The Redistribution Revolution

A multiple case study of climate impact comparison of food redistribution tests

Bachelor's thesis in Industrial Engineering and Management

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Omdistribueringsrevolutionen

En flerfallstudie om matomdistribueringstesters klimatpåverkan

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Preface

This bachelor's thesis was written at the Department of Service Management & Logistics at Chalmers University of Technology, Gothenburg during the spring of 2021. First of all, we wish to express our deepest gratitude to our supervisor Ceren Altuntas Vural, Associate Professor at the Division of Service Management and Logistics. Her support and continual feedback have been vital and her passionate engagement has been a tremendous motivation throughout the writing process.

The study has been executed in collaboration with the food redistribution initiative ReSvinn to whom we also wish to express our gratitude. Without the material, contacts, and support from ReSvinn, and in particular Kristina Liljestrand, the execution of this report would not have been possible. Furthermore, we also want to give a great thank you to all of the actors who have taken their time to attend our interviews and provide us with important insights into the tests.

Sofia Leffler Mober, Sustainability Manager, and Henrik Boding, Environmental Specialist at Postnord further deserve our most sincere gratitude for guiding us and providing insight on the subject of distribution systems and sustainable logistics.

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Sammandrag

En snabbt ökande befolkning och den påföljande efterfrågan på mat ställer stora krav på hållbara distributionssystem för dessa varor. Vidare är det av stor betydelse att minska den idag ohållbara mängden producerad mat som slängs utan att tas tillvara på, vilket exempelvis kan göras via omdistribuering. Dock har alla logistiksystem, även de för omdistribution, en negativ klimatpåverkan vilken måste täckas av den positiva klimatpåverkan som härrör från att inte behöva producera maten på nytt.

Syftet med denna studie är att undersöka miljöpåverkan från omdistribueringssystem för överskottsmat i svenska butiker samt identifiera vilka parametrar som är av störst betydelse för att skapa långsiktigt hållbara logistiska system. Målet är att med dessa insikter skapa ett ramverk för framtida implementering av omdistribueringslösningar som säkerställer att klimatpåverkan från omdistribuering av överskottsmat är mindre än den för att producera maten på nytt. Således skall ramverket guida användaren till insikter kring huruvida den totala klimatpåverkan vid en potentiell omdistribuering faktiskt är positiv.

Litteratur inom cirkulär ekonomi, cirkulära affärsmodeller, matsvinn samt hållbar logistik och transport har tillsammans byggt upp teorin där cirkulär ekonomi har varit ett övergripande tema. Därpå har en flerfallsstudie genomförts, i vilken teori har varvats med intervjuer för att skapa en förståelse för vilka parametrar som är av störst betydelse i praktiken. Åtta test för omdistribution av överskottsmat har analyserats och betydande aktörer har intervjuats för att skapa en djupare insikt i hur framtida omdistributionssystem bör designas.

Resultatet av denna studie visar att distans och matens vikt är viktiga parametrar men att de dock är svåra att påverka. Då är istället fordonstyp, bränsletyp, trafiksituation och samtransport viktiga parametrar vilka kan bidra till en minskad klimatpåverkan. Intervjuerna har även visat att kommunikation mellan aktörerna är av stor betydelse och att det rentav är avgörande för systemets funktionalitet. Därmed är kommunikation dessutom direkt bidragande till att ta till vara på överskottsmat. Som resultat av denna studie beräknades ett matematiskt värde som, tillsammans med distans och produktens vikt, kan ge en vägledning om transporternas miljöpåverkan och därmed kan klimatpåverkan av framtida omdistribueringssystem utvärderas före eventuell implementering. Ramverket i denna studie har utvecklats för en kontext med överskottsmat men kan i framtiden bidra till applicering på andra varor.

Abstract

A rapidly growing population and the consequent demand for food results in constantly increasing demands on sustainable distribution systems for these goods. Furthermore, it is of great importance to reduce the currently unsustainable amount of food wasted without making use of it. A possible solution for this is the redistribution of surplus food. However, any logistic system, including redistribution systems, result in a negative environmental impact which has to be covered by the resulting positive climate impact stemming from the lowered need for producing the food anew.

The purpose of this study is to investigate the environmental impact of redistribution systems for surplus food and to identify which parameters are important for creating long-term sustainable logistics systems. The goal is to use these insights to create a framework for future implementation of redistribution systems that ensures that the climate impact from food redistribution is less than that for producing food anew. Thus, the framework strives to give the reader an insight into whether the total climate impact of a potential redistribution is climate net positive.

Literature on circular economy, circular business models, food waste, as well as sustainable logistics and transportation, have helped to build the frame of reference with circular economy as the overarching concept for the frame of reference. Then, a multiple case study has been conducted where theory has been supplemented with interviews to create an overall understanding of which parameters are of the greatest importance in practice. Eight tests from a surplus food redistribution project were analyzed and important actors were interviewed to gain a deeper understanding of how future redistribution systems should be designed.

The results of this study show that the distance and the weight of food are important parameters, but difficult to influence. Instead, vehicle type, fuel type, traffic situation, and co-transport are important parameters that can contribute to a reduced climate impact. Further, the interviews have shown that communication between the actors is of great importance and crucial for the system's functionality, and thus a directly contributing factor to save the surplus food. As a result of this study, a mathematical value was calculated which, together with the distance and the climate impact of the production of the goods, can provide guidance regarding the transport's environmental impact, and thus, the climate impact of future redistribution systems can be evaluated before a possible implementation. In this study, the framework has been developed in the context of surplus food but its use could be extended to other goods as well.

Table of contents

1. Introduction

This introductory section initiates with a background followed by the purpose of the study being presented. Thereafter, a problem analysis is conducted, and the research questions are defined. Lastly, the section ends with the delimitations of the study being established.

1.1 Background

Food waste is a prominent problem of modern times with consequences such as global starvation, substantial climate impact, and economic implications (UN General Assembly, 2015). The problem is not that there is an actual lack of food, but rather that the food produced is distributed in a way where there is an abundance in some regions, while others experience a shortage. Given all the food currently wasted in the world, every undernourished person could be sufficiently fed - twice (Food and Agriculture Organization, 2017). Substantial social gaps and different conditions regarding natural resources globally lead to misallocation of food which makes starvation a significant problem in some regions while food is thrown away in others (FAO, 2011). The Ellen MacArthur Foundation (2017) relates these problems associated with misallocation of food with the linear way in which food is currently produced, and which represents approximately 25% of greenhouse gas emissions worldwide.

The currently unsustainable production and consumption of food further have an explicit impact on the global economy and the 1.3 billion tons of food waste accumulated annually correspond to roughly US$1 trillion (World Food Programme [WFP], 2020). The major costs of food sold lie in the production and distribution stages. Discarding edible food thereby implies that all of the value added throughout the supply chain is being wasted (Nahman & De Lange, 2013).

To illustrate the huge scope of the carbon dioxide emissions derived from food waste and the problems that come as a result of this, WFP (2020) states that *"If wasted food were a country, it would be the third-largest producer of carbon dioxide in the world, after the USA and China."* According to the Ellen Macarthur Foundation (2019), a wide range of actions are needed to reduce the amount of food thrown away, such as making the most out of the food produced by for example using inedible food to create bioenergy or producing more food closer to where it is actually consumed - that is to act in a more circular manner.

To make the production, distribution, and consumption of food more sustainable, there is an urgent need to move from linear consumption modes towards acting in a more circular manner (Ellen MacArthur Foundation, 2017). Within the concept of circular economy, designing out waste and preserving resource value for as long as possible is of essence (Romero-Hernández & Romero, 2018). One way of approaching circularity is through reconfiguration of logistic systems to increase redistribution and reuse of lower value material, which, in a linear model would be considered as waste and be discarded (Bocken et al., 2015). Adapting this way of consumption makes it possible to decrease human impact on the climate as well as on finite resources (Orjuela-Castro, 2017).

In Sweden, where this study is being conducted, approximately 100 000 tons of food are thrown away from retailers every year (Swedish Environmental Protection Agency [EPA], 2018). Many retailers take initiatives to reduce the food thrown away to enhance sustainability, including both environmental impacts but also cost savings (Eriksson et al., 2014). Other initiatives to decrease the amount of food that is discarded are independent organizations, such as Karma and ReSvinn, acting to make use of the food that otherwise would have been thrown away by the retail sector. In the initiatives where the food needs to be transported in order to be used, it is of great importance to design sustainable redistribution systems to help reduce the surplus food.

1.2 Purpose

The aim of this study is to evaluate and compare important parameters for sustainable redistribution systems striving to rescue food that can no longer be sold. The comparison of the parameters will be made regarding their contribution to the resulting net climate impact on the environment from rescuing the food.

In this multiple case study, qualitative factors are also taken into account, providing a general framework of potential success factors for the implementation of future redistribution systems. By performing a multiple case study on eight different tests for food redistribution in Sweden, and analyzing the environmental impact of transport in the context of circular economy, the intention is for the resulting comparison between the tests to provide a general framework for future implementations of redistribution systems.

1.3 Problem analysis and Research Questions

As presented above, the aim of this study is to construct a general framework applicable to a wider range of logistic solutions for the redistribution of food. This framework will provide a useful assessment for future setups as to if the implementation actually will have a small enough negative climate impact compared to the positive impact derived from keeping food in the system and limit the need for resource-intensive production.

The development of this general framework gives rise to two main sub-problems, including both quantitative and qualitative aspects. First of all, the parameters to be assessed and compared from a quantitative point of view must be representative of what actually impacts the environment the most in a redistribution system. A further problem arises when calculating the climate impact for circular flows when using already existing transport systems, for example when using milk runs to redistribute the rescued food. When using transports that would otherwise return empty, consideration will have to be taken to whether the climate impact assigned to the rescued food corresponds to for example the extra distance traveled, a percentage calculated from its weight, or the total climate impact from the return transport.

The second problem regards the obstacles and opportunities arising from the qualitative aspects of a redistribution logistics system. Thereby, an analysis regarding which of the qualitative aspects matter the most for good collaboration becomes pertinent. In Sweden, approximately 100 000 tons of food are thrown away from retailers every year. However, these 100 000 tons amount to a fairly small quantity per store on a daily basis. It is also important to consider that some of the food saved will not be edible, which can potentially reduce the amount of food that can be redistributed and further used. A solution to make the relatively small amount of daily surplus food worth the effort of redistribution could be to rearrange the frequency of the pick-ups. With less frequent transports, more weight could be co-transported and thereby reduce the emissions per kg transported food, but unfortunately, that also increases the risk of inedible food. Therefore, a relevant aspect is to find out if there is a limit where the amount of food thrown away is insufficient with respect to the environmental cost derived from rescuing it.

Based on the problem analysis above, the problem in question has been derived to an overall research question which can be further divided into three sub-questions:

1. Which parameters, alone or in combination with each other, contribute the most to the total climate impact, and what qualitative prerequisites are needed for the collaboration between the different parties to be environmentally beneficial?
    a. Which are the quantitative parameters to be compared and how can these parameters be optimally combined?
    b. How should the environmental impact caused by the transport be assigned to the redistributed food in cases of co-transport?
    c. What qualitative circumstances contribute to a beneficial setup of a future redistribution system?

1.4 Delimitations

This study is limited to Sweden and the food redistribution initiative ReSvinn established there. Delimitations that will be taken into account are consequently that the comparison will be limited to the eight tests that ReSvinn provides. The reason for this limitation is that these eight tests are the only ones up and running. Although narrowing the scope, using ReSvinn's tests help ensure homogenous performance and measurement of the tests. However, the tests are supposed to be different in ways that make it possible to compare them and draw conclusions about which factors contribute the most to reducing the environmental impact. Within the ReSvinn project, this study focuses on the redistribution part but not on changing consumer behavior. The reason for this focus is to enable more in-depth study of the selected subject.

Yet another limitation to the scope of the study will have to be made regarding what sort of food is being rescued. Rather than calculating the climate impact for every individual type of food, standard LCA values and averages of these will be used for larger categories such as ‘vegetables and fruit’ and ‘meat’. Due to the scope of the study being Sweden, LCA values for this region will be used. Furthermore, no consideration will be taken to what steps the groceries have gone through before reaching the store. That is, no difference will be made between vegetables that have been shipped in from a central warehouse in Italy to those originating from a local Swedish farmer. The stores in question will thereby be regarded as the starting point for measurements for all food rescued. This limitation is a consequence of the otherwise increased complexity resulting from performing LCA calculations for which established values already exist.

1.5 Structure

In section 2, the frame of reference is developed by using three different literature streams. There, circular economy is used as an umbrella concept, and together with literature on circular business models, it provides a basis for understanding the specifics of circular redistribution systems.

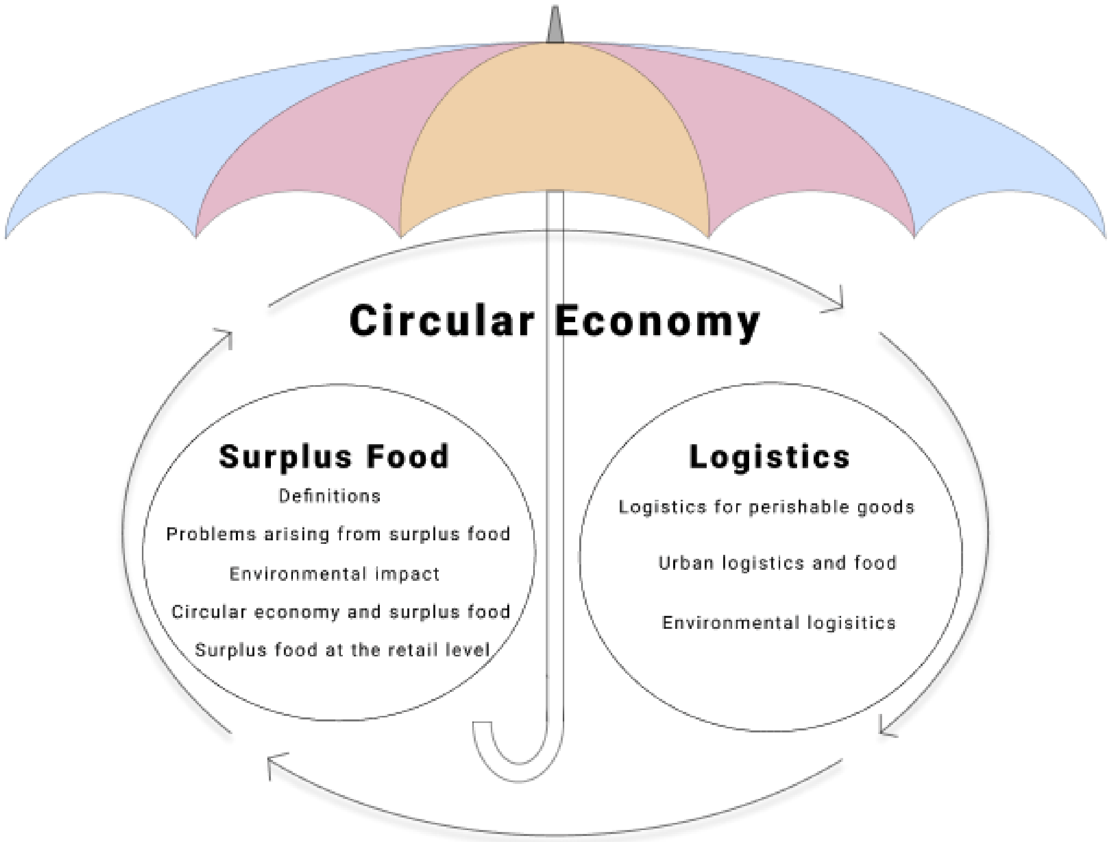
In the succeeding section 3, the approach of the study is presented together with the research context, i.e. the project ReSvinn with whom this study is in collaboration. The methods used to collect both qualitative and quantitative data are described, as well as the ways in which they are analyzed. In section 3.4 a data analysis is performed regarding how to calculate transport emissions, and in section 3.5, the research quality is discussed. Thereafter follow section 4, results and analysis, where the eight different tests and the results of the calculations are summarized together with standard LCA average values for different food types.

In section 5, a discussion is given, arguing for the varying importance of the factors derived regarding their impact when implementing redistribution systems. This section further discusses how to design future redistribution systems in an advantageous way, leading up to section 6 where a conclusion is presented. In this last section, ideas for further research are also given.

2. Frame of reference

In this chapter, the frame of reference is presented which will later form the foundation for further discussion and conclusions. As illustrated in Figure 2.1, this chapter provides an overview, and a problematization of food waste, as well as logistic systems, which are both permeated by the concept of the circular economy.

Figure 2.1, Illustration of how the frame of reference is structured



2.1 Circular economy and business models

According to Kirchherr et al. (2019), circular economy can be defined as “an economic system that replaces the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes”. The circular economy thereby largely differs from the traditional line of value creation, originating from the days of the Industrial Revolution (Bocken et al., 2016). Tendencies today, however, reveal the flaws and unsustainability of the take - make - dispose systems of the past centuries (Saritali, 2017).

Approaching the limits of finite resources, acquiring these resources is becoming ever more expensive and demanding and consequently, with a take - make - dispose approach to production and consumption, the resources will eventually become insufficient (Scheel et al., 2020). Kirchherr et al. (2019) introduce a taxonomy for slowing, closing, and narrowing the loops and argue for the difference in the terms ‘slowing’ and ‘narrowing’. Whereas ‘slowing’ implies making use of products for a longer period of time through, for example, reparations, while ‘narrowing’ refers to minimizing the use of resources within the production and restoration processes (Kirrchherr, 2019). To ‘close’ the circle, however, is about making the products go ‘from cradle to cradle’ and be of use to create new products in a circular manner, instead of going ‘from cradle to grave’ in the way products linear models does (McDonough & Braungart, 2002).

The Ellen MacArthur Foundation presents three principles that are at the base of a circular economy, being *Designing out waste and pollution, Keeping products and materials in use* as well as *Regenerating natural systems* (Ellen MacArthur Foundation, 2017). These three principles align well with what Sairatli (2017) presents to be the core ideas of Circular Economy which is “elimination of waste by design, respect for the social, economic and natural environment and resource-conscious business conduct”.

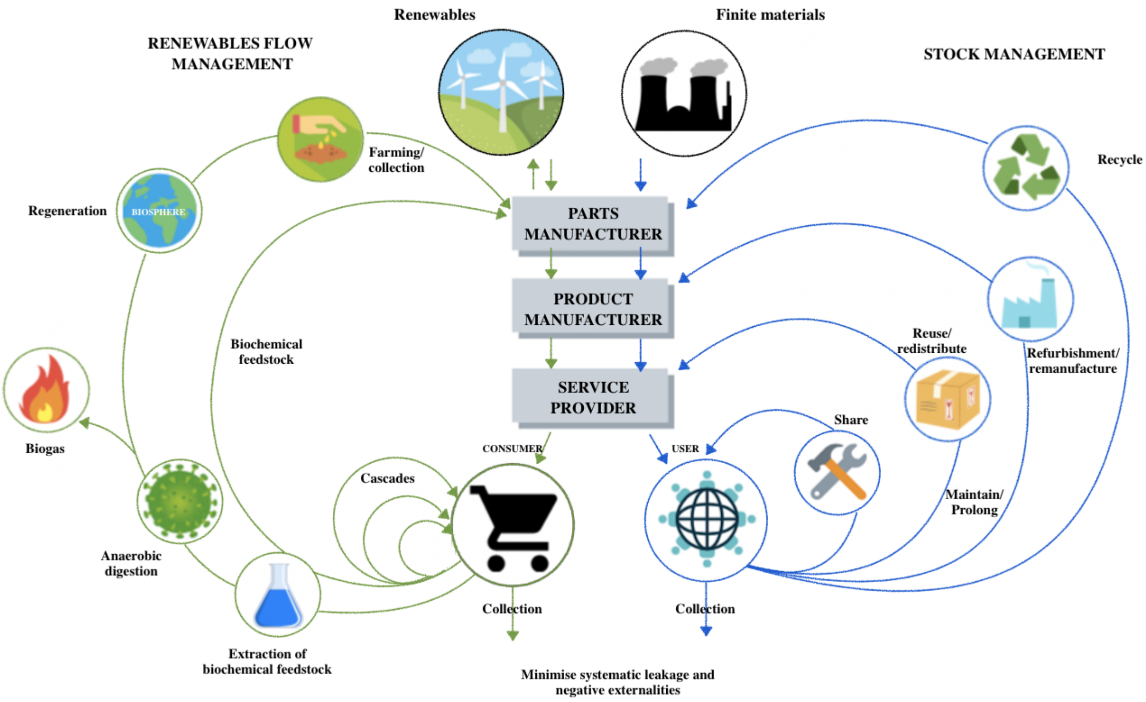
Other than offering a more sustainable and environmentally friendly approach to production and consumption, a circular economy also provides a possibility to promote efficiency along with productivity, reduce dependency on finite resources, and increase growth (Rizos et al., 2017). Schroeder et al. (2018) further argue for the relationship between the shift towards a circular economy and the achievement of several of the UN Sustainable Development Goals.

The Ellen MacArthur Foundation (2017) presents the economic benefits of adjusting to circularity as being economic growth, materials cost savings, job creation potential, and increased innovation. They argue that the economic growth would be obtained from lower production costs resulting from more efficient material utilization, in addition to increased revenues due to new circular activities. Further, Horbach et al. (2015) present positive effects on employment as a consequence of applying circular thinking within businesses. These effects will to a great extent give rise to an increase in spendings due to lower prices as well as to the creation of new professions, increasing innovation, and the development towards a service-based economy (Horbach et al., 2015). Finally, replacing the linear system with a circular will require great creativity and innovation (Ellen MacArthur, 2017). As mentioned above, taking proper advantage of the changing conditions, the transition towards circular use and production can provide the possibilities of contributing to increased efficiency, increased revenue for businesses who take advantage of the opportunity, along with more sustainable use of finite resources (Swedish EPA, 2019).

