litre residual waste bin. With more frequent collection will the customer be charged for an amount each time the garbage bin is collected. On average is the collection frequency for a customer fourteen days. The minimum price also includes one collection each month for paper- and plastic waste (BIR 2019b).

Waste management system in Stavanger offers the customers garbage bins for bio-waste, residual waste and paper waste. Some customers is also offered collection of plastic waste, glass/metal waste, hazardous waste and garden waste (Renovasjon-IKS 2018). The customers are charged for a fixed price which includes paper waste and bio-waste, the fixed charges do not depend on the size of the garbage bin and how much waste there is collected. The variable charges for residual waste is depending on the frequency of collection and size of garbage bin chosen (Stavanger Municipality 2019).

3.0 Literature review

A literature review is used to analyse ideas, find the relationship between different ideas and understand the nature and use of argument in research. Writing a literature review is important because it makes the researches acquire an understanding of the topic on what has been done before and key issues (Hart 1998). The literature review in this study is used to investigate recycling of general waste, but more related towards food-waste. The literature review justifies the research.

The literature for the recycling of food-waste is extensive, but research is narrowed to fit the research problem. To fit the research problem, household recycling behaviour is used in searches. The research on waste collection is wider because there is no exclusive waste management handling system for food-waste. The system is similar to different fractions.

The first part of the literature review presents consumer orientation. Further circular economy and reverse logistics is discussed to highlight the importance of how food-waste can be used over again. The literature review ends with a discussion about which impacts the consumer-oriented system will have from present literature. The second part narrow it to consumer theory and Stated Preference. The theoretical framework relates to theories used in Stated Preference methodology.

3.1 Consumer orientation

Consumer orientation is from the consumer behaviour literature and refers to an individual's specific inclination towards a behaviour during a given consumption act. The predicted nature of the behaviour adds to the orientation a sense of stability and duration over time. To accomplish stability and duration over time, motivation and value is highlighted as the most important components to achieve this (Pons, Mourali, and Nyeck 2006). The motivation factor calls upon the capacity to a given service to satisfy a need for the consumers. The value component calls upon the value and individual gain from a given situation (Pons, Mourali, and Nyeck 2006). In the case of waste collection of food-waste, the motivational components refer to how consumers participate in the waste recycling. This could be to have incentives that benefits consumers to make a bigger effort in waste recycling. The value component is related to when consumers need to choose between

different activities, such as recycle or something else. So individuals orientation is the output of motivation + value (Pons, Mourali, and Nyeck 2006).

Another aspect of the orientation, is the modality among individuals (Hirschman 1984). This relates to the way of doing or experiencing an activity. The activity of recycling needs to be simple for consumers and they want to the activity again. There isn't so many modalities in waste recycling, so therefore it is important that the experienced in doing the activity gives the motivation to do it the next time. Waste recycling is referred to a boring task and is also a voluntary activity (Bruvoll, Halvorsen, and Nyborg 2002). This means that individuals can decide themselves if they want to participate or not. For instance, some individuals can obtain their orientation by doing recycling activities more interestingly by changing their attitude towards the activity. By focusing on reducing the time before the garbage bin is full, instead of how time-consuming it is (Werner and Makela 1998). Others can obtain the same orientation by thinking that recycling is important for the long-term benefit of society (Cheah and Phau 2011).

3.2 Circular economy

The growing population and increased demand for food, low efficient resource use and food distribution, environment factors, and the increasing amount of food loss and waste in the food system are applying for transition towards sustainability. The inefficiency in the food economy leads to loss in productivity, energy, and natural resources, and the costs of throwing food away. Tools from circular economy can be used to improve and optimize for sustainability of food system (Jurgilevich et al. 2016).

Circular economy main objective is to keep the highest utility level for products, components, and materials. Using the advantage circular economy offers can help towards this. Benefits provided from circular economy is helping toward the resource related challenges that occur in the business and economy. And focusing toward stabilizing the growth and reduce environmental impact such as greenhouse gas emission (Ellan MacArthur Foundation 2015). A report from Ellan MacArthur Foundation (2015) characterizes circular economy in three principals:

1. "Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows."
2. "Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles."
3. "Foster system effectiveness by revealing and designing out negative externalities."

Figure 4 below describes the three stages at which principles of circular economy regarding food system can be implemented. The arrows represent the flows of nutrient and matter flows (Jurgilevich et al. 2016).

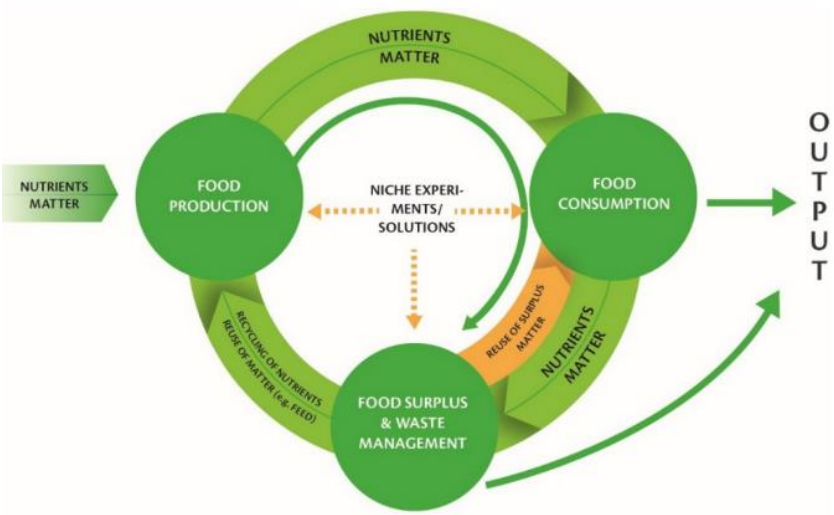

Figure 4. Three stages of food systems in a circular economy (Jurgilevich et al. 2016).

The circular economy aims first to use the products, then reuse and recycle, before it can be used to energy. The most important factor for food surplus reduction is prevention and reuse of food surplus to people with low food shortages, through redistribution networks and food banks. Technology advances has successfully been implemented in reducing food-waste on the production side. Material flow of new materials into the market and the exclusion of circulating material as waste need to be minimized. Localized food network contributes with sustainable control system that is simpler and easier, and the collected food-waste can then be composted and used in agriculture or for anaerobic digestion in biogas production (Jurgilevich et al. 2016).

3.3 Reverse logistics

The growing population in the world affect the increase of level consumption, this leads to a decline of natural resources while the amount of used products continue to grow (Kilic, Cebeci, and Ayhan 2015). Rapid changes on the technology is a factor due to the problem mentioned, since the lifecycle of products decreases due to the technology changes. This indicates that new products will be produced, and the amount of waste produced will increase (Pedram et al. 2017).

The problem is negative to the environment, and relevant approaches is necessary to deal with it. Reverse logistics is a common approach used to deal with this problem and is defined by Rogers and Tibben-Lembke (1999):

> *"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."*

Economic- and social concern make the manufactures aware of minimizing the environmental impact and energy consumption and state their willingness to reduce the problems the society meets (Choi, Hwang, and Koh 2007). Suggested recovery options is repair, refurbishing, remanufacturing, cannibalization and recycling (Thierry et al. 1995). Figure 5 below is presented to give the reader an understanding of the supply chain for materials, and the process of direct logistics and reverse logistics. The process for direct logistics is from raw material to consumption of the material, while the reverse logistics covers the product recovery steps reuse, remanufacturing and recycling (Sellitto 2018).

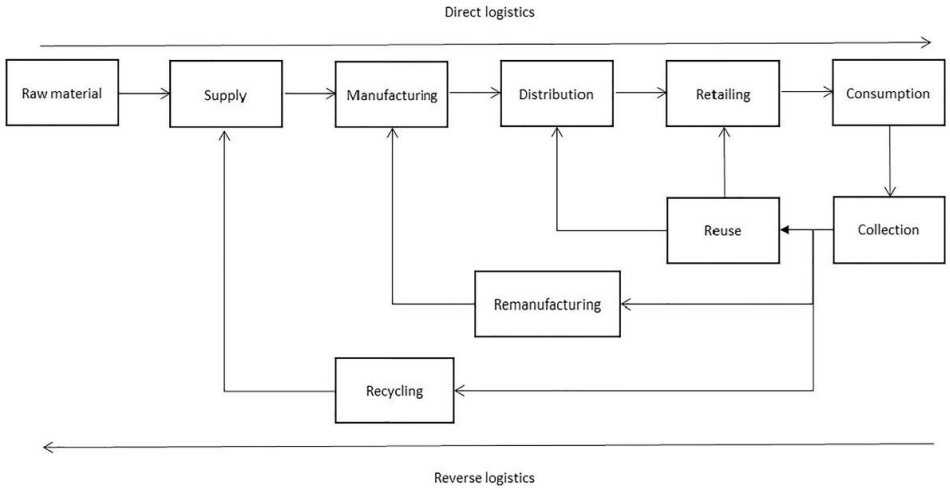

Figure 5. Typical flows of direct- and revers logistics (Sellitto 2018).

The recovery process of products is about reusing the products that is collected from the consumers, where the plan is to minimize the amount of waste delivered to landfills because of the high amount of greenhouse gas emission that occur from landfills. Table 2 from Eriksson, Strid, and Hansson (2015) shows the amount of greenhouse gas emission produced from the different waste management methods. Remanufacturing is about turning old products into new once by disassembly, refurbishing and replacement operations (Pedram et al. 2017). The recovered parts and products from the process will then be used in the repair, remanufacturing of other products and components and for sale. The purpose of the recycling of materials is disassembly for separation and processing of materials of used products. Which will minimize the amount of disposal and maximize the number of materials that will be returned back into the production cycle (Gungor and Gupta 1999). The purpose of reuse is to use the materials from the products and components that have lost their identity and functionality (Choi, Hwang, and Koh 2007).

The rising awareness of food-waste has become more important the resent years due to food shortages for poor people, food quality, and environmental factors (Gustavsson et al. 2011), and by 2050 is it expected to feed the population of nine billion (Parfitt, Barthel, and Macnaughton 2010). Lot of losses of food is occurring due to the food supply chain, this thesis is focusing on the losses that is occurring at the end of the food supply chain which is called the food-waste and relates on retailers and consumers behaviour (Parfitt, Barthel, and Macnaughton 2010).

By increased knowledge about the different food-waste management methods and more awareness of the different greenhouse gas emission produced from each of them could affect the consumer's behaviour. The different food-waste management methods are landfill, incineration, composting, anaerobic digestion, animal feed, and donations (Eriksson, Strid, and Hansson 2015). An analysis is presented to show the differences of the food-waste management methods. Table 2 below shows the results of how much greenhouse gas emission that is produced between the different food types and food-waste management methods.

Scenario/food product	Banana(kg CO_2e/kg food waste)	Chicken(kg CO_2e/kg food waste)	Lettuce(kg CO_2e/kg food waste)	Beef(kg CO_2e/kg food waste)	Bread(kg CO_2e/kg food waste)
Landfill	1.4	3.1	0.21	2.1	1.9
Incineration	0.10	−0.31	0.25	0.003	−0.67
Composting	0.043	0.043	0.043	0.043	0.043
Anaerobic digestion	−0.38	−0.26	−0.047	−0.67	−0.55
Animal feed	−0.011	−0.038	0.005	−0.030	−0.13
Donation	−0.12	−0.35	−0.013	−0.31	−0.61

Table 2. Greenhouse gas emission produced (Eriksson, Strid, and Hansson 2015).

The results performed from the analysis shows that anaerobic digestion and donation is recommended methods for reduction of greenhouse gas emission (Eriksson, Strid, and Hansson 2015). Waste management solutions is mentioned to provide a better understanding about where the food-waste ends up after collection. RIR is using an anaerobic digestion where the collected food-waste is transported to a biogas plant where the waste is transformed into gas through collecting the gas that arises when the waste is decomposed (RIR 2019b).

Material flows, information flows, and financial flows are three types of flows in reverse logistics that needs an in-depth understanding due to the difficulties of persuading supply chain optimal solutions while preserving the decentralized decision making. The material flows are affected by the quantity, time, and place of returns, and the level of their reuse value. The value of the product can only be known after the dissemble of the product. The information flows are important due to reducing uncertainty in the timing and reusability of the returned products. While financial flows cover such as buy-back clauses, disposal costs, and other end-of-use costs. It could be difficult to sign contracts where the products will be taken back, this is due to the unknown of the quality of the product after use (Dekker 2004). Use of financial incentives could help to managing the physical return flow (Guide Jr and Van Wassenhove 2001).

The review of reverse logistics performs the ideas about the approach and shows the different solution for the recovery process. Developing this approach could help to reduce the increase of new products and reduce the amount of waste produced. Further will the thesis investigate the different collection systems used to collect waste from private households and how this will affect the transportation impact.

3.4 Impact on waste collection with consumer-oriented approach

How a consumer-oriented approach will impact the waste collection would differ due to the consumers preferred waste collection system. The research will look at waste collection entirely, and not just food-waste since the system would be the same.

3.4.1 Waste collection

The most common methods for collection of waste it either kerbside collection or drop-off collection, or a mix of these collection methods. The collection methods are often varying between the municipals in the country (McLeod and Cherrett 2008). RIR is using a kerbside collection system. For bio-waste is the most common collection frequency two weeks (RIR 2018). One objection mentioned due to this is the health issue that can arise with food-waste being left in bins for two weeks, especially in public areas. With rarely collection frequency requires there more from the households to recycle to avoid full bins outside the house (McLeod and Cherrett 2008). This is one of the reasons why consumer-oriented system should be considered.

An analysis is performed to investigate waste collection systems in two different regions from Spain and the USA. The current system in Spain is kerbside collection, while the current system in the USA is drop-off sites. Further will recycling behaviour of the different regions be considered. Distance to the garbage bins varied in Spain from one to five minutes, while in the USA it varied between five to ten minutes. The consumers in the USA were positive to a change of kerbside collection, and more then half of the respondents thought it would enhance the recycling. The distance to the drop-off sites was

a factor why the consumers would like a change of the waste collection system. In Spain did they complain about the smell and noise with kerbside collection, and the frequency of collection was important for them. The main results from the analysis are that kerbside collection would enhance to better recycling behaviour, the reduction in time effort is what trigger them. Further is it important that the frequency of collection is on the same level due to noise and smell that could occur (González-Torre, Adenso-Díaz, and Ruiz-Torres 2003).

3.4.2 Route optimization

The impacts will vary due to the preferred collection system for the consumer. The rising awareness of reacting to the increased amount of waste has led to a focus on this topic, optimization of transport has due to this got an important role. Vehicle rout optimization for Radio Frequency Identification (RFID) integrated waste collection systems can be used to locate the bins at any point, know the net weight of the waste in the bin, and register who the bin belongs to due to unique ID numbers. An analysis indicates that by using RFID with the possibility to locate each bin is a critical factor due to an effective capacity and route planning of a waste collection system (Ustundag and Cevikcan 2008).

A system that is used for waste collection is cyber physical, this is based on an internet of things prototype. Which let the waste collection worker be aware of the amount of waste in the garbage bins. The data provided from this system will further be used to optimize a collection rout. This system is making the waste collection more effective, and the garbage bins will be collected the same day that they are full. The downside with this system is that the required distance of transportation is increasing, which leads to higher total costs (Gutierrez et al. 2015).

3.5 Previous studies of recycling behaviour

Recycling behaviour has fascinated researchers for decades, and there are extensive studies and different methodologies used to describe recycling behaviour among individuals. This thesis is investigating consumers of RIR recycling behaviour regarding bio-waste and a suggestion of a consumer-oriented system. Stated Preference choice modelling is used as the main approach to find consumer preferences.

Stated Preference (SP) approach is used to induce individuals to reveal their preferences within a hypothetical situation. Based on the result from the survey is it possible to estimate consumers' willingness to pay (McConnell and Walls 2005). SP approach can be applied in several economic valuation context (Johnston et al. 2017).

There are several methods for SP, where the most commonly used SP approaches are choice experiment (CE) and contingent valuation (CV). In CE is the respondents asked to answer among alternatives with two or more attributes due to their preferences, and to be able to interpret the results in standard welfare economics terms must one of the alternatives be a currently feasible choice for the respondents (Hanley, Mourato, and Wright 2001). In CV is respondents asked to choose if they would vote for a proposed change at a specified cost (Johnston et al. 2017).

SP and revealed preferences (RP) are often mentioned together in the same sentence. SP choices are based on experimental and hypothetical, the researcher can than choose to explore to add hypothetical alternatives. While RP choices are revealed in the real world. Common in both approaches is that the analyst doesn't know all the factors that influence the respondent's choice. But the unobserved factors are not the same in SP and RP. The unobserved factors from SP is (1) individual factors, (2) the omission of relevant variables affecting the choice context under examination and (3) characteristics of the experimental design. While the unobserved factors from RP is (1) individual decision-maker factors, (2) unmeasured alternative attributes and (3) measurement error in variables. In the utility function is these unobserved factors often subsumed within the error term (Bhat and Castelar 2002).

The biggest weaknesses for SP are the reliability. This is because the respondents can choose under hypothetical situation, which can cause that the expressed preference is not consistence with the actual behaviour. Other drawbacks related to SP is that respondents try to justify their actual behaviour and to control policies (Sanko 2001).

