Wageningen University - Department of Social Sciences

Operations Research and Logistics

MSc Thesis

Addressing food insecurity with food voucher systems

A scenario analysis from a food waste, retail value, and cost perspective in the Netherlands

Abstract
Purpose: Food voucher systems have proven to be effective in providing food aid, but are rarely used in developed countries, where food banks tend to be the norm. The purpose of this study was to find out if the food voucher system could be a possible addition or alternative to the current food bank system, by comparing the two systems from an operational point of view.
Design/methodology/approach: The food voucher system was compared to the food bank system in the form of a quantitative scenario analysis, taking food waste, retail value, and costs as key indicators.
Findings: Food banks prevent around 1% of the total food waste in the Netherlands. In the food voucher system, this food would go into compost and bio-digestion. The average retail value in both systems is on a similar level. The food voucher system is more cost-efficient than the food bank system in terms of distribution, but the voucher system is more expensive when the value of the voucher is taken into account.
Value: This thesis contributes to the ongoing food aid discussion, by providing a quantitative operational perspective on food bank and food voucher systems.

Keywords: Food vouchers, food bank, food waste, retail value, costs

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Student	Marije Lanting
Registration number	1039576
MSc program	Food Quality Management
Specialisation	Quality and Food Logistics
Supervisor(s)	Renzo Akkerman
Examiner/2nd supervisor	Sander de Leeuw
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1. Introduction

Food insecurity can be defined as a lack of regular access to enough safe and healthy food to provide for one's dietary needs (FAO, 2009). While it is commonly a problem associated with developing nations, developed countries also still struggle to feed their population (Long et al., 2020). In 2021, 21.7% of the population in the European Union was at risk of poverty or social exclusion (Eurostat, 2022). At the same time, the EU generates 88 million tonnes of food waste a year, leaving 20% of all produced food unconsumed (FUSIONS, 2016).

To challenge both food insecurity and food waste, food bank initiatives have been set up in numerous countries. Food banks are non-profit organizations that distribute food to people who experience food insecurity (Bennett et al., 2021). Food banks are dependent on donations, which typically come in the form of food, but sometimes also money and services (Voedselbanken Nederland, 2020). The food is mostly donated by companies and often contains products that are close to or past their expiration date, and which would otherwise get thrown away (Byrne and Just, 2022b). This way, food that would potentially go to waste gets redistributed to help people in need.

In the Netherlands, there are 172 local food banks with 521 distribution points and 10 regional distribution centres that provided food for 147.500 people in 2021 (Voedselbanken Nederland, 2021). This food most commonly gets to the recipients in the form of food parcels, for which volunteers try to divide the donated food as fairly as possible over parcels to be picked up by beneficiaries at specific times. The products can normally be picked up weekly and provide food for 2-3 days (Neter et al., 2016). A food parcel contains an average of 25 products (Voedselbanken Nederland, 2021).

The content of the food parcel is completely dependent on the donation streams. Therefore, it is essential to gather enough donations, specifically getting enough of every product category (Akkerman et al., 2023). This tends to be a challenge, because the food streams arriving at the food banks are high in variability in terms of quantity and type of food, making it difficult to match supply and demand. Next to that, Akkerman et al. (2023) mention that the incoming food streams seem to be decreasing because retailers have found ways to reduce their leftover food, for example by selling their nearly expired products at a discount price or by improving their forecasting and inventory management practices. Additionally, there are now alternative, more profitable ways to deal with food waste. Manufacturers can for instance sell their leftover food to energy recovery sites and sometimes even to consumers through online platforms such as TooGoodToGo and ResQ. These seem to be positive developments from a food waste and business point of view; however, it makes it more difficult for food banks to gather donations and keep providing the same level of food aid to people in need.

Looking at the challenges food banks are facing, it would be valuable to explore alternative food aid systems. Several countries make use of food voucher systems to provide food aid. In the UK, food vouchers are available which can be spent on infant formula, plain cow's milk, as well as fruit and vegetables (Lucas et al., 2015). In the USA, there is the Supplemental Nutrition Assistance Program (SNAP) (United States government, 2022). In this program, beneficiaries receive monthly benefits on Electronic Benefit Transfer (EBT) cards which be spent on eligible food items in SNAP-approved stores and farmers' markets.