The integration of circular economy into the business model should occur early in the design steps of a new product or a process since these are the stages where changes and adaptations can most easily be made (Kirrchher et al., 2017). Several different kinds of circular business models are encountered in literature and found as a common base is that these business models jointly offer a way for interpreting connections between companies and their environments as well as present opportunities for designing businesses in a more sustainable way with regard to their environment (Lüdeke-Freund et al., 2018). According to Bocken et al. (2016), a circular business model implies a model which accomplishes a positive outcome for the environment and the society due to the way the company and its associated network create and capture value. Mark Esposito (2015) of Grenoble School of Management introduces three principal approaches for companies to capitalize on circular advantages: reducing waste, servicing products instead of selling them as well as making the product last longer.

As previously mentioned, the Ellen MacArthur foundation argues that a circular economy is one that “seeks to rebuild capital, whether this is financial, manufactured, human, social or natural...”. In the spirit of “Cradle to Cradle” the Butterfly diagram (picture 2.2, Butterfly Concept), developed by the foundation, illustrates how different materials flow, the value-adding activities that are performed, and suggests approaches for capturing value from waste (Ellen MacArthur Foundation, 2019). Included as an essential part of this model are the different bicycles where organic waste and by-products are brought back into the economic system for further use. According to the Ellen MacArthur Foundation (2017), this waste is commonly viewed as expensive and as a problem from both an economic and an environmental perspective. They further reason that by reconfiguring logistic flows and business models, organic by-products can become a source of material rather than problematic waste. In this report, the main focus is on the left side of the model describing the flow management for renewables.

Figure 2.2 Butterfly Diagram - Image as described in “Growth within” (2015) - Ellen MacArthur Foundation and McKinsey Center for Business Environment.



The Butterfly Model could, in the context of food waste and losses, be applied throughout the whole supply chain and permeate it by an increased opportunity of capturing value. The environmental and economic savings that could be achieved with such an approach are of great importance, as well as the prevailing global ethical problems with some people starving while others discard food.

2.2 Surplus food

The following section is introduced by defining and differentiating surplus food, food waste, and food losses before providing information about what problems, both ethical, societal, and environmental, arise due to the overproduction of food. The overproduction leads to the concept of circular economy in the context of surplus food and thereafter follows the current situation of food wastage at the retail level of the food supply chain.

2.2.1 Food losses, surplus food, and food waste

There is no definition of food waste widely agreed upon - it differs between different institutions and countries. According to the Food and Agriculture Organization of the United Nations (FAO, 2011), food waste is defined as the food thrown away in the latter stages of the supply chain, including retail and final consumption. Further, food losses are defined as the decline of edible food in the early stages, such as post-harvesting and processing (FAO, 2011).

In this study, however, the definitions of food waste and food losses will from now on refer to the definition provided by the Swedish Board of Agriculture (2021). Food waste is here defined as food that has been produced with the purpose of being consumed by people, but for various reasons is not. Food losses are defined as the food lost before production, for example, potential food discarded before harvest, animals that are killed but could have been eaten, or fish that is thrown back into the sea dead (Swedish Board of Agriculture, 2021). Further, the distinction between the terms food waste and surplus food is important and according to Helgadóttir and Jónsdóttir (2019), surplus food is often incorrectly referred to as food waste. The definition of surplus food is the food produced beyond our nutritional needs (Papargyropoulou et al., 2014), and thereby food waste is a subset of surplus food (Helgadóttir & Jónsdóttir, 2019).

As described in section 2.1, The Butterfly model presented by the Ellen MacArthur Foundation proposes ways to capture value from by-products in the food supply chain. Swedish EPA (2012) argues that some of the food that is lost or wasted along the supply chain could be used for other purposes instead, for example, be biologically treated, combusted, and transformed into heat or used as animal food. Despite that, it is still considered surplus or food losses as long as the original intention was to become human nourishment (FAO, 2011), and the biggest gain would have been obtained if the food that was intended to be human food but was never eaten by humans, would not have been produced at all (Swedish EPA, 2012).

2.2.2 Problems arising from surplus food

An important problem, whose size increases due to the overproduction of food, is climate changes arising from greenhouse gas emissions (Smith & Gregory, 2013). Steffen et al. (2015) present Climate Change as one of nine Planetary Boundaries, and argue that this boundary is crossed and currently in the zone of uncertainty. According to Watts (2018), the feedback loops that could be initiated by crossing this boundary can result in consequences such as the world becoming a “hothouse” with for instance increased sea levels. At this stage, Watts further describes the difficulties for humanity to anticipate the reactions of nature. Food accumulates its carbon footprint along the production chain and thereby, food wasted in the later stages of the food life cycle generates a much larger impact on the environment than when it occurs in the early stages (FAO, 2013). Grocery stores are a part of the food life cycles’ later stages and are often one of the last steps before consumption. At this stage, the food has thereby been produced, transported, and sometimes stored in refrigerators before being thrown away, and all these activities cause greenhouse emissions to some extent (Swedish EPA, 2012). The disposal of food will thereby not only be an unnecessary waste but also contribute to worsening global warming, which is a very urgent concern (Steffen et al., 2015).

According to Poorse and Nemecek (2018), the carbon footprint created by the food supply chain is around 13.7 billion tonnes CO_2 equivalents per year, and that almost one-quarter of these emissions originates from food that is lost throughout the supply chain or discarded by consumers. The urgency and importance of this issue is emphasized by the UNs twelfth sustainable development goal for 2030, which aims to ensure sustainable consumption and production patterns. More specifically, target 12.3 is about halving the global per capita food waste, where reducing food waste and losses can help achieve this objective (UN, 2015).

FAO (2015) estimates that globally, food losses and waste corresponds to one-third of all food produced throughout the whole supply chain, which results in about 1.3 billion tonnes per year globally. Further, Stenmarch et al (2016) states that approximately 88 million tonnes of food are wasted in the EU-28 (European Union, including United Kingdom) annually, and according to Swedish EPA (2021), approximately 1.3 million tonnes of food are discarded throughout the whole food life cycle in Sweden every year, both avoidable and unavoidable disposal included. Around 67 000 of these tonnes arise at the grocery store and retail level (Swedish EPA, 2013). The wastage of food across the globe gives rise to not only economical and environmental problems, but also ethical concerns (Melikoglu & Webb, 2013).

The Swedish Environmental Protection Agency (2012) summarizes all these problems to what they call a market failure, i.e. a situation where the market fails to allocate the resources of the society in an optimal way from a societal point of view. This further leads to ethical problems with some parts of the world starving while others discard large amounts of food. According to the Ellen McArthur Foundation (2017), more than 800 million people across the globe currently suffer from hunger and starvation, while one-third of all produced food is discarded.

Another ethical issue is animal welfare. Barnhill and Civita (2020) states that every year, approximately half a billion sheep, 1.5 billion pigs, and 50 billion chickens are slaughtered with the purpose of becoming human food. Further, they describe that many of these animals are, while still in life, treated in ways that are considered inhumane by many ethicists and activists and conclude that less animal-source food waste would require fewer animals to live under such conditions.

Surplus food is not only related to food. It is also a big problem for water as a critical resource (FAO, 2020). The production of food consumes a significant amount of water resources and the disposal of already produced food would result not only in the loss of food but also in the draining of these critical resources. This becomes a vicious cycle where overproducing and wasting food only exacerbate the lack of freshwater. Water shortages and scarcity also affect food production in itself since freshwater is essential in agriculture and food production (Mancosu et al., 2015). To emphasize the importance of this issue, one in three people worldwide have no access to freshwater (UN, 2019), and goal number 6 of UNs sustainable development goals for the year 2030 reads "ensure access to water and sanitation for all" (UN, 2015).

2.2.3 A closer look into environmental impact from surplus food waste

The planetary boundaries, previously mentioned in section 2.2.2, focus on nine environmental areas that each have a limit which, if exceeded, can lead to unmanageable threshold effects for the environment. If humanity can manage to stay within the boundaries, both present and future generations can continue to thrive and develop (Rockström et al., 2009). One of these planetary boundaries is called "Biogeochemical flows" and includes the extraction and cycles of the elements Phosphorus and Nitrogen (Steffen et al., 2015). Both these elements are used to produce chemical fertilizers and have been identified as being in the high-risk zone for the planetary boundaries (McConville et al., 2015), which means that the risk of causing large-scale, sudden and irreversible environmental changes increases (Rockström et al., 2009). Although chemical fertilizers, in combination with pesticides and irrigation, have been contributing factors to increased productivity of food production since the 1950s, alternative approaches must be considered to cope with the current global environmental situation (McConville et al., 2015).

Food waste generates about 8% of the total greenhouse gases (GHG) created by humans, which is almost as much as the second-largest contributor, namely global road transportation, the contribution of which stands for 9.2% (Scialabba, 2015). Disposal in landfills has one of the greatest impacts on the environment caused by the disposal of food. This is due to the decomposition process emitting methane and carbon dioxide, which are GHGs that contribute to global warming (Papargyropoulou et al., 2014).

To summarize, the earlier stages of the production are also contributing to environmental impact and the environmental impact is related to the life cycle stages of the food before it became waste (Papargyropoulou et al., 2014). As goods are moving through the supply chain, their accumulated carbon intensity increases as a direct consequence of activities performed on the product along the supply chain. Consequently, food waste in the early stages has a lesser carbon footprint (Scialabba, 2015). The distribution phase where retailing is included, and where the main focus of this study lies, i.e all the activities included between the processing to the consumption, corresponds to 15% of the total food waste throughout the supply chain based on weight, while the corresponding carbon footprint for this phase amounts to almost 20% (Scialabba, 2015).

Different types of food leave different carbon footprints due to being different in their carbon concentrations. For example, the share of the total food waste being meat is only about 4% compared to vegetables with a share of 25%. However, meat is responsible for 21% of the total carbon footprint from all wasted food, while vegetables stand for 22% (Scialabba, 2015).

2.2.4 Circular economy and surplus food

Composing the Sustainable Development Goals, the United Nations formulated goal number 2 to be ‘zero hunger’ which is to be implemented by, amongst other things, profoundly changing agricultural productivity. Further, the third target of SDG number 12 (to ensure sustainable consumption and production patterns) was defined as 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, 2015).

Applying the circular economy principles reduce, reuse and recycle to food can be summarized as reducing the amount of food that is lost as waste, reusing by redistributing excess food and recycling food waste, resulting in the creation of value in the form of by-products such as biogas (Jurgilevich et al., 2016). FoodDrinkEurope (2020) distinguishes between the different parts of recovering food by developing a “Food Recovery Hierarchy” with source reduction and reuse as the most preferable hierarchical level and landfill/incineration as the least preferred. The hierarchy further illustrates the different levels at which food waste can be reduced or prevented in the value chain of agri-food. Examples of such preventing activities are improved logistics, more efficient storage, turning waste into by-products such as energy or fertilizers as well as aiming to increase the general knowledge regarding the subject (FoodDrinkEurope, 2020).

There are many examples internationally of initiatives aiming to make food production, logistics, and consumption more sustainable (Morganti & Gonzalez-Feliu, 2015). One such initiative is the European Commissions' Farm to Fork Strategy (2020) which strives to speed up the adoption of sustainable food systems across Europe and, as a consequence, mitigate climate change. Further long-term effects from the project are thought to be, maintained biodiversity, ensured supply of nutritious and sustainable food to everyone, as well as promoted competitiveness within the EU. The Farm to Fork Strategy (2020), presents the main targets for reaching these goals as being sustainability within food production, sustainability within food processing and distribution, and sustainability within consumption as well as preventing food loss and food waste. Further, PACE (2021) reasons that it is essential for governments, businesses, and civil society to cooperate for this transition towards a circular food industry to be possible.

The Ellen MacArthur Foundation (2019) elaborates on the idea of cooperation and defines the areas in which the different actors need to take responsibility. They argue that governments possess the opportunity to facilitate via creating national or regional visions, implement policies, provide practical support and incentives, engage with stakeholders as well as enacting legislation. The industry in turn has the possibility to reduce, reuse, recycle, and thereby mitigating the waste throughout the agri-food supply chain. Finally, society plays a catalytic role in the transition towards a circular economy and should, according to the FAO (2017), aim to produce locally and in a regenerative manner, producing healthier products and finally making the most of the food produced.

Currently, biogas production is the most commonly used method for making the food industry more circular (Al-Wahaibi et al., 2020). In Denmark, Norway, Sweden, Finland, and Iceland, 22% of all food waste becomes biogas which can be compared to the 30% that is still being incinerated and the 12% which is composted (Mycorena, 2021). There are several ways to complete the circle and use food waste to create energy. A broad distinction can be made between biological and thermochemical courses of action respectively (Pham et al., 2014). By using biological waste-to-energy technologies, biogas or bioethanol can be made whereas heat, electricity, bio-oil, char, or gas can be made using thermochemical methods (Pham et al., 2014). The various end products differ in environmental as well as energy-economic aspects. In line with circular conduct, the strive should be to find and continue to develop methods with which the energetic value remains as high as possible but to an environmental and economic cost that is as low as possible (Pham et al., 2014).

In terms of energetic value, bioenergy can be seen as one of the last resorts (Papargyropoulou et al., 2014). In the spirit of circular economy and closing the loops in the food supply chain, the strive should primarily be to make full use of the product - that is, use the food for direct consumption. The utilization of food on a high level of energetic value can most easily be achieved by implementing logistic systems for redistribution at the retail level.

2.2.5 Surplus food at the retail level

Stores are characterized both by being located in the later stages of the food supply chain and by collecting large amounts of food to limited physical spots, which makes them potentially beneficial for measures of waste (Eriksson, 2015). Compared to the waste or losses in other parts of the supply chain, the waste in the retail stage contributes with the smallest share. The numbers for the surplus food in the retail sector in Sweden vary substantially depending on when the measurements were done and how they were performed. Swedish EPA (2016) estimated the food discarded in stores in Sweden during 2016 to be 30 000 tons, and two years later, new methods for measuring were applied and the estimates for 2018 point at 100 000 tons were being wasted in Swedish stores. This high variance indicates the insecurity in the existing estimates, and also the complexity of measuring amounts of surplus food in different stages of the supply chain (Swedish EPA, 2020). The insecurity and high variance are, for instance, due to the fact that neither packaged food nor products with a return system to the wholesaler are included in these numbers (Eriksson & Strid, 2011). The food waste from stores most commonly arises due to best-before-date, which occurs because of reasons such as misjudgment when ordering, irregular buying patterns of customers, or that the store prioritizes a broad assortment over actually selling every item to be able to build up a stable customer base (Swedish EPA, 2020).

The Swedish government has decided that the proportion of initialized food production that reaches the stores and consumers shall increase but has also set a milestone that the total food waste in Sweden should be reduced by a minimum of 20% by weight per capita from 2020 to 2025 (Swedish EPA, 2020). The biggest source of waste in stores in Sweden is by far perishable goods (Eriksson & Strid, 2011), and Lagerberg F. et al (2011) suggests several measures to lessen these, including “Tidiness and order in the storage space and in the sales area”, and “Use of foodstuffs at risk of being wasted to produce ready to eat meals”. Vegetables and fruits are by far the most discarded categories in Swedish stores if measured by weight and cost (Eriksson & Strid, 2011). Scholz et al (2015) measured the wastage share, in weight, of fruit and vegetables to be 85%, while the meat was responsible for 3.5%. However, when converted to carbon dioxide equivalents, the environmental impact from meat results in being almost as high as for fruit and vegetables (Scholz et al., 2015). There are various reasons why food waste occurs and according to Lagerberg F. et al (2011), a combination of measures together with letting the awareness of the issue permeate the business usually is the best way to go about reducing this amount.

Campaigns on selected items are a significant reason for food waste in stores (SLU, 2013). When promotional items are sold cheaper than usual, the sales of similar products tend to decrease and therefore become waste. Other contributing factors to food wastage in the stores are fresh fruits, vegetables, and meat. Normalizing and promoting the consumer to buy these products frozen would help reduce this type of waste (SLU, 2013). A third reason a lot of food is discarded in the retail sector is that the consumers’ buying behavior is hard to predict, and thereby it is hard to order the right amount of food and a common consequence of this is the so-called Bullwhip effect (Mena et al., 2011). The Bullwhip effect describes how small changes in customer demand are amplified throughout the supply chain, leading to small changes in customer behavior having a large effect on the supply level which makes it hard to predict the scope of the logistics system (Jonsson & Mattsson, 2019).

2.3 Logistics for redistributing food

In the following section, transport solutions will be elaborated on within the scope of circular economy and the redistribution of perishable food. Different solutions will be explored in the context of last-mile logistics, sustainability, and environmental externalities. Finally, an evaluation of logistic systems will be presented in the context of their emissions.

2.3.1 Logistics for perishable goods

Designing effective and sustainable logistics systems is always a challenge, but this task is made yet more arduous when distributing perishable goods, including fresh food and produce (de Keizer et al., 2017). One of several problems concerning the last-mile distribution of perishable goods is the relatively poor prospect of consolidation. However, due to the complexity of the challenge, Morganto and Gonzalez-Feliu (2015) presents the payback of improving the delivery systems, if successful, as being a great conquest.

The risks associated with food perishability have a close connection to seasonality and contingent imbalances between supply and demand according to Orjuela Castro et al. (2021). Changes in demand and supply seriously influence logistic flows, seasonality results in varying perishability, and there is a constant transformation in the quality of the product from the moment it leaves the producer (Orjuela-Castro et al., 2021). This constant transformation results in losses being associated with the transport. Depending on the design of the logistics network, Orjuela-Castro and Adarme-Jaimes (2018) argue that different supply, storage, and distribution conditions will prevail.

Effective use of logistics enables coordination of supply, production, and distribution as a means to reduce these losses (Orjuela-Castro, 2016). For supply chains handling perishable foods, certain constituents are required for optimal preservation of the quality of the food and to minimize the otherwise subsequent losses (Orjuela-Castro, 2017). Niu et al. (2019) describe how the reconfiguration of a supply chain for perishable food needs to meet several different goals and according to Trisna et al. (2016), these goals are often in conflict with each other. Limitations such as product-specific handling, perishability and aims to shorten lead times increase delivery costs and increases the economic sensibility of the logistics system (Morganti & Gonzalez-Feliu, 2014). Further, as argued for by de Keizer et al. (2017), the decay of perishable products tends to vary between different product units. This lack of heterogeneity in the way that the product quality develops over time must also be taken into account. Finally, logistics costs and coordination problems increase with an increasing number of suppliers and buyers (Orjuela-Castro, 2017).

2.3.2 Urban logistics and food

In the world of today, where the focus on sustainability and the lowering of greenhouse gases and CO_2 is constantly intensified, Rossi et al. (2020) establish that sustainable freight methods, as well as activities within the field of perishable food logistics, have become a more frequently discussed matter. In the United States, Weber and Matthews (2008) estimate food transportation to account for 11% of the private food consumption emissions, a number which is even higher when observing perishable food products. As much as 50-70% of the carbon footprint of perishable products can be accredited to longer distance transportation (United Nations FAO report, 2013).

Approximately 50% of the population in the world is currently living in cities and this number is expected to increase to 68% in the coming 30 years (Faccio & Gamberi, 2015). By 2050, the United Nations (2019) estimates that almost 6.8 billion people will be living in cities, resulting in approximately 80% of the total food consumption taking place in urban areas (Ellen MacArthur Foundation, 2017). The increasing part of the population living in cities instead of in closer proximity to where most of the food is produced will result in higher demands on effective urban distribution systems (Morganti & Gonzalez-Feliu, 2015).

Morganti and Gonzalez-Feliu further argue that the current logistic inefficiencies can be derived from three factors. The first factor is that the deliveries of perishable food products are made more frequently but in smaller parcels compared to other goods. Secondly, the recipients are relatively widely spread, and lastly, wholesales, suppliers, and shopkeepers engage in a significant amount of informal distribution operations. Several studies (Anderson et al., 2005;

Dablanc, 2007) points to the inefficiency of urban logistics and its effect on emissions, pollution, and congestion.

The impact of inefficient logistics systems on the environment is increasing due to trends in supply chains such as just-in-time-delivery which results in a lesser degree of co-transportation and an increase in vehicles running empty (Faccio & Gamberi, 2015). From a logistics point of view, the last mile is the most costly, inefficient, and environmentally harmful part of the whole chain according to Gevaers et al. (2009). During the last couple of years, however, the change in consumer behavior has disrupted the traditional last-mile supply chains for food and perishable goods (Guthrie et al., 2015). The changes in behavior and demands call for, amongst other things, shorter delivery times and cost-effectiveness which requires more integrated supply chains which link the different actors as well as the inventing of sustainable logistic strategies (Melkonyan et al., 2020). At the same time as the demand for just-in-time deliveries increases, demands are also growing concerning environmental issues (Liu et al., 2013). Although customers are becoming increasingly aware of the environmental impact of transport and deliveries, Reinhardt et al. (2009) claim that last-mile delivery is often overlooked.

The inefficiency due to lacking possibilities of consolidation, widespread customers, and the perishability of goods have resulted in the efficiency potential of the last-mile logistics not being met (Morganti & Gonzales-Feliu, 2015). As mentioned in section 2.2.2, the Swedish EPA (2012) points out the deficiencies in several of the stages of production, refinement, and handling of food as being a market failure. They argue that the environmental damage posed upon society as a consequence of the way that we currently produce food is not included in the price for the final product when sold in stores. Insufficient pricing of environmentally demanding products leads to increased consumption and, in the longer run, to increased climate damage (Swedish EPA, 2012). To be able to handle the imminent environmental threats, these market failures must be corrected for and according to The Swedish EPA (2012), such adjustments could help society save resources.