Previous studies have been done investigating people's behaviour. Czajkowski, Kądziela, and Hanley (2014) has in their paper used a choice experiment and collected stated choices from a Polish municipal. The investigation is toward the choices of household-based recycling, where the respondents will choose over private recycling at household or leaving the recycling to a third party. Main factors by choosing waste management systems for the respondents seems to be mainly economic and environmental. Interesting findings is that consumers are more willing to sort waste at household than let a third party do it for them even do the unsorted waste wouldn't be collected with additional costs. Some possible explanations for this could be that respondents wants to promote their environmental self-image, which can be driven by a desire for green external image. Respondents can also believe that recycling at households would be more effective than collection by a third party, even do this requires more privately costs, time and effort. Last is that the respondents may also feel that recycling at households is a moral duty.

A cost-benefit analysis on the Norwegians households recycling efforts is performed by Bruvoll and Nyborg (2002). The survey provides that individuals are motivated based on a preference to conform legal, social and moral norms. Mostly of the respondents that is recycling, would let a third part recycle for them as long it wouldn't reduce the environmental impact. This provides that recycling is a burden for most of the respondents.

A municipal in south-west Sweden was used in survey from Bartelings and Sterner (1999), where they introduced a weight-based billing system for household waste by charging 1 SEK per kg waste. The minimum yearly fee was 300 SEK and free kerbside collection of paper and glass, other fraction could be disposed at nearby recycling centres. The weight-based billing system changes the responsibility from collection companies to households, and if the bins wasn't placed at the kerbside for collection wouldn't there be any fee for the household to pay. This action reduced the average yearly fee for households by about 230 SEK and the average waste by the households where reduced by 35%. Further in the survey did they compare four different municipalities, for the analysis they used linear,

exponential and log-linear analysis. The findings provide that economic incentives are not the only force for reduction of waste, with infrastructure that facilitates recycling make people more willing to use time than what savings on the waste management bill does.

Summing up the previous studies above about recycling behaviour provides that the preferences differs due to countries. The study about Norwegian households shows that they would let a third party do the recycling for them, while the study of household recycling in Poland and Seattle would prefer to do the recycling themselves. From the literature is attributes and drivers discussed in different waste management systems which can support the decision of attributes used in the SP questionnaire.

3.6 Theoretical framework

The theoretical framework consists of economic and social theory. This provides a structural theoretical framework that presents a systematic way to understand behaviour. As a foundation of understanding consumers behaviour to implement a consumer-oriented system, microeconomic consumer theory and random utility model is presented and discussed in the following sections.

3.6.1 Consumer theory

The difference of consumer theory and producer theory is that consumer theory is to demand while producer theory is to supply. Producer theory is driven by profit, and this is something that can be measured (McAfee 2006). While consumer theory is difficult to measure, and you must instead infer, this is because consumer theory is about what people like. By choices is it possible to understand what people would infer, but it doesn't make it easier to predict possible mistakes from the respondents. The consumer theory doesn't implicate the mistakes but rather focuses on the choices that give the consumer the most satisfaction (McAfee and Lewis 2009). The microeconomic consumer theory is seeking how people decide to choose to maximize their utility based on their preferences and budget constraints (Chugh 2015).

Analysing people's choice looks at each individuals' preferences towards the alternatives that are given. Each alternative is a collection of goods and services, and the individual chooses the alternative that fits them the most taken all the things into considerations. In this case would a utility function be used to show the satisfaction a person experience, flow of pleasure or happiness that a person enjoys is factors that can be used to measure satisfaction (McAfee and Lewis 2009). Some experiments may include choice sets which is dominant alternatives. With alternatives where there is more preferred levels with respect of the attributes is considered as dominant, in such a situation is it common that the respondents is choosing this dominating alternative (Crabbe and Vandebroek 2012).

The article from Lancaster (1966) provides the new approach of Lancaster's model of consumer choice. Lancaster proposed that the consumers achieve satisfaction from the attributes the goods provides, and not from the goods themselves which the traditional approach meant it was. The input is the activity of goods in single or in combination, while the output is the collection of characteristics. The utility or preference orderings are then used to rank the collections of characteristics. Sited from Lancaster (1966) is the new approach of consumer choice summarized as follows:

1. *"The good, per se, does not give utility to the consumer; it possesses characteristics, and these characteristics give rise to utility."*
2. *"In general, a good will possess more than one characteristic, and many characteristics will be shared by more than one good."*
3. *"Goods in combination may possess characteristics different from those pertaining to the goods separately."*

And due to the challenges of measuring the utility of happiness the classical economist chooses to switch the utility of being a measure of happiness, to be a measure of consumer preferences. An alternative includes the goods and services, and the one alternative that provides the highest amount of consumer preference utility is the one that matters. How much higher the utility is towards the other alternatives doesn't matter. By using the utility function is it possible to assign a number to each of the alternatives, and the more-preferred alternative will have a higher utility than the less-preferred alternative (Varian 1996). This is explained by Varian (1996), if there are two alternatives: utility (X_1 X_2) and (Y_1 Y_2) and the utility (X_1 X_2) is larger than utility (Y_1 Y_2), would give this expression [utility (X_1 X_2) > utility (Y_1 Y_2)].

Further Shiv and Fedorikhin (1999) divide between two processes that can occur to an alternative in a choice task, this is affective and cognitive. The affective process is that the choice is made based on an affective reaction, which can end up both positive and negative. The cognitive process is choices made on more controlled grounds where the alternatives are considered based on the stimulus and memory and will be either favourable or unfavourable.

3.6.2 Random utility theory

Random utility theory (RUT) was first expressed by Thurstone (1927) where the m´s are constant and the X´s are independent with a common distribution in the utility function $U_i = m_i + X_i$ (Robertson and Strauss 1981). McFadden (1986) developed the original theory to include choices with multiple comparisons and the multimodal logit model. The popularity of using market surveys to find preference among customers is now a common approach. When introducing new products or change product attributes, surveys are used to expose consumers preferences, and then analysed. RUT suppose that every consumer is rational decision makers, and will maximise their utility when they do the decision making (Louviere, Flynn, and Carson 2010). If consumers find their utility maximized, they are more eager to buy the product or service.

RUT proposes that individuals have a choice utility in their head, that cannot be observed by researchers. Because these can't be observed by researchers, they are therefore called by the term latent. Individuals are also imperfect measurement devices, and there will be random components associated with variability and differences in choices (Louviere, Flynn, and Carson 2010). Equation (3.1) is called the random utility model (RUM) and this is a complex model which account for individual behaviour and represent all variables that explain preferences in the utility function. The latent variables in RUT can be summarized by two components, one deterministic systematic component and one random unexplainable component (Louviere et al. 2000).

$$U_i = V_i + \varepsilon_i \tag{3.1}$$

Where U_i is the latent utility for individuals, associated with the alternatives in i. The V_i is the systematic and explainable component, related to attributes collected from primary and secondary data. ε_i is the random and unexplainable component.

Individuals will try to choose the alternative that yields them the highest utility. The key assumption for latent decision-making is that individuals choose one alternative A over another. The two different alternatives are represented by, *i* and *j*. Individuals will choose *i* if and only if *i* have greater utility than *j* (Louviere et al. 2000). The expression is outlined in equation (3.2)

$$U_i > U_j \text{ and } j \neq i \in A \tag{3.2}$$

The systematic V_i component is the mean utility among individuals who have the same attributes. Attributes included in the systematic utility can be classified in different ways. These are performance attributes (cost, time, service), activity system attributes (e.g. number of return points) and socioeconomic attributes (income, number of people in the household) (Cascetta 2009). This systematic utility is established by collecting primary and secondary data from in-depth interviews, focus groups, questionnaires and literature review. Once these attributes are identified, the analyst have to specify how these variables can be combined to drive systematic preferences (Adamowicz, Louviere, and Swait 1998). This is expressed as a linear function in equation (3.3) with only one attribute and equation (3.4) include more than one attribute.

$$V_i = \beta_i X_i \tag{3.3}$$

$$V_i = \beta_{0i} + \beta_{1i} X_{1i} + \beta_{2i} + X_{2i} + \cdots + \beta_{ki} X_{ki} \tag{3.4}$$

Where V_i is the systematic utility and β is called the coefficient and are a vector associated with the vector X of explanatory variables and alternative *i*, such as income and time. The coefficient is assumed to be constant across individuals. The $\beta_0$is the alternative-specific constant (ASC) and are not associated with any of the observed and measured attributes. β_0 represents the on average of all unobserved sources of utility. The ASC can be used to

check potential biases, due to the fact that respondents choose the first alternative just because they are in the first position (Hensher, Rose, and Greene 2005).

The latent utility function includes key attributes with coefficient and random errors. To understand consumer patterns, different random utility functions is applied to analyse key factors and their influence on consumer choices.

3.6.3 Discrete choice modelling

General theory of discrete-choice is the existence of choice behaviour, defined by a set of individual behaviour rules and an indirect utility function that contains random component. The random component does not suggest that individuals make choices in some random fashion, but important unobserved influences on choice exist and can be characterised by a distribution in the sampled population. Then it is difficult to locate any particular individual on the distribution (Louviere et al. 2000).

Discrete choice modelling (DCM) is used to analyse data derived from RUT which is the decision rule. DCM can be analysed in different ways and have different alternatives to model consumer heterogeneity (Hensher, Rose, and Greene 2005). Example of different choice models is multinomial logit (McFadden 1973), multinomial probit (Thurstone 1927) and mixed logit. Extended models such as mixed logit and latent class models (LC) have used a multinomial logit model (MNL) as the base model for further development (Fiebig et al. 2010). The most commonly used model of DCM is the MNL model and the form is written in equation (3.5).

$$Prob(i|j) = \frac{\exp V_i}{\sum_{J=1}^{J} \exp V_j}; \qquad j = 1, \dots, i, \dots, J \quad i \neq j \tag{3.5}$$

The MNL model is based on the assumptions of independence-from-irrelevant alternatives (IID) and extreme value type 1 (EV1). The IID assumption is that the random residuals ε_i are independently and identically distributed about their means (Cascetta 2009). The difference between a normal distribution and the EV1, is the tail of the distribution where extreme values resides (Hensher, Rose, and Greene 2005). Because of the independence between random residuals, the covariance between pairs are independent in the IID and are zero (Cascetta 2009). This is expressed in equation (3.6)

$$Cov[\varepsilon_i, \varepsilon_j] = 0 \qquad j \neq i \in A \tag{3.6}$$

3.6.4 Experimental design

Stated Preference (SP) data are generated through a systematic framework and planned design that the attributes and their levels are pre-defined without measurement error and create choice alternatives (Louviere et al. 2000). Louviere et al. (2000) state that *"a designed experiment is a way of manipulating attributes and their levels to permit rigorous testing of certain hypotheses of interest".* An "*experiment"* involves observation upon a response variable and manipulates levels of one or more attributes. Specialised form of statistics is used to determine what to manipulate (Hensher, Rose, and Greene 2005). The term "*design*" relates to the planning of which observations to take and to permit the best possible inference from the data regarding hypotheses (Louviere et al. 2000).
When designing an experiment, decisions need to be taken before the data collection starts. These decisions are blocking factors, which treatments to study, defining treatments, choosing how to randomize, specify the experiment units, choose sampling size and choose the proportion of observations (Chaloner and Verdinelli 1995). All these decisions is done sequentially and presented in next section as figure (4.1).

Factorial design are a design where each level of attribute is combined with every level of other attributes (Louviere et al. 2000). This is called full factorial design and consider each possible choice situation (ChoiceMetrics 2018). With full factorial design, each respondent is addressed to answer all the possible choice situations. Full factorial design guarantee that all attribute effects are truly independent (Louviere et al. 2000). The equation of full factorial design is presented in equation (3.7):

$$S = \prod_{J=1}^{J} \prod_{k=1}^{K_j} I_{jk} \tag{3.7}$$

Where

S represents choice situations

J represents alternatives

K_j represents attributes, where attribute $k \in K_j$

I is the levels

The number of choice situations increase rapidly when adding attributes and attribute levels. So only the smallest problems of full factorial design, can be used. However, generating the full factorial design can be useful to determine other design, such as fractional design. In fractional factorial design, each respondent is only shown a fraction of the full factorial design choice situations (ChoiceMetrics 2018). This is a systematically selected subsets of treatment combination from the full factorial and the primary interest can be estimated under the assumption that interactions are not significant (Louviere et al. 2000). The analyst can randomly choose choice situations from the full factorial, or give the first respondent choice set one, and the second respondent choice set two, and so on. By using these options, biased answers can easily occur, in the way that some of the respondents can only be faced with high or low values of certain attributes. This can be avoided by choosing subsets, so the attributes levels are balanced and satisfied. Orthogonal design is used to choose subsets so the attribute levels are balanced and satisfied. (ChoiceMetrics 2018).

Orthogonal design is satisfied only if attributes levels are balanced and independent. This means that each attribute column in the design need to be uncorrelated. The sum of the inner product of any two columns need to be zero. The advantage of orthogonal design is that it allows for independent determination of each attribute contribution on the dependent variable and maximize the power to detect statistically significant relationship (ChoiceMetrics 2018). This thesis will use orthogonal factorial design and Ngene software to generate the design.

4.0 Methodology

The methodology used in this study will be described through this section. Many of the steps in the Stated Preference (SP) experiment are intertwined, so the main steps will be described in this chapter. The main steps are illustrated in figure 6 below and the figure has taken inspiration from Louviere et al. (2000) model for steps in SP choice study. Problem definition is first refined. The second step is to do supporting qualitative study. In-depth interviews were done 11 February 2019 and the focus group interview 21 February 2019. The goal for these two qualitative studies was to understand which preferences these persons had towards recycling of bio-waste. The literature review is done to get a broad knowledge of the recycling sector and other studies done with the same subject.

Further, a pilot study was done from 4 April to 6 April 2019 and a collection of 31 respondents collected from citizens in Molde. The answers for the pilot study was analysed and improvements were done for the main survey. The main SP was used to collect 189 questionnaires, and this included the 31 respondents for the pilot study.

Figure 6. Main steps from Stated Preference experiment (Louviere et al. 2000)

4.1 Define study objects

Often the most difficult task in a project is to define the study object. The substantive question is difficult to answer through the study (Louviere et al. 2000). This study will focus on a consumer-oriented system for food-waste collection. Further, a discussion of managerial implications and the proposed new consumer-oriented system is presented.

4.2 Data collection

There are two different approaches for data, these are qualitative and quantitative data. When these two approaches is combined, the approach is called mixed-method approach and is the approach used during this study (Creswell and Creswell 2017). In-depth interviews and focus group are used to collect qualitative data, supported by earlier research to identify alternatives, attributes, and attribute levels. This lay the ground for the questionnaire and SP choice sets, that are collected through a questionnaire. Qualitative and quantitative data collection methods are described in this section. Both the qualitative and quantitative data is used in the managerial implications, because both are relevant for the motivation and values of consumers.

4.2.1 In-depth interviews

For sampling qualitative primary data, in-depth interviews are often used to explore perceptions from individuals on a new idea or situation. Typically, individuals are asked to tell which thoughts they have from a personal view as involvement in the idea or situation. In-depth interviews are useful when detailed information for a particular behaviour or want to explore new issues more in depth before a full questionnaire are outlined (Boyce and Neale 2006).

The goal is to explore perceptions from individuals and therefore it is important to have open-ended questions, so the interviewees doesn't answer "yes" or "no". It is important to pre-plan questions before the interview. This should be done systematically, so questions are in the right order. It is also important to have questions that flow with previous questions (Boyce and Neale 2006).

The semi-structured interview can have a different meaning for people. It could mean entirely about open-ended questions with some instructions. For others, it can mean both open-ended and closed questions (Brace 2018). In this study, it means that there were asked both open-ended and closed questions in the in-depth interviews.

4.2.2 Focus groups

Another sampling method for qualitative data is focus groups. Focus groups are used to find different opinions among group members. The difference between other groups is that focus groups don't seek to find consensus or conclusion at the end of a discussion. Rather focus groups will obtain attributes that are relevant for the research project. Focus groups are typically between five to six participants with different backgrounds. Groups need to be small enough, so all participants can come with their perceptions of the subject discussed. Quality of the discussion is affected by the number of participants (Krueger and Casey 2009)

Focus groups can gather useful qualitative data for a research project, but it can also give biased answers. Stewart and Shamdasani (2014) focus on the bias from the moderator and point at the moderators' experience towards focus groups as a problem to bias. This problem occurs when there is too many questions, sensitivity, and comfort for the participants. The bias that occurs from the participant's side is that individuals have different personalities. Some are more dominant than others, this can prefer and influence other group members answers. Participants can also make up answers because they have limited or no experience about the topic. To cope with such problems, the moderator should be aware that situations like this can happen, and be able to handle the situation (Krueger and Casey 2009).

The guidelines for in-depth and focus group is attached to appendix I.

4.2.3 Questionnaire

A questionnaire is a tool used by researches, that is important for the researcher to understand, interpret and complete. Two important concepts considered in a questionnaire design are reliability and validity (Adams and Cox 2008). Cited from Adams and Cox (2008)*"Reliability refers to the consistency of a measure whilst validity refers to its ability to measure what it is supposed to be measuring."*

The questionnaire length and structure are important consideration to take into account. Too many questions have proved to lower the attention of the respondents due to the rush of finishing, and only skim reading the questions. Another source of biased answer, is obvious question repetition. This is due to respondents repeating their previous answer, whether the new question is accurate or not. The structure of the questionnaire is also an important factor for usability and how effective it would be. The way the questions are ordered may bias the respondents to give favourable answers. The questions should therefore be sequenced carefully and grouped under a teamed heading that would help the respondents contextualize the subsequent questions (Adams and Cox 2008).