In the Netherlands, the municipality of Rotterdam is experimenting with a food voucher system: project "Beter eten" ("Eat better") (de Jonge, 2022). In this project, people eligible for food aid get a debit card similar to the EBT card. On this card they receive weekly payments, varying from 20 euros for a single person, to 70 euros for a household of two parents with children. To

promote healthy eating, only healthy food products are reimbursed. These food vouchers could form a possible addition or alternative to the food bank system in the Netherlands.

According to Meijer (2022) from Buyproxy, the producer of the food aid debit cards used in the Rotterdam project, it would not take much effort to implement this system on a national level in the Netherlands. Various studies worldwide have also highlighted the efficiency and effectiveness of food voucher systems (Gentilini, 2016; Hidrobo et al., 2014; Tappis & Doocy, 2018). However, many factors need to be considered in evaluating a system's appropriateness (Lentz et al., 2013; WFP, 2014). To support discussions about the addition of a voucher system or the (partial) replacement of the food bank system by a food voucher system in the Netherlands, more knowledge is required with regards to the costs and benefits of each of these systems. For instance, the operational costs of food banks have not been studied before, and neither has the cost price per parcel. Also, it is unclear how the food voucher and food parcel compare in terms of retail value, considering the value of the voucher and the value of the food parcel according to retail prices. Finally, there is the question of what the impact on food waste streams would be in case a food voucher system would be implemented and less food products would be rescued through donations.

The aim of this thesis is therefore to compare the food voucher system to the current food bank system, taking food waste, retail value and costs as key indicators. This will be done in the form of a quantitative scenario analysis in which both systems will be tested, taking different circumstances into account when necessary. The results of this research would provide an operational perspective to the current food aid debate, which usually tends to be more sociologically orientated and focused on developing nations. The insights coming from this thesis could assist policymakers and the Dutch food bank organisation to improve food aid systems and offer support in the corresponding decision-making processes.

The following section provides a literature review on food bank and food voucher systems, discussing the advantages and disadvantages of each system, the previous research on the subject, and the resulting knowledge gap. This is followed by section 3, which will go into greater detail about how the food bank and food voucher system exactly operate in the Netherlands. Section 4 will explain the methodology and research design of this study. Section 5 follows with the results. Section 6 discusses the meaning, importance and relevance of the results. Finally, Section 7 goes into the study's conclusions, limitations, and recommendations for future research.