Yet another reason for inefficiency in logistics systems for food is the higher operational and environmental costs due to cold chains and storage of the perishable goods add to the complexity of the last-mile logistics system of perishable goods (Harrington et al., 2016). According to Melkonyan et al. (2020), the development of integrated distribution channels between the key actors, synchronization of private and public marketplaces as well as the creation of sustainable logistics strategies is needed to achieve sustainable last-mile logistics. Whereas eco-logistic solutions are being implemented across Europe (Faccio & Gamberi, 2015), there is still a long way to go and, in the words of Isaac Hellemn, Brand manager at P&G, "The last mile remains the biggest challenge both economically and ecologically … " (Bring, 2019).

A common way to tackle the challenges of last-mile logistics in cities is by using the so-called milk runs (Arvidsson, 2013). Brar and Saini (2011) explain that milk runs are characterized by the transport vehicle collecting goods at one or multiple different locations and delivering them to multiple destinations. Further, they elaborate that co-loading in this manner lowers emissions by transporting multiple shipments at once, thereby lowering the total distance driven while maintaining a high fill rate. While laudable, this efficiency does make attributing emissions to one specific shipment of goods more troublesome (Kolb & Wacker, 1994). There are two established ways to perform this calculation. In both cases, the emissions for the entire milk run are first calculated, then, when using the first method, each shipment gets attributed emissions according to the percentage of the total transported weight it constituted (Brar &

Saini, 2011). Using the second method, emissions are attributed according to the relative direct transport emissions of the various shipments (Jönsson et al., 2018). That is to say, if a milk run consists of two shipments which would have 30 kg CO_2 and 20 kg CO_2 emissions respectively using direct transport then the first would be attributed 60% of the milk runs emissions and the second would be attributed 40%.

2.3.3 Environmental logistics

Environmental logistics is the practice of taking environmental externalities into account when planning and executing logistic operations as opposed to traditional logistics where monetary efficiency is the primary concern (Seong-Tae & Chul-Hwan, 2011). Public concern for the environment has been steadily increasing in the latest decades which has led to environmental logistics becoming ever more prominent (Rodrigue et al., 2017). Despite this, all too few companies take minimizing environmental impact into account when planning their logistical activities, rather they focus their efforts on improving monetary efficiency (Rodrigue et al., 2017). These efforts do sometimes lead to increases in both environmental and economic efficiency, such as with better route planning, but in other cases, they are in a direct contest, such as when choosing different fuels (Seong-Tae & Chul-Hwan, 2011).

Barthel et al. (2010) argue that by rescuing food which would otherwise have been discarded, there are potential environmental gains to be made. They expand on this by clarifying that additional transportation is required for redistribution to be practically accomplished and that it has to be accounted for when deciding on a transport solution. In the traditional distribution of food, large amounts are transported from producers to wholesalers, and finally to local stores (Helo & Ala-Harja, 2018). With this distribution system, large quantities are aggregated in every step allowing for both economic and environmental efficiency by achieving high fill rates with regular transports negating the problems of perishable goods (Helo & Ala-Harja, 2018). Therefore, traditional distribution methodology achieves high efficiency leading to relatively low emissions per kilogram of food being caused by transportation (Ntinas et al., 2017). Local redistribution systems contrarily are characterized by being smaller scale and thereby potentially causing greater emissions from transportation because a high fill rate in large vehicles is unattainable with small flows of perishable goods (Morganto & Gonzalez-Feliu, 2015). Cristóbalm et al. (2018) argue that increasing the magnitude of redistribution is undesirable as well because it is environmentally better to not produce the surplus food than to redistribute it. Because of this inefficiency in local redistribution systems, it becomes relevant to evaluate that the redistribution will not contribute to more emissions than to produce the food anew and distribute it with more efficient transportation.

Andersen (2007) explains that making the economy more circular requires additional transports which have a negative effect on the environment and consequently, the climate effects of the additional transports are important to consider when evaluating redistribution. Boriboonsomsin and Barth (2009) discuss the fact that climate effects of additional transports include CO_2 emissions as well as increased congestion of roads and other transport infrastructure. Increased congestion, though outside the scope of this study, is an important issue to consider when planning for the entirety of society to become more circular as it lowers the efficiency of all transports which in turn worsens emissions. CO_2 emissions can be calculated with the parameters of transportation (Evans, 1978).

Fuel consumption is dependent on the vehicle used, the distance driven, and the speed (Evans et al., 1976). Vehicle manufacturers make fuel consumption by distance driven for their models easily available online, but it is heavily affected by the vehicle speed. In turn, the vehicle speed is determined by speed limits on the road, the traffic situation, and driver behavior (Evans, 1978). Speed limits on the route used and traffic situation can be determined by collecting data on what type of roads (rural, highway, or inner-city roads) the route uses as well as what time the transport occurred. Driver behavior on the other hand is much harder to account for and has a much smaller effect compared to other factors and as such will be omitted from the calculations performed in this study (Evans, 1978).

Klug and Muhl (2016) present the problem with calculating the distance driven with transport using co-loading and moving goods to multiple locations. They further elaborate that in cases where the same route is used every day a definitive positioning distance can be added to the route to account for the extra distance driven. Arvidsson (2013) explains that a different method should be used when a concrete distance is not available, where the percentage of the emission of the total milk run is considered as opposed to the percentage of every separate distance of the total milk run. To solve this, a template value presented by Brar and Saini (2011) is used to adjust the direct distance for the route and while it is not exact to the particular route it gives a good approximation of the effect of the average milk run.

Carbon dioxide emissions of different fuels are provided online by both government agencies and private organizations. Hee Suh (2019) explains that as a result of modern fuels being used by transportation firms, additional calculations on the CO_2 emissions data, collected from government and private agencies, are often necessary. Further Hee Suh (2019) describes that this is due to the fact that many modern fuels are usually blends of various levels of biofuel. According to Demirbas (2007), these biofuel blends are characterized by having part of it come from renewable sources, most common being soybean oil, and thereby releasing less CO_2 coming from non-renewables.

2.4 Synthesis

As illustrated in this section, surplus food is a major problem made all the more pertinent due to how many people are living in famine, and how the limits of the earth are being strained. Currently, there is more food being wasted than what is needed to feed those who are starving. There are many ways in which this is being attempted, one of which is using circular economic business models to redistribute surplus food. Redistribution of food is more complex than most other types of redistribution because of the goods being perishable by nature. Therefore, it requires more frequent transportation, often leading to smaller quantities being transported which, in turn, can lead to a net increase in CO_2 emissions compared to if new food was produced. Carbon dioxide emissions from transportation depend on a number of different factors, therefore this study aims to analyze different setups to calculate which ones have a positive impact on CO_2 emissions and what factors should be considered when establishing new redistribution setups.

Figure 2.3. Simplified and diagram showing traditional, linear food supply chain - Image inspiration from the original diagram - Source: Livsmedelssvinn i butiksledet - en studie av butikssvinn i sex livsmedelsbutiker (Report 035). (2011) Eriksson, M., Strid, I. Department of Energy and Technology, Uppsala.

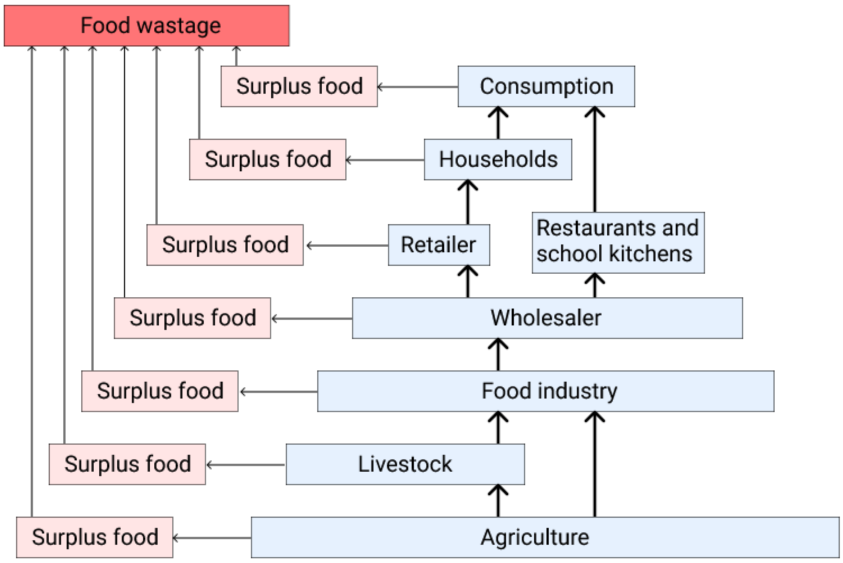
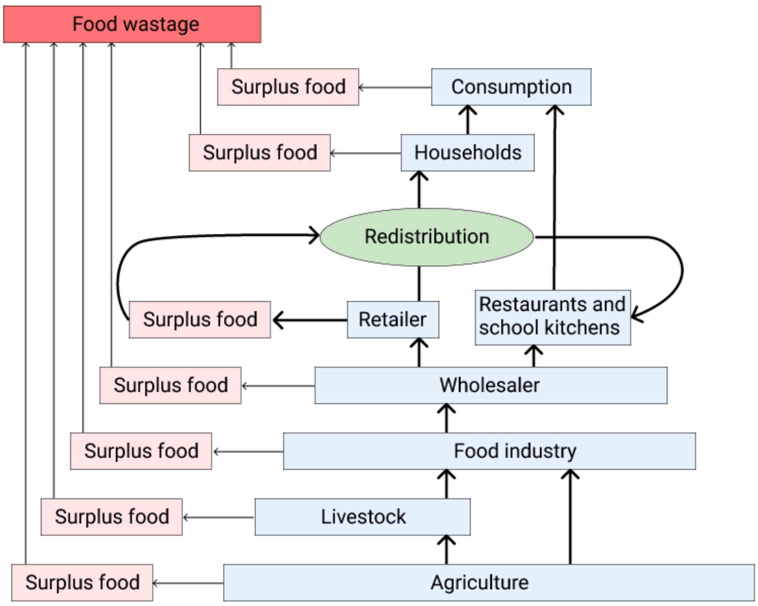


Figure 2.4. Simplified diagram showing the circular approach of the retail stage in the food supply chain - Image inspiration from the original diagram - Source: Livsmedelssvinn i butiksledet - en studie av butikssvinn i sex livsmedelsbutiker (Report 035). (2011) Eriksson, M., Strid, I. Department of Energy and Technology, Uppsala.



The linear and more traditional food supply chain is shown in figure 2.3 above, where all the stages from agriculture to end consumer and disposal are shown. The focus of this study starts in the box for retail in picture 2.3. However, the target of this study is to encourage circular models in the context of food production. Thereby, the extended version shown in figure 2.4 indicates the focal point of this study in the supply chain, and also expresses the need for new, innovative business models, which was discussed more in-depth in section 2.1. As pointed out in section 2.2.4, food accumulates carbon footprint intensity along the supply chain, and since ‘Retailing’ and ‘Catering and Restaurants’ appears close to the end, the environmental benefits that could be achieved by redistributing food otherwise discarded at this stage are of great importance.

3. Methodology

This study is a multiple case study with eight tests that were analyzed and compared. The study was based on both quantitative and qualitative research. Case studies can both compile much information and clarify patterns and are often used when analyzing an already given case.

3.1 Research design

This study compared eight tests implemented by a Swedish food redistribution initiative to get a deeper understanding about redistributions systems, therefore a multiple case study seemed suitable. Case studies allow for both effective compiling of information and for clarifying patterns, often used with a previously given case (Eriksson & Wiedersheim-Paul, 2008). Yin (2003) explains that a multiple case study opens up the ability to understand the similarities and differences between the different cases, it also opens up the ability to compare the data both between and within the cases. The goal is to discover similar findings within the multiple case study (Yin, 2003). Yin (2014) further explains that a case study is an examination of an event in its real situation. Since this study was based on already provided cases, where the goal was to compare factors between the cases, a multiple case study was the logical choice.

This study used an abductive angle. The groundwork was mainly built upon both interviews and literature and from there a hypothetical pattern was formulated. As per Patel & Davidson (2019), abduction is a combination of induction and deduction. They continue to describe how the method will alternate between collecting data and formulating a hypothesis, to finally result in a more generalized theory. According to Dubois and Gadde (2002), using abduction in a case study requires that the researcher continuously shifts between the work with theory and empirical observations to develop an overall and integrated understanding. In this study, the literature and interviews were performed simultaneously and if there were questions stemming from the literature, it was possible to conduct more interviews in a later phase to receive the desired information. Contrarily, results from the interviews also led to further literature being consulted in areas previously not explored.

Eisenhart (1989) also describes that the research in a case study often is based on multiple kinds of sources. Qualitative and quantitative data can complement each other and together result in a broader perspective (Eisenhardt, 1989). Data and information in this study were collected from interviews, questionnaires, and literature, and therefore, once again, performing an abductive multiple case study, seemed appropriate.

3.2 Research context

This study was conducted in Sweden where there are several projects aiming to reduce food waste. Lagerberg F. et al. (2011) states that the most effective way of decreasing food waste from stores is to use a combination of several methods and by using well-established routines, as well as engaging the staff to make the waste visible for them, the waste can decrease.

Stores can use preventional methods or take care of the food that still is good enough to eat but not to sell. Food products that are approaching their expiration date could be sold on a secondary market or be given to charity. Moreover, stores can use the food that can no longer be sold but is still edible for cooking in a restaurant or café in the store. One example of this is a supermarket at Liljeholmen that takes care of fruit and vegetables that can no longer be sold and uses it in the kitchen of the store to make smoothies, juices, and prepared lunch boxes (Ica

Gruppen, 2021). A different approach that can be used by stores is to receive help with marketing to facilitate and make it cheaper for the customer to buy food that does not hold the measure for being sold but still is edible. For instance, Karma is a Swedish project that provides an application for connecting stores and restaurants with customers and offering the customer to buy surplus food at a lower price (Karma, 2021).

The ReSvinn project, which was established in 2018, aims to redistribute food that has been sorted out by wholesalers and grocery stores and is no longer sellable so that schools and restaurants can make use of it (ReSvinn, 2021). To understand how effective redistribution systems can be implemented, the ReSvinn project is currently running different tests and evaluating various aspects. One of these aspects is testing different logistic solutions that are connecting the different actors. On their webpage, ReSvinn describes that one of the greatest problems with a long-term and functional system is to establish a stable, sustainable logistic system that is also cost-efficient (ReSvinn, 2021).

The tests utilized in this study are trial logistics systems established with recipients of surplus food, such as restaurants or schools, and sources of surplus food, such as supermarkets, as well as the transporters moving the food between them. This study has taken into account eight tests conducted by ReSvinn located in Gothenburg, Stockholm, and Skövde, utilizing different transporters and recipients.

Originally, the ReSvinn-project works with eleven tests but in this study, only eight have been inquired into. The reason for not including all tests is that some of them have not yet started and furthermore, a few of the tests have completely different logistic chains than the ones included in this study and thereby, making a valid comparison would not be possible. The tests are more thoroughly described in sections 4.1- 4.8.

In the following parts of the study, the tests are called Test 1 through 8 considering the companies involved in the project are anonymized. Test 1 consists of three different stores where the transporter takes different routes called 1a, 1b, and 1c. Similarly, Test 7 is divided into two parts called 7 part 1 and 7 part 2 due to the fact that the transporter uses different vehicles during the redistribution/transportation.

3.3 Data collection

The data collection is divided into primary and secondary data collection due to different kinds of sources being used. The primary data collection consisted of different kinds of meetings together with related actors in the tests and people working with redistribution systems. The secondary data was collected through already published studies, as well as from ReSvinn since they already had collected important data.

3.3.1 Primary data collection

The primary data collection consisted of both quantitative and qualitative data, collected through semi-structured interviews with the transporters, stores, and schools. Patel and Davidson (2019) state that semi-structured interviews are often used together with abductive research. The purpose of the interviews was to gain knowledge about the logistics in the project and the parties experience of the collaboration with ReSvinn in addition to how they think that the collaboration can develop in the future.

For a semi-structured interview, the interviewers create an interview guide with all topics that he or she wishes to get answers to (Bryman and Bell, 2015). Also, the interviewer can ask follow-up questions in response to what the interviewee replies. An interview guide was made for use during all the interviews. Some questions were altered or added if the question only concerned a specific case. The interview template used in the interviews can be found in Appendix A. The questions for the interview were formulated in a comprehensible way and relevant to the respondent, according to the course of action proposed by Bryman and Bell (2015). Technical terms or advanced words were therefore avoided in the interview guide to ensure that every respondent understood the question and to minimize the risk of misinterpretation. The questions regarding the parameters from the interview guide were sent to the interviewee before the interview so that he or she got the chance to prepare answers for these beforehand.

In most cases, one person from every test was interviewed since it was enough to get all the information needed. One person from the transporting company was interviewed for most of the tests. For each category of receivers (one school, one preschool, one restaurant, and one store), one person was also interviewed. The roles of the people interviewed and which test they represent are compiled in Table 3.1. In total eight interviews were conducted for the study.

Table 3.1. Summary of meetings.

Actors	Number of attendants	The roles of the attendants	Format
Transporter/Restaurant Test 1	1	Founder, CEO, and customer manager	Online interview
School Test 2	1	Project manager	Online interview
Transporter Test 2	1	Environment and quality manager and Teamleader Thermo	Online interview
Transporter Test 3	1	Project manager	Online interview
Transporter Test 4	1	COO	Online interview
Store Test 4	1	Project manager	Online interview
Transporter Test 6	1	Project manager	Email
Transporter Test 7	1	Environment and quality manager Thermo	Online interview and email
Transporter/store and school Test 8	2	Store manager and project-and food manager	Online meeting
ReSvinn project	More than 15	Several involved actors in the Resvinn project	Workshop online
ReSvinn, PostNord	3	ReSvinn - project manager. PostNord - sustainability and environmental specialist	Online meeting

The interviews were conducted via web meetings and lasted between 20 and 30 minutes. On the one hand, web meetings are more flexible and time-saving compared to meeting face-to-face, but on the other hand, there is a chance of technical problems when relying on the Internet for an interview (Bryman and Bell, 2015). Since the transporters were based in different cities together with the fact of the Covid-19 pandemic, web interviews were preferred over meeting face-to-face. Two members of the group were present for all the interviews. One of the interviewers asked the questions and the other one took notes. Both members asked follow-up questions if they thought of something during the interview. The same two members from the group performed all the interviews together since two interviewers that work well together conduct better interviews (Trost, 2010). Another reason is that two people can discuss their interpretation and compare their impressions afterward. Bryman and Bell (2015) mention that two interviewers rather than one, can contribute to a more informal atmosphere and make the respondent feel like it is a discussion rather than an exchange of information. Three of the interviews were conducted together with ReSvinn. In these interviews, the interviewees were schools, preschools, and stores which are the receivers in the project.

The interviews were not audio-recorded due to technical problems during the first web meeting. Since two interviewers conducted each interview and the interviews were short, just taking notes was considered sufficient. Moreover, the main purpose was to collect data about the tests, therefore the interviewer had time to write down the answers during the interviews. Trost (2020) points out the importance of taking notes during the interview and adding personal notes immediately afterward so that nothing gets forgotten. The personal notes may consist of preliminary interpretations, incidents, or irritation. Bryman and Bell (2015) mention that if the interview generated new questions of interest the interviewer should note these questions as well. Accordingly, the interviewers reviewed the notes and made additional notes of things that arose under the interview. If some answers were incomplete or there was a possibility that an answer could be misunderstood, an email with follow-up questions was sent. The interviews were conducted in Swedish because it is the native language for both the interviewers and the interviewees. After the interview, the notes were translated to English before the data was analyzed.

Two of the companies in the project could not conduct the planned interviews via web-meetings. For this reason, to get answers from all the transporters from the different cases, questionnaires were sent to them via email. An advantage of using a questionnaire is that they are easier to administrate, and they give the interviewees the possibility to answer when he or she has the ability (Patel and Davidson, 2019). A disadvantage is that fewer people tend to respond when they get asked to fill out a questionnaire (Patel and Davidson, 2019). However, the companies are included in the project ReSvinn and therefore have incentives to answer the questions. Hence, the risk of not getting the answers was considered low. The questions were similar to the ones from the interview guide yet altered to be clearer when written. For the reason that the questionnaires only concerned two transporters, the questionnaires were adjusted with specific questions for each case. The questionnaires can be found in Appendix A.

The quantitative data of volumes of surplus food and transport setup from ReSvinn was mainly obtained from a presentation that the project group presented during a workshop. The information from the presentation was later accessible to use as a base for the calculations. There was a meeting together with PostNord where mostly validation questions were discussed. Both during the discussion with Postnord, as well as during the workshop, new ideas and perspectives were discussed, which acted as a foundation for the discussion.

3.3.2 Secondary data collection

The secondary data collection consisted of quantitative data from the tests carried out by ReSvinn and LCA values found from published studies. The data from ReSvinn was the foundation for all required calculations. ReSvinn had already collected the data regarding weight of surplus food in the tests and when additional data was required but missing, it was remedied through interviews with the parties involved. The different average weights and different food types are presented in Table 3.2. Other parameters such as specific weights from the different food types were obtained from an excel sheet provided by ReSvinn.

Table 3.2 Average redistributed weight of surplus food.