The questionnaire in the thesis will include two main types of factual questions and likert scale. Simple factual questions requiring a yes or no answer, while the complex factual questions require more interpretation. Examples of such questions are "how many garbage bags do you dispose during the week?". The likert scale is used to measure the attitude/opinion of the respondents, an example is "do you want to contribute to a better environment?" and the respondents must choose between: Very good – good – acceptable – poor – very poor (Adams and Cox 2008).

4.2.3.1 Template modification

The collection tool used for the questionnaire was an excel template developed by Valerio Gatta, which is an expert on choice discrete choice models and lecturer at the University of Roma in transport demand analysis. This template was developed to suit a SP data collection and gives output for the SP analysis. Commercial software for surveys was discussed, but it was difficult to implement the SP part, and also get the correct data from data sheet. Most of the modification was to suit the design in this study.

4.3 Experimental design

The data collection methods are used to identify the alternatives, attributes, and attribute levels, before the development of the experimental design (Hensher, Rose, and Greene 2005). An experiment in its simplest form involves manipulation of variables with one or more observations, taken in response to each manipulated value of the variable. The manipulated variable is called a "factor" and the manipulated values are called "factor levels". The manipulated variable is also referred to in the literature to be attributes, and the manipulated values attribute levels. Attributes are characteristics of products or services. The term "treatment" is used when there is one attribute level that is manipulated, and "treatment combination" if there is a combination of manipulated attribute levels. (Louviere et al. 2000).

When the alternatives, attributes, attribute levels, and attribute-levels labels are identified, the decision about which treatment combination to be used. The most commonly used design is the full factorial design. Full factorial design enumerate all possible treatment combinations so that each attribute level have a unique number (Hensher, Rose, and Greene 2005). In this study, two alternatives and two attributes are used, where one attribute has three levels and the other two levels. For unlabelled experiments, the enumeration of possible choice sets is presented in equation (3.6). An unlabelled experiment is when alternatives don't convey any information and are generic (Hensher, Rose, and Greene 2005). From the equation, the possible choice sets are (3x2)(3x2)=36

4.3.1 Labelled and unlabelled experiments

When designing the experimental design, the decision as to whether use labelled or unlabelled alternatives is important. An unlabelled experiment presents generic titles, instead of a labelled experiment, where each respondent faces a labelled alternative (e.g train, car, bus). The advantage of using unlabelled alternatives is that they don't require identification within alternatives. It is easier to be under the assumption of IID, because alternatives are uncorrelated with an unlabelled experiment. With a labelled experiment, the alternatives can act like attributes and the different alternatives can become attribute levels. This can be correlated with the attributes in the experiment, and are not under the

assumption of IID. Labelled experiments help respondents to decide more realistic than an unlabelled experiment (Hensher, Rose, and Greene 2005).

It is possible to construct unlabelled experimental in the same way as labelled experiment, but this may prove grossly inefficiency. Because the only way for respondent to differentiate between each alternative, is by attributes and attribute levels in an unlabelled experiment. So, it is important that alternatives over the entire experiment is undefinable. If not, the alternatives can represent a labelled alternative. When this is the case, the respondent easily make biased answer when associating with e.g. a brand (Hensher, Rose, and Greene 2005).

In this study, the unlabelled experiment will be used, because respondents aren't faced to choose between different labelled alternatives for waste collection, but rather the preferred utility between price and frequency with no specific labelled alternative.

4.3.2 Fractional factorial design

When the experimental design and the number of possible choice sets are designed, there are 36 treatment combinations. 36 treatment combinations are not the most extensive, but 36 is also to many for an individual respondent to answer. Rather than use all of the treatment combinations, a fraction of the treatment combinations can be used. The number of treatments can be randomly selected, but this can produce statistically inefficiency or sub-optimal design. To ensure a statistically efficient design, scientific methods are used to select the optimal treatment combination (Hensher, Rose, and Greene 2005).

The scientific method used in this study is orthogonal fractional design. Orthogonal design requires that all attributes are statistically independent of each other (Hensher, Rose, and Greene 2005). For an independent determination of each attribute contribution of the dependent variable, the power of design to detect statistically significant relationships is maximised. Attribute levels for each attribute column in the design need to be uncorrelated. The orthogonal design satisfies the property that the sum of the inner product of any two columns is zero. Orthogonal is only persevered if columns are left out, and not rows. Randomly selected columns can enter the design, if an orthogonal array exists with more columns than needed, this can be re-range to have them in a preferred order. When

replacing the orthogonal coding with the actual attributes in the questionnaire construction, the attribute levels don't need to be in the same order as the orthogonal coded levels (ChoiceMetrics 2018).

Orthogonal design can be created manually, in documents and with software such as Ngene. Ngene can generate simultaneously and sequential orthogonal design. While sequential orthogonal design holds within each alternative of the orthogonality, simultaneously also holds across alternatives. Sequential orthogonal design will lead to smaller designs in terms of the number of choices. Sequential orthogonal design will only work if the utility function has the same attributes and levels. The alternative simultaneously approach in Ngene, combines different design dimensions across alternatives and combines separate orthogonal arrays for each alternative. This gives different orthogonal arrays and alternatives can have diverse attributes and levels (ChoiceMetrics 2018). Simultaneously orthogonal design is used in this research, because alternatives have different attributes and attribute levels.

4.3.3 Blocking design

There are still too many choice sets for the individual respondent to answer after the orthogonal design. The way to give the respondent fewer choice sets to answer, is blocking the design. Blocking involves introducing another orthogonal column to the design, with attribute levels which are used to segment the design. This provide each respondent different choice sets. The blocks are not orthogonal, but all the block combination is orthogonal. By blocking the design, the respondent doesn't only need to consider high or low attributes, but attribute levels are balanced (Hensher, Rose, and Greene 2005)

The new uncorrelated column with a number of levels added to the design has three levels. The design is then broken down into three blocks. Each of these blocks will be given to different respondents, and three different decision makers are needed to complete the full design. In this study, there are two questionnaires provided for the decision makers. One for households having 140 litres and one for 80 litres garbage bins. To complete the full design, three for each questionnaire need to be answered by respondents. These questionnaires are independent of each other, so the number of respondents doesn't need to be the same, but blocking design needs to be fulfilled for each of the questionnaires.

4.4 Define sampling strategy

The sampling frame must be defined so the substantive question can be answered with the model from the sample. The target population consists of who receive benefits of the non-market effects in questions. Target population can be determined by expert judgment and information from available data sources (Bateman 2002). The target population in this study are geographically and is the connected municipalities to RIR.

There are many different sampling strategy methods. The most common sampling strategy in the discrete choice is the simple random sample (SRS) and exogenously stratified random samples (ESRS). In SRS, each decision maker in the sampling frame have the same possibility to be selected, while ESRS divide the population into different groups, and each of these groups represents a proportion of the population. The basis for creating the groups is personalized characteristic, except the choice and these groups are called *stratums*. Within each stratum, individuals have an equal chance to be selected, this means that there is a simple random sample within the stratum (Louviere et al. 2000).

For the case of this study, there are two independent questionnaires. A stratified sampling approach was used, and randomly selected individuals were surveyed primarily in Molde and the ferry from Molde to Vestnes. The population using the different garbage bins (80L and 140L) was delivered from RIR, and the sampled population was separated in the same percentage. Respectively 66 percent 80 litres and 34 percent 140 litres.

4.5 Data analysis methods

There are different ways of data analysis depending on the method and data analysed. Thematic data analysis is used for the qualitative data. For the quantitative data analysis, descriptive data analysis and Factor Analysis is used. These data analysis methods will be described in more detail further in this section.

4.5.1 Thematic data analysis

Thematic data analysis is used to analyse interview and focus group interviews. The data analysed is used to define the attributes and attribute level. Thematic analysis is a method for qualitative research and provide skills that can be conducted in other forms of qualitative analysis. Thematic data analysis identifies, analyse and report patterns within data. The method can both detect or untangle the reality and the main advantage is the flexibility (Braun and Clarke 2006).

There is a number of decisions involved that need to be made. The theme captures something important about the data and represents some level of patterned response and meaning within the data set. There is two primary ways to identify themes or patterns in thematic analysis, an inductive (bottom up) way and theoretical or deductive (top down) way. Inductive approach means the themes are linked strongly to the data themselves. This approach is used if the data are collected for the research, such as interviews and focus groups. The top down deductive approach is more analyst-driven than the inductive approach. The deductive approach are more detailed analysis of some aspect of data (Braun and Clarke 2006). This study uses the inductive way through interviews and focus groups.

4.5.2 Descriptive data analysis

Descriptive analysis is used to describe data and make it easier to understand. Raw data is difficult to understand and see patterns or special characteristics. The goal is to reveal these patterns and describe trends, averages, and variations. The most commonly used is frequency, central tendency, and variation (Larson and Farber 2009). Frequency is often the first analysis to be done on a data set. This is a valuable method in discrete data to

describe nominal or ordinal data (Thompson 2009). Central tendency describes the typical or central entry of data set, and the most commonly used measures are mean, median and mode. Mean describe the average of the number of entries, thus the median is the value that lies in the middle of the data. The mode is the value that occurs with the greatest frequency. Variation in a data set describes the range, variance and the standard deviation (Larson and Farber 2009).

Descriptive statistics are used for the analysis of pre-interviews, post-interviews and socio-demographics and the analysis tool used is Excel and Statistical Package for the Social Science (SPSS). This study will use frequency, mean and standard deviation to describe the descriptive data.

4.5.3 Factor Analysis

The paper from Thompson (2007) explains Factor Analysis as *"a statistical method for empirically identifying the structure underlying measured or factored entities."* Before the modern computers and statistical software, was Factor Analysis difficult to use due to the complex of the required mathematics (Thompson 2007). There is two major Factor Analysis, these are exploratory Factor Analysis (EFA) and confirmatory Factor Analysis (CFA). In a guide to Factor Analysis from Yong and Pearce (2013), the difference between the two major Factor Analysis is explained by Child (2006) as follows:

> *"CFA attempts to confirm hypothesis and uses path analysis diagrams to represent variables and factors, whereas EFA tries to uncover complex patterns by exploring the dataset and testing predictions."*

This thesis will use an EFA, the idea is to simplify the raw data and predict possible correlation among the variables of which is affecting the behaviour of people to recycle. Section 4.5.4 present how Factor Analysis is conducted, using the statistical program SPSS.

By exploring the dataset and testing predictions it is possible to define the underlying structure of the variables in the analysis. Based on the relationship represented from the correlation matrix, the Factor Analysis classifies the grouping among variables. The tool

can be used to understand the structure of the data, and it is possible to simplify analysis of a large set of variables by replacing them with composite variables. A properly done Factor Analysis can find interesting relationships that could have been difficult to predict from inspection of the raw data or in the correlation matrix (Hair 2010).

4.5.4 Factor Analysis with SPSS

The following sections explain how SPSS is used as a statistical program for Factor Analysis and how to run an EFA on SPSS. EFA consist of five different decisions. The first decide which matrix of association statistics to analyse and can be Pearson r matrix or covariance matrix. The second step is to decide how many factors to extract, with use of Kaiser-Guttman suggestion to retain all factors with eigenvalue greater than one. Further, in the third step must the factor pattern coefficients be computed by use of a statistical method. Common factor extraction methods are principal matrix and principal axis. The fourth step is to decide whether using an orthogonal- or oblique factor rotation. Orthogonal factor rotation are uncorrelated initial factors, rotated such they continue to remain perfectly uncorrelated. While the oblique factor rotation, uncorrelated initial factor is rotated to become correlated. The most commonly used in orthogonal factor rotation is VARIMAX and for oblique factor rotation is OBLIMIN (Thompson 2007).

Step 1: Descriptives

In the *Descriptives* dialog box, all options in both statistics and correlation matrix is selected as illustrated in figure 7 below (Yong and Pearce 2013).

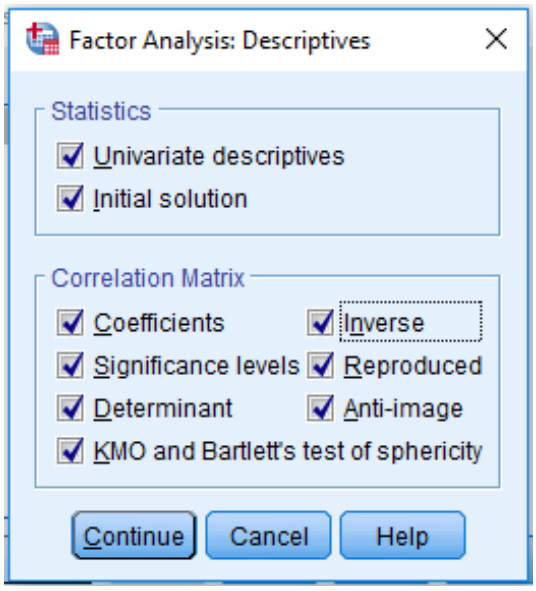

Figure 7. Factor Analysis: Descriptives

Step 2: Extraction

Figure 8 illustrates the possible selection for extraction. First, *principal component*s are selected as the method. *Correlation matrix* is chosen when variables are default, and when variables are commensurable. There is also an opportunity to choose the *eigenvalue cut off* and the eigenvalue is set to greater than one. Selecting *unrotated factor solution* and *scree plot*, displays the interpretation. The *unrotated factor solution* provides the *unrouted pattern matrix*, which is used to compare the factors before and after rotation (Yong and Pearce 2013).

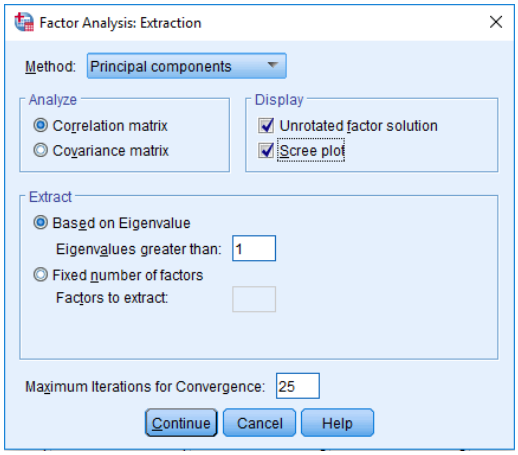

Figure 8. Factor Analysis: Extraction

Step 3: Rotation

The most common method chosen for rotation technique is VARIMAX, especially when you start exploring a dataset. Selecting *rotated solution* provide the output for the rotated factor interpretation where the interpretation varies due to the method chosen. Selecting *loading plot(s)* provides the factor loading plot. Maximum iteration for convergence decides how many times SPSS should run the analysis, the default value of 25 should be enough to produce a sufficient analyse (Yong and Pearce 2013). Figure 9 illustrates the selections for rotation.

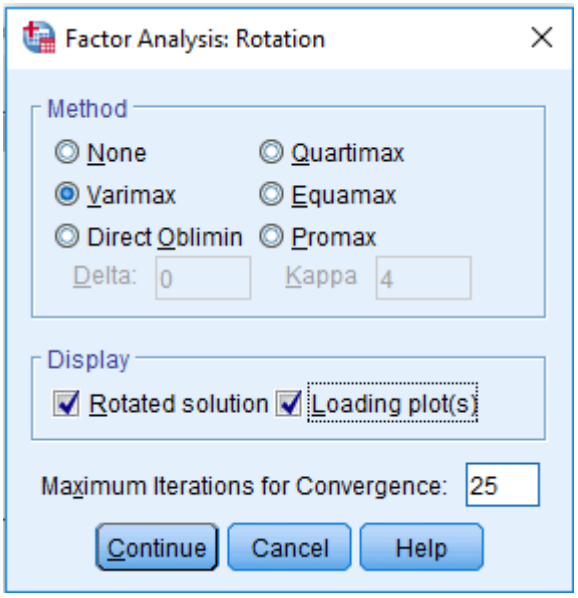

Figure 9. Factor Analysis: Rotation

Step 4: Factor score

Anderson-Rubin method is used to create a new column in the dataset called factor score. Selecting *display factor score coefficient matrix* provides the correlation between the factor and the coefficients that are used to produce the factor score through multiplication (Yong and Pearce 2013). Factor scores are illustrated in figure 10.

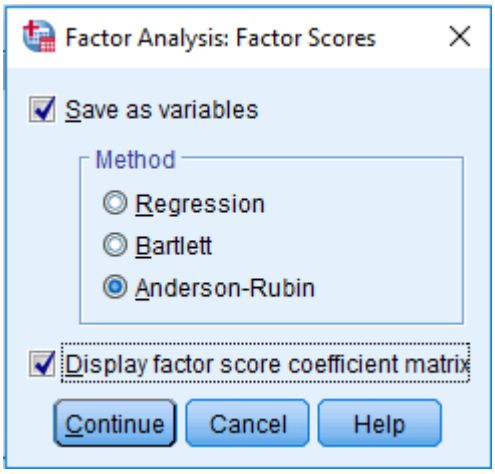

Figure 10. Factor Analysis: Factor Scores

Step 5: Options

To prevent overestimation of the big dataset, *exclude cases listwise* is selected. Illustrated in figure 11, selecting *sorted by size* and *suppress small coefficients*, the coefficients display format box is the loading ordered by size and suppress the small coefficients by setting an *absolute value below*. (Yong and Pearce 2013).