2. Related literature

2.1 Literature search

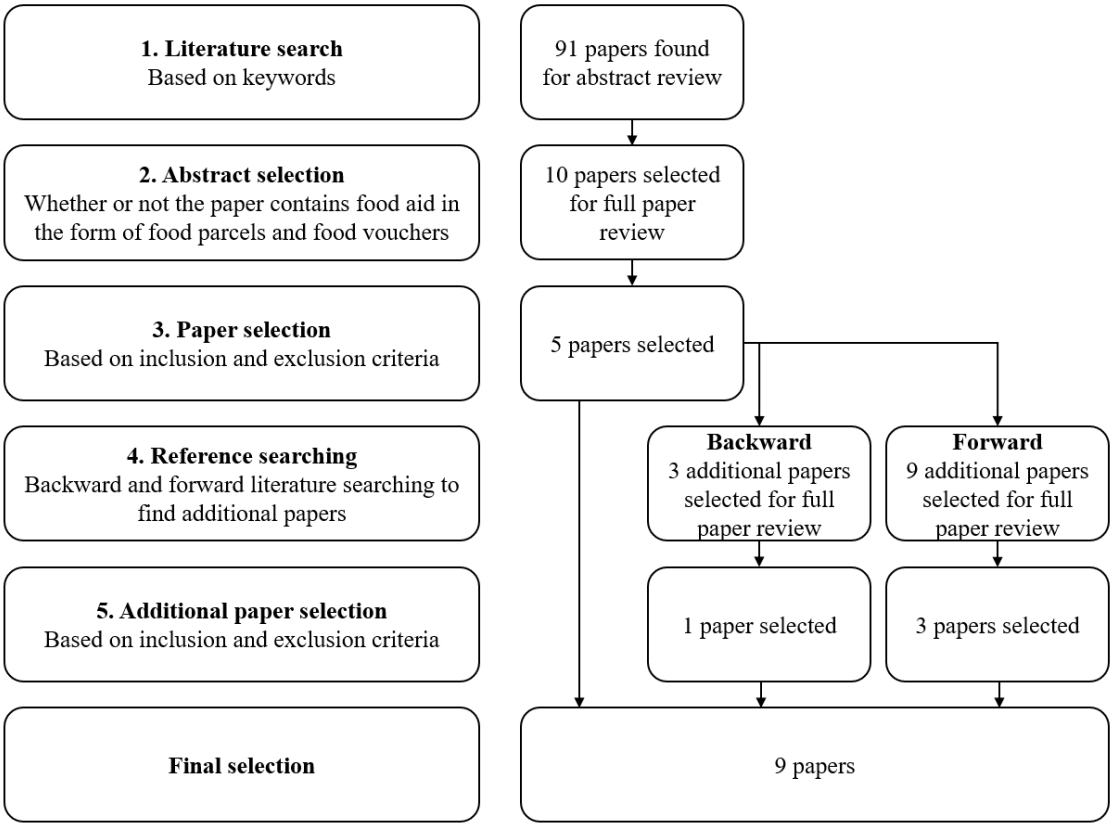

***Figure 1**: literature search process*

A structured literature review has been done to gain insights on the current state of research on food banks and food voucher systems. Due to the lack of research specifically focusing on comparing those two systems, papers comparing general food transfers with food vouchers have also been included in this review. The focus of this thesis is on the operational perspective of food bank and food voucher system. Therefore, studies solely looking into the sociological and psychological effects of the different food aid systems have been excluded. The main objective was to find information regarding food waste, retail value, and costs. To achieve this, inclusion and exclusion criteria were formed, which can be found in Table A3. Out of this initial literature search, 91 articles were found and 5 were selected. Using forward and backward referencing, 4 additional articles were found and also included in this review, giving a total of 9 relevant articles. Appendix A gives an overview of the literature search process.

The 9 selected papers were used to analyse the advantages and disadvantages of food bank/transfers and food voucher systems. Additionally, the papers were categorised on which perspectives they contain: food waste, retail value, costs, or operations. Summaries have been created to give an overview of each perspective. Furthermore, this review offers a quantitative approach to the food aid discussion, describing which factors and conditions are used in modelling to find the optimal food aid system. Finally, to supplement and broaden the perspectives of the 9 initial papers, additional papers on food aid were investigated through an exploratory search method and included in this review.

2.2 Results

Food aid modalities can be categorised as food transfers, vouchers, and cash (WFP, 2014). Vouchers can be defined as *"a subsidy that grants limited purchasing power to an individual to choose among a restricted set of goods and services"* (Steuerle, 2016). Vouchers come in commodity-based and value-based forms (Gentilini, 2013; Sahinyazan et al, 2021). With commodity-based vouchers, the products the beneficiary receives are already predetermined. While with value-based vouchers, beneficiaries receive a specific monetary amount which they can use to pick their own products. Additionally, vouchers can also be earmarked to a specific set of products or retailers (Lieven & Lennerts, 2013).

The research on food transfers and vouchers mostly takes place in the context of developing nations (Gentilini, 2013; Gentilini, 2016; Hidrobo et al., 2014; Sahinyazan et al, 2021). This discussion seems to be lacking in developed nations, specifically from an operational perspective, which this thesis is focused on. Most developed countries have food banks, but very few have a food voucher system in place (Byrne and Just, 2022b). Only studies from the United States (Byrne and Just, 2021; Mable and Worthington, 2017) have gone into the effectiveness of their government-provided food vouchers (SNAP benefits) and the role of food banks as an additional source of food aid. However, the costs of these two systems were not covered. Only studies taking place in developing countries have covered the costs of the different food aid modalities in an experimental setting (Gentilini, 2013; Gentilini, 2016; Hidrobo et al., 2014). In addition to the experimental evidence, researchers have also created quantitative models on what the most effective food aid modality would be depending on the conditions (Ryckembusch et al., 2013; Sahinyazan et al., 2021), and how to calculate the value of donated food (Byrne and Just; 2022a). An overview of all the studies used in the structured literature review can be found in Table A4.