Tests	**Weight of transported food [kg]**	**Food type**
Test 1	66,1	Vegetables / Fruits
Test 2	132,8	Vegetables / Fruits
Test 3	14,2	Meat
Test 4 Min (Max)	56,8 (67,1)	Vegetables / Fruits
Test 5	62,9	Vegetables / Fruits
Test 6	20	Vegetables / Fruits
Test7	57	Vegetables / Fruits
Test 8	30	Vegetables / Fruits

In this study, relevant climate footprint values of CO_2, called LCA values, for different food types were found in already published LCA studies, and the necessary parameters are presented in Table 3.3. An environmental life cycle analysis (LCA) is a thorough study of the total emissions caused by a particular product throughout its life, including, but not limited to, raw material, design, production, transportation, and disposal (Ciambrone, 1997). Values for the different parameters, shown in Table 3.3, required for the transport calculations were also found in already published reports.

Table 3.3 Parameters that were collected through secondary data collection.

Parameters	Value	Source
LCA value for pork	6 [kg CO_2 /kg_{food}]	Röös, 2014
LCA value for chicken	26 [kg CO_2 /kg_{food}]	Röös, 2014
LCA value for beef	3 [kg CO_2 /kg_{food}]	Röös, 2014
LCA value for vegetables	1.2 (1 - 1.4) [kg CO_2 /kg_{food}]	Röös, 2014
LCA value for fruits	0.4 (0.2 - 0.6) [kg CO_2 /kg_{food}]	Röös, 2014
Co-transport factor	0.8477	Brar & Saini, 2011
Diesel emission density	3.212 [kg CO_2 /L]	Eriksson & Ahlgren, 2013
HVO emission density	1.2 [kg CO_2 /L]	Bonomi et al., 2018
Transport emission factor (rural)	1.3079	Treiber et al., 2007
Transport emission factor (outer city)	1	Treiber et al., 2007
Transport emission factor (inner city)	2.333	Treiber et al., 2007

3.4 Data analysis

Eriksson and Wiedersheim-Paul (2008) describe that summarizing the data is a common technique for analysis of qualitative data and summarizing of interviews facilitates finding patterns and connections between expressions. To accomplish this, the eight different tests that were received from ReSvinn were first analyzed one by one. Then the results were compared in a cross-case analysis, partly divided into qualitative and quantitative analysis. Eisenhart (1989) describes that, by initially having knowledge about each case separately and analyzing their own pattern, it is easier to understand and analyze patterns across the different cases. Stake (2005) agrees and says that it is important to first study each case separately to understand them, a later step is then to relate them to each other.

Eisenhard (1989) gives an example of two cross-case analysis methods that could be suitable for the qualitative analysis in this report. The first method is about selecting some categories and then looking for similarities within each group. This was done by analyzing the interviews and then finding what keywords that were common in many of the interviews, and then looking for similarities between the interviews that included those words. In this study, common words and sentences used in the interviews were about communication, organization and the actors' interest in the project. Interviews which include these factors were analyzed both within and between the different tests to find similarities and potential differenties.

When analyzing the qualitative data, it is a good complement to compare the data to the quantitative collection to see if the information matches. The other method, as described by Eisenhardt (1989), is to divide the information by source and then find insights separately in the different data collection methods. She says that when these findings are confirmed in different collections, the better and safer ground the result and conclusions will stand upon. This method was also used in the analysis by having a table that separately summarized information from the literature and the interviews, which then allowed for easier analysis.

Eriksson and Wiedersheim-Paul (2008) describe that the analysis of the quantitative part of the study facilitates making the data concentrated, comparing different data to each other, calculating the spread, and looking for patterns. In this study, the quantitative data was first analyzed with the help of calculations, where the total net climate impact per kilo rescued food was compared between the eight tests. Those results were then taken into context with the qualitative information from the interviews, and together with the frame of references some conclusions and patterns were found. The analysis and data of the different tests were continually compared with literature, making the data collection improve throughout the study allowing for new conclusions to be drawn.

3.4.1 Climate footprint value calculation for the different food types

All the tests, except Test 3, consisted of a mixture of vegetables and fruits. Data was received regarding all the weights of vegetables and fruits respectively in each delivery for Test 2 and Test 3. By summarizing all the weights of the different food types, a procentual average share of each food type in the deliveries from the two tests could be calculated. The share of each food type was then used in the other tests as well. Test 3 consisted of a mixture of different meat types, and since the different weights were received there as well, a percentual share of the different meat types could be calculated.

To be able to perform the transport calculations, an average meat and vegetables/fruits LCA value was needed. The different meat types had different average LCA values, and to receive an appropriate average meat value based on Test 3, the LCA values for each meat type was multiplied with the percentual amount of each meat type that was transported, and then summarized to an average meat value. The same calculations were then applied to the fruits and vegetables. However, from the secondary data collection, vegetables and fruit had different LCA values depending on if the food was produced in Sweden or imported. In this study, an average value based on 50% imported and 50% non-imported food was calculated since the calculations only needed an overall value from each food type. That average LCA value for each food type was then multiplied to the percentual share of each type, and then summarized to an average vegetables/fruit value.

3.4.2 Calculation of transport emissions

All transport emissions presented in this study were calculated manually using the following process. Firstly, the total distance driven (d), caused by each instance of redistribution, was calculated. In the case of direct transport this consisted of the distance between the retailer and the restaurant as well as half the positioning distance before and after the transport. In the case of milk runs, the distance driven was calculated as the extra distance the transporting vehicle must drive to complete the delivery compared to not doing so in the cases where the extra distance is known. Otherwise, the direct distance multiplied by the factor presented in Appendix I and obtained from Gurinder Singh Brar and Gagan Saini (2011) was used. Next, emissions per kilometer were calculated by multiplying the vehicles' fuel consumption per kilometer (f) with the emissions per liter (e) and a factor representing the traffic conditions (t) obtained from Treiber et al. (2007) presented in Appendix I. The distance of the transport was then multiplied with emissions per kilometer to calculate the emissions released by the transport ($e(t)$) (Eq. 1). To calculate the emissions from producing new foodstuffs instead of redistributing, the emissions per kilogram (ef) calculated according to 3.4.1 were multiplied with the average shipment weight (w) (Eq. 2). The emissions from producing the foodstuffs anew ($e(f)$) were then subtracted from the emissions caused by redistributing the food, resulting in the net change in emissions from redistributing food as opposed to producing new food (Eq. 3). This net change is then divided by the weight of the foodstuffs resulting in the net change in emissions per kilogram of food that has been redistributed (Eq. 4).

$$(1)\ e(t) = d * e * t * f$$
$$(2)\ e(f) = ef * w$$
$$(3)\ net = e(f) - e(t)$$
$$(4)\ net\ per\ kilogram = net/w$$

3.4.3 Calculations required for additional analysis

An important figure to study for insight on when redistribution of excess foodstuffs were the breakeven points. The breakeven points (b) are the amount of foodstuffs redistributed required for the emissions from the transport to be equal to the emissions for producing the foodstuffs anew. This was calculated by taking the emissions caused by the transport and dividing by the per kilogram emission value for the foodstuffs redistributed for each test (Eq. 5).

$$(5)\ b = e(t)/ef$$

For applying the findings of this study in future decision making it was also important to be able to calculate the minimum amount of foodstuffs to redistribute for the transportation to be motivated. The purpose of the factor (k) is to provide a simple way to calculate how many kilograms of foodstuffs must be saved for every kilometer they are transported. Initially, this value can be calculated for the tests in this study by dividing the emissions per kilometer by the emissions per kilogram of food produced (Eq. 6).

$$(6)\ k = (e * t * f) \div ef$$

General values for different types of setups were also generated in the same manner using emissions per kilometer values for hypothetical setups. In the general case fuel consumption was divided into three different categories according to vehicle type used. In Test 1 and Test 7, part 1, a large truck was used with a consumption of 0.3 L/km. In Test 4 and Test 5, a small truck was used with fuel consumption of 0.2 L/km. In the remaining tests not using electric fuels, cargo vans were used with fuel consumption of 0.1 L/km. These values were taken from the Test 2 interview, the Test 4 interview, and the Test 6 interview respectively. The emission per liter factor of HVO and diesel are 1.2 and 2.5 respectively and were the only fuels included because they are the only non-electric fuel encountered in the tests. Diesel was only included with the legally mandated 21% carbon dioxide reduction to ease calculations and because it is the most common. The traffic situation was divided into the three categories heavy, medium, and light in the same manner as the calculations were carried out.

3.5 Research quality

Reliability, construct validity, internal validity, and external validity could be used to ensure high quality of research. Also, information evaluation is an important part to ensure reliable data. By the same order as presented above, all these quality establishments can be read about in the succeeding section, followed by covering the ethical issues of this study.

3.5.1 Reliability

Reliability is about making sure that the study could be repeated and still result in the same answers. The goal is to describe and document the process such that there will be minimal errors when someone else will repeat the study (Yin, 2014). It is also about knowing that the investigations are made in a reliable way and that the instruments resist random errors and influence well enough (Patel & Davidsson, 2019).

Bryman and Bell (2015) describe how external reliability is about how well the study can be repeated and still result in the same answers. It is harder to succeed with this criterion in a qualitative study due to the fact that social situations rarely are the same. A solution is to not compare a researcher's opinions and experiences to the initial research (Bryman & Bell, 2015). In this study, some of the values related to the different tests were different every time of transportation. The study handled the situation by asking for average values, or sometimes instead performing calculations with standard values. In several tests, actors that were transporters, stores, and schools were interviewed which could verify that the information was in agreement, therefore, providing additional validity.

Internal reliability is about whether all the team members agree about what they have seen in research (Bryman & Bell, 2015). To ensure that the data collected from the interviews was perceived correctly a discussion was conducted with the two interviewers.

3.5.2 Validity

Good validity is about investigating the things intended to be investigated (Patel & Davidsson, 2019). Construct validity can be achieved by using several sources and by making sure that the right measures are being studied (Yin, 2014). By, in this study, using interviews and then comparing that information to literature, the construct validity increased.

Bryman and Bell (2015) explain the importance of the connection between the research questions and the interview questions. To ensure this connection and overall quality, the group members that did not write the template reviewed and validated the questions. Before sending the questionnaires and conducting interviews, the questions were also assessed by the project manager of ReSvinn and the sustainability manager and environmental specialist at PostNord to ensure that the questions were asked correctly and to increase the likelihood of getting the desired answers from the transporters. PostNord was contacted at the beginning of the study and provided continuous support and validation for the environmental calculations.

Internal validity is about whether the findings correspond to, and captures the reality, and if the study examines the intended (Merriam, 1994). Internal validity could be achieved by, for example, using pattern matching in the data analysis with the goal of finding how some circumstances will lead to other circumstances (Yin, 2014). Since the qualitative parts of the interviews were analyzed based upon common keywords, patterns within the tests were examined to understand how certain factors led to better cooperation.

A multiple case study is often, compared to a case study, seen as more convincing, especially when the study contains replicated findings (Yin, 2014). By for example having replication logic within the cases, external validity could be reached. External validity is about understanding if the findings are generalizable, especially when using other research methods or situations than those that have been used in this particular study (Yin, 2014). The generalizability of this study was limited because of the eight tests. There is no guarantee that a result or pattern that may be found in this study, always is correct or holds. However, the tests were designed by ReSvinn to reflect many different logistic systems that could be used in

Sweden, to create such a broad and full covering study as possible. The results were also compared with similar literature to strengthen the generalizability of the findings.

The calculations were partly based on literature, as well as based on information from the interviews, PostNord and ReSvinn. When the calculations were completed, they were assessed and validated by both ReSvinn and PostNord to ensure that the calculation process was reliable and correct.

3.5.3 Information evaluation

During the data collection, evaluation of the sources was an important part of the process. The sources needed to be of high standards and reliability to be seen as useful. Eriksson and Wiedersheim-Paul (2008) explain that information evaluation is important in a study due to the fact that all literature is not reliable. They continue to explain how information evaluation can be seen as a selection method where the reader analyzes, assesses, and chooses only the relevant information from the collected sources. It is suitable to use four criteria that can be used to control the source of information; requirement that the source is close in time to what it describes, be critical to whether the source has its own interests in the matter, verify that the source is not interdependent and control that the information is genuine (Eriksson & Wiedersheim-Paul, 2008). All the criteria and principles were used throughout the data collection to ensure that the study was based on correct data and was based on sources of high quality.

3.5.4 Ethics

Ethics can be defined as what is morally right or not (Cambridge, 2020). The type of methods used can create ethical problems depending on how they are being used. The secondary data collection did not induce any ethical problems considering references were used in the correct way. The secondary data collected from ReSvinn did not concern any sensitive data either. The primary data collection, consisting of interviews, could possibly have created ethical problems if sensitive questions were asked, but this was not a problem in this study since the questions were not of a personal nature. In summary, the methods and the results did not imply any ethical consequences, and further analysis was therefore not made.

4. Results and analysis

In this section, the qualitative and quantitative findings collected from the interviews and questionnaires are presented. Each test and the data collected from the interviews and questionnaires are summarized and presented below, see appendix C-H for the interview notes. An overview of the tests is shown in Table 4.1, the actors have been given anonymous names connected to the test number. The LCA values used for the carbon dioxide emission calculations are also presented. Additionally, an analysis of the calculation results and parameters, along with a sensitivity analysis of the carbon dioxide emissions calculations are presented. Lastly, a summary of the most important qualitative aspects for a good working set-up is offered.

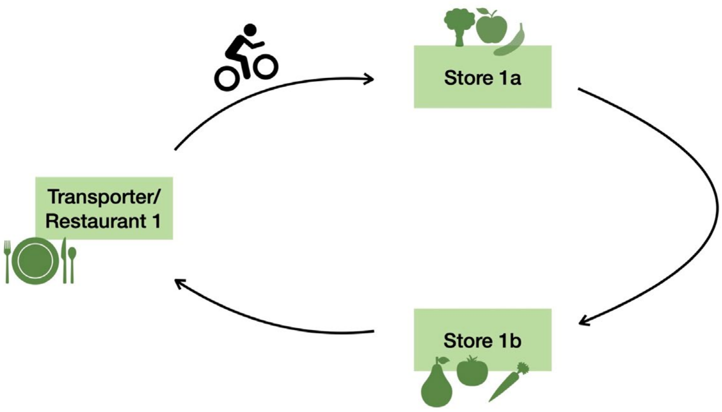
Table 4.1. Overview of the 8 tests, data collected from the interviews.

Test nr	Parties	Vehicle	Type of Fuel	Distance	Type of food
Test 1	Store 1a Store 1b Store 1c Transporter/ Restaurant 1	Cargo bike/ Electric car	N/A	Route 1: 3 km Route 2: 2 km Route 3: 33 km	Vegetables/ Fruits
Test 2	Store 2 Transporter 2 Restaurant/ School 2	Larger truck	Diesel Mk3 EU 32% redux	27 km	Vegetables/ Fruits
Test 3	Store 3 Transporter 3 School 3	Cargo bike	N/A	3 km	Meat
Test 4	Store 4 Transporter 4 School 4	Delivery van	HVO	27 km	Vegetables/ Fruits
Test 5	Store 5 Transporter 5 School 5	Smaller truck	Diesel Mk3 EU 21% redux	4 km	Vegetables/ Fruits
Test 6	Store 6 Transporter 6 School 6	Delivery van	Diesel Mk3 EU 21% redux	10 km	Vegetables/ Fruits
Test 7	Store 7 Transporter 2 School 7	Large and small truck	Diesel Mk3 EU 32% redux	26 km	Vegetables/ Fruits
Test 8	Store/ Transporter 8 School 8	Delivery van	Diesel Mk3 EU 21% redux	3 km	Vegetables/ Fruits

4.1 Test 1

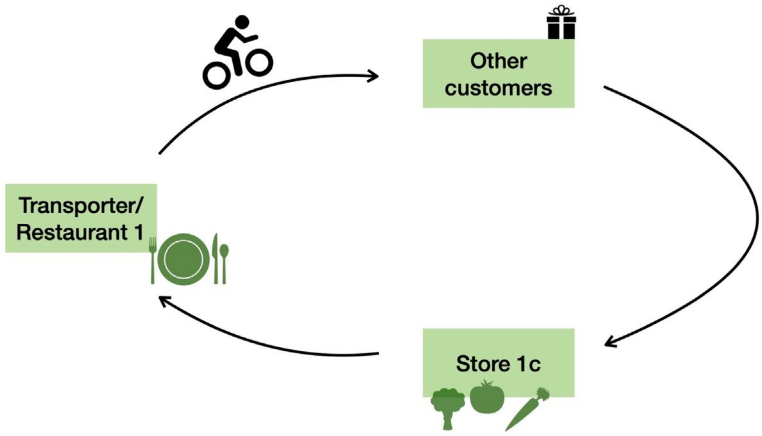
In this test, the transporter and restaurant are the same actor, Transporter/Restaurant 1, and was the only party interviewed from this test. They get their surplus food from four different stores, Store 1a, 1b, 1c, and 1d. The test is constructed of three different routes. Two of the routes include inner-city traffic, the third is driven in outer city traffic.

Figure 4.1 model of Test 1a



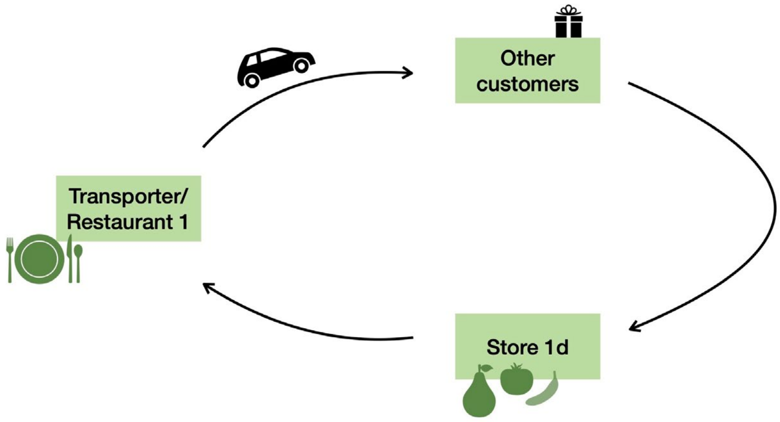
The first route begins, as illustrated in figure 4.1, at the transporter's premises, located in central Gothenburg. This route is performed using an electric bicycle and starts with an empty cargo load. From the premises of the transporter, the route continues to the first grocery store, Store 1a, to pick up the first batch of surplus food. Thereafter, the route progresses to the next grocery store, Store 1b, to pick up the second load of surplus food. Lastly, the route returns to the transporter's premises. In total, the distance included in the route is around 3 kilometers. The restaurant calls the stores before picking up the surplus food to get an overview of how much to collect on the day of transportation, which transpires five times a week. The transporter can walk into the grocery store and collect the surplus food without having to wait for a staff member.

Figure 4.2 model of Test 1b



The second route is similar to the first and is illustrated in figure 4.2, with a starting point on the transporter's premises. This route includes stops at other customers that are not a part of this test. From their premises the route goes to other customers and then to the grocery store, Store 1c, to pick up the store's surplus food. From the store, the route continues back to the transporter's premises. The distance of this route is about 2 kilometers and is also performed by electric bicycles. The restaurant is supposed to pick up surplus food five times a week but the store is not always able to provide that amount. Contrary to Store 1a and 1b, Store 1c does not collect surplus food in the store equally regularly, and sometimes, mostly because of lack of routines, the surplus food is discarded in the store.

Figure 4.3 model of Test 1c



The third route is set in the outer city borders of Gothenburg, in Partille. Like in the other tests, the route begins at their premises in central Gothenburg although this route is performed by electric car instead of a bicycle, as shown in figure 4.3. Thereafter the route proceeds on to other customers before it reaches the grocery store, Store 1d, and then returns to the premises of the transporter. This route covers 33 kilometers. Like the first route (Test 1a), the transporter can walk into the store and collect the surplus food without the assistance of a grocery store worker. The redistribution occurs three times a week. The power used to charge the electric car and bicycles is household electricity, fossil-free fuel. During the routes, no co-transport transpires, and all the food transported is stored in SRS-crates that are returned back to the grocery stores. All the transport occurs during morning and lunch hours, not during rush hours. The food transported is vegetables and weighs around 66 kilograms.

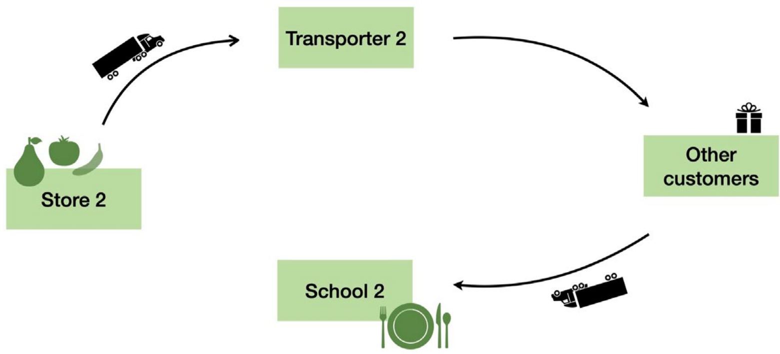
According to the interviewee, communication is key. Transporter 1 values the fact that they have good connection with Store 1a, 1b, and 1d since this connection makes collaboration and delivery easier. They can call these three stores in the morning to acquire information about the surplus food, weight, volume, and what kind of vegetables they have a surplus of. A similar relationship is missing between Transporter 1 and Store 1c. This can, according to the interviewee, contribute to the fact that the delivery from Store 1c has not been as efficient as the others. Store 1c does not have an employee that is in charge of this project, something that complicates the collaboration for Transporter 1. In the interview, Transporter 1 mentioned the fact that they used to work with another store but had to discontinue the partnership as a result of little to no communication between store and transporter. It resulted in discontinuity in the deliveries and food waste. When the parties had a meeting to decide the schedules, the transporter brought forward the restaurant's time preferences. The chefs need some of the food before lunch so they can set the menu, know if something extra is needed or if they should start a project for the next day. Transporter 1 also prefers to have some sort of continuity in the transportation to fit in with the rest of their schedule. But the main thing is to discuss with all parties involved and decide the best time slot that works for everyone, says the interviewee.