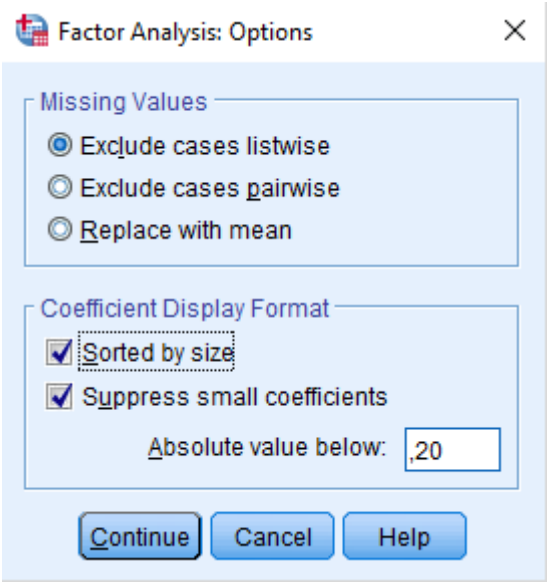

Figure 11. Factor Analysis: Options

Interpretation of the SPSS output

The correlation matrix developed from the analysis can be used to check for patterned relationships, variables with a large number of low correlation coefficient ($r < +/- 0.3$) is removed. Multicollinearity can occur in a situation where the correlation is above ($r = +/- 0.9$). If multicollinearity exist, the data could be unreliable. This multicollinearity needs to be identified and removed from the analysis. *Kaiser-Meyer-Olkin Measure of Sampling Adequacy* is used to test the data for the suitability. Closer the value is to 1.0, the chance is higher that the Factor Analysis fits the data. With an exploratory Factor Analysis, it is usual to set a cut-off of above 0.5 (Hair 2010). A *Bartlett's Test of Sphericity* is used to confirm a patterned relationship, with a significance level lower than 0.05, patterned relationship is confirmed (Yong and Pearce 2013).

The *total variance* table is used to find the number of significant factors. Extracted and rotated values is meaningful for interpretation. In the table, factors are arranged in descending order, with the most explained variance first. The *Initial eigenvalues* and *extraction sums of squared loadings* have the same value, but in the *extraction sums of squared loadings* is only the factors with an eigenvalue higher than 1.0 presented. These two columns present the rotation and the variance prior to rotation. After rotation, eigenvalues and variance is presented in column *rotation sums of squared loadings*. By looking at the *Scree Plot* output from SPSS, significant factors is displayed (Yong and Pearce 2013).

Further, *Kaiser´s criterion* is a measurement to see if the model is a good fit for the analysis. By looking at the summary from the *reproduced correlation matrix*, the percentage of the non-redundant residuals is displayed. Are there less than 50% non-redundant residuals with an absolute value which is lower than 0.05, the model represents a good fit. The SPSS output for *factor matrix* and *rotated factor matrix* presents the VARIMAX rotation, before and after, to illustrate how the rotation aids interpretation. It is also possible to choose a different significant loading cut-off on pragmatic reasoning. By rerun the analysis without the non-significant items or by choosing a lower cut-off. This may resolve the issue (Yong and Pearce 2013).

Factor transformation matrix's presents the rotation technique and is used to check if the rotation technique is sufficient. If the result shows a rotation technique in a nearly

symmetrical off-diagonal element, the technique is suitable. If the orthogonal rotation is not suitable, an oblique rotation is run to see if the technique is suitable. The last step is to labelled the factors found from the Factor Analysis (Yong and Pearce 2013).

5.0 Questionnaire description

This part describes how the questionnaire is developed. The first section describes consumers current behaviour and personalised choice situation. Section two identifies alternatives, attributes, and attributes levels by research from literature review, in-depth interviews and focus group interview. This is used to develop the Stated Preference choice tasks. After the alternatives, attributes and attribute levels is identified, the random utility model for this study is specified. The fourth section describes the post-choice, consisting of two parts. The first part consists of scenarios that is different from the current system, while the second part is socio-demographic questions. The last section contains of bias found during the pilot phase, and the improvements done for the main Stated Preference questionnaire.

5.1 Description of pre-choice tasks

The pre-choice tasks consist of two parts, the first part investigates consumers current behaviour and personalised choice situations. The second part consists of scale questions about respondents recycling behaviour. The pre-choice task is also helpful to discover how much food-waste each household produce during a week. Due to the pre-choice tasks, respondent's actual behaviour is revealed, and is useful later to sub-group comparisons done in descriptive statistics. Respondents answering the 140 litres questionnaire, may have a different utility than respondents answering the 80 litres questionnaire. Before answering the questionnaire, respondents had to read an information document and accept at first question to continue.

5.2 Choice tasks

Choice tasks identified the alternatives, attributes and attribute levels. This is the foundation for the Stated Preference part in the questionnaire. Qualitative method is conducted to reveal the most important elements for respondents, regarding food-waste recycling.

5.2.1 Alternatives identification

Respondents are faced with different alternatives when answering a SP questionnaire. These alternatives can be labelled or unlabelled. The advantage and disadvantages choosing between a labelled or unlabelled experiment are presented in section (4.3.1). As mentioned in the same section, this experiment uses an unlabelled experiment, where respondents will choose between two alternatives. In an unlabelled experiment, respondents choose between attributes and attribute levels, rather than the presented alternatives. The attributes and attribute levels are identified during the next section, using in-depth -, focus groups interviews and a literature review. Searching for different alternatives will help to find the utility maximization and the willingness-to-pay (WTP). Experiment with different alternatives is useful to understand consumers utility towards a consumer-oriented system.

5.2.2 Attributes identification

For an unlabelled experiment, respondents choose between attributes. It is necessary that attributes are realistic for respondents, so they can choose the most preferred option. Identifying attributes is done through literature review, in-depth -and focus group interview. From the literature review 13 attributes are revealed and based on our in-depth interview and focus group has it been eliminated down to six attributes. After discussion, two remaining attributes are used in the final questionnaire and express consumers utility function.

Attributes identified from literature review

From the literature review, different attributes are identified related to the thesis. Some of those attributes will be used in the SP to develop the utility functions for different alternatives. Further in this section, relevant findings of the attributes are listed in table 3.

Household recycling is today the most important factor for recycling, and the two most common methods are kerbside collection and drop-off sites (Halvorsen 2012). The literature review below, defines factors positive or negative for consumers related to recycling, and describe different recycling systems applied in foreign countries.

Consumer tend to consider the environmental impact as an element to waste recycling. Halvorsen (2012) state that the motivation behind recycling, is the wish to contribute to a better environment because this is viewed as a civic duty for today's generation. The result shows that focus on recycling is beneficial for the environment. Consumers attitude towards the environment is a element for how they act towards recycling. For those who see the importance considering the next generation is more aware of recycling. Czajkowski, Kądziela, and Hanley (2014) mention that people with strong connections to their neighbours, often increase recycling due to the opinion neighbours will have about you. The result from a survey done by Karousakis and Birol (2008) about respondents in London, showed that the frequency of collection was important. They thought that collecting more than once a week is unnecessary, and can cause a problem for the environment, due to transportation emission from trucks. But collection to rarely, makes the respondents consider using a third-party company to do their recycling.

An interesting finding from a case study done in USA, show that by turning up the cost for garbage collection through a higher variable collection fee. The volume of waste produced from households decrease and generate a positive result towards recycling (Huang, Halstead, and Saunders 2011). Households with higher income is using more time cost per hour of recycling than households with lower income, this is due to the earning opportunity on the extra time spent on recycling (Huhtala 2010). It is also predicted that households with higher income lead to higher motivation towards pro-environmental behaviour (Videras et al. 2012).

Miliute-Plepiene et al. (2016) found in their conclusion that more information and communication provided to customers, will help to enhance the quality of recycling. This can be regular information about recycling, so customers know how to sort their household waste and better labelling of garbage bins.

An article about norms and economic motivation regarding household recycling from Hage, Söderholm, and Berglund (2009), presents some suggestions from Schwartz about norms that influence behaviour. The two important norms is problem awareness and ascription of responsibility (Schwartz 1973, 1977). Due to recycling, it is important that individuals believe that waste recycled from their household, has a positive impact on the environment, knowing that they are responsible encourage them to make a better recycling

effort (Hage, Söderholm, and Berglund 2009). Consumers with the perception that other households take responsibility for recycling, are also more responsible (Nyborg, Howarth, and Brekke 2006).

It is mentioned from Hage, Söderholm, and Berglund (2009) that there are two external motivators, those are financial and convenience-related. With financial incentives, the households should be more aware of their recycling, due to increased costs. The convenience-related factor is about the ease of use transaction and the transparency of collection schemes. Wagner (2013) mentioned categories of convenience as; (1) knowledge requirement (2) proximity to collection sites (3) opportunity to drop off materials (4) the attractiveness of collection points (5) the ease of the process.

Some municipalities in Sweden have changed from using fixed prices for waste collection to volume-based or weight-based solution (Hage, Söderholm, and Berglund 2009). An economy study from Hage and Söderholm (2008), states that volume-based waste pricing schemes can be ineffective when you want to enhance the recycling levels, the weight-based has also been mentioned to be ineffective (Ackerman 2013).

Pay-as-you-throw (PAYT) is a system used in waste management, where the consumer is charged for waste they deliver to collection. The approach has provided to enhance the recycling but requires well developed waste collection systems, responsible citizens and applied circular economy policies. Case study performed in Germany concludes that PAYT and weight-based billing system can have an effective impact on the material reuse and recycling (Morlok et al. 2017). By an investigation of municipalities in Sweden didn't the weight-based billing system predict evidence that enhanced the recycling rates. But it provided that waste collected from households decreased with 20 percent. The investigation found strengths and weaknesses by using weight-based recycling systems. As mentioned did the system reduce the amount of waste. The consumers do also find the system to be fair, since they are charged for the waste produced by themselves. But they were also afraid that unknown would use their bins to avoid charges. When the weighting system did not work, it made problems due to the charges. Something that lead to complaints about incorrect charging prices (Dahlén and Lagerkvist 2010).

Table 3 summarize the attributes identified through the literature research. 13 attributes considered to express the alternatives utility functions in the questionnaire design.

Environment	Recycling behaviour
Frequency collection	Economic motivation
Waste collection fees	Income
Education	Information
Age	Time
Price	Social influence
Price incentives	

Table 3. Attributes from the literature review

Attributes identified through in-depth -and focus group interviews

To get a deeper understanding of the subject, two in-depth interviews and one focus group interview is conducted. The in-depth interviews took place at a local shopping mall in Molde, and the interviews lasted for about 15 minutes. The focus group took place at Molde University College with four participants and lasted for approximately one hour. The interviews and interview guide were completed in Norwegian, and validating can be misleading due to translation from Norwegian to English. The interview guide is attached in appendix I.

First in-depth interview

Interviewee one is a middle-aged man, living in a private house in Molde city. He identifies himself as a recycling nerd and competes with other household members about who is the best recycler. The motivation behind his recycling is driven by compressing garbage, so it takes less space in the bin. His bio-waste bin is never full when collected. He is not motivated by environmental aspects and does not believe their household can help the environment if recycling. He does not have any concern about the current recycling system but is open for other systems and procedures. He thinks the current system is easy, with combining municipalities taxes. If the system is changed, it needs to be as easy or easier than now. He mentioned that the only thing that motivates for a system change, is economy incentives. He does not think so much about recycling at work, that's because the system is complicated and lack of information. He thinks that recycling is a social norm and people are motivated to be good citizens in their city.

Second in-depth interview

Interviewee two is a guy in his thirties and lives at a cooperative in Molde. The current system works well for him, the payment for the recycling is in the pricing system of the public expenses for the residents in the cooperative. The motivation for recycling is that he finds recycling important to be a good citizen. About the environmental impact, he is not quite sure that recycling contributes to a better environment. He thought that introducing the system where each of the residents needs to carry the cost of their own resident waste is interesting. The reason for this is due to the possibility of saving money, and he also means that it could help toward better recycling awareness. At work there is a stricter policy for recycling, the different type of waste is separated into more categories. But he admits that due to tasks at work, he doesn't find enough time to recycle as much as he does at home.

Focus group interview

The focus group interview consists of four participants who use RIR as their renovation company. The participants are three men and one woman, with age varying from 25 to 63. Two of them lives in private houses and two of them lives in cooperatives. The interview is done to get their opinion about how they think the current waste collection system works with bio-waste most in mind and their meaning about important and less important factors.

The respondents are aware of RIR and are familiar with their operations and frequency of collection among the different waste types. How full the bio-waste is for the respondents differs, but most often the bio-waste bin is only half-full. One of the respondents also wondered about the possibility of more frequent collection in the summer, since the garbage often begins to odour more during the warmer months. The other participant supported this idea and wanted a more frequent collection in the summer months. Some of the respondents mentioned that RIR is offering bins with higher volume if there is a need for it. But due to the price increase mentioned, respondents found the price increase to expensive. They thought that the possibility of drop-off sites in addition to kerbside collection during summer, could be a solution to avoid the odour. Participant preferred the kerbside collection, because this is less time-consuming.

The importance of recycling that has grown lately has led to higher expectations from the households to separate and recycle for every type of waste. Due to that would the participants like the information where more public, they don't feel that the information gets out to everyone. What they want to state is that the more information about where to throw each fraction would give a higher level of separation and recycling.

The motivation for recycling, is that they think it is a civic duty and easier to keep a cleaner home. Recycling also gives a good feeling, due to the importance of reuse materials. The participants could not tell how much they pay and how often, because the cost is added to the municipal's taxes. The solution of paying only when your bio-waste is full is something that could motivate for even more recycling, because of the possibility to decrease their taxes. They were positive to the use of economics fines and thought that this could give a higher pressure to recycle more.

After the completion of in-depth interviews and focus group is these six attributes chosen:

1. Environment (Co2): Pollution
2. Collection frequency (days): How often is the waste collected at households
3. Waste collection fees (%): To low recycling would give fines
4. Price (NOK): Payment yearly or each time your bins is collected
5. Information (%): How is information regarding separation/recycling
6. Social influence (%): How much do you care about the people, neighbours etc. around you

Attributes chose based on the research

From the literature review, in-depth -and focus group interview, two attributes have frequently highlighted as two important factors towards recycling of food-waste. These are price and collection frequency, and these are the two attributes used in the SP choice set. These attributes also match what RIR can change and offer to optimize their system. This gives realistic choices for respondents for the unlabelled experiment. Many of the attributes identified above, are used in the pre-choice questions instead. Table 4 summarize the process for identifying the attributes.

Attributes identified from literature review	Attributes from in-depth interview and focus group	Final attributes used for stated preference
Environment	Environment	Frequency collection
Frequency collection	Frequency collection	Price
Waste collection fees	Waste collection fees	
Education	Price	
Age	Information	
Price	Social influence	
Price incentives		
Recycling behaviour		
Economic motivation		
Income		
Information		
Time		
Social influence		

Table 4. Attributes process

5.2.3 Attributes level identification

The attributes levels can differ between being generic where the levels are the same for the alternatives, or alternative specific where some attributes and/or levels differs across the alternatives (Lancsar and Louviere 2008). This thesis will have alternative specific attributes levels.

The alternative given by RIR where the households can choose the size of food-waste bin, is affecting both attributes price and frequency. The thesis will focus on 80 litres and 140 litres garbage bins offered from RIR. How often these bins are full will then also be affected by the frequency of how often the bins is collected by RIR.

Price:

The price given from RIR depends on the size and frequency. Consumers have the possibility to choose between 80 litres or 140 litres and collection frequency every seven or fourteen day. RIR decides the prices for bio-waste collection, and the prices are approved by the municipality board of Molde. The price for 80 litres garbage bins is NOK 1726 every seven day and NOK 798 every fourteen days, and the prices for 140 litres garbage bins is NOK 2978 every seven day and NOK 1391 every fourteen day. Further hypothetical choices are added, which will give the respondents the opportunity to choose estimated prices for each time they throw. The estimated price for 80 litres is NOK 32 and 140 litres NOK 56 (RIR 2019c).

To make it simpler for the respondents, the prices is estimated for 80 litres to NOK 1700 for collection every seven day, NOK 800 every fourteen day and NOK 32 PAYT. For 140 litres the price is NOK 3000 yearly for collection every seven day, NOK 1400 collection every fourteen day and NOK 56 PAYT. These will be the attributes levels in the choice tasks.

Frequency:

Frequency represents the time between bio-waste bins are collected. RIR is offering a collection frequency of every seven day or every fourteen day (RIR 2019c). By offering different frequency to the households, consumers have the possibility to decide how often they want RIR to collect their bio-waste. How full the bio-waste bin is varying among the households, reasons for this can be related on how many people sharing the bin.

More people sharing the bin, often increase household waste production and the volume of bio-waste bins can often be higher. The variance of frequency would be necessary for the households to have the possibility to choose which collection frequency they want due to volume of food-waste produced. The attribute levels for frequency for the choice sets is every seven day and every fourteen day.

Because the experiment is unlabelled, respondents will be faced with alternative specific choice sets, attributes and attribute levels differ across the alternatives. Table 5 summarize the attributes and attributes levels for 80 litres and 140 litres bio-waste garbage bins.