2.2.1 Advantages and disadvantages of different systems

Table 1 presents the advantages and disadvantages of the food bank/transfer and food voucher system that were found in this literature review. Food vouchers seem to be the preferred option when it comes to operational complexity and freedom of product choice for the recipients (Hidrobo et al., 2014; Sahinyazan et al., 2021). It also gives policymakers the possibility to encourage healthy eating behaviour by putting certain restrictions on the vouchers. Furthermore, the system is easy to scale up and down, especially when using electronic vouchers (WFP, 2014). However, distribution via digital systems could also mean that the system becomes less accessible for people with poor digital literacy skills. In the food bank system, technology generally does not play a large role (Byrne & Just, 2022b). In the case of food banks, accessibility is more affected by the specific time slots and distribution locations beneficiaries are bound to (Akkerman et al., 2023). Furthermore, food banks face supply chain challenges. The food provided by food banks is dependent on donation streams, which highly fluctuate and may not always provide healthy products (Akkerman et al., 2023; Byrne & Just, 2022b; Neter et al., 2016). However, the benefits of this system are that it plays an active role in preventing food waste and that the food is free of cost (Byrne & Just, 2022b). The food being free and the labour costs being very low due to the big reliance on volunteers, may outweigh the expenses of accommodation, storage, transport and other operations.

Whether a food bank/transfer system or a food voucher system would be a better option, also highly depends on the country and circumstances (Gentilini, 2013; WFP, 2014). In the case of developing countries, food vouchers would generally be a better alternative for overall development, because wealth would be transferred to local businesses improving the overall economy of the community (Sahinyazan et al. 2021; Gentilini, 2016). However, food transfers

Table 1: *advantages and disadvantages of the food bank/transfer and food voucher system*

	Food bank/transfer	**Food voucher**
Advantages	• Reduces food waste by redistributing food that would otherwise go to waste (Byrne and Just, 2022b). • Food banks receive free food and free labour (volunteers) (Byrne and Just, 2022b). • Provides a more robust source of food aid, specifically in unstable economies and markets that are not functioning well (Sahinyazan et al., 2021; Gentilini, 2013; WFP, 2014). • Most effective method in emergency settings (Sahinyazan et al., 2021).	• Enables the recipients to make their own purchasing decisions (Hirdrobo et al., 2014; Sahinyazan et al., 2021), therefore increasing dignity (Allahi et al., 2020). • Gives easier access to fresh products (Sahinyazan et al., 2021). • Can be used to achieve specific objectives, like increasing dietary diversity (Hirdrobo et al., 2014) • Cost-efficient, due to simple operational activities with no commodity distribution (Gentilini, 2016; Hirdrobo et al., 2014; Tappis & Doocy, 2018). • More effective in developing countries, because wealth is transferred to local businesses (Sahinyazan et al., 2021; Gentilini, 2016). • Easy to scale up and down once the system is established (WFP, 2014).
Disadvantages	• Lack of choice for beneficiaries (Hirdrobo et al., 2014). • Beneficiaries bound to pick up their food at specific distribution points, with limited pick-up moments (Akkerman et al. (2023); Byrne and Just, 2022b). • Questionable nutritional value (Akkerman et al., 2023; Byrne and Just, 2022b; Neter et al., 2016). • Dependency on donations, causing fluctuations in supply (Akkerman et al., 2023; Byrne and Just., 2022b). • Complex operations and supply chain management (Akkerman et al., 2023; Byrne and Just., 2022b; Sahinyazan et al., 2021).	• Requires a well-functioning market and adequate food supply near recipients (Sahinyazan et al., 2021; WFP, 2014). • Food banks and other private food aid alternatives often still necessary in developed countries to complement food vouchers (Mabli & Worthington, 2017; Byrne & Just, 2021). • Beneficiaries who lack knowledge and/or skills in technology may face difficulties using an electronic voucher system (WFP, 2014).

do offer a more effective and robust source of food aid when a country is in an emergency situation or has a very unstable economy (Sahinyazan et al. 2021).