The interviewee mentioned that working with surplus food acquires creativity as you never know what vegetables and fruits are to be delivered. Restaurant 1 wishes to receive more information from the stores in the future, such as what type of food the store supplies. Something that would simplify the chef's work, it would also minimize the risk of transporting surplus food from the stores that later get discarded in the restaurant as sometimes, some of the food distributed is unusable. The interviewee concluded that a project like this requires a will to try new things, creativity, good communication, continuity, and the ability to collaborate.

4.2 Test 2

Test 2 entails Transporter 2, Store 2, and Restaurant/School 2, both the transporter and the school were interviewed, and some of the questions posed to the transporter were answered via email.

Figure 4.4 model of test 2



This test is conducted in the inner- and outer-city limits of Gothenburg and is illustrated in figure 4.4. The surplus food picked up from the grocery store is vegetables and weighs on average 133 kilograms per route. The transport occurs five times a week. The vehicle used is a middle-sized truck that is fueled by diesel with a 35 percent carbon dioxide reduction.

The route begins from Store 2, located north of Gothenburg. Therefrom it continues to the terminal of Transporter 2 in northeastern Gothenburg. The route also includes other customers, who have other types of goods transported by Transporter 2, before reaching Restaurant/School 2, which in this test is a school with a restaurant, based in central Gothenburg. Overall the route's distance includes around 27 kilometers, the exact distance to the other customers varies as the customers vary. The route is performed during the daytime and can entail rush hour.

Transporter 2 is one of the biggest logistics companies in Gothenburg and the largest included in these tests. According to the interviewee, the level of climate impact from their transportation depends on their customer. Transporter 2 works according to the customers' requirements, for example fossil-free fuel is more expensive so if the customer requests a cheaper alternative the climate impact may be larger, although the transporter wishes they could run only on fossil-free fuel. They also have a lot of laws and regulations they need to adjust to, for instance, larger diesel vehicles are not allowed to operate in the inner city at night which narrows their schedule.

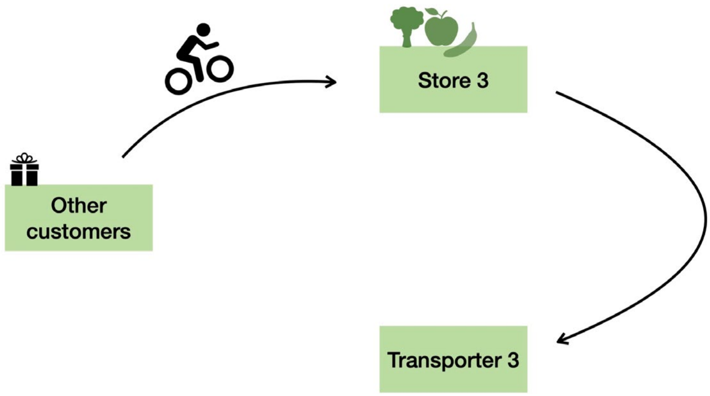
A separate interview with School/Restaurant 2 was conducted. They have worked with the project since autumn 2020. According to the interviewee, the test worked well during the autumn and winter but after the new year, the test has come to a halt. There have been no deliveries during spring 2021, which the interviewee thinks is caused by miscommunication between the transporter and store. A better connection has been established between the school and the store, one way the school constructed a good relationship with the store was to schedule a visit at the store in the beginning. This visit helped in bettering the communication between the two parties and made the start of the test easier for both, according to the interviewee. The interviewee alleges that the lack of communication between the store and the transporter has contributed to the issue with the start-up of the test after their break, first, the store was ready to begin again but not the transporter and later vice-versa. Another factor to the problem can, according to the school, be internal problems within the store that have been communicated to the school as a reason for the delay.

The interviewee from the school also reflected upon the quality of the food they got delivered. A lot of the food distributed from the store was edible and they were surprised that the store sorted it out. The school mainly uses the food in their teaching, since the school focuses on cooking, they also run a restaurant and café where the students make the food that is sold. As an account of the surplus food delivered being only vegetables and fruits it is used as an extra during the lessons, used for garnish, jams or as side-dishes. In conclusion, both interviewees are overall satisfied with the collaboration but there are potential for improvement at all parties.

4.3 Test 3

This test consists of Transporter 3, Store 3 and Restaurant 3, all located in central Gothenburg, with the only party interviewed being the transporter. The test is illustrated in figure 4.5 and is conducted by electric bicycle in central Gothenburg during the morning, after rush hour. The route begins at other customers of Transporter 3, located near the grocery store. From the other customer, the transport continues to Store 3, where the surplus is collected for redistribution to Restaurant 3. Therefrom the route usually goes to the transporter's terminal located in central Gothenburg. Occasionally the route includes other customers before returning to the terminal, with the other customers having different goods than surplus food being delivered. The test is conducted two times a week and, overall, the distance is 2 kilometers. Approximately 14 kilograms of surplus food is redistributed, mostly meats of different kinds.

Figure 4.5 model of test 3



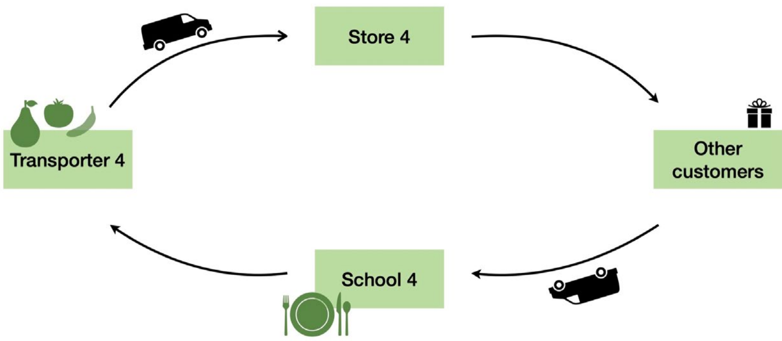
The interviewee said that they are pleased with the collaboration and the test has worked well from their perspective. The only negative aspect mentioned was that they had to wait at the store for the personnel to pack the surplus food and that the amount of food varies significantly. This insecurity is something that complicates the transporters' work since they do not know how much of the space on the bike's cargo load will be used.

Transporter 3 usually decides the schedule in consultation with all parties concerned. They have this consultation as a standard when working with different customers to make sure that the time slot works for everyone. While it has to fulfill the customers' preferences it also needs to match the transporters' own schedule. They mention the value of having good communication in a collaboration like this, and the need to see to the different requirements the parties may have. For example, the restaurant needs to have the food before lunch and the store wants to find time slots when there are not a lot of customers in the store for performing the packing. Transporter 3 regards this delivery as a routine route, they have worked with similar distribution before. Lastly, the transporter reflects over what would be needed if a system like this would expand, it would need to be more systematic.

4.4 Test 4

Test 4 is shown in figure 4.6 and operates in the inner city of Stockholm. The parties interviewed were Transporter 4 and Store 4. The transporter uses a delivery van and distributes the food from Store 4 to School 4, a direct route with only one other customer, who requires delivery of other types of goods, between the store and school. Transporter 4 usually tries to do milk runs, where they fit in several different customers in the same route. According to the interviewee, a milk run, with more than one other customer, was not possible since the school had a strict time slot in which they wanted the food delivered. The transporter only had one other customer that fit with this schedule. The route is performed during lunch hours two times a week and is approximately 30 kilometers in total. Only vegetables and fruits are delivered with a weight between 57 and 67 kilograms.

Figure 4.6 model of test 4



According to the transporter, the collaboration overall has worked well for them and the only problem has been finding time slots that fit all parties. They mention that finding suitable delivery times is a recurring problem with some customers, particularly customers who have high demands and requirements. The interviewee also speculates about when the transport no longer is worth driving, for example can small volumes be expensive, both economically and environmentally. For future collaborations, Transporter 4 encourages finding companies and people interested in working with this kind of problem as it can require time and effort.

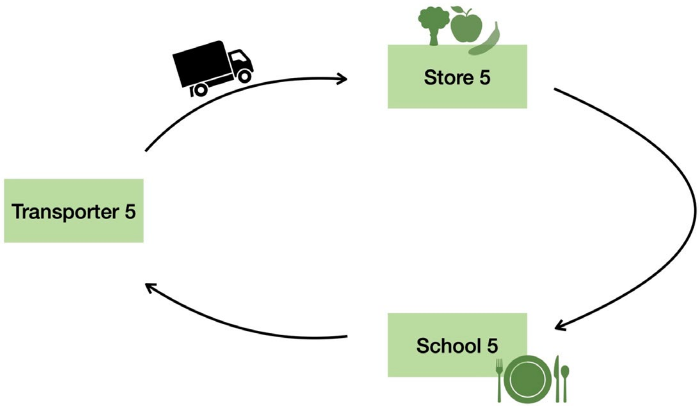
In the second interview, conducted with Store 4, the interviewee stressed the importance of communication. They experience that they have a good connection with the school and get feedback about the amount of food delivered. The interviewee brought up the fact that they have not had as good of a conversation with the transporter. There have been uncertainties about when the deliveries should occur and incidents where the transporter has arrived at the wrong time or not at all. The store concludes that good communication between all three parties could reduce these problems and contribute to a better collaboration.

Working with surplus food prevention and distribution is not something entirely new for the store. They mention several different projects in-store that concern this issue, and that they have been looking out for collaborations similar to this test but have had problems with finding interested recipients. The interviewee talked about the importance of being creative and flexible when working with surplus food. They offer special" food waste"-boxes and use the surplus food to cook meals sold in-store. Not being new to working with surplus food prevention and distribution made it easy for them to get into this test and find food that could be redistributed to the school. Although, they mention that this test has made it possible to save more food than they were able to before, according to the interviewee. Lastly, they mention that they chose to pack the food in recyclable boxes instead of SRS-crates that would require return transportation to the store, and which would create a need for the store to keep count of the number of crates used and so on.

4.5 Test 5

The transporter in Test 5 was not available for an interview, but the setup is illustrated in figure 4.7. All data used in the calculations for this test was collected as secondary data from ReSvinn. Test 5 transpires between Store 5 and School 5, with Transporter 5 redistributing the surplus food. The surplus food consists of vegetables and fruits with a weight of approximately 63 kilograms per transport. The transportation occurs two times a week with a distance of 4 kilometers. The vehicle used is a smaller refrigerator truck fueled by diesel.

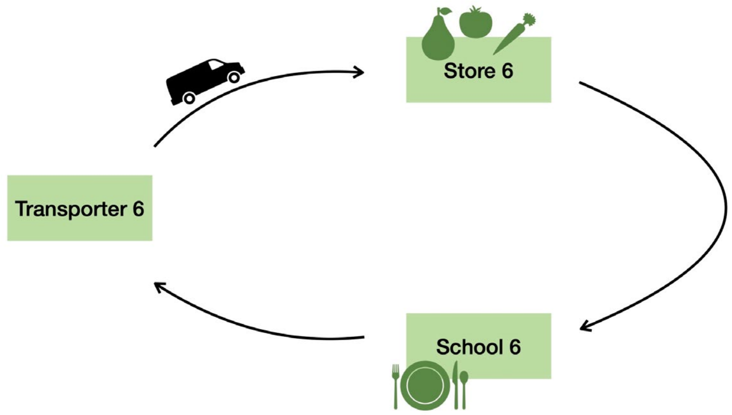
Figure 4.7 model of test 5



4.6 Test 6

In this test, transportation occurs between Store 6 and School 6 with the help of Transporter 6, as shown in figure 4.8. The information was received from a questionnaire instead of an interview, and consisted only of quantitative data for the calculations.

Figure 4.8 model over test 6

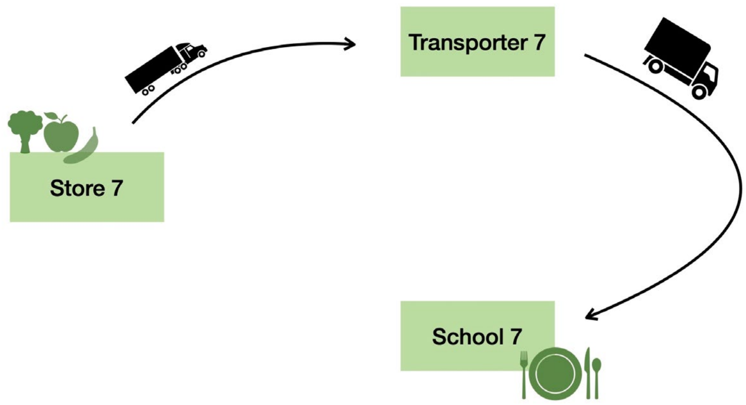


The test includes a distance of approximately 6 kilometers with no returns to the store from the school. The delivery contains only vegetables and fruits, with an average weight of 20 kilograms, and is performed by a smaller truck. The test is conducted at the outer limits of Skövde in the morning hours.

4.7 Test 7

Test 7 uses the same transporter as Test 2 (see section 4.2 for a summary of the interview with Transporter 2). In this test, the transporter redistributes surplus food from Store 7 to School 7, as shown in figure 4.9. The pick-up at the store is done with a larger diesel truck and the drop-off at the school is done with a smaller one. The route is approximately 30 kilometers with different customers in Gothenburg. Sometimes the route stays in central Gothenburg whereas other times it spreads to the area surrounding the inner city. The transport consists of approximately 57 kilograms of vegetables and fruits and is often co-transported with other goods. The weight, volume, and type of goods in the transport vary depending on the other customers that day.

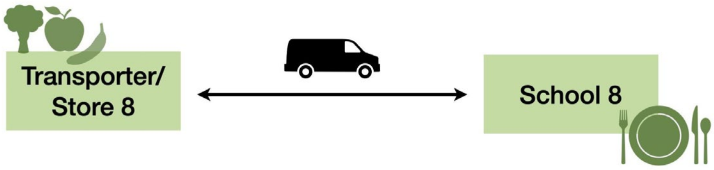
Figure 4.9 model of test 7



4.8 Test 8

The last test is also the newest and had only been active for three weeks when the interview was conducted. In this test, the transporter and the store are the same company, Transporter/Store 8. The transporter delivers around 30 kilograms of vegetables and fruits, however, the two parties have discussed expanding the surplus food to include dry goods in the future. The delivery occurs two times a week to School 8, located in central Stockholm, as shown in figure 4.10. The distance between the store and the school is around 4 kilometers and the transport is done via a smaller diesel truck. The interviews conducted for this test were done with both parties present at the same time.

Figure 4.10 model of test 8



According to the interviewee from Transporter/Store 8, the test has been working well for them. They have had some difficulties with the delivery because of internal issues about for example how they should make the delivery. The store has people responsible for sorting out unsellable food already before the start of this test. So far the store is satisfied with the test and the impact it has had on the store's work.

Since the food is mainly cooked for lunch, the school mentions that the preparation sometimes can be stressful. However, they are overall content with the outcome from the test. The response School 8 has received from parents, students and teachers has been positive. The students and the teachers also appreciate having new types of fruit for snacks, such as grapes or melon. The interviewee also mentions that most of the food has been usable, and they feel that it is a manageable and appropriate amount of food being delivered, sometimes they can even cook a whole meal based on the surplus food. In conclusion both parties are happy about their collaboration so far and look forward to continuing it.

4.9 LCA values from different food types

From Test 2, Test 3, and Test 4 the weights of the transported food were received and divided into each food type. With those values, an average weight of each food type was calculated and resulted in the values presented in Table 4.2. The shares of fruits and vegetables in Test 2 and Test 4 were quite similar and therefore merged to an average share. The shares were then used in the remaining five tests: (Test 1, Test 5, Test 6, Test 7 and Test 8) that consisted of vegetables and greens since the values between Test 2 and Test 4 did not have a major difference.

Table 4.2. Average procentual share of each meat type based on weights from Test 3 and average procentual share of vegetables and fruit based on weights from Test 2 and Test 4.

Food type	Average share in the deliveries
Pork	18%
Beef	45%
Chicken	37%
Fruit	43%
Vegetables	57%

The secondary data collection resulted in LCA values of different food types that were based on emissions from the entire value chain. The LCA values that were used during this study were based on food in Sweden and were according to Röös (2014) roughly estimated values that were still representative and creating a clear view. Röös (2014) further clarifies that the values have large variation, and they are all mean values, but still gives a good indication of the order of magnitude. The average LCA values for the different food types are presented in Table 3.3.

When calculating LCA's with climate footprint values, meat is usually divided into different meat types due to the big variety in the emission from the different processes. In Test 3, the meat types were beef, pork, and chicken, but for the calculations an overall LCA value for meat was desired. As can be seen in Table 4.3, the average LCA value for meat resulted in 13.89 kg CO_2/kg food and was calculated according to the method in section 3.4.1. Also for vegetables and fruits, an average value was needed and it was calculated according to the method described in section 3.4.1. The LCA value for the vegetables and fruits, as can be seen in Table 4.3, resulted in 0.86 kg CO_2/kg food.

Table 4.3. Calculated average LCA values for meat and vegetables and fruits.

Food type	**Average kg CO_2 / kg food**
Meat	13.89
Vegetables and fruits	0.86

4.10 Calculations results and analysis of parameters

To be able to perform the carbon dioxide emission calculations, several different factors were required to calculate the impact from: type of fuel, weight and type of surplus food, distance, traffic situation, and whether or not the tests were conducted with co-transportation. The compensatory factors were collected from previously published studies or from ReSvinn, and are presented in Table 3.2 and Table 3.3. See section 3.4.3 for an overview of the method used to produce the factors.

The results of the calculations are presented below in Table 4.4 and Table 4.5. See section 3.4.2 for a description of the calculation methods. Not every result from the calculations is presented in the tables (see appendix I for full results). Table 4.4 presents the most relevant results from Test 1 to 4 and Table 4.5 from Test 5 to 8.

Table 4.4 Carbon dioxide emissions calculations for Test 1 - 4.

	Test 1a	**Test 1b**	**Test 1c**	**Test 2**	**Test 3**	**Test 4 Min weight**	**Test 4 Max weight**
Co-transport	No	Yes	Yes	Yes	No	No	No
Weight of food [kg]	66	66	66	133	14	57	67
Distance [km]	3	2	33	27	2.1	18	18
Traffic situation	Heavy traffic	Heavy traffic	Medium traffic	Heavy traffic	Heavy traffic	Heavy traffic	Heavy traffic
Fuel [L/km]	N/A	N/A	N/A	0.3	N/A	0.2	0.2
Total net climate impact **[kg CO_2]**	-57	-57	-57	-74	-197	-35	-44
Total net climate impact per kilo rescued food **[kg CO_2 /kg_{food}]**	-1	-1	-1	-0.6	-13	-0.7	-0.7
kg food required for breakeven	0	0	0	47	0	16	16
km driven required for breakeven	N/A	N/A	N/A	77	N/A	114	114

Table 4.5 Carbon dioxide emissions calculations for Test 5 - 8.

	Test 5	**Test 6**	**Test 7**	**Test 7 part 1**	**Test 7 part 2**	**Test 8**
Co-transport	No	No	Yes	Yes	Yes	Yes
Weight of food [kg]	63	20	57	57	57	30
Distance [km]	4	10	26	16	10	4
Traffic situation	Medium traffic	Medium traffic	Medium traffic	Medium traffic	Medium traffic	Medium traffic
Fuel [L/km]	0.2	0.1	N/A	0.3	0.1	0.1
Total net climate impact **[kg CO_2]**	-52	-15	-37	N/A	N/A	-25
Total net climate impact per kilo rescued food **[kg CO_2 /kg_{food}]**	-0.8	-0.7	-0.7	N/A	N/A	-0.8
kg food required for breakeven	2	2	14	N/A	N/A	1

km driven required for breakeven	107	67	121	121	121	106

From the result presented in Table 4.4 and 4.5, an observation can be made of how the parameters affect the emissions generated in the different tests. The parameters that have the greatest impact on the amount of carbon dioxide emitted are type of vehicle, type of fuel used, and distance.

Type of vehicle is a contributing factor to the scale of emissions generated. For instance, in Test 2, the transporter is driving a bigger truck and during heavy traffic. In contrast, the transporter in Test 6 is driving during medium traffic with a smaller truck. Both the vehicles are operating on diesel, with varying rates of renewable fuel mixed in. In Test 2 the transporter emits more than twice as much carbon dioxide compared to the transport in Test 6, despite the emissions from Test 6 being equalized by the heavy traffic.

Another parameter that has a great impact on the emissions is the fuel powering the vehicle. The data obtained demonstrate that one liter of pure diesel and one liter of HVO result in 3.2 respectively 1.2 kilograms of carbon dioxide emissions. However, only one transporter uses vehicles powered by HVO in this study - the delivery van in Test 4. Considering that the vehicle in Test 4, which is fueled by HVO, is bigger and therefore consumes more fuel than the smaller vehicles from for instance Test 5 the emissions from these tests are the same per kilometer.

The distance from the pick-up point to the delivery point naturally effects the emissions generated. Another parameter that is contributing to the emissions is the type of traffic prevailing when transportation occurs. The distance is a parameter that cannot be changed during a running test although this is an important factor to remember when a new test is being set up. A vehicle driving during rush hour emits 2.3 times more carbon dioxide than a vehicle driving during normal traffic as can be seen in Appendix I. The traffic type varies throughout the day and the transporter could have that in mind when deciding when to pick up and deliver the food. However, the stores need to be able to have time for packing and handing over the food to the transporter and likewise, the receiving end needs to be available for receiving the food surplus when the transporter arrives.