Size	Attributes	Attributes level
80 litre	Price	NOK 1700 yearly, NOK 800 yeraly, NOK 32 PAYT
	Frequency	Every 7 days, every 14 days
140 litre	Price	NOK 3000 yeraly, NOK 1400 yearly, NOK 56 PAYT
	Frequency	Every 7 days, every 14 days

Table 5. Overview of alternatives with attributes and attributes level

5.2.4 Model specification

After the attributes and attribute levels is identified, the model can be specified. The model assume that respondents will try to maximise their utility. The latent utility model for individuals consist of two parts; the explainable deterministic component and an unexplainable random component. According to the utility function in equation 2.1, the utility function used in this choice experiment is:

$$U_{80} = V_{80} + \varepsilon_{80} \quad (5.1)$$

$$U_{140} = V_{140} + \varepsilon_{140} \quad (5.2)$$

The explainable deterministic components can be describes as followed with their attributes and weighting parameters:

$$V_{80} = \beta_1 PR_{80} + \beta_2 FR_{80} \quad (5.3)$$

$$V_{140} = \beta_1 PR_{140} + \beta_2 FR_{140} \quad (5.4)$$

5.3 Description of post-choice tasks

The post-choice task contains of two parts. The first part consists of a scenario that is different from the current system. This is hypothetical scenarios with follow-up questions. This can be used to determine trends and acceptance for a different system. The scenario is described and then two questions are related to the scenario. The second part of the post-choice task is socio-demographic questions. These explain demographic attributes for respondents. This background information is asked to find the overall goodness of sample coverage and is used to describe the difference between subgroups, for instance age, gender, income, and resident. There is different characteristics of generations, and the age is divided in generations. These are generation traditionalists (before 1945), baby boomers (1945-1964), generation X (1965-1980), generation Y (1980-1996) and generation Z (1997-) (Eisner 2005). To simplified this, the age is divided into traditionalists (Above 72 years), baby boomers (54-72 years), generation X (39-53 years), generation Y (23-38

years) and generation Z (under 22 years). The Stated Preference questionnaire is attached to the appendix III.

5.4 Pilot Stated Preference questionnaire

The completed Stated Preferences were piloted to find the possible biases that occurred during the process. Out of a sample of 189, 31 questionnaires were piloted. The first five pilots found some bias, that made some changes in the questionnaire. One pre-interview question was added, because one of the respondents missed an alternative towards recycling. The respondents didn't recycle food-waste at all, and therefore it was necessary to add a simple factual question "do you recycle? Another change was made on the socio-demographic question about how many you share bio-waste bin with, it got changed from "how many lives on average in the house" to "how many do you share garbage bin with". This change minimized biased answer from the respondents. Better description of the SP was added to explain the amount of the prices, so the respondents understood which of the sums represented a yearly payment or PAYT. Some bias due to the language was also found, and changes where done to avoid misunderstandings from the respondent on the questions.

Excel scheme is used to make the SP questionnaire, and it was natural that is was done on computers. It turned out that it was time consuming to collect the answers with computers. Paper questionnaire was tried instead, and it turned out that this was the most effective way of collecting questionnaires. The questionnaire on paper must later be transformed into the excel scheme, and some possible bias can due to this can occur. Further collection is done with both papers and computers. Some problems occurred when both interviewers uploaded the excel-file. It happened that the excel-file was uploaded with the same block and ID. To avoid this one starts to collect from 100, while the other is continuing from 31.

This section is describing the SP questionnaire, and have explained the pre-choice tasks, post-choice tasks, and socio-demographic tasks. Attributes and attributes levels is also developed for the SP. The data provided from the SP questionnaire will be displayed in the next part.

6.0 Results

This part will describe the results obtained from the questionnaire. The first section describes the data from the pre-interview, post-interview and socio-demographic questions. The next section outlines the results from the Factor Analysis in SPSS. These are the last scale questions in the pre-interview. The third section contain the econometric results from the SP-questionnaire. The last section in this part, outline feedback from respondents during the questionnaire. This is elements the in-depth and focus-groups did not identify, and is useful for the managerial implications and further research. The data from this part is used in the policy and managerial implications outlined in part 7.

6.1 Data description

Data collected from focus groups and in-depth interviews are presented in earlier sections. This section focuses on the main results of the questionnaire survey.

During the pilot phase, different sampling methods were tried. Questionnaires through e-mail and social media without guidance, was difficult for respondent, so all questionnaires where done through face-to-face interviews. Also under the pilot face, the most efficient way to collect questionnaires was attempted. Using computers was difficult, because only two computers was available, so with more than two respondents answering the questionnaire at the same time, paper questionnaires was most efficient. For the main questionnaire, almost only paper questionnaires were used. 35 questionnaires are done through computer and 154 on paper. It was more time consuming to type in each questionnaire on the computer, but more efficient when undertaking the questionnaire.

The sample consist of 189 questionnaires and all these have completed the choice sets. From the sample of 189, 126 (66 percent) questionnaires are 80 litres and 63 (34 percent) questionnaires are 140 litres. Because all the 189 questionnaires are valid, 945 choice tasks can be used in the analysis.

Firstly, there is equal with male and females on average, but a little difference in 140 litres and 80 litres. For both of the garbage bins, the bachelor is the most frequent education level, followed by high school or master. The most common working situation is a full-

time job and over 90 percent are either students or have a full-time job. The residence is the question with the highest deviation. Private house is the most represented on average, but the percentage is lower with 140 Litres. The mean age and standard deviation are slightly higher within 80 litres. The age range is from 19 to 84 years. This information is summarized in table 6, and gives the main characteristics in percent for the two garbage bins and on average. Age is reported as mean and standard deviation of the sample.

Individual characterstics	Garbage bin size		
	140L	80L	On average
Gender			
Male	54,0 %	48,0 %	50,0 %
Female	46,0 %	52,0 %	50,0 %
Education			
No education	0,0 %	1,6 %	1,1 %
Secondary school	0,0 %	2,4 %	1,6 %
High school	20,6 %	12,7 %	15,3 %
Certificate of apprenticeship	7,9 %	11,1 %	10,1 %
Bachelor	50,8 %	56,3 %	54,5 %
Master	20,6 %	15,1 %	16,9 %
PHD	0,0 %	0,8 %	0,5 %
Working situation			
Full time job	61,9 %	73,6 %	69,7 %
Part time job	9,5 %	4,0 %	5,9 %
Student	25,4 %	17,6 %	20,2 %
Retired	3,2 %	4,0 %	3,7 %
Disabled	0,0 %	0,8 %	0,5 %
Residence			
Private house	52,4 %	65,1 %	60,8 %
Appartment	14,3 %	7,9 %	10,1 %
Dorm	17,5 %	16,7 %	16,9 %
Other	15,9 %	10,3 %	12,2 %
Age			
Mean	40,07	44,18	42,82
Std-dev	14,68	15,56	15,36

Table 6. Percentage from the socio-demographic answers

The largest age group is generation Y, with 38 percent and the proportions are presented in figure 12.

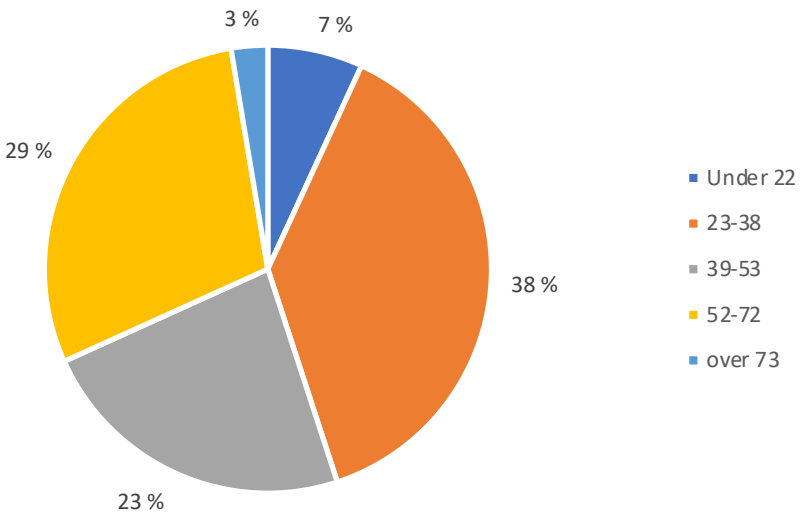

Figure 12. Proportion of age

The income level covers almost every income levels in Norway, and 25 000 NOK - 40 000 NOK is the most frequent and are also the most common income levels in Norway. Figure 13 shows the proportion of income levels.

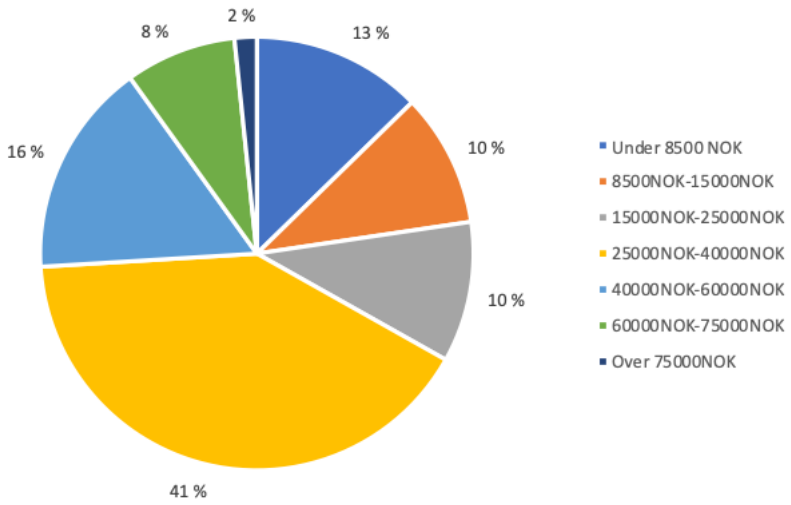

Figure 13. Proportion of income level

106 of the respondents says they pay the municipality taxes, and interestingly only 21 percent know how much they pay for their waste. Respondents with higher income are also more aware of what they pay for the municipality taxes. 85 percent answer they recycle and 84 percent of the respondents share garbage bins with six or less people (see figure 14). From table 7, the mean of how many bags households throws each week is reported.

The table shows that respondents with full bio-waste bins throws five bags of garbage every week, and half full throws three bags each week. Interestingly 95 percent of respondents above the mean of 42 years old answer they recycle, compared to 75 percent of the respondents under the mean age.

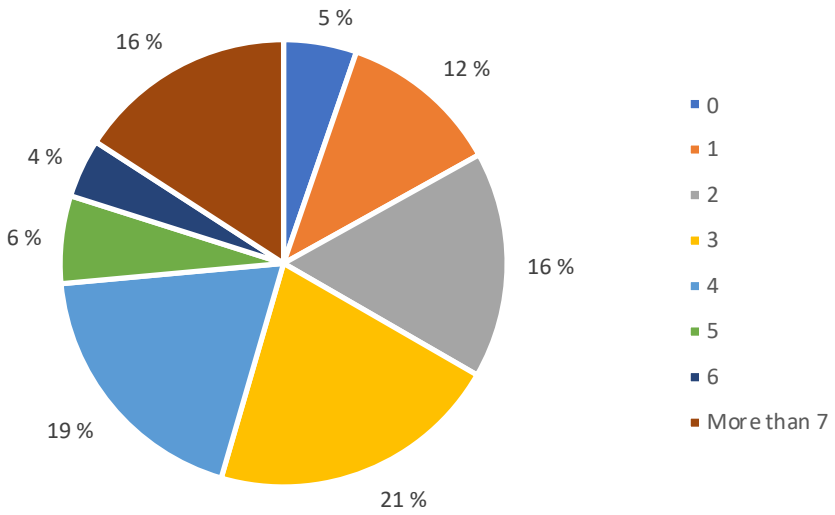

Figure 14. Proportion of household's garbage bin sharing

Garbage bin	140 litres	80 litres	140 and 80
Full	4,528	5,588	5,043
Half full	3,053	3,007	3,017
Under half	2,4	1,964	2,079

Table 7. Mean of bags disposed each week

Of the sample of 189, 70 percent responds they are familiar with the current system operated by RIR and respondents are generally satisfied with the system. Only 34 percent want to decide themselves when the garbage bins are collected, but interestingly 55 percent of the respondents under the mean age find this more preferable.

187 of 189 respondents have a smartphone and describe their talent by using it to relatively high with a mean of 4 on a scale from 1 to 5. 70 percent find it interesting to see how good they are at waste sorting on their smartphone and there is no big difference in the age span.

Post-interviews had a scenario where you could decide yourself when the garbage bin was collected. Of 189 respondents, 65 percent answered they would be more aware of their recycling if this was the case and 70 percent answered it would be easier.

To summarize, the most important findings from the descriptive statistics towards consumer-oriented system is the mean of bags thrown each week for the full, half full and under half full. The other interestingly finding is that respondents find it easier to do their recycling, if they could decide when the garbage is collected.

6.2 Factor Analysis

The questions about behaviour and attitude towards recycling are used to run an exploratory Factor Analysis (EFA), the Factor Analysis is based on six questions with 189 respondents. The program used to run this Factor Analysis is IBM SPSS Statistics 25.

The first Factor Analysis was run with all seven variables and ended up with only one of the seven variables with cross-loadings. Further a VARIMAX rotation was made, this did not remove cross-loading of variable d16 (time to recycle) for component one and two is presented in table 8. Direct Oblimin rotation was tried but did not remove the cross-loading either. Since the variable persist in having cross-loading, it is decided to delete variable d16. The Factor Analysis is running with six variables and with VARIMAX rotation.

Component Matrix[a]

	Component 1	Component 2
d10_Improve_Environment	,785	
d12_Like_Recycling	,701	
d11_Responsible	,649	
d16_Time	,646	-,237
d15_Information	,542	
d14_Authorities		,872
d13_Neighbours		,843

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Rotated Component Matrix[a]

	Component 1	Component 2
d10_Improve_Environment	,787	
d12_Like_Recycling	,698	
d16_Time	,652	-,220
d11_Responsible	,649	
d15_Information	,539	
d14_Authorities		,872
d13_Neighbours		,844

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Table 8. VARIMAX rotation with seven variables

The *correlation matrix* reveals that there is enough evidence for correlation above 0.3, which means that the Factor Analysis is appropriate to run. The Kaiser-Meyer-Olkin value is 0.584 which is over the recommended value of 0.5 for being a good Factor Analysis. But it should be in mind that the value is close to 0.5. The Bartlett's test of sphericity should be significant ($p < 0.05$), the P-value is reported to be 0.00 which indicates that the Factor Analysis is considered appropriate. The value of eigenvalue is set to 1.0, and table 9 provides two components with eigenvalue exceeding 1.0. These two components explain respectively 32,970 percent and 25,271 percent and in total 58,240 percent of the variance.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1,978	32,970	32,970	1,978	32,970	32,970	1,959	32,653	32,653
2	1,516	25,271	58,240	1,516	25,271	58,240	1,535	25,587	58,240
3	,883	14,724	72,964						
4	,708	11,793	84,758						
5	,503	8,390	93,148						
6	,411	6,852	100,000						

Extraction Method: Principal Component Analysis.

Table 9. Total variance explained

Further search figure 15 that is provided by the Factor Analysis. The scree plot shows there is a clear break between component one and two, and a clear break between component two and three. Component one and two is both strong factors with eigenvalue

of 1,978 and 1,516, the components with eigenvalue below 1,0 is seeming to be weak factors. From the scree plot, the drop off from component two and further to component six with eigenvalue below 1,0. These components are not considered to represent real traits underlying the six question. The observations made support to choose a two-factor solution since this would be most appropriate in this case.

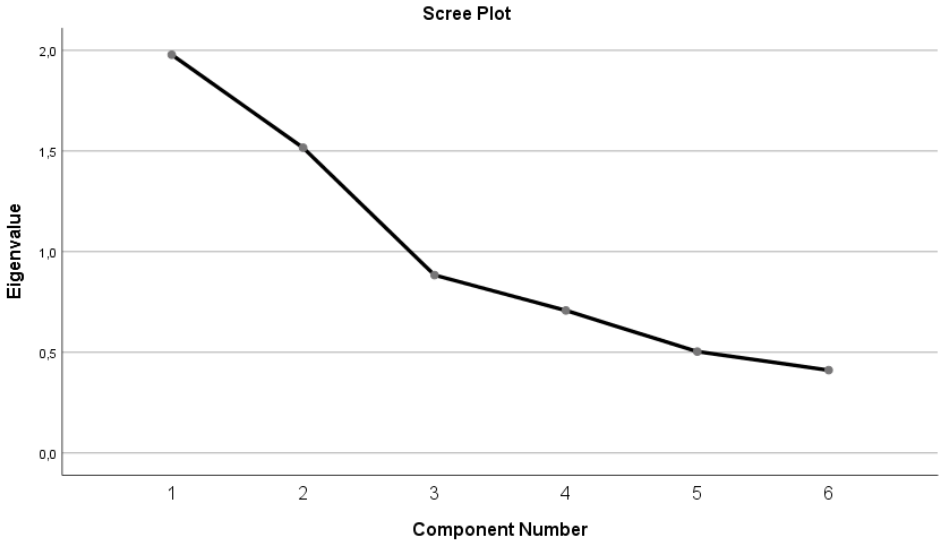

Figure 15. Scree Plot

To explain the interpretation of these two components, the rotation method of VARIMAX is chosen in this Factor Analysis. The VARIMAX rotation and the factor loadings to the two components is provided in table 10. The variables for component one is d10, d12, d,11 and d15. While the variables for component two is d14 and d13.