To succeed in reducing emissions by doing a milk run it is essential to have a well-planned route and ensure that pick-up and deliveries are being performed seamlessly. Otherwise, a potential detour could increase the emissions instead of decreasing them. Although, in this study, the milk run calculation is based on templates, and accurate numbers from the individual tests have not been taken into account.

Furthermore, the drivers' driving style has an impact on the generation of emissions. In this study, however, the different driving styles of the transporters have not been taken into account. The information about the transports has mainly been obtained through short semi-structured interviews and questionnaires that did not include any analysis of the transporters driving style. Further analysis on how the drivers' driving style affects emissions will therefore not be performed. In this study, the focus has been on the emissions from fuel that the transports are running on. No account has therefore been taken to any eventual emissions from the tires from the cargo bikes or the electric cars. The type of electricity that is used to charge the bikes and the cars will not be accounted for in the analysis.

4.11 Sensitivity analysis

An important figure to study for insight on when redistribution of excess foodstuffs are environmentally beneficial is the breakeven point. The breakeven point is the amount of foodstuffs redistributed required for the emissions from the transport to be equal to the emissions for producing the foodstuffs anew. As can be seen in Table 4.6 and 4.7 below, the breakeven point has high variation depending on the type of transportation used. In this study, the emissions from bikes and electric vehicles are assumed to be zero, and since Test 1 and Test 3 uses those vehicles in their transportations, the breakeven point resulted in 0 kg. Remaining tests can for the purpose of studying the breakeven point be put into three groups: Test 2 with a high break-even point, Test 4 and Test 7 with medium breakeven point, and Test 5, 6, and 8 with a low break-even point. Taking a closer look at Test 2 it is made apparent that the high value is the result of multiple factors. Test 2 uses the largest transportation vehicle of any test studied which has the consequence of also having the highest fuel consumption. In addition, the transport goes through heavy traffic and is one of the longest transports at over 27 km effective distance traveled.

The group of tests with medium breakeven points share some of the characteristics of the tests with higher break-even points. They both have quite long distances, similar to Test 2, but they also have other mitigating factors bringing the emissions down. They both, at least partially, use smaller vehicles with lower fuel consumption and either use HVO or a route with less traffic contributing to lower emissions. The final tests with low break-even points are all short distance routes with smaller vehicles. Despite them using the type of fuel with the highest climate impact, diesel with low carbon reduction, the emissions are low, lending credence to the conclusion that transport distance is an essential parameter.

Table 4.6. The kg food required for breakeven in test 1-4.

	Test 1 A	**Test 1 B**	**Test 1 C**	**Test 2**	**Test 3**	**Test 4**
Kg food required for breakeven	0	0	0	47	0	16

Table 4.7. The kg food required for breakeven in test 5-8.

	Test 5	**Test 6**	**Test 7 Total**	**Test 8**
Kg food required for breakeven	2	3	14	1

For applying the findings of this study in future decision making it is important to be able to calculate the minimum amount of foodstuffs to redistribute for the transportation to be motivated. Providing a simple to use factor for various transport setups to calculate how many kilograms of foodstuffs must be saved for every kilometer they need to be transported is therefore a valuable contribution. Initially, this value can be calculated for the tests in this study by dividing the emissions per kilometer by the emissions per produced kilogram of food the result of which can be seen in Table 4.8 and 4.9 below. The columns marked N/A are due to the fact that these transports were performed with climate neutral transports.

Table 4.8. K-value for test 1-4.

	Test 1 A	Test 1 B	Test 1 C	Test 2	Test 3	Test 4
k (km*k=kg)	N/A	N/A	N/A	1.7	N/A	0.6

Table 4.9. K-value for test 5-8.

	Test 5	Test 6	Test 7 Total	Test 7 Part 1	Test 7 Part 2	Test 8
k (km*k=kg)	0.6	0.3	N/A	0.7	0.2	0.3

4.12 Important qualitative aspects for a good working setup

An important party to consider when ensuring sustainability and circularity in systems like the above presented is the transporter. Looking at the qualitative data collected from the interviews, several similarities as well as divergences arise. Table 4.10 allows for a quick overview of the important qualitative aspects for a good working setup, according to the interviewed parties.

Table 4.10. Overview of the important qualitative aspects for a good working setup.

Parties	Important qualitative aspects
Transporter	Availability to co-transport, details about the goods, continuity in the deliveries, easier access in store
Transporter, bigger vehicle	Large volume of goods
Transporter, smaller vehicle	Small volume of goods
Store + Restaurant/School	Understanding between the parties, interest in the project
All actors	Communication, flexibility, all parties having a responsible person, cooperativeness

One word repeated throughout the interviews with the transporters in the tests was ‘communication’. Having good communication between the parties is essential to ensure a sustainable and cost-efficient logistic system. Most of the interviewees mentioned that they try to meet the time requirements of both parties in the tests, to find time-slots matching both the dispatcher and the recipient. They also need to match the time intervals with their own schedules. From the transporter's perspective, matching the deliveries with other customers is desirable, both to lessen the climate impact and make the route more cost-efficient. Deliveries co-transported may decrease the distances driven and consequently, minimize the climate impact from the transports. Good communication between the transporter and the customers is also a fundamental part when designing logistic systems. For example, Transporter 2 bases their different routes on the customers’ requirements. If a customer requires a fossil-free delivery and is willing to pay for it, Transporter 2 will be able to carry out a more sustainable delivery. If instead, the customer necessitates a cost-effective delivery the fuel is more likely to be diesel or an equivalent.

In Test 1, 3, and 8 the transporters are smaller companies using electric bicycles and electric cars. These transporters work with shorter distances and often operate in inner-city traffic. One possible disadvantage of using electric bicycles as a delivery method is the limiting cargo load; if the surplus food is more than the transporter can transport, it could require extra deliveries or disrupt the transporter's schedule. Transporter 1 and 3 both called for better communication with Store 1 and 3 respectively. They wanted more information beforehand about the weight and volume of the food to be transported to make room for co-transportation and optimize their schedule. Transporter 8 is also the store in Test 8, and for them, designing a logistic system like this was something new. Although the test is relatively new, they made sure to have a good connection with School 8 from the beginning, to find time-slots that work for everyone involved. They also wanted feedback on the food delivered to the school to ensure that the food redistributed were of use. All three interviewees expressed a personal interest in finding solutions to lessen the amount of surplus food. Transporter 1 delivers the food to their own restaurant that base their business model on finding new use for surplus food. Transporter/Store 8 spoke about their goal to work continuously with minimizing the amount of surplus food in their store. This interest was less apparent in the interviews with the bigger transporters.

Test 2, 4, and 7, where Test 2 and 7 use the same transporter, are bigger companies that use trucks of different sizes as transportation methods. The interviews showed that they have a more standardized way of working than the smaller transporters. For them, these tests were a smaller routine route, something they have done several times before. With these deliveries the level of sustainability is decided by the customers and their will to pay extra for the environment. These interviewees talked about the volume of a delivery having to be big enough to be worth it, environmentally and economically. For them, a small volume is too expensive and they speculate that it would probably do more harm to the environment than good. The smaller transporters, Transporter 1 and 3, discuss the opposite. For them, using smaller vehicles, means that a too large volume would require either a larger vehicle or more delivery rounds.

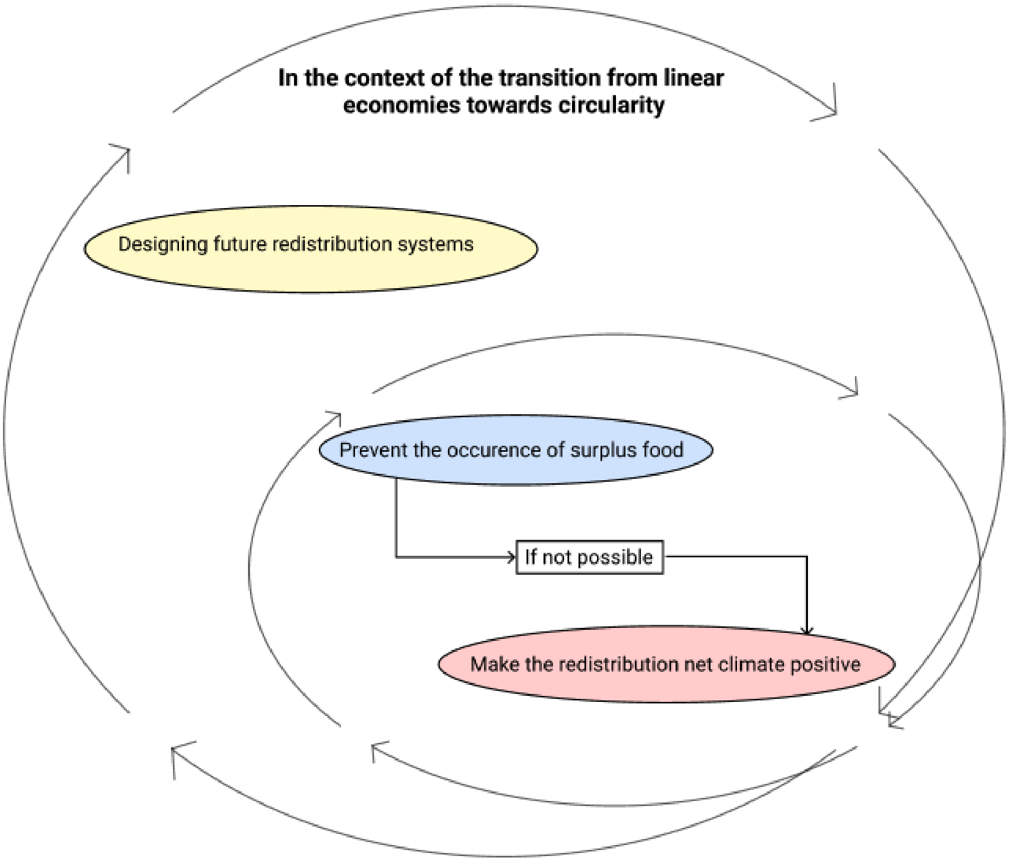
As well between the stores, transporters and receives, the most common opinion between all the parties is the importance of good communication. Lacking communication clearly was the factor that led to the most problems, and when it was improved, the systems worked better. School 2 had great contact with Store 2, and they even visited each other in the beginning to get a good connection and understanding for their different situations. Both Store 4 and Transporter 4 agreed that it is important that all of the parties involved need to have an interest in the project and as long as the parties could be flexible and cooperate, the logistics would work out. Transporter 1 mentioned the importance of having one person that was responsible in each part of the project since it made all communication much easier. Transporter 1 pointed out that continuity is important and also the chefs would like more information about what food that would be delivered. A suggestion for the future was a digital solution that could give the ability to inform and register the deliverable food already in the store. Transporter 1 also wanted a better system for entering the stores, suggesting an access card.

A majority of the actors brought up the mission with scheduling the transportations and deliveries, and the fact that all of the different actors in the setups had different wishes, demands and time requests. Many restaurants want an early delivery to be able to prepare the food before lunch, but consideration also needs to be taken in regard to the stores and transporters. It is also important to show up on the scheduled time slots, for example, Transporter 3 sometimes had to wait since the store was not ready to deliver, which complicated the transporters' work. Transporter 4 expressed that high demands from customers could complicate the scheduling and Transporter 3 mentioned the importance of having an understanding for the different actors’ needs to be able to create a good collaboration. For a good working future project, the great lessons to be learnt would be good continual communication, flexibility within the organization and understanding for all the other businesses involved. A responsible person that structured the projects and has an interest in all the parts of the system would also simplify the work. An additional improvement would also be to have the ability to inform the transporter and recipient in advance of the amount and food type.

5. Discussion

In this section, a discussion regarding the above presented literature and collected data will be purveyed. The importance of the different factors will be argued for with respect to their contribution to the environmental impact of redistribution systems. Based on the interviews performed and the data collected, concrete as well as more soft parameters are evaluated and hence, the research questions of this study will be attended to. The discussion is structured as implied by Figure 5.1 below and begins by implications on how to design redistribution systems of the future. Thereafter, the importance of preventing the occurrence of surplus food is underlined followed by a covering of the cases when surplus food can not be avoided. Then, assuring the redistribution of the surplus food has positive net climate impact is essential. Both the prevention and the redistribution efforts should always be discussed in the context of moving from linear models towards circularity.

Figure 5.1 Illustration over the steps throughout the discussion.



5.1 Designing future redistribution systems

This study can provide valuable information on how to design redistribution systems for surplus food in the future and make it environmentally beneficial. Firstly, the k-value presented in Table 4.8 and 4.9 can be expanded to a more general series to ease calculations of minimum amount of redistributed food depending on test parameters. To calculate the factor k for relevant general cases, the parameters having the greatest effect on emissions must be taken into account. As reasoned for in section 4.10, the three parameters with the largest impact on carbon dioxide emissions per kilometer are fuel consumption of the vehicle, fuel type, and traffic on the route. These three parameters are therefore divided into the general cases in the following manner with the calculations done according to the methodology presented in 3.4.3. The emissions for producing the foodstuffs are based on a mix of fruit and vegetables calculated in section 4.9 being transported and will therefore not be applicable to redistribution of meat and other foodstuffs.

Table 5.1. K-values for different trucks and traffic situations using HVO.

HVO	Large truck	Small truck	Cargo van
Heavy traffic	0.9	0.6	0.3
Medium traffic	0.4	0.3	0.1
Light traffic	0.5	0.3	0.2

Table 5.2. K-values for different trucks and traffic situations using diesel.

Diesel	Large truck	Small truck	Cargo van
Heavy traffic	2.0	1.2	0.7
Medium traffic	0.9	0.5	0.3
Light traffic	1.1	0.7	0.4

As seen in Table 5.1 and 5.2 the transport solution with the smallest environmental impact, other than cargo bikes and electric vehicles, is a cargo van run on HVO going through medium traffic. The caveat to that is however, that if the quantities available for redistribution are greater than a cargo van can feasibly transport, this mode of transport becomes ineffective, requiring additional trips. Traditional logistics contrarily try to maximize the fill rate of larger vehicles thereby creating both economic and environmental efficiency (Helo & Ala-Harja, 2018). In the case of redistributing food, however, large quantities are not the goal, rather redistributing the smallest amounts possible is the objective. Thereby, there are two options for optimizing fill rate: either co-load with other goods on larger vehicles or use smaller vehicles. Larger vehicles, while more efficient per quantity transported, will also need to travel a longer distance because co-loading generally leads to more destinations. Contrarily, using smaller vehicles leads to better fill rate without having to take the entire logistics system of the transporter into account and can therefore be an easier way to lessen the environmental impact of one's own redistribution.

The choice of fuel for the redistributing vehicle is largely economical in nature with the most expensive ones being the best for the environment. Therefore, what fuel is chosen largely comes down to how much one is willing to pay to alleviate the climate impact, though it is important to note that redistribution, even when using fuels with relatively large environmental impact, can be environmentally beneficial. Substantial reasoning can be done on the tradeoff between the environment and its monetary value, but it is outside the scope of this study.

The state of traffic on the route used for the transport also has an effect on the scale of the emissions. While the traffic itself usually is hard to avoid without using much longer routes, it is sometimes possible to avoid heavy traffic by choosing appropriate times of the day for transport. Often, the time for executing the transport is hard to adjust though, seeing as restaurants need the food early enough to be able to cook food with it. So while additional environmental benefits might be gained from having transportation later in the day, all the benefits will be nullified if it arrives so late the restaurant is unable to use it.

Designing a future working setup is not only about making the transport as environmentally friendly as possible. By summarizing the interviews, a big aspect for success is also good continual communication as well as flexible and adaptable organization between the actors in the setup. Morganti and Gonzales-Feliu (2015) describes how consolidation is a big problem for the environmental aspect of the last mile distribution of perishable goods, and Faccio and Gamberi (2015) explains that a big factor to the problems is inefficiency in the transports, which partly derives from low levels of co-transportation and an increase in empty running vehicles. According to the interviews, misunderstanding and lack of following schedule also led to some of the biggest problems. Melkonyan (2020) discusses how better strategies for sustainable logistics, such as integrated distribution channels between the key actors, could improve the environmental aspect of the last-mile logistics. However, the interviews showed that a good setup with well-functioning communication requires good initial planning, and continual meetings to reflect on the processes and the situation overall. These meetings enable the actors to improve the system and reduce problems and irritations but do require a lot of time from the actors' original work and require good organization. Unfortunately, there is always a risk with these kinds of requirements. Some actors in the setup may think of the redistribution as an unnecessary action since not all actors are interested in the environmental aspect of saving food and creating environmentally friendly transportations, especially if it does not generate money. If creating a setup that is complex and requires more effort than just making a logistic solution, the requirements could risk the whole setup in terms of losing important actors and so on lose the ability to save the food and contribute to a better environmental impact.

5.2 Redistribution as a last resort

An important initial point to be made is that there should be a never-ending strife to save more food. However, an increased amount of rescued food should not be due to each store wasting more food and thereby having a larger amount to be rescued, but rather, as argued for by Girotto et al. (2015) that more parties that currently discard food choose to act towards saving it. The aim should be to minimize the total food wasted and the individual stores ought to continue their efforts to mitigate food waste, which, according to Lagerberg F. et al (2011), is best done by combining several methods. From a larger perspective, there is still a need for more stores to join the movement towards a more circular consumption of food. Although outside the scope of this study, the prevention of food waste is at its essence.

Worth mentioning is that the LCA values (see section 3.3.2), as well as the weights used in this study are all average values. The LCA values for fruits and vegetables vary a lot depending on its origin. However, the difference between average LCA values for meat and fruits/vegetables is even greater and the LCA value for the fruits/vegetables was therefore not calculated more precisely. The most important aspect from the different LCA values is that rescuing meat is more beneficial since the LCA value is so much higher compared to fruits and vegetables in terms of the net climate impact per kilogram rescued. Therefore, preventing the wastage of meat and other products with high LCA values is of great importance. By the same reasoning as above, the solution is not an increased consumption of meat and more meat being rescued. Instead, the high climate impact of production implies that the aim should rather be a decreased meat consumption and stores having more ambitious goals regarding minimizing the waste of meat.

In the case of meat products, SLU (2013) suggests the option of freezing it and thereby prolonging the lifespan. The freezing of products with short best-before-date and getting a broad customer acceptance of this treatment of food, could lessen the total waste, avoiding redistributing transports altogether. Since neither dairy products nor vegetables maintain the same quality when using this mode of conservation, it is rarely an option for these types of goods. Due to their perishability, the importance of well-functioning redistribution systems with sufficient pickup frequency is more urgent for perishable goods, such as fruits and vegetables, than for food whose quality is not influenced by freezing.

In summary, redistribution of surplus food should always be seen as a last resort and the stores should always primarily strive to minimize its appearance. Redistribution should thus never replace the efforts to prevent food waste. Even though prevention efforts are made, some food will still be discarded and the importance of increasing the share of the discarded food being redistributed or used in a new way is of great significance.

5.3 Making redistribution net climate positive

Although the primary goal for the reduction of food waste is for the stores to minimize the waste, and not end up in a situation where the waste prevention is prioritized lower than redistributing, the waste will occur and there will be a need for redistribution. However, this redistribution system must ensure that the environmental benefits of the rescued food exceed the environmental harm caused by the logistics system providing the redistribution, provided that less new food is produced. By preventing more food waste, and thereby wasting less, the daily amount to be redistributed will be smaller and this is only one of the conflicting goals presented by Trisna et al. (2016). If the daily waste is halved, transport is only needed half as often compared to before. When quantities are reduced, the frequency of transports can be decreased. This facilitates generating a positive environmental impact of rescuing food that exceeds the negative impact of the transport. However, this becomes a problem when the aspect of perishability is taken into account, which aligns with the arguments presented by Orujela Castro et al. (2021). Decreasing the pick-up frequency will result in food getting inedible due to prolonged waiting time and hence, contradict the initial aim of rescuing food. Thus, in essence, when the amount of food to be redistributed is too small to compensate for the negative environmental impact of transports, there are cases when it is favorable to throw the food away rather than redistributing it, and this breakeven point for each system should always be considered.

When taking the volume of the surplus food into account, the transporters using smaller vehicles, such as electric cars and cargo bikes, may have an advantage. The break-even points for how many kilograms that are required for the test to compensate for the negative environmental impact of the transports for Test 1, 3 and 8 are all around 0, see Table 4.6 and 4.7. The break-even points for Test 2, 4 and 7 are significantly larger. Test 1, 3 and 8 all use an electric car and/or a cargo bike while 2, 4 and 7 use larger trucks or delivery vans. These results indicate that, while cargo bikes and electric cars cannot carry the same amount of cargo as trucks and vans, they can be beneficial from an environmental standpoint. Using cargo bikes and smaller vehicles is profitable from the emission perspective, Test 1, 3 and 8 all have an average climate impact from transportation around zero. However, it is not faultless, a small vehicle could be a problem as it could affect, and potentially minimize, the total amount of surplus food that could be rescued. As transporter 3 mentioned, the electric cars and cargo bikes work best within shorter distances and in smaller systems. As described by Faccio and Gamberi (2015), a big part of the population today lives in the cities and the amount will increase even more, therefore the solution with smaller vehicles seems suitable for a majority of the transportations. Ellen MacArthur Foundation (2017) also mentions that 80 % of the total food consumption around the year 2050 will take place in urban areas, zones where it is a big advantage to use these flexible and environmentally friendly vehicles.