Component Matrix[a]

	Component	
	1	2
d10_Improve_Environment	,771	-,285
d12_Like_Recycling	,744	
d11_Responsible	,682	
d15_Information	,526	
d14_Authorities		,842
d13_Neighbours	,222	,831

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
d10_Improve_Environment	,813	
d12_Like_Recycling	,741	
d11_Responsible	,701	
d15_Information	,505	
d14_Authorities		,865
d13_Neighbours		,859

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Table 10. VARIMAX rotation with six variables

These components will be labelled due to the questions that are related to each other. Component one is labelled as “attitude to recycling”. Related questions to component one are:

- d10: Your willingness to improve the environment
- d12: How much you like recycling
- d11: Your consideration of yourselves as a responsible person
- d15: Information given to recycling

Component two is labelled as “recycling impacts” and the questions related to component two are:

- d14: Do you recycle because of the authorities?
- d13: Do you recycle because of the neighbours?

From the Factor Analysis results, there is two labelled factors detected. These are attitude against recycling and recycling impacts. For the attitude to recycling factors, contribution to improve the environment is the most powerful factor. Both the authorities and neighbours have a strong recycling impacts for respondents in the sample. Interestingly, information does not have so much impact on respondents’ attitude towards recycling. This means that the consumer-oriented system needs to take these elements in consideration.

6.3 Econometric results

This section will outline the econometric results from the SP data sample. This section will describe the result from 80 litres and 140 litres garbage bins using NLOGIT software. In addition, two different analysis are done for the 80 litres and 140 litres. This is due to many of the dominant answers are answered incorrectly. Analysis 1 have excluded only the incorrectly answered price questions, and the reason for the exclusion is described in section 6.3.2. Analysis 2 have excluded choice sets where respondents have answered incorrectly at two or more questions. The exclusion in analysis 2 is based on microeconomic theory, the fact that all respondents should always and ever choose the cheapest alternative. The section starts by describing results from analysis one, and determine the model fit. Further factors for the model fit are discussed, before the deterministic parameter estimation is outlined. Then the willingness to pay (WTP) is calculated. After these sections, the same procedure is done with analysis 2.

```
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -405.28514
Estimation based on N =    630, K =   2
Inf.Cr.AIC  =    814.6 AIC/N =    1.293
---------------------------------------
           Log likelihood R-sqrd R2Adj
ASCs  only  model must be fit separately
              Use NLOGIT ;...;RHS=ONE$
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=   630, skipped    0 obs
--------+------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
Alt     |  Coefficient       Error      z    |z|>Z*         Interval
--------+------------------------------------------------------------------
      PR|    -.00056***   .8216D-04    -6.76  .0000     -.00072   -.00039
      FR|     .05885***      .01556     3.78  .0002      .02835    .08935
-------------------------------------------------------------------------------
***, **, * ==> significance at 1%, 5%, 10%
-------------------------------------------------------------------------------
```

Table 11. NLOGIT output 80 litres analysis 1

```
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -204.20234
Estimation based on N =    315, K =   2
Inf.Cr.AIC  =    412.4 AIC/N =    1.309
---------------------------------------
           Log likelihood R-sqrd R2Adj
ASCs  only  model must be fit separately
              Use NLOGIT ;...;RHS=ONE$
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of obs.=   315, skipped    0 obs
--------+------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
Alt     |  Coefficient       Error      z    |z|>Z*         Interval
--------+------------------------------------------------------------------
      PR|    -.00034***   .6593D-04    -5.09  .0000     -.00046   -.00021
      FR|     .00489         .02158      .23  .8207     -.03741    .04720
-------------------------------------------------------------------------------
***, **, * ==> significance at 1%, 5%, 10%
-------------------------------------------------------------------------------
```

Table 12. NLOGIT output 140 litres analysis 1

6.3.1 Determining model fit

The utility function is linear, but the probability output from MNL choice analysis is non-linear. Because of this, the R^2 in linear regression cannot exist when using the MNL model. The R^2 used in an MNL model is pseudo-R^2 and this will be used to determine the model fit. When calculating the pseudo-R^2 in NLOGIT, the log likelihood (LL) function with equal market share is used, instead of the LL function estimated with alternative specific constant (ASC) (Hensher, Rose, and Greene 2005). The equation is presented in 6.1.

$$pseudo - R^2 = 1 - \frac{LL_{estimated\ model}}{LL_{Base\ model}} \quad (6.1)$$

The R^2 for linear regression and pseudo-R^2 is not the exactly the same, but there exists an empirical relationship between the two R^2 calculations. The range goes from zero to one, and closer to one the pseudo-R^2, the better it fits the model. As an example, if the pseudo-R^2 is 0.3, this represents a pseudo-R^2 of approximately 0.6.

Before testing the model goodness-of fit, the maximum likelihood estimation (MLE) need to be calculated first. The MLE can solve more complex problems involving simultaneous estimation of a number of parameters. The advantage is the robustness and ability to deal with complex data. For more complicated likelihood functions, the values are so small and it is more convenient to use log likelihood function (LL) (Hensher, Rose, and Greene 2005). The LL function is expressed in equation 7.2

$$LL_M = \sum_{n=1}^{N} \sum_{s=1}^{S} \sum_{j=1}^{J} y_{njs} \ln(P_{njs}) \quad (7.2)$$

Where
J is alternatives

N is respondents

S represents choice situations

M = NS

The output in table 11 shows that the estimated log likelihood (LL) for 80 litres are -405.28514. According to table 12, the estimated LL for 140 litres are -204.20234. From the accordingly 960 observations, analysis one consists of 945 observations. Only three questionnaires are excluded ($\frac{15}{3} = 3$). The respondents have two alternatives to choose between, and the probability of selecting one of the alternatives is 1/2. With 630 observations (5 tasks and 126 questionnaires) for 80 litres, the value of LL base model is calculated from equation (6.2) at -436.6827. For 140 litres it is 315 observations (5 tasks and 63 questionnaires), and the value for the LL base model is calculated from equation (6.2) at -218.3417. From these calculations, the pseudo-R^2 is 0.072 for 80 litres and 0.065 for 140 litres garbage bins. This is a relatively low and represent a bad model fit. The factors for the bad model fit are discussed in the next section (6.3.2).

$$LL_{estimated\ model\ 80\ litres} = -405.28514$$

$$LL_{estimated\ model\ 140\ litres} = -202.20234$$

$$LL_{base\ model\ 80\ litres} = (126 \times 5 - 0) \times \ln\left(\frac{1}{2}\right) = -436.6827$$

$$LL_{base\ model\ 140\ litres} = (63 \times 5 - 0) \times \ln\left(\frac{1}{2}\right) = -218.3417$$

$$pseudo\ R^2 = 1 - \frac{LL_{estimated\ model\ 80\ litres}}{LL_{base\ model\ 80\ litres}} = 1 - \frac{-405.28514}{-436.6827} = 0.0719\ \approx 0.072$$

$$pseudo\ R^2 = 1 - \frac{LL_{estimated\ model\ 140\ litres}}{LL_{base\ model\ 140\ litres}} = 1 - \frac{-202.20234}{-218.3417} = 0.07392\ \approx 0.074$$

Bad model fit factors, analysis 1

There are several factors why people don't choose the dominant answer as the theory suggest. Theory suggest that every person always and every time choose based on price, and the obvious answer. In the questionnaire, respondents need to consider three different choices. This is price, frequency and PAYT. PAYT is still a price, but another way of paying. When choosing between a fixed price and PAYT, the price is almost the same ($\pm$ 70 NOK each year). The different way of paying may have strong implications on choice and this is why people are not asked to pay upfront, rather asked to pay monthly instalments (e.g. mobile phones). This was a price that respondents needed to calculate during the questionnaire and because the price difference is so small, respondents considered which payment method they preferred. Choosing between PAYT or a fixed price every year.

One advantage when the questionnaire was collected face-to-face, was that the interviewers had the possibility to speak to the respondents. This gave insight why respondents answered as they did. The factors respondents highlighted, was some felt it was enough that their garbage bins were collected every fourteen day. Because the garbage bin was under half when it was collected, and they did not need to collect it every seven day. Many of the respondents have bought to much capacity and does not fill their garbage bins when it was collected. Based on this, the respondents choose every fourteen day every time, and did not look at the price. Another factor was the environment impact many respondents considered when answering the choice sets. Based on environmental impact, respondents choose every fourteen day, regardless if they had to pay twice as much. This because they did not want the garbage truck to collect even oftener. A third factor was that respondents liked the fixed price, payed every year, instead of bills coming more frequent. Respondents said that "there is enough bills to pay every month, so we do not want any more bills coming more frequently". Others said that "we need to pay for the garbage collection as we want or not, so it is easier for us to pay it every year, instead of more frequently". Norwegian are traditional and sceptic, and do not like changes their daily activities (Bruvoll, Halvorsen, and Nyborg 2002).

Respondents and their preferences can be one cause to the bad model fit, the other is the experimental design. In the experimental design, there is three different prices the respondents need to consider. Two fixed prices and one PAYT price. Because the MNL

model analyse and consider PAYT as a dominant answer, respondents do not find this dominant, rather a way of choosing which payment method they would consider. As an example, consider these two alternatives:
Alternative 1: paying 3000 and collect it every 14 day
Alternative 2: pay 56 every time the garbage bin is collected and collect the garbage bin every 14 day
The dominant answer in this choice set is alternative 2, but respondents choose alternative 1, because they find it more preferable to pay a fixed price. This regardless as the price is twice as much. This is not a wrong answer for the respondents, but it makes biased answers and a low pseudo-R2.

These are the factors the interviewers observed during the questionnaire collection. But another factor regardless of these, are the fact that this is an unlabelled experiment and does not have the reality perspective. Respondents choose between alternatives and no branded alternative. This can misdirect respondents and they choose the first alternative they see, without considering the second alternative (Hensher, Rose, and Greene 2005). This gives biased answer for the analysis, and the pseudo-R2 will be very close to zero, something that gives a bad model fit. If this is the case and not the factors above, they are then excluded from the analysis to get a better model fit.

6.3.2 Estimates of deterministic parameters

Model estimations contains of variations and is used to explain the dependent variable within the sampled data. The attached coefficients explain the weight of each alternative in choices. According to table 11 and 12, PR is negative for both 80 and 140 litres and FR is positive, something that is not surprisingly.

The analyst tries to explain whether a variable contributes to explain the choice response and understand why individuals choose alternative A over alternative B. This is done by adding variables to a model. To determine significance for the estimated parameters, t- or F-tests are used to explain this in linear regression. For choice analysis of MNL models, these two tests can´t be used. instead the Wald-statistic is used to determine the significance for each parameter. The Wald-statistics is shown in equation (6.4). Assuming a 95 percent confidence level and the alpha at 0.05, the critical Wald-value is 1.96. If the

absolute value of the Wald-statistic is greater than the critical Wald-value, the null hypothesis that the parameter equals zero are rejected, and the explanatory variable is statistically significant. If this is the case, the explanatory variable is statistically significant (Hensher, Rose, and Greene 2005). From the output, only coefficient FR for 140 litres are not statistically significant and the null hypothesis cannot be rejected. One reason for this, can be the variation of households sharing garbage bin. The range is from 0 to 200, and bias the significance. The FR for 140 litres will be presented, but not commented due to the significance.

$$Wald = \frac{\beta_1}{standard\ error_i} \tag{6.4}$$

The deterministic parts of the utility function can now be written according to table 11 and 12. The first utility function relates to 80 litres bio-waste garbage bin and the second for 140 litres bio-waste garbage bin. The utility functions for each alternative, yields as followed from equation (3.4):

$$V_{80} = -0.00056PR_{80} + 0.05885FR_{80}$$

$$V_{140} = -0.00034PR_{140} + 0.00489FR_{140}$$

6.3.3 Willingness to pay

The willingness to pay (WTP) is used to determine the amount of money individuals are willing to pay for a particular good. This is derived from measures designed to determine what individuals are willing to pay of obtaining a benefit when doing a specific task. This is done to provide a financial indicator, using linear models where the ratio between two parameter estimates is calculated and holding all else constant. This ratio between the two parameters gives the financial indicator of WTP, as in equation (6.5). When calculating the WTP, it is important that the attributes used in the calculation are statistically significant. If not, the WTP measure will not be meaningful (Hensher, Rose, and Greene 2005).

$$WTP_k = -\frac{\frac{\partial V_{nsj}}{\partial_{xk}}}{\frac{\partial V_{nsj}}{\partial_{xc}}} = -\frac{\beta_k}{\beta_c} \quad (6.5)$$

Where

K represents the attribute

C represents the constant

From table 7-1 and 7-2, the willingness to pay for frequency is calculated through equation (7.5) and is presented below. Because frequency for 140 litres is not statistically significant, the willingness to pay will not be meaningful and will not be calculated and compared with the other results. The frequency is positive and this is not surprising, because consumers are willing to pay more for a higher frequency. The WTP for consumers equals 105 NOK to decrease or increase their frequency for 80 litres.

$$WTP_{FR80} = -\frac{0.05885}{-0.00056} = 105\ (NOK/frequency)$$

Just to illustrate the not statistically significant answer for 140 litres. Consumers are willing to pay 14 NOK/frequency, something that is not meaningful at all.

6.3.4 Result second analysis

In addition to the result when excluding dominant answers based on price, it is convenient to look at the result when respondents have answered wrong two or more times are excluded. The result of the second analysis is presented in table 13 (80 litres) and table 14 (140 litres). A first look at the result, shows that both results are statistically significant. This gives the possibility to calculate the WTP for 80 and 140 litres.

```
------------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -107.55675
Estimation based on N =    456, K =   2
Inf.Cr.AIC  =    219.1 AIC/N =     .481
--------------------------------------
           Log likelihood R-sqrd R2Adj
ASCs  only  model must be fit separately
              Use NLOGIT ;...;RHS=ONE$
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
--------------------------------------
Response data are given as ind. choices
Number of obs.=   456, skipped    0 obs
--------+---------------------------------------------------------------------
        |                 Standard            Prob.      95% Confidence
SCELTA_1|  Coefficient       Error       z    |z|>Z*         Interval
--------+---------------------------------------------------------------------
      PR|    -.00314***      .00030   -10.33  .0000     -.00373   -.00254
      FR|     .47066***      .04765     9.88  .0000      .37727    .56404
--------+---------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
------------------------------------------------------------------------------
```

Table 13. NLOGIT output 80 litres analysis 2

```
------------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function       -55.51327
Estimation based on N =    218, K =   2
Inf.Cr.AIC  =    115.0 AIC/N =     .528
--------------------------------------
            Log likelihood R-sqrd R2Adj
ASCs  only  model must be fit separately
               Use NLOGIT ;...;RHS=ONE$
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
--------------------------------------
Response data are given as ind. choices
Number of obs.=   218, skipped    0 obs
--------+---------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
SCELTA_1|  Coefficient       Error       z    |z|>Z*         Interval
--------+---------------------------------------------------------------------
      PR|    -.00172***      .00024    -7.26  .0000     -.00219   -.00126
      FR|     .41292***      .06366     6.49  .0000      .28814    .53770
--------+---------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
------------------------------------------------------------------------------
```

Table 14. NLOGIT output 140 litres analysis 2

From the sections above, the first calculations is to check the goodness-of fit. The second analysis consist of 456 observations for 80 litres and 218 observations for 140 litres. This means that additional 271 observations have been excluded from the analysis. This equals 54 questionnaires ($\frac{271}{5} = 54$). The pseudo-R^2 is calculated from equation (6.1) and is 0.66 for 80 litres and 0.63 for 140 litres. According to Hensher, Rose, and Greene (2005) a decent model is represented when the pseudo-R^2 is 0.3. A pseudo-R^2 above 0.6 represent a good model fit. The reason for this, is that respondents are asked to confirm what they prefer, and not choosing. When also the wrong answered dominant questions is excluded, there is only answers confirming the price and frequency left.

The advantage of the second results, is that both 80 litres and 140 litres are statistically significant. The deterministic parameters are written from equation (3.4) and the parameters yield:

$$V_{80} = -0.00314PR_{80} + 0.47066FR_{80}$$

$$V_{140} = -0.00172PR_{140} + 0.41292FR_{140}$$

With both 80 and 140 litres statistically significant, the WTP can be calculated through equation (6.5) at:

$$WTP_{FR80} = -\frac{0.47066}{-0.00314} = 150\ (NOK/size)$$

$$WTP_{FR140} = -\frac{0.41292}{-0.00172} = 240\ (NOK/size)$$

6.4 Questionnaire feedback

In addition to the quantitative results, all the questionnaire where collected face-to-face. This gave some additional elements that the in-depth and focus groups interviews did not reveal. Because this is a pilot project and an example for further research, it is important for further researchers to know these elements. This qualitative feedbacks will support the quantitative results in the managerial implications.