Transporting the surplus food shorter distances also decreases the necessity of having specialized storage, such as refrigerated containers. According to Harrington et al. (2016) the need for specialized storage is an added dimension to the dilemma with redistributing surplus food, which increases the environmental costs. Using electric cars and cargo bikes are therefore good both practically and environmentally, even if the cargo load may be smaller compared to a truck. However, the results presented from the stores included in this research, clearly show that the amounts of surplus food in the stores normally are big enough to make the positive climate effects coming from redistributing it compensate for the negative climate impact from the transport needed to redistribute it. Hence, one could say that the prevention approaches are not yet good enough to render redistribution efforts obsolete.

When setting up conventional transport systems, without taking redistribution into account, an important aspect to make the transport as sustainable as possible is to keep the fill rate high, as presented by Ntinas et al. (2017). Likewise, the strive when setting up redistribution systems is to increase the fill rate in order to make as many goods as possible share the negative climate impact owing to the transport. Thereby, the amount of carbon dioxide assigned to each product will be lower. In many logistic systems, either weight or volume set the limits of the amount that can be transported. For example, in all of the 8 tests studied all transporters had the capacity to transport a larger amount of goods, but the volume of redistributed food was determined by the grocery stores and the quantity of their surplus food. This issue could be further problematized here, but an important point in the context of food waste is that the underlying goal is to decrease the amount of food in need of rescue. Therefore, the aim is that none of these parameters should be limiting the transport in question only by filling it with surplus food, but rather that the transports should be fully utilized by co-transporting it with other goods. However, when using vehicles with small cargo spaces, such as cargo bikes, the volume of the food could limit the transport, but since these kinds of transports are assigned zero carbon footprint, the solution would be that more trips would have to be made.

To be able to optimize the cargo space available, the interviews with the transporters show that both Transporter 1 and Transporter 3 wished for better communication from the stores regarding the amount of food to transport beforehand. By being provided with this information, better planning opportunities would be enabled, which could help handle the problem of transports not being optimally utilized. To co-transport the surplus food with other goods is especially important for the transporters using larger vehicles, especially when running on fossil fuel. Transporter 2 and 4, both companies using larger trucks, mention during the interviews the importance of the ability to co-transport. Since the volume of surplus food being redistributed in the tests is relatively small, they would not be able to optimize the use of their cargo loads without co-transportation and the amount of surplus food may not compensate for the carbon dioxide emissions from the vehicle. Helo & Ala-Harja (2018) discuss that the environmental and the economic efficiency increases by having higher fill rates, which Transporter 2 and 4 only achieves with co-transportation. Although, co-transportation could affect the net climate impact from the transportation as it could lead to larger distances driven. To summarize, the environmental payoff from rescuing the surplus food may not outweigh the climate impact from the transportation, the net climate impact for the transportation system is dependent on the vehicle and the ability to co-transport.

Another aspect to keep in mind when setting up redistribution systems is what type of food is to be redistributed and the climate impact stemming from its production. As seen in the results, the climate impact of redistributing meat is more often beneficial compared to fruits and vegetables from an environmental point of view, which leaves room for more options when designing a redistribution system. For example, longer distances can be driven with less amount of meat and still result in a net positive climate impact compared to when redistributing vegetables.

5.4 Transition towards circularity

Yet another important point to be made is that the systems in this study are circular. Since food production in itself has a high climate impact, the climate impact of redistribution has to be compared to the climate impact of potentially producing new food and distributing it. When redistributing a good in a circular system, as compared to producing it anew and distributing it in a linear system, the climate cost of production can be compared to the climate cost of the redistribution transport. Thereby, when the footprint of production for a good is high, the incentives for redistribution compared to production anew are even higher.

As seen in the results, rescuing food with a vehicle running on fossil fuels will in many cases still be better than producing new goods from an environmental point of view, even though a climate-neutral mode of transport is preferable. This environmental effect, however, is never the case in a linear model since all activities throughout the supply chain, including the transport, will only add to the total climate impact of the good. This means that for a linear model, the greater the impact from the transport, the greater the total climate impact will be. When redistributing food, a positive net climate impact can be achieved even if the transport itself has a negative climate impact. In contrast to the situation with the linear model, circular models imply that a heavier impact from the transport fuel will only decrease the net positive climate impact due to redistribution, but rarely make the overall impact negative. However, from the calculations based on the tests, we could see that rescuing food with fossil-fuel-transports requires that a larger amount is being transported, which, as mentioned above, is never the aim of this type of system.

In order to move from traditional, linear logistics systems to circular logistics systems as described by Bocken et al. (2016) for redistribution, an adaptation of the business models is of essence, and this requires innovative and forward-looking mindsets and solutions. Moving from linear to circular business models and supply chains requires tremendous changes and the exploration of new, innovative ideas, something that is in line with what Esposito (2015) argues for. To succeed, business models ought to be designed in the spirit of seizing value from what is considered as by-products and waste in the linear systems of today - a way of design presented by The Ellen MacArthur Foundation and their butterfly concept. Circularity must be implemented at all stages and permeate the whole network. Therefore, going circular is not only about changing the business but also about influencing the whole network and ensuring sustainability and circularity from cradle to cradle. Store 4 and Transporter 4 agreed that a future setup and collaboration would be facilitated if the actors had a genuine interest in the project. However, interested actors could potentially be hard to find, hard to maintain, and this demand could limit the possible growth of future projects. The same aspects have to be considered regarding having a responsible person in each part of the setup. This person has to have an interest in the environmental aspects as well as in the setup. The person further needs to be willing to continuously improve the setup and keep good contact with the other responsible persons.

The strive towards circularity and increased sustainability must permeate the whole redistribution system. Restaurant 1 wished for better information about the delivery, in terms of what kind of food, and the amount that would be delivered. That could potentially be a big opportunity to reach new restaurants, since many chefs today may find it difficult to prepare the meals without knowing what food will be received in the morning. However, providing more detailed information about the surplus food to be delivered may be problematic for the retailer because it's hard to know what food that needs to be rescued that day, and it varies to a great extent. A possible solution could be an application that informs the restaurant when the retailer has collected the surplus food, albeit this would require effort from the store to update the application. An effort that would be lesser if the store had a person responsible for the test. The overall conclusion from the interviews shows that having a responsible person simplifies collaboration in the transition towards circular redistribution systems. The importance of good communication, in addition to the qualitative aspects, as discussed above, lays the foundation for a successful implementation of redistribution setups.

6. Conclusions

The purpose of this study was to evaluate different parameters and their environmental effects in redistribution systems of perishable food, which was done by analyzing redistribution tests created by ReSvinn. Our findings resulted in several factors, which can make future redistribution systems more environmentally friendly, while calculations show that the tests studied all have a net positive environmental impact. The parameters that substantially affected the environmental emissions are type of vehicle used, traffic situation, fuel used, co-transport, weight of the food, and distance driven. The two last parameters are rarely possible to change in a setup, rather they are a result of the setup's circumstances, however, they are important for calculating the environmental effect of a setup.

The interviews with the different actors, combined with the frame of reference, show that good communication between the parties involved is the most important factor for a redistribution system to continue in the long run in the long run. Bad communication and misunderstandings can lead to actors no longer wanting to continue the setup which leads to less food being saved. Other important aspects are flexibility within the distribution, openness for changes and improvement, and having an understanding of the other actors in the setup.

A wider consequence of this study is the proven viability of local redistribution of perishable foodstuffs from an environmental perspective. This means that governing bodies should strive to provide additional support to establishing and continuing local food distribution networks. Additionally, the result may affect consumer behavior in favor of actors involved in redistribution which can be a further incentive. This study shows that local redistribution systems of surplus food for the most part have a net positive environmental impact and should be encouraged, as long as the goal is not to increase the amount of surplus food but rather take care of more of it. For transporting the surplus food, the k-value provided in 5.1 is an easy way to decide if a specific redistribution system will have a positive net climate impact, which should ease the process of starting new redistribution initiatives.

This study was conducted in collaboration with ReSvinn and included eight tests, future research could include more tests in Sweden to allow for further generalization but of even more pertinent may be to see if the results are the same in the rest of the world. Due to lack of available data, this study's calculations are based on a template number for co-transport and future research should focus more on the effect milk runs have on environmental impact. Despite being outside the scope of this study, the economic aspect is also of interest and relevance, especially when it comes to influencing private companies to develop redistribution systems. For future research it is of interest to analyze the applicability of redistribution systems in other scenarios. Redistribution could potentially be environmentally viable in a wide range of different industries not only among those using food but other resources as well. This study only took local redistribution between companies into account, but it could be of interest to study both longer range redistribution but also redistribution to private persons and homes to truly see the extent circular economy is applicable.

7. References

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Appendix A - Interview guide

The transport system in the test:
Can you describe how the transport system in the test is built? (Together we make a sketch over the system and create a picture over the test)

What type of vehicle is used?
Is it always the same type or does it vary?
Details about the vehicle (make, model, and year of production)

If fuel-powered, what type of fuel is used?
Do you have data over average fuel consumption for the test?

If an electrically driven vehicle, what is the source of the electricity?

Co-transport - is other goods transported in the same vehicle with the food in the test?
If so, what is the average volume and weight of the goods?
Can you, very shallow, describe how the co-transport is built?

Return transports - do you return SRS-crate or rolling cages back to the store?
If so, what distance does this cause? Is there extra distances or detour because of this?

What positioning distances does the test bring?

What kind of traffic situation is it normally during the transport?
Inner-city traffic, outer city traffic, or countryside?
Is the transport during rush hour?

Open questions:
What do you think has worked well during this collaboration? What areas for improvement are there?
How did you decide the pick-up and delivery times?
Is the schedule preferable?
Would the transport efficiency increase with different times? If so, what times?
Is there something else that could be changed to increase the efficiency?

What lessons can be learned from the collaboration/test?

What do you think is important for future collaboration between a grocery store, collector, and a transporter where surplus food is redistributed?
What do you think is important to develop a more efficient system, environmentally and cost-effectively?

Are there situations where ”new” food is co-transported with the surplus food and there is a risk of conflict?
Is there anything else you would like to add?

Transportsystemet i lösningen:
Kan du beskriva hur transportsystemet är uppbyggt i testet? (Vi hjälps åt att rita upp systemet och skapa en bild av hur det ser ut)

- Typ av fordon
    - Är det alltid samma typ av fordon eller varierar det?
    - Detaljer om fordon som fabrikat, modell och årsmodell.
- Om bränsledrivet fordon: Vilken typ av bränsle används?
    - Har ni data på genomsnittlig bränsleförbrukning för sträckan i fråga?
- Om eldrivet fordon: Vilken är källan till elen?
- Samtransport
    - Kör ni annan mat eller andra varor i kombination med det matsvinn som hämtas?
    - I så fall; vad är ungefärlig vikt och volym på det övriga?
    - Kan du snabbt beskriva hur samtransporten är uppbyggd?
- Returtransporter:
    - Kör ni SRS-backar eller rullburar i retur som ger upphov till extra sträckor eller omvägar?
    - Antal?
- Avstånd:
    - Vilka positioneringsavstånd medför testet?
- Trafiksituation:
    - Stadstrafik eller landsvägstrafik?
    - Rusningstrafik eller inte?

Öppna frågor:

- Vad tycker du har fungerat bra i detta samarbete och vad finns det för förbättringspotential utifrån ditt perspektiv?
    - Hur bestämdes upphämtnings- och leveranstider?
    - Är det tiderna ni föredrar?
    - Skulle ni kunna öka transporteffektiviteten om andra tider valts, vilka är dessa i så fall?
    - Är det något annat ni skulle vilja ändra för att öka transporteffektiviteten?
- Vad har du lärt dig av testet?
- Vad tror du är viktigt för att fler samarbeten mellan butik, mottagare och transportör ska startas där överskottsmat omdistribueras?
- Finns det situationer när en konflikt med att samlasta matsvinn med "ny" mat uppstår?
- Inför framtida uppsättningar av omdistribution av matsvinn, vad tror du är viktigt för att systemen ska kunna utvecklas och bli effektiva både miljömässigt och kostnadsmässigt?
- Något annat du vill tillägga?

Survey sent to Transporter 6:

- When you transport for ReSvinn, describe the total transportation system (including schedule, routines and distances)
- Distance between Store 6 and School 6
- Positioning distance to Store 6
- Positioning distance to School 6
- What type of vehicles were used and how often were they used? (Model, type of fuel)
- Describe eventual return-transport back from the school to the store (SRS-crates and similar)
- What kind of traffic was it during the ruote? (Inner city, outer city, or country road?) If different kinds, describe the distribution
- Is the test done during rush-hour?
- If it is done during rush-hour, would it be possible to re-route the route? What effects would this bring with?
- What has worked well during the collaboration? What kind of areas of improvement are there?
- To future setups, what are important to have in mind?

Enkät skickad till Transporter 6:

- När ni transporterar åt ReSvinn, beskriv det totala transportsystemet (inkl. tider, rutiner och avstånd)
- Ange avstånd mellan Ica Maxi och Förskola enligt eran rutt
- Ange positioneringsavstånd till butiken
- Ange positioneringsavstånd från förskolan
- Vilka typer av fordon används och hur ofta används varje fordonstyp? (Ange fabrikat, modell, typ av bränsle & år för resp. fordonstyp)
- Beskriv eventuella returtransporter tillbaka från förskolan till Ica Maxi (returtransport av SRS-backar eller rullburar etc)?
- Vilken trafiksituation rådde under körning? Är det Innerstadstrafik, ytterstadstrafik eller landsvägstrafik? Om flera trafiksituationer, beskriv gärna fördelningen.
- Råder det vanligtvis rusningstrafik när ni kör mellan Ica Maxi och Förskolan?
- Om rundan sker under rusningstrafik skulle det finnas möjlighet att lägga om rutten, vilka effekter skulle detta medföra?
- Vad tycker ni har fungerat bra i samarbetet och vad finns det för förbättringspotential?
- Inför framtida uppsättningar av omdistribution av matsvinn, vad tror du är viktigt för att systemen ska kunna utvecklas och bli effektiva både miljömässigt och kostnadsmässigt?

Appendix B - Interview: Transporter/Restaurant 1

A. **Kan du beskriva hur transportsystemet är uppbyggt i testet?:**
- Vi hämtar matsvinn på fyra butiker, tre i centrala Göteborg och en i Partille

- En av rundorna fungerar som så att varje dag (5 dagar i veckan) hämtar vi matsvinn på två av de centrala butik kl 9-10 på morgonen, detta görs med lastcykel. Rundan är ungefär 1 km totalt. Vi ringer på morgonen och kollar hur mycket matsvinn som ska hämtas. Vi går direkt in i butiken är en smidig process.

- Den andra runda ska hämta varje dag men blir inte alltid så, plocket av svinn är inte lika regelbundet i butiken. Ibland slänger butiken svinnet istället något vi tror är pga okunskap hos anställda om projektet. Det ändras en del i de anställda på butiken och de har ingen ansvarig för projektet så som butikerna i första rundan har. Denna runda sker med lastcykel efter lunch, vid 13-tiden. Denna runda sker efter andra lunchrundor och är den sista kund. Totalt är rundan ca 1 km beroende på de andra kunderna.

- Den sista rundan som sker i Partille sker på måndagar, onsdagar och fredagar. Vi har alltid leverans till annan kund i närheten som görs innan transporten går vidare till butiken. Efter det fortsätter rundan till en annan kund innan vi åker tillbaka till våra kontor. Detta görs med en elbil, elbilen klarar av hela rundan på en "tank". Här byter vi tomma SRS-backar till fulla SRS-backar. Rundan sker under lunchtid (12-12.30), även här är det smidigt pga kan gå direkt in i butiken då de vet vad svinnet finns och har bra kontakt med butiken.

B. **Om eldrivet fordon: Vilken är källan till elen?:**
- Hushållsel från kontoret som är green key certifiering. Elen är fossilfri samma med lastcyklarna (de har elassistans).

C. **Samtransport:**
- Nej

D. **Returtransporter**:
- Bara SRS-backar, tar med samma dag och returnerar är olika mängd varje dag men runt 5-9 backar per gång. Men detta sker under samma transport som sker när maten ska hämtas. Dvs inga extra transporter sker.

E. **Trafiksituation**:
- Morgon och lunchtid men ingen direkt rusningstrafik.

F. **Vad tycker du har fungerat bra i detta samarbete och vad finns det för förbättringspotential utifrån ditt perspektiv**?:
- Butikerna i den första och tredje rundan har projektansvariga i butiken vilket underlättar samarbetet. Det är bra kommunikation med dessa tre då vi kan ringa och kolla ungefär hur mycket matsvinn som ska levereras och vad det är för varor. Vi vet vem vi kan kontakta och vem som har koll på svinnet och allt runt om. Vi vet hur man hittar i butiken samt finns kontinuitet i butikerna i när svinn rensas och när vi kan hämta.

- I den andra rundan är det inte lika bra kontinuitet då det är sämre kommunikation med butik och det finns inte personal på butiken som är ansvarig för projektet, det är stor rullinas med anställda och chefer.

- Jobbade med en femte butik innan men det funkade inte. Vi var tvungen att avsluta samarbetet. Detta då det var svårt med kommunikationen samt ingen kontinuitet i när maten rensades ut och kunde levererar matsvinn.

- Vi tycker att kontinuitet och kommunikation är viktigt för ett fungerande samarbete.

- Vi bestämde tider för leveranser med både kockarna på vår restaurang och butikerna. Våra kockar vill ha en del på morgonen för att veta om de ska göra extra, om de ska påbörja ett stort projekt till morgondagen vill de veta vad för mat som finns tillgängligt tidigt. Vi vill även ha en viss kontinuitet för att vår personal ska kunna bestämma sina schema med transporter och leveranser.

- Vår önskan är att när butiken har kollat vilket matsvinn som finns skulle de kunna registrera den infon direkt till oss så vi kan förbereda sig till ex lunch. Att vi helt enkelt skulle få info snabbare från butik. Hade även varit bra med att ha passerkort till butikerna. Det kan vara svårt att komma in ibland, kan behöva vänta på att någon i butiken kan öppna.

- Ett problem är att det kan vara en lastbilar i vägen när i lastzonen vid butikerna vilket gör det svårt att komma åt maten eller komma ut ur butiken igen. Hade varit bra att ha signal som signalerar att det är många transporter i affären, att det finns risk att vi kan fastna där eller så skulle kunna ha system tillsammans med info om hur många transportörer som är där.

- Vi har jobbat med detta sen april/maj -19

G. **Vad har du lärt dig av testet?:**
- Att vara kreativ ibland kan det levereras väldigt mycket av en viss sort mat som inte är så vanlig i matlagning. Kan vara svårt att använda och ibland måste maten slängas. (Då hade det varit bra att få info om det innan, ex om det får två backar med päron har det svårt att använda och skulle kunna behöva distribuerar detta till andra parter eller att inte behöva hämta allt).

H. **Vad tror du är viktigt för att fler samarbeten mellan butik, mottagare och transportör ska startas där överskottsmat omdistribueras?:**
- Avgörande: är att ha någon som är ansvarig för projektet i alla parter.

- För butikens del, att de inte behöver sortera flera gånger att transportören kan ta allt, minskar deras stress i butiken.

- Restaurang: Vi behöver struktur, meny bestäms i förväg, att rest. måste kunna vara flexibla, vet inte riktigt vad som kommer varje da. Snabbmats- och lunchrestauranger kanske inte är så intresserade i denna typ av jobb då det är svårt att passa deras affärsmodell.

- Om en ny restaurang ska börja med liknande måste de kolla att de har kapaciteten, kolla om det är möjligt med transport mellan parterna, frågan för många är: är det värt att lägga pengar på det?

- Idé: att ha typ 10 restauranger med olika typer mat som serveras som kan ta hand om olika svinn, nån vill ha bröd, nån annan frukt osv. Transportören/tredje part gör den andra sorteringen efter butiken och delar ut till de olika restauranger beroende på vad de behöver/vill ha för mat (vilket är typ som vi jobbar just nu, men de har kunnat ta hand om det mesta själva och skulle vara en idé att utöka med fler restauranger).

I. **Något annat du vill tillägga?:**
- Viktigt att hitta tydliga kommunikationsvägar. Kommer behövas samordningssystem om systemet ska bli större.

- Det är oberäkneligt (kul men utmanande). Vissa dagar kan det hämtas med bil eller cykel beroende på mängd svinn från butik och det är olika varor varje gång.

- Matsvinnet är flexibelt så det finns en viss poäng i att vara flexibel så man vill/kan inte standardisera för mycket.

- Men kommer till en punkt att man måste planera rutter för de anställdas skull, när blir det värt att ha en standardiserad rutt?

Appendix C - Interview: Transporter 2/7

A. **Typ av fordon**: Är det alltid samma typ av fordon eller varierar det?
- Det är livsmedelstransporter, vi har 200 fordon så det som används här är antagligen 3 1/5 ton bilar och citytrailers, alternativt en 15 ton lastbil med lastförmåga på 8 ton och har 3 (2.9) l/mil i bränsleförbrukning.

B. **Om bränsledrivet fordon: Vilken typ av bränsle används?**:
- Vi använder en diesel mix med 35% CO_2 reduktion med Euro 6a - klassificering på motorerna (det styr utsläppsvärdena inte CO_2 - alla de övriga gaserna) det styr om man får köra i olika zoner eller inte Euro 5a inte köra i stan från och med i år.

C. **Något annat du vill tillägga?:**
- Det sker inga miljömässiga ändringar vid liknande uppdrag, bara om det finns specifika krav tex om en kund har krav på att alla fordon ska vara fossilfria (HVO ist) eller krav på hur mycket utsläpp under well to wheel, om det ska användas biogas. Vi kommer investera i elbilar, gasbilar, RME (raps) mer kommande år.