Many of the respondents highlighted the problem with smell from the bio-waste bin when the collection date was approaching. The respondents said that every fourteen day was the limit for bio-waste waste collection. So, they wouldn't appreciate the collection date to be less frequent than every fourteen day. Some of them also said that the collection dates could be more frequent during the summer, rather than the winter. Having bio-waste collected every week during the summer and every fourteen day through the winter. The answers from the questionnaire was collected in March, and there had recently been winter. Respondents said that if the answers from the questionnaire had been collected after the summer, they could have answered different regarding a more frequent solution.

Regarding the choice set design, respondents said that they would have a much clearer separation between choosing todays payment system and PAYT. They didn't understand the separation between the alternatives and choose the fixed alternative, because it was too difficult to understand the PAYT price.

7.0 Policy implications

This section will first outline the current situation with the values from the actual price and frequency. Both of the analysis will be outlined and the output is shown. Further, scenario simulations will be done to analyse if a change in frequency or price will change the current attitude towards every fourteen day or seven day. After the scenario simulation, managerial implications are outlined and discussed.

7.1 Analysis of current situation

As mentioned in section 2, consumers related to RIR can chose between either an 80 or 140 litres bio-waste garbage bin. These have fixed prices and a collection calendar consumer follows. The current situation for 80 litres is 798 NOK for garbage collection every fourteen day and 1726 NOK every seven day. For 140 litres garbage bins, the price for garbage collection every fourteen day is 1391 NOK and 2978 NOK every seven day.

Based on this exploratory condition above, the probability to choose between frequency every seven or fourteen day can be calculated. This probability is calculated with the MNL model presented in equation (3.3). Under the condition of the first analysis, the derived deterministic part of the utility functions can be described as followed. In these calculations, the 140 litres are presented, but will not be commented because of the significance.

$$V_{80,14D} = -0.00060 \times 798 + 0.06152 \times 14 = 0.38248$$

$$V_{80,7D} = -0.00060 \times 1726 + 0.06152 \times 7 = -0.60496$$

$$V_{140,14D} = -0.00036 \times 1391 + 0.00833 \times 14 = -0.38414$$

$$V_{140,7D} = -0.00036 \times 2978 + 0.00833 \times 7 = -1.01398$$

According to the numbers above, the exponential value for each alternative is:

$$\exp(V_{80,14D}) = 1.46592$$

$$\exp(V_{80,7D}) = 0.54610$$

$$\exp(V_{140,14D}) = 0{,}68104$$

$$\exp(V_{140,7D}) = 0{,}36278$$

When calculating the probability of choosing between garbage collection every fourteen or seven day, the probability choosing between the two frequencies for 80 litres are:

$$\text{Prob}(V_{80,14D}|j) = 72{,}86\%$$

$$\text{Prob}(V_{80,7D}|j) = 27{,}14\%\%$$

And for 140 litres garbage bins:

$$\text{Prob}(V_{140,14D}|j) = 65{,}24\%$$

$$\text{Prob}(V_{140,7D}|j) = 34{,}76\%$$

From these calculations, most of the respondents choose to have the garbage collected every fourteen day instead of every seven day for 80 litres.

In addition to these calculations, it is interestingly to look at analysis two, where respondents that have chosen wrong dominant answer two or more times are excluded. When these are excluded, the utility function will be different and the new utility functions is shown below. In this case, the FR for 140 litres are also significant. The significance gives a better representation of the population, and the numbers are valid (Hensher, Rose, and Greene 2005).

$$V_{80} = -0.00314 \times 798 + 0.47066 \times 14 = 4.08352$$

$$V_{80} = -0.00314 \times 1700 + 0.47066 \times 7 = -2.12502$$

$$V_{140} = -0.00172 \times 1391 + 0.41292 \times 14 = 3.38836$$

$$V_{140} = -0.00172 \times 3000 + 0.41292 \times 7 = -2.23172$$

For 80 litres, the probability between choosing every seven or fourteen day is:

$$\text{Prob}(V_{80,14D}|j) = 99{,}80\%$$

$$\text{Prob}(V_{80,7D}|j) = 0{,}20\%$$

And 140 litres

$$\text{Prob}(V_{140,14D}|j) = 99{,}64\%$$

$$\text{Prob}(V_{140,7D}|j) = 0{,}36\%$$

The model estimation shows that with almost certainty, consumers will choose garbage collection every fourteen day. This tells that frequency doesn't have any impact to consumers. Consumers are just looking at price and choose the cheapest alternative every time. But it is not surprisingly, because there are just two questions among the fifteen choices that are a real trade-off. The other thirteen choices have a dominant answer, and under these conditions, the wrong answers are excluded from this analysis. So if one respondent have chosen every fourteen day, but this is not the cheapest, this have been excluded.

7.2 Scenario simulation

Scenario simulation is used to analyse if the probability changes with a hypothetical calculation. Three hypothetical scenarios simulation is conducted, to analyse if the probability for frequency change. The results from the scenario simulation is summarized in table 15 and 16, respectively analysis 1 (table 15) and analysis 2 (table 16).

Scenario 1: free service cost

RIR have two types of price strategies for their fractions. Mentioned in part 2, paper/cardboard, plastic and glass/metal are free of charge, and consumers does not pay a charge to have these garbage bins collected. The fractions consumers pay for are residual waste and bio-waste. If these two also are free of charge, it is interesting to see if consumers prefer to have the garbage collected more frequent.

A simulation of this scenario can be conducted to investigate if respondent will choose to have the garbage collected more frequent. When this is the scenario, consumers still find it more convenient to have the waste collected every fourteen day (60,60 %) in analysis 1, but it is not as certain anymore. From analysis two, consumers are almost certain to choose every fourteen day, but a slightly decrease from almost certainty.

Scenario 2: Same price for seven and fourteen days

To give consumers the ability to change the frequency during the summer months, RIR can have the same price every fourteen day and seven day, so consumers can choose between frequency and not price. The factor to have more frequent garbage collection in the summer months, is because the temperature is higher and organic materials tend to release a stronger odour. So give the consumers the possibility to change between every fourteen and seven day in the summer months without extra charge, is a suitable approach to give consumers better terms.

When simulating this scenario, it gives the same results as the free service cost. This is not surprisingly, because there are only two variables and changing these equally will give the same effect. But the probability to choose every seven day increase.

Scenario 3: Collection once a month and every fourteen day

For cardboard/paper, plastic and glass/metal the collection frequency is once a month. It is interestingly to see if consumers still prefer to have the garbage collected at lowest frequency. If this is the case, the transportation impacts for waste management for RIR will decrease. Collecting once a month will give RIR economic benefits, if consumers find it preferable.

Changing the collection frequency to once a month and every fourteen days, increase the probability to have the lowest collection frequency even more. This means that consumers are willing to have garbage collection even less frequently than today.

To summarize the scenario simulation. Free service cost and same price for frequency, the probability of choosing the less frequent seven day collection enhance. On the other side, if garbage collection is every month, consumers still prefer to have the garbage collected least frequent. But with only two attributes included in the scenario simulation, the change of one attribute does not affect the other attribute considerably.

	Analysis 1					
	80 litres				Probability of choosing an alternative	
	Every fourteen day		Every seven day		80 litres	
	Price	Frequency	Price	Frequency	14	7
Base	798	14	1726	7	72,86 %	27,14 %
Scenario 1	0	14	0	7	60,60 %	39,40 %
Scenario 2	798	14	798	7	60,60 %	39,40 %
Scenario 3	798	30	1726	14	72,80 %	27,20 %

Table 15. Scenario simulation analysis 1, 80 litres

	Analysis 2											
	80 litres				140 litres				Probability of choosing an alternative			
	Every fourteen day		Every seven day		Every fourteen day		Every seven day		80 litres		140 litres	
	Price	Frequency	Price	Frequency	Price	Frequency	Price	Frequency	14	7	14	7
Base	798	14	1726	7	1391	14	2978	7	99,80 %	0,20 %	99,6 %	0,36 %
Scenario 1	0	14	0	7	0	14	0	14	96,42 %	3,58 %	94,74 %	5,60 %
Scenario 2	798	14	798	7	1391	14	1391	7	96,42 %	3,58 %	94,74 %	5,60 %
Scenario 3	798	30	1726	14	1391	30	2978	14	99,95 %	0,05 %	99,87 %	0,13 %

Table 16. Scenario simulation analysis 2, 80 litres and 140 litres

7.3 Managerial implications

Managerial implications will both include qualitative and quantitative data. There are only two attributes identified for the utility function. This does not give enough evidence for the consumer-oriented system, so additional qualitative data collected supports the managerial implications. This is useful information for further researcher, and the findings can be applied in the utility function for further research.

7.3.1 Differentiate frequency

The current waste management system RIR provide for their consumers, does not give consumers much of a choice based on frequency. Both of the frequency alternatives are fixed, and they only inform their customers with the every fourteen day at their website. By offering their customers limited information about their ability to change frequency, RIR makes it easy for themselves and customers does not need to think about how often the waste is collected, something the participants in the focus group also highlighted. But the results from the Factor Analysis, indicates that information does not have so much impact on consumers attitude towards recycling. Information is one aspect of the ability to change the frequency, but another is the goal to decrease the amount of waste. If this information have been more public, and consumers have had the chance to change the frequency to every seven day more easily, maybe there have been even higher percent that had preferred every seven day. Changing the price equally enhance the probability of respondents choosing every seven day. However most of the respondents in the questionnaire answer that their food-waste garbage bin is never full when collected. So the consumers would rather prefer to have the waste collected less frequent, supported by scenario simulation three.

Mentioned in section 2, waste management firms in Norway have different systems for garbage collection. Most of them have fixed collection frequency but can choose to place the garbage bin at the kerbside. From scenario simulation one and two, the probability choosing the more frequent alternatives is increased. The price is equal, so consumers choose based on frequency. There could be periods during the year when it is more proper to have higher frequency and other periods less frequent as one of the respondents in the focus group stated. Norway is a country where the fluctuation in temperature are relatively

high during one year. Food-waste is a fraction where higher temperature gives an increase in odour. So during summers, consumers could find it more appropriate to have a higher frequency, rather than during winters where the food-waste does not odour as much. Another factor is when customers are on vacation and does not produce any food-waste. With the current system, RIR collects the garbage bin at the same frequency independently of the amount. This is time consuming and have low efficiency for the waste management firm, and does not convey consumers any additional value or utility. The third factor to differentiate the frequency, is that this could save RIR time and kilometres if respondents choose a more or less frequent garbage collection.

However, with a differentiated frequency system, consumers have to do a bigger effort recycling at indoors to avoid full garbage bins outside their house (McLeod and Cherrett 2008). But as most of the respondents to the questionnaire answered, their garbage bins are not full. So they doesn't need to make a big effort yet, because the garbage bins already have too much capacity.

7.3.2 Collection price strategy

Both the in-depth and focus group interviews mentioned that to make a better effort in recycling, the most effective incentive is price. The current system offers fixed prices, same as the frequency. This does not give the consumers any incentive to have a higher motivation in waste recycling. The only current incentive consumers have, is to be a good citizen and recycle because they are intended by the authorities. These are also the factors related to recycling impacts from the Factor Analysis.

However, there is example to increase the economic incentives for consumers, so they have higher motivation in waste recycling. One method to increase the recycling incentives, are PAYT. This gives consumers the chance to have garbage collected less frequent and they can also save money. This system can give consumers an increased motivation towards recycling (Morlok et al. 2017). The system intends consumers to have the availability to set their garbage bin at the kerbside and if they do not, the garbage truck does not pick it up and consumers need to wait until next time to have the garbage collected. If consumers are good at recycling indoors, and reduce their amount of waste produced, they have an incentive to save money with a less frequent garbage collection.

However, the downside with the PAYT system, is that if the garbage bin is full or odour, respondents does not have the possibility to order waste collection. Another downside is that consumers need to be more aware and decide if they need collection. They need to plan their waste ahead, and this requires more effort.

The other payment system, is the pay per kilograms introduced in Sweden (Bartelings and Sterner 1999). This system has the same frequency, but instead of paying a fixed price as the current system, consumers pay for the kilograms in their garbage bin. This requires weighting sensors, that know the weight of the garbage bins. Mentioned before, RIR already have RFID sensors that detect kilograms in the garbage bins. As the PAYT system, pay per kilograms gives consumers incentives to have a higher motivation in recycling, because they can save money by reducing their waste production. If consumers can reduce their amount of waste produced, their garbage bin is lighter, and they will be charged with a lower amount. However, there can also occur problems with this payment system. As one of the participants in the focus group highlighted, there will be consumers that will try to save as much money as possible, and can then throw garbage in the nature instead of the garbage bins. But in the case of food-waste, consumers can also get incentives to compost at home, instead of the waste management firm doing it. By composting at the households, this contributes to the circular economy and can be used as fertilizer to produce new food.

These two payment system can help to increase the recycling motivation for consumers, and give them economic incentives. However, from the questionnaire, most of the respondents are satisfied with the current system delivered by RIR. This could be a problem when introducing a new system for consumers. As the in-depth interviews highlighted, if there should be a change in the waste management system, it needs to be as simple as the current system.

7.3.3 Consumer oriented system

From the discussion above, there is possibilities to increase the recycling motivation for consumers. This section discusses how a consumer-oriented system will affect the motivation for consumers towards recycling. As mentioned before, the incentive for consumers to change their behaviour, is about decreasing their payment for recycling.

A consumer-oriented system tends to give the consumers higher incentive to participate in recycling. The current system is fixed with collection calendar and fixed prices, and does not tend to give consumers incentive to save any money. But as the questionnaire, in-depth and focus groups suggest, respondents are satisfied with the current system. This could be because they have not tried any other system and have accepted the current system. They may not care so much, because they need to pay either way. Another aspect is that only 22 percent of the people who pay municipality taxes, know how much they pay in waste fee. Consumers may not have thought of other possibilities, before they respond to the questionnaire. This could be a problem when introducing a new payment system, because they have to change their attitude towards recycling and learn a new system. Another interestingly thought is that 67 percent would still prefer the collection calendar instead to decide themselves when the garbage is collected. But when this was the scenario in the post-interviews, 65 percent reported that they would be more aware of their recycling behaviour and 70 percent answered that it would be easier. These are considerations that need to be taken into account when introducing a consumer-oriented system. The system needs to be as simple as today and there need to be economic incentives for consumers to have a higher motivation towards recycling.

Taken the consumer considerations into account, there is also important that the new system is sustainable for RIR. This means that the reduction in price for consumers cannot be so low that RIR does not earn money on their waste management. There need to be a trade-off between the consumers utility and the price RIR charge their consumers. The consideration towards RIR are not investigated in this study, and can be investigated in further research. This study takes this consideration in account, but not with calculations.

Another fact that was discovered through the study, was the aspect of odour from bio-waste. Highlighted during the in-depth interviews and focus groups, and also by respondents in the questionnaire. The questionnaire has not covered this element, but it is an element that the consumer-oriented need to take into account.

The consumer-oriented system can be outlined based on the qualitative, quantitative and managerial implications. The frequency should be fixed with a collection calendar. This makes it easier for consumers to know when the garbage is collected and can look at the calendar when the waste is collected. In addition to the collection calendar, consumers

should have the possibility to order waste collection through the mobile application with an additional fee. The reason for this collection calendar, is that respondents does not get any additional value by having a waste collection system where they choose themselves and that many of the respondents was sceptic to change from the current system. As mentioned earlier, economy incentive is the incentive consumers need to increase their motivation towards recycling. From the discussion with the two payment systems PAYT and weight payment, present literature suggest that PAYT is the payment system that increase motivation for consumers. But as the literature highlight, the recycling rate does not increase. But this give consumer additional motivation to reduce their waste production.

The two orientation characteristics is motivation and value (Pons, Mourali, and Nyeck 2006). The motivation consumers get through the consumer-oriented system are the price incentive that they can decide when the garbage is collected, by putting the garbage bin at the kerbside or not when the truck drives by. The value gained through the consumer-oriented system relates to the activity is more satisfying because consumers know there is additional savings for taxes in reducing waste produced.

8.0 Conclusion

As mentioned by way of introduction, food disposal has gained a lot of attention the recent years through the UN Sustainable Development Goals, including the goal of reducing food loss by 50 percent before 2030. The food production sector has a deal with the authorities to mitigate food disposal, but there is no such deal for the waste management sector. Therefore it is important to understand how consumers motivates and can decrease their production of food-waste. This thesis aims to give a method, which can help the waste management understand recycling behaviour and motivation and how to change their system to be more consumer-oriented. This can help to prevent food loss and give consumers stronger incentives to reduce their food-waste production.

Through the Stated Preference choice modelling, both analysis of the thesis finds that consumers prefer to have their waste collected every fourteen day. Interestingly, people prefer the collection calendar, but would be more aware of their recycling if they could decide themselves when the garbage is collected. This study gives an example of how the Stated Preference method can be used in the waste management sector to increase the consumer motivation towards recycling. As shown in the thesis, the results are interesting both for the waste management sector and for policy makers deciding the price for waste management collection.

In addition to the research problem, the thesis answered the following two questions:

RQ1: What factors affect the recycling behaviour of consumers to recycle?

RQ2: What can motivate consumers to increase their food-waste recycling?

Recycling behaviour can be influenced by various factors. From the Stated Preference choice experiment, researchers found that price and frequency affect the recycling behaviour. Price has a negative impact and frequency has a positive impact. The WTP calculations shows that consumers are willing to pay 105 NOK to increase the frequency from every seven day to every fourteen day in analysis one and 150 NOK in analysis two.