- vill erbjuda men det blir dyrare kollar även på robotar och drönare inom transportsektorn

- Får inte lov att köra med dieselbilar på natt på grund av buller så det minimerar tiderna då det går att utföra uppdrag på. Det är allmänt svårt att köra vid natt, kan behövas vakt och att någon öppnar, kan funka om vi får en nyckel.

Appendix D - Interview: School/Restaurant 2

A. **Hur är systemet uppbyggt?**: Vi har en representant på skolan en som är produktionsledare och tar hand om upphandling, service på maskiner, kommunikation mellan lärare, träffar mycket elever. Skolan jobbade inte med hållbarhet eller åtminstone väldigt dåligt med det. Ville testa nytt projekt för att jobba lite mer med hållbarhet och matsvinn.

B. **Vad har fungerat bäst i testet?**: Under hösten fungerade projektet superbra, lyhörda på butiken. I början var det stora mängder och dåligt rensat. Efter några gånger (2-3 ggr) blev bättre sorterat. Butiken är lätta att samarbetar med. Samarbetet pågår fortfarande men har inte fått någon mat under hela våren. Antagligen då anställda på butiken har haft semester eller att butiken har haft det svårt med kommunikation internt. Sen var butiken redo men då visste inte GLC att de skulle hämta.

C. **Vad har fungerat sämst?**: Vi hade ett avbrott efter jul pga distansundervisning (corona). När vi kom tillbaka fungerade inte, inga leveranser hela 2021, kommunikationsproblem mellan parter, ska komma denna vecka, komma igång igen

D. **Varför fungerat sämre nu i vår?**: Vi har blivit informerade att de hade driftstopp i butiken, men antagligen har det blivit fel internt hos butiken samt kommunikationen mellan butiken och leverantören. Butiken upplevs inte som slarviga men har nog blivit en miss. Vi har skickat mail men enligt butiken har de missat att vi vill ha maten levererad igen.

E. **Hur har kontakten med butiken fungerat?**: Kommunikation med den specifika butiken som levererar maten, allt sker inom samma butik. Har funkat bra under hösten.

F. **Vad har ni lärt er?**: Mycket av maten som butiken slänger går att använda. Förvånad över att maten inte verkar vara svinn, att de skickar så fina saker. Vi skriver upp en lista över vad som finns sen får lärarna ta maten. Den mat som inte används blir en bonus (bonus: vem som helst kan ta, annars slängs det eller används utöver undervisningen). Ibland skänker vi maten till andra delar om de blir för mycket av en sak, ex får för många bananer.

G. **Hur mycket har ni fått?**: 40 gråbackar i början (80x40cm) minskade till 20 för att vi skulle kunna använda all mat. Detta är delvis pga corona men också pga lärare som behöver sätta ett recept. En del lärare har varit väldigt kreativa och har kunnat använda mycket av maten. En del av maten har ibland skickats till bamba, går det inte att använda i undervisningen skickas det till lärarrum eller att eleverna får ta själva. 1-2 leverans i veckan, max 20 backar men kan variera mycket mellan veckorna.

H. **Vad är ert bästa tips för att starta upp något sånt här?**: Kontakta butik och se om det går att fixa samarbete. Sen finns det en del att hitta via social media tex att man kan köpa in billigt matsvinn. Hitta en leverantör att jobba med. Vi ifrågasatte varför de är så mycket matsvinn och av vissa varor detta väckte tankar hos butiken. Som har gjort att de har gjort åtgärder för att minska svinnet. Butiken säljer svinn-lådor. Enligt butiken måste de alltid ha vissa varor inne annars kan de riskera att förlora kunder, speciellt viktigt med de vanligaste varorna som mjölk, banan, blöjor.

I. **Vad är viktigast med ett sånt här samarbete?**: Vi åkte till butiken och skapade en bra relation sinsemellan. Att prata om vad man säger till varandra och vad allas gränser går. Transportörerna har de inte lika bra kontakt med, men har gått bra med tider och har haft bra leveranser. Vi har fasta tidsintervall de levererar på. Behöver inte mer från transportörer men kanske mer kommunikation mellan butik och skola, veta mer om vad för svinn som kommer och hur mycket.

J. **Vad gör ni med råvarorna?**: Vi gör soppor, lunchlådor osv att sälja i vår restaurang. Elever har färdigskrivna menyer så matsvinnet blir bonus till maten i undervisningen. Eller så används det i metodmatlagning att man fryser in, gör marinader eller sylt, inlagda grönsaker, dekorerar tårtor och marmelad. UF företag har använt det som grund till sina projekt. Det är bara frukt och grönt som vi får, vill inte ha kött då det är så planerat på skolan och vi kan inte begära att eleverna arbetar så flexibelt.

K. **Hur har ni kommunicerat med elever och kunder**: Vi har inte kommunicerat så mycket i restaurangen. Men mycket med eleverna och i butiken, berättat om det och har presenterat projektet. Vi har även kollat upp med elever (är med i generation waste också dvs väger all matsvinn, matrester både det från butiken men också eget).

L. **Vad har responsen varit?**: Många av eleverna tycker det är kul och är engagerade, en del bryr sig inte (beror på mognadsgrad och intresse). En del lärare tycker de är besvärligt när de kommer in en vagn med mat utan att det är förplanerat. En del tycker det är jättekul och är intresserade och kreativa och förbereder innan då de vet att de kommer frukt och grönt. Tycker det är roligt att de kan jobba fritt ibland tex med elev-maten. Vi har marknadsfört lite att de är svinn men har inte gjort det lika mycket som vi har tänkt. I restaurangen gjort informationsblad på borden om svinnet, lite data. Här har vi fått lite respons och frågor av kunderna där eleverna har fått svara och pratat om hur de har gjort maten.

M. **Hur har det gått med mätningarna?**: Det har fungerat bra att mäta (väga all mat när de kommer och skriver upp vad de är för något). Vi har gjort diagram över vad vi får in, (bananer, isbergssallad, tomat osv, dvs de vanligaste). Vissa artiklar har fått egna kategorier, andra har fått klumpats ihop. Vi delar upp och väger dem var för sig samt väger allt tillsammans. Vikten beror mycket på vad det är som levereras har legat runt 100-200 kg. Det har varit tidskrävande, speciellt i början pga behövs rensas, mer tid än vad vi förväntade oss. Vi har vägt hur mycket vi själva var tvungna att rensa bort. Men tiden har minskat, bättre sortering i backarna från butiken efter att vi kommunicerade detta med butiken. Idag tar det ca 30min- 1h 30min med 2 personal. Datan används för att informera gäster och elever för att de ska se vad vi har gjort och vad som har använts.

N. **För att förbättra**: Total vikt från butiken och hur mycket butiken själva slänger utöver det som skickas till oss. (dvs hur mycket butiken som rensar bort).

O. **Har ni saknat några riktlinjer, tips eller material från ReSvinn när ni har startat projektet?**: Tycker vi har fått bra info av ReSvinn.

Appendix E - Interview: Transporter 3

A. **Kan du beskriva hur transportsystemet är uppbyggt i testet?:**
- Det är en direkt transport mellan restaurang och butik. Men andra kunder innan och efter dock ingen större distans skillnad med eller utan detta projekt.

- Sista sträckan efter restaurangen kan se olika ut olika dagar. Det kan vara till andra kunder men det vanligaste är tillbaka till terminalen.

B. **Typ av fordon Vilken är källan till elen?:**
- Vi använder elassistans på cyklar, enbart cyklar används. Som laddas i vår terminal i centrala Göteborg. Är ganska säker på att det är fossilfritt. Använder sig av Göteborgs energi.

C. **Samtransport:**
- Ingen samtransport, vanligast, kan hända men sällan.

D. **Returtransporter:**
- Frigolit, tillbaka till terminalen i så fall (eget material), som återvinns.

E. **Trafiksituation:**
- Det är innerstadstrafik: 8/9/9.30 på morgonen klart strax efter 9. Vi har tidsintervallet
8-10 på oss, ingen rusningstrafik.

F. **Vad tycker du har fungerat bra i detta samarbete och vad finns det för förbättringspotential utifrån ditt perspektiv?:**
- Överlag, funkat bra, vi är nöjda

- Dock kan packning som sker i butiken ta tid från uppdraget. Ibland kan vi behöva vänta på att packning ska ske.

- Det är även osäkra mängder (varierade), svårt att veta hur mycket plats som kommer tas upp på cykeln.

- Tiderna bestämdes i samråd med alla parter.

- För oss är det vanligast att samråda med alla parter i system vid bestämning av tider. Sen måste det passa vårt eget schema, men har som vana att vilja ha med alla parter vid schemaläggning

G. **Vad har du lärt dig av testet?:**
- Ingen direkt förändring har kommit ur projektet, är som en rutinkörning för oss

- Alltid en lärdom att finna när man jobbar med nya kunder samt när man transporterar ny sorts mat, har kört liknande saker innan (kött och grönsaker).

H. **Vad tror du är viktigt för att fler samarbeten mellan butik, mottagare och transportör ska startas där överskottsmat omdistribueras?:**
- Kommunikation mellan parter är viktigt, det ska passa in i allas schema. Alla har

olika tider, om de ska vara till lunch för restaurangen måste det levereras innan lunch. Affären vill helst lämna maten då de är färre människor i affären. Att hitta tidsfönster som passar oss och våra kunder kan ibland vara svårare. Speciellt om kunderna har ett tidskrav som är snävare.

- Sträckan var bra för oss, både distans och tider. Om systemet ska förstoras skulle det bli svårare, skulle behöva systematisera mer. Men i detta fall funkade det väldigt bra för våran del.

I. **Något annat du vill tillägga?:**
- Kul projekt, kul grej att göra!

Appendix F - Interview: Transporter 4

A. **Typ av fordon**:
- Mercedes Sprinter (2020) som körs på HVO, dvs fossilfria leveranser.
100 egna bilar, 40 HVO. HVO dyrare och drar mer än diesel. 1.8 - 2 l/mil i bränsleförbrukning.

B. **Samtransport:**
- Det är direkt transport, pga skolan är strikta med tider, går inte att samordna med andra rutter för oss. Annars brukar vi vilja satsa på det.

C. **Returtansporter**:
- Det är inga returer som sker mellan skolan och butiken.

D. **Avstånd**:
- Från vår terminal till butiken är det ca 29 km. Sen är det oftast en annan kund emellan butik och skolan.

E. **Trafiksituation**:
- Vi kör denna rutt under dagtid (11 - 14) i innerstad södermalm (centrala stockholm)

F. **Vad tycker du har fungerat bra i detta samarbete och vad finns det för förbättringspotential utifrån ditt perspektiv?:**
- Det har funkat bra för oss. Har varit lite problem med tider men det är vi vana vid. Logistik är alltid svårt mellan alla parterna. Det kan vara svårt att tillmötesgå kunder ibland då de kan har höga krav, då kan det vara svårt att pricka in rätt tider som passar både dem och oss. Vi kör med fast upplägg 2 ggr/vecka.

G. **Vad tror du är viktigt för att fler samarbeten mellan butik, mottagare och transportör ska startas där överskottsmat omdistribueras?:**
- Man måste först säkerställa att intresse finns. Om det är små volymer kan det bli ovärt för oss. Kan bli dyrt (både ekonomiskt och miljömässigt). Ibland har det varit höga krav från kunder vilket försvårar det för oss att kunna samordna och hålla det miljövänligt. Stora volymer är väldigt bra att säkerställa ett hållbart system.

Appendix G - Interview: Store 4

A. **Vad har fungerat bäst?**: Samarbetet med skolan, dialogen emellan. Skolan tycker att det är en bra mängd som vi har levererat som de har kunnat använda. Bra att vi har kunnat använda vårt matsvinn istället för att slänga den.

B. **Vad har fungerat dåligt?**: Transportfrågan, har inte vetat vad de ska hämta eller vilken avdelning de ska till osv då vi är en stor butik med många avdelningar. Det har varit problem med att transporten inte har dykt upp eller vid fel tider osv. Det har varit planerat med fasta dagar med ett tidsintervall för att de ska få en smidig leverans på transportsidan. Vi har försökt hitta lösningar pga corona (skolan har stängt), levererat till två olika adresser, annars bra med skolan.

C. **Vad har ni lärt er?**: Inte supermycket, transportfrågan har varit svår, lärt oss att dialogen med skolan är viktig. Internt har vi redan jobbat med svinn och hållbarhet. ReSvinn projektet har varit det nya, ett nytt sätt att jobba med svinn på.

D. **Vad har ni för tips för ett lyckat samarbete?**: Ha bra dialog och samarbete. Att ge feedback till varandra, hur det ska förpackas, var de ska levereras, vad för artiklar som funkar bäst osv.

E. **Vad har ni för tips att starta ett liknande samarbete?**: Det svåraste är att hitta samarbetspartner, vi har sökt länge efter en part att ge svinn (bröd) till. Vi har jobbat med organisationer innan men ingen som vill ta emot maten. Det kan vara svårt att komma igång med en annan part. Kan vara svårt att nå fram till de som vill ta emot maten, svårt att hitta kontakter. Vi jobbar aktivt med svinnet.

F. **Vad har ni för uppgifter i butiken med ReSvinn?**: Vi rensar frukt och grönt varje dag, 4 dagar i veckan samlar vi svinn till skolan. Vi sorterar ut det som kan passa till skolan, sen också matsvinn till svinnlådor, till vårt eget kök. Vi har lagt till sorteringen till skolan utöver våra egna uppgifter som vi har haft sen innan. Skolkockarna är mer kreativa än vad vi själva är. För oss är det jobbigare att laga maten och sen måste vi markera vad som är i maten osv på förpackningen, något skolan inte behöver göra.

G. **Hur har ni kommunicerat om resvinn till medarbetare och kunder?**: Via sociala medier (2 inlägg om resvinn). Sen har vi interna veckobrev och pratat om det internt till de som de berör. Vi följer upp hur mycket vi förädlar mot svinnet (procentuellt) det är en del av veckans svinnbrev.

H. **Hur har det tagits emot?**: Positivt, lite jobbigt med transportören och så men överlag positivt.

I. **Hur jobbade ni med svinn innan, var det jobbigt att ta med ReSvinn?**: Projektet möjliggjorde mer förädling. Vi kom igång med svinnpåsar då vi såg att vi kunde göra det också. Vi gör en massa olika saker, det var inte lika etablerat innan men vi har kunnat bygga på det och göra den mer utvecklad för att slippa slänga lika mycket. Alla som jobbar frukt och grönt är involverade men det är en som följer upp projektet internt.

J. **Hur har det gått med mätningar?**: Det har fungerat bra, ReSvinn har varit nöjda med datan. Det är svårt att få precision och att få alla att skriva upp datan. Vi har tillsatt en projektansvarig i butiken sen följer vi upp dagligen hur mycket vi skickar (kg), fördelat på frukt och grönsaker. Det är inte jätteexakt, så varit ganska tidseffektivt, mindre precision men de har räckt för projektet. Vi har kört lite på känsla, använder en metod som känns tillräckligt bra. Sen har vi ett internt system hur vi svinnar där vi skriver exakt hur mycket kg vi svinnar och vad det är för orsak (har orsakskod förädlat, utgångsdatum osv). Internt pratar vi mer om förädlingsprocent på avdelningen inte specifikt om ReSvinn. Det används mer som uppmuntran på hur mycket vi jobbar med matsvinn osv. Vi hade velat jobba mer med skolan kanske åka till skolan och äta svinnmaten eller så. Vi har gjort en video på sociala medier om projektet, sen dialog från skolan om hur det funkar och vad för mat skolan har kunnat göra och vad för mat som är bra att få. Detta system fungerar, vi har en bra excel och överlag bra nivå på systemet.

K. **Finns det något material, tips, riktlinjer som hade underlättat?**: Vi har bra koll på processen sen innan, vi löste systemet själva. Vi valde att använda bananlådor så vi slipper returer med SRS-backar. Tänkte använda SRS-backar först men valde bananlådor istället för att de kan bli dyrt om backarna försvinner. Samt jobbigt med logistiken att skriva ner hur många som används och som kommer tillbaka.

L. **Hur fungerade samtalet för vilka tider osv?**: Alla tre parter var med, anpassade oss efter transportören för att de inte skulle behöva göra fler rundor. Fick ändra tider lite för att de skulle passa alla. Det har varit jobbigt ibland med transporter men överlag bra.

Appendix H - Interview: Transporter/Store 8 + School 8

Hur ser projektet ut för er?: Det är 20-60 kg (30 kg i snitt per leverans) matsvinn som levereras, 2 ggr i veckan. Det är enbart grönsaker och frukt (men vi har pratat om att kanske köra torrvaror senare i projektet). Kostnadsmässigt pratar vi om 3 kr/kg räddad mat, väldigt billigt i jämförelse med det vi säljer det för.

Butik/transportör: Det har gått bra för oss. Vi har haft det lite svårt med leverans pga sjukdomar och med planeringen internt. Först vad det butikschef som körde leveransen. Men nu har vi en transportör som jobbar med det. Vi har några i butiken som plockar svinn sen innan och det har funkat bra för henne då hon nu slipper packa det för att sälja det i s.k. svinnpåsar/lådor. Överlag har detta projekt fungerat bra för oss i butiken. Vi i butiken levererar själv ingen extern transportör. Vi försöker alltid hitta nya lösningar för att minska matsvinnet och jobba mer hållbart.

Skola: Vi har haft lite tidsbrist ibland, men har funkat överlag. Har varit roligt att få olika matartiklar och att kunna bli inspirerad. Har varit väldigt uppskattat bland elever, lärare och föräldrar. Barnen är glada över olika typer av frukter till mellis och sylt osv, lärarna tycker det är ett roligt projekt. Det mesta av maten har kunnat användas, lite kastas pga är för dåligt. Tidsmässigt lite jobbigt men försöker få in några gånger i veckan. Vissa rätter har vi kunnat göra helt på svinn. Vi (skolan) skulle vilja markera detta (i butiken och bland elever/föräldrar) för att synliggöra att man kan göra mycket med matsvinn. För att ge en signal till lärarna och eleverna för att uppmuntra till minskad matsvinn. Föräldrar har varit positiva till detta och tycker att det är ett bra initiativ. Kanske man kan ha affisch i frukt och grönt avdelning (i butiken) som visar upp detta projekt eller ha en filmsnutt. Vi (skola och butik) vill undvika användning av ordet matsvinn. (Det är ju inte riktigt matsvinn då maten inte slängs, de omdistribueras). Egentligen är det ju mer konsumenterna och hela systemet som är problematisk. Vi har fått lagom mängd mat (60 kg i vecka, snitt). Vi har haft en bra kontakt sinsemellan (butik och skola). Dock har projektet bara pågått i ca 3 veckor så mycket kan ske/ändras.

Appendix I - Carbon dioxide emissions calculations

	Test 1 A	Test 1 B	Test 1 C	Test 2	Test 3	Test 4 min weight	Test 4 max weight
Weight of food [kg]	66	66	66	133	14	57	67
Distance [km]	3	2	33	28	2	18	18
Positioning distance [km]	N/A	N/A	N/A	N/A	1	9	9
Total distance [km]	3	2	33	28	3	27	27
Traffic situation	Heavy traffic	Heavy traffic	Medium traffic	Heavy traffic	Heavy traffic	Heavy traffic	Heavy traffic
Type of fuel	N/A	N/A	Electricity	Diesel Mix 32% redux	N/A	HVO	HVO
Fuel [L/km]	N/A	N/A	N/A	0,3	N/A	0,2	0,2
Type of food	Vegetables	Vegetables	Vegetables	Vegetables	Meat	Vegetables	Vegetables
Climate impact per kilometer [kg CO_2/km]	N/A	N/A	N/A	1,5	N/A	0,5	0,5
Average climate impact from producing food [kgCO_2]	57	57	57	114	197	49	58
Average climate impact from transportation [kgCO_2]	0	0	0	41	0	14	14
Total net climate impact [kgCO_2]	**−57**	**−57**	**−57**	**−74**	**−197**	**−35**	**−44**
Total net climate impact per kilo rescued food [kgCO_2/kg_food]	**−0,9**	**−0,9**	**−0,9**	**−0,6**	**−14**	**−0,6**	**−0,7**
Kg food required for breakeven	**0**	**0**	**0**	**47**	**0**	**16**	**16**
k (km*k=kg)	**N/A**	**N/A**	**N/A**	**2**	**N/A**	**0,6**	**0,6**

	Test 5	Test 6	Test 7 Total	Test 7 Part 1	Test 7 Part 2	Test 8
Weight of food [kg]	63	20	57			30
Distance [km]	4	10				4
Positioning distance [km]		2.8 : 3 : 5		16	10	
Total distance [km]	4	10		16	10	3
Traffic situation	Medium traffic	Medium traffic	Medium traffic	Medium traffic	Medium traffic	Medium traffic
Type of fuel	Diesel	Diesel	Diesel Mix 32% redux			Diesel
Fuel [L/km]	0,2	0,1		0,3	0,1	0,1
Type of food	Vegetables	Vegetables	Vegetables	Vegetables	Vegetables	Vegetables
Climate impact per kilometer [$kgCO_2/km$]	0,5	0,3		0,6	0,2	0,2
Average climate impact from producing food [$kgCO_2$]	54	17	49	0	0	26
Average climate impact from transportation [$kgCO_2$]	2	3	12	10	2	0,8
Total net climate impact [$kgCO_2$]	**−52**	**−15**	**−37**	**10**	**2**	**−25**
Total net climate impact per kilo rescued food [$kgCO_2/kg\_food$]	**−0,8**	**−0,7**	**−0,6**			**−0,8**
Kg food required for breakeven	**2**	**3**	**14**			**1**
k (km*k=kg)	**0,6**	**0,3**	**N/A**	**0,7**	**0,2**	**0,3**

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