Consumers prefer to have the garbage collected every fourteen day in both of the analysis. However, if there is an equal price for seven and fourteen days, consumers are more willing to have the garbage collected every seven day.

From the Factor Analysis results, two labelled factors were discovered; consumer attitude and motivation for recycling and the recycling impacts. Both authorities and the consumers neighbours affect their recycling behaviour. Environmental concerns and how much the consumers liked to recycle were the two most important factors towards their attitude to recycle. In addition to the Factor Analysis revealed through the in-depth and focus group, economic incentives are the highest motivation to increase the consumers' effort in recycling.

With the research questions in mind the proposed customer-oriented system is outlined like this:
Continuing with the collection calendar and the PAYT. Where consumers can choose to set the garbage bin at the kerbside, and is charged every time it is collected. This price needs to be calculated by RIR.

8.1 Research contribution

This study has established the following contribution to the academic environment and the waste management sector:

An example and pilot project for Stated Preference method to investigate consumers behaviour, motivation and value. This example can be used in further research to understand the recycling behaviour among consumers, and their preferences. Consumers prefer to have the collection calendar, but as this study shows, there is additional incentives for consumers to have a higher motivation towards recycling. Consumers also find it easier to use the system, if they can have more influence on their waste collection.

In addition, this study contributes with a detailed database of 189 respondents' choices towards recycling of food-waste. The data consist of their opinion of RIR, their opinion of recycling, Stated Preference choices, attitudinal value and socio-demographic information.

This can be used in further research within the waste management sector and for policy makers.

Furthermore, the study contributes with a detailed description of how the Stated Preference and Factor Analysis is conducted. This is useful for further research, because the same method can be used, but adding additional attributes to the Stated Preference or questions to the Factor Analysis. The research is also simple to understand and researchers can use it at guidelines.

8.2 Limitations

The thesis has several limitations. The SP was developed in two different categories, where one of them was with bio-waste bin of 80 litres and one 140 litres. The thesis also just looked at bio-waste, and not additional fractions. Respondents were asked to choose the category with the same size of bio-waste bin that they have at their households. The researchers have chosen to only ask respondents with private bio-waste recycling and not work-related. Due to this, researchers choose a limitation that only respondents with bio-waste bin of respectively 80 litres and 140 litres could answer the SP. The attributes levels are chosen based on information from RIR, literature review and common knowledge about the subject, today there is no standard method how to choose attributes levels, and it can therefore give bias. The attributes are limited down to only two attributes, and the sample of the whole questionnaire are collected in limited quantities which can give bias. By adding additional attributes, the pseudo-R^2 would have had a higher value, without excluding many questionnaires. Additional attributes will give the scenario simulation a more realistic approach when changing the vector paraments. This will give a better representation of the choices. Using additional attributes, give the possibility to use efficient design. Efficient design is used to generate an experimental design, and can then be tested to see if the design is efficient. The collection of questionnaires is limited because of time and cost constraints, with more money support would it be possible to collect additional questionnaires. The questionnaire is developed in Norwegian, this was because all of the respondent has Norwegian as their mouther tongue and it was easier to get people to answer the questionnaire.

Some of the literature investigated to get a better understanding of the waste-industry is based on the waste collection system other places around the world. This is done due to lack of relevant literature from Norwegian waste collection system, and because researchers want to get inspiration about how it is done outside of Norway.
The thesis is based on the consumer choices of people from Romsdal (Aukra, Eide, Fræna, Gjemnes, Midsund, Molde, and Nesset) which is the connected municipalities to RIR. This is only a small part of Norway, and the findings will therefore not reflect Norway as a whole.

In this thesis is only the frequency or price attributes taken into consideration when modelling the utility function. Other factors that can influence recycling behaviour is social factors, psychological factors, and situational factors. The thesis has the focus from the consumer side and not the implementation side. This is because of the time and scope of the thesis. So, the consumer-oriented system suggested will not include the implementation phase.

8.3 Further research

Because this is a pilot project and example for further research, it is convenient to give further researchers additional case studies. The first suggested case study is to do the same project again, but add additional attributes to the choice experiment. These are numbers of bags, how full the garbage bin are, price reduction and environmental impact. In addition to this, the Factor Analysis should include which incentives consumers have towards recycling. Other case studies can look at the transportation impacts for a consumer-oriented system. The Stated Preference can be used to simulate the Co2 emitted from trucks.

Further research could be to look deeper into how the implementation of a consumer-oriented system could be applied. This could also include more than one fraction and the scope could be increased to include Norway. In addition to include Norway, a study could also include other countries and look at the differences.

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Appendix

Appendix I: In-depth and focus group interview guide

Alder

Kjønn

Enebolig eller bofelleskap?

Har du kjennskap til RIR?

Kjenner du til systemet til RIR for innsamling av avfall?

Hvordan synes du systemet fungerer i dag?

Hva er resirkulering for deg?

Adferd til resirkulering

Hva er din motivasjon for å resirkulere?

Ser du på resirkulering som en viktig oppgave?

Mener du resirkulering er viktig for miljøet?

Hvor mye tid bruker du per uke på resirkulering?

Har dere stor (140L) eller liten (80L)?

Er matavfallsdunken din full hver gang den blir tømt?

Hvis ja, hva er det som tar mye plass?

Tror du resirkulering hjelper på miljøet?

Er du like flink til å resirkulere matavfall på jobb?

- Hvis ja, er det samme motivasjon som hjemme?
- Hvis nei, hvorfor ikke?

Informasjon

Får du nok informasjon?

Hadde du resirkulert mer om informasjonen var bedre?

Er informasjon viktig?

Pris

Kjenner du til dagens betalingssystem?

Hvordan synes du prissystemet fungerer i dag? For høy, lav eller bra

Istedenfor å betale 818 kroner i året og heller betalt 35 kroner hver gang dere setter fram dunken, ville dette hatt en innvirkning på resirkulering hos deg?

Oppsummerende spørsmål

Av det vi har diskutert nå, hva er det viktigste for deg når det gjelder resirkulering av matavfall?

Hva må til for at du skal resirkulere matavfall?

Har du noen forslag til forbedring av systemet i dag?

Hva vil være mest foretrukket, slik som det er i dag, eller betaling for hver gang restavfall kastes?

Appendix II: Stated Preference questionnaire

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Questionnaire

80 Liter

1) Godtar og har du forstått informasjonsskrivet?
1: Ja

2) Er det du som betaler de kommunale gebyrene?
1: Ja
2: Nei

3) Hvor ofte blir søppeldunken din hentet?
1: Hver uke
2: Annenhver uke

4) Kjenner du til systemet som RIR tilbyr i dag?
1: Ja
2: Nei

5) Vet du hvor mye du betaler for tjenestene hos RIR?
1: Ja
2: Nei

6) Hvor fornøyd er du med systemet som RIR tilbyr?
1: Veldig misfornøyd
2: Misfornøyd
3: Helt greit
4: Fornøyd
5: Meget fornøyd

7) Kildosorterer du?
1: Ja
2: Nei

Hvis ja:

a) Hvor full er matavfallsdunken i gjennomsnitt, hver gang RIR henter den og blir tømt?
1: Full (90%-100%)
2: Halvfull (50%-89%)
3: Under halvfull (0%-49%)

b) Hvor mange matavfallsposer kaster dere i gjennomsnitt hver uke?

8) Har du smarttelefon?
1: Ja
2: Nei

Hvis ja:

a) Hvordan vil du beskrive dine ferdigheter ved bruk av smarttelefon er?
1: Veldig dårlig
2: Dårlig
3: Middels
4: Gode
5: Veldig gode

b) Hvis du kunne se resirkuleringsgraden på telefonene din, ville dette vært interessant for deg?
1: Ja
2: Nei

9) Hvis du selv kunne bestemt når søppeldunken din blir hentet, hva ville du foretrukket?
1: Hentekalender slik som det gjøres nå
2: Bestemme selv når søppeldunken skal hentes

Nå skal vi over til noen spørsmål om din oppfatning av resirkulering

Svarene går fra **veldig uenig** til **veldig enig**, du skal skrive inn det nummeret som representerer deg bes

10) Jeg vil bidra til et bedre miljø
1: Veldig uenig
2: Uenig
3: Hverken eller
4: Enig
5: Veldig enig

11) Jeg ser på meg selv som en ansvarlig person
1: Veldig uenig
2: Uenig
3: Hverken eller
4: Enig
5: Veldig enig

12) Resirkulering er noe jeg liker
1: Veldig uenig
2: Uenig
3: Hverken eller
4: Enig
5: Veldig enig

13) Naboene resirkulerer, så da gjør jeg også det
1: Veldig uenig
2: Uenig
3: Hverken eller
4: Enig
5: Veldig enig

14) Jeg gjør det fordi myndighetene ber meg om det
1: Veldig uenig
2: Uenig
3: Hverken eller
4: Enig
5: Veldig enig

15) Jeg mener informasjonen jeg blir gitt er tilstrekkelig for å kunne resirkulere
1: Veldig uenig
2: Uenig
3: Hverken eller
4: Enig
5: Veldig enig

16) Jeg har tid til å resirkulere
1: Veldig uenig
2: Uenig
3: Hverken eller
4: Enig
5: Veldig enig

Valg

I denne delen av undersøkelsen skal du velge hvilket av de to alternativene du føler passer deg best.	
Forklaring: * 800 og 1700 representerer den **årlige** prisen du betaler I NOK * 32 kroner representer det du kan betale hver gang du setter søppeldunken din frem	

Her er det du har oppgitt i første del av spørreundersøkelsen.

Deres søppeldunk er **80** Liter

Her er flere måter du kan betale for hvor ofte søppeldunken din blir tømt. Vi ber deg velge det alternativet som passer deg best.

SCENARIO 1	**Alternativ 1**	**Alternativ 2**	
Pris	800 årlig	800 årlig	NOK
Hvor ofte søppeldunken blir hentet	14	7	Dager
Hva vil du velge?			

Valg

I denne delen av undersøkelsen skal du velge hvilket av de to alternativene du føler passer deg best.	
Forklaring: * 800 og 1700 representerer den **årlige** prisen du betaler I NOK * 32 kroner representer det du kan betale hver gang du setter søppeldunken din frem	

Her er det du har oppgitt i første del av spørreundersøkelsen.

Deres søppeldunk er **80** Liter

Her er flere måter du kan betale for hvor ofte søppeldunken din blir tømt. Vi ber deg velge det alternativet som passer deg best.

SCENARIO 2	**Alternativ 1**	**Alternativ 2**	
Pris	800 årlig	32 hver gang søppeldunken hentes	NOK
Hvor ofte vil du at søpla skal hentes?	14	14	Dager
Hva vil du velge?			

Valg

I denne delen av undersøkelsen skal du velge hvilket av de to alternativene du føler passer deg best.	
Forklaring: * 800 og 1700 representerer den **årlige** prisen du betaler I NOK * 32 kroner representer det du kan betale hver gang du setter søppeldunken din frem	

Her er det du har oppgitt i første del av spørreundersøkelsen.

Deres søppeldunk er **80** Liter

Her er flere måter du kan betale for hvor ofte søppeldunken din blir tømt. Vi ber deg velge det alternativet som passer deg best.

SCENARIO 3	**Alternativ 1**	**Alternativ 2**	
Pris	800 årlig	1700 årlig	NOK
Hvor ofte vil du at søpla skal hentes?	7	7	Dager
Hva vil du velge?			

Valg

I denne delen av undersøkelsen skal du velge hvilket av de to alternativene du føler passer deg best.	
Forklaring: * 800 og 1700 representerer den **årlige** prisen du betaler I NOK * 32 kroner representer det du kan betale hver gang du setter søppeldunken din frem	

Her er det du har oppgitt i første del av spørreundersøkelsen.

Deres søppeldunk er **80** Liter

Her er flere måter du kan betale for hvor ofte søppeldunken din blir tømt. Vi ber deg velge det alternativet som passer deg best.

SCENARIO 4	**Alternativ 1**	**Alternativ 2**	
Pris	1700 årlig	1700 årlig	NOK
Hvor ofte vil du at søpla skal hentes?	14	7	Dager
Hva vil du velge?			

Valg

I denne delen av undersøkelsen skal du velge hvilket av de to alternativene du føler passer deg best.	
Forklaring: * 800 og 1700 representerer den **årlige** prisen du betaler I NOK * 32 kroner representer det du kan betale hver gang du setter søppeldunken din frem	

Her er det du har oppgitt i første del av spørreundersøkelsen.

Deres søppeldunk er **80** Liter

Her er flere måter du kan betale for hvor ofte søppeldunken din blir tømt. Vi ber deg velge det alternativet som passer deg best.

SCENARIO 5	**Alternativ 1**	**Alternativ 2**	
Pris	1700 årlig	32 hver gang søppeldunken hentes	NOK
Hvor ofte vil du at søpla skal hentes?	7	14	Dager
Hva vil du velge?			

Se for deg at du nå kan bestemme selv når søppeldunken hentes, og at du betaler en fast sum hver gang du setter fram søppeldunken

17) Ville du blitt mer bevist på din resirkulering om dette var tilfellet?

1: Ja
2: Nei

18) Hvis søppeldunken automatisk sa fra til RIR og deg på SMS/app at den er full, ville dette gjort det enklere for deg?

1: Ja
2: Nei

19) Tror du resirkulering hjelper til å redusere utslippet av Co2?

1: Ja
2: Nei

Appendix III: Information paper from NSD

Vil du delta i forskningsprosjektet

«Resirkulering av matavfall fra kundens perspektiv»?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å se om andre systemer kan hjelpe til økt resirkulering av matavfall. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Denne oppgaven er en avsluttende masteroppgave innenfor master i logistikk ved Høgskolen i Molde. For å gjennomføre denne oppgaven skal vi bruke en spørreundersøkelse, som blir brukt til å samle inn data som vi skal bruke til å analysere hvor villige folk er til å resirkulere matavfall. Vi skal bruke benchmarks som det er nå og komme med forslag til hvordan systemet for innsamling og resirkulering kan endres, slik at kundene får en bedre opplevelse og Co2 utslippene kan reduseres. Oppgaven vil bruke spørreundersøkelsen i forskningsspørsmålet.

A consumer-oriented bio-waste recycling system. The case of household bio-waste collection at Romsdal Waste Management Company

Denne masteroppgaven kan bli brukt som eksempel i en bok senere, men det er bare analysen. En bok som omhandler Stated Preference techniques.

Hvem er ansvarlig for forskningsprosjektet?
- Høgskolen i Molde

Hvorfor får du spørsmål om å delta?
Du får spørsmål om å delta i denne undersøkelsen fordi du er kunde av RIR og har RIR som ditt renovasjonsselskap. Undersøkelsen vil i hovedsak bli utført av personer i Molde, men noen kan også bli utført andre steder i regionen. Det vil bli utført om lag 200 undersøkelser, omfanget kreves for at vi skal kunne få et gyldig resultat.

Undersøkelsen vil bli utført på kjøpesenter og liknende, vi vil ikke ha noen personopplysninger om deg.

Hva innebærer det for deg å delta?
Beskriv metode (spørreskjema, intervju, observasjon etc.), omfanget, hvilke opplysninger som samles inn og hvordan opplysningene registreres (elektronisk, notater, lyd-/videoopptak), f.eks.:
- Hvis du velger å delta i prosjektet, innebærer det at du fyller ut en Excel-fil. Det vil ta deg ca. 10 minutter. Spørreskjemaet inneholder spørsmål om din atferd til resirkulering, og opplyser oss gjennom «stated preferences» hva du ville valgt ut ifra to alternativ basert på pris og frekvens på henting.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

- Høgskolen i Molde vil behandle denne konfidensielt.
- Det er studentene Henning Hellebust og Vegard Øye som vil ha tilgang til dataene.
- Veilederne Harald Martin Hjelle og Edoardo Marcucci vil også ha innsyn i dataene.
- Det er undertegnet et konfidensielt skriv sammen med RIR som har en lengde på fem år.
- Ditt navn vil ikke komme fram i undersøkelsen, det vil derfor ikke være mulig å spore.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes 14 juni 2019. Undersøkelsen vil ikke kunne bli brukt på fem år og etter disse årene vil dataene være utdatert til videre forskning. Svarene fra undersøkelsen vil bli slettet fra vår database.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Høgskolen i Molde har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Høgskolen i Molde
- Student, Henning Hellebust. henning_hellebust@hotmail.com. 47590019
- Student, Vegard Øye. V_oye@hotmail.com. 95039396
- Professor, Harald Martin Hjelle. Harald.hjelle@himolde.no. 71214241
- Professor, Edoardo Marcucci. Edoardo.marcucci@himolde.no . 71214221
- Vårt personvernombud: personvernombud@himolde.no
- NSD – Norsk senter for forskningsdata AS, på epost (personvernombudet@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen
Henning Hellebust og Vegard Øye
Student
Harald Martin Hjelle og Edoardo Marcucci
Veileder

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «Resirkulering av papp og papir fra en kundes perspektiv», og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i en spørreundersøkelse

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. 14.juni 2019

(Signert av prosjektdeltaker, dato)

Glossary

Bio-waste: When talking about bio-waste, it is the garbage bin collected from the waste management companies. It is used interchangeably with food-waste in this study.

Food-waste: Food-waste is the largest fraction in the bio-waste garbage bin. This include organic materials from food disposal.

NOK: NOK is the currency in Norway

Scandinavia: Scandinavia is a geographical location including Denmark, Sweden and Norway.