A thing to consider for developed countries in particular would be the actual effectiveness of voucher systems. Studies covering the SNAP benefits from the United States (Mabli & Worthington, 2017; Byrne & Just, 2021) have found that in many cases those benefits do not fulfil people's needs and need to be complemented by private food aid initiatives. So, this means a voucher system may not be able to completely erase the need for food banks.

2.2.2 Insights on food waste, retail value, and operational costs

Food waste

Regarding food banks, Byrne and Just (2022b) mentioned that alongside providing food aid to people in need, reducing food waste is an important objective. Food banks plays an active role in overall food waste reduction by redistributing donated food that would otherwise get thrown away. However, the role of food banks in overall food waste prevention may not be as significant as thought. It is estimated that only 3 to 5% of the food surplus in the USA is ultimately donated. In addition, a study in the Netherlands (Neter et al., 2016) found that only 39.4% of food bank beneficiaries use all the foods provided in the food parcel. So, a significant part of the redistributed food still gets wasted. The main reasons for food bank recipients to not fully use their food parcels are the foods being beyond their expiration date (45.9%) and people not liking the food (22.3%).

Food waste at the consumer level may be reduced in the case of food vouchers, since people have the freedom to pick their own products (Hirdrobo et al., 2014). However, food waste has not been measured or discussed in any of the studies covering voucher systems, and these systems do not directly contribute to the prevention of food waste like food banks do. However, Byrne and Just (2022b) point out that there are numerous alternate places for food waste to go at every stage of the supply chain, such as energy recovery facilities and animal feed (see also Garrone et al., 2014).

Retail value

In the case of Ecuador (Hidrobo et al., 2014), the retail values of both food parcels and food vouchers have been mentioned. This is the value of a product considering retail prices. In the case of the USA, only the retail value associated with SNAP benefits is known. The retail value of food parcels has not been researched. However, Byrne and Just (2022a) have tried to estimate the value of donated food at the food banks in Colorado, USA, based on travel cost and revealed preference models. They found the value of a food parcel to be between $40 and $60, with beneficiaries visiting their local food banks an average of 15 times a year. Food banks are an alternative or addition to SNAP benefits in the USA. SNAP benefits are paid out on a monthly basis on an electronic benefit (EBT) card and are dependent on the household size, income, and expenses. SNAP benefits averaged $129.83 per person in 2020 (Byrne & Just, 2021). However, many households that receive SNAP benefits still need additional support (Mabli & Worthington, 2017; Byrne & Just, 2021). SNAP beneficiaries tend to go to the food bank when their monthly budget is exhausted. It is estimated that of the people who visit the food bank, at least 54.7% also receive SNAP benefits. (Byrne & Just, 2021).

Looking at the study in Ecuador by Hidrobo et al. (2014), the food transfer and the food voucher had the same value at $40 a month per household. Food voucher beneficiaries were earmarked to a specific set of retailers. Unlike the US food pantries studied by Byrne and Just (2022a), the food in the food transfer scenario was purchased by the organisation and did not come from donations. The value of the food transfer was based on the local market prices. Recipients were

found to be satisfied with both variations of food aid. The big advantage food vouchers had over food transfers, was that they gave recipients a higher autonomy over their food choices. This enhances people's sense of dignity (Allahi et al., 2020). Next to that, vouchers were found to be more effective in increasing calorie intake and dietary diversity (Hidrobo et al., 2014). However, Gentilini (2013, 2016) noted that these kinds of results should not be generalised and highly depend on the program design and objectives, the beneficiaries, the local markets, and the type of measurements that were applied. Nevertheless, it is generally agreed upon that vouchers can use restrictions to direct recipients towards achieving certain nutritional goals, while also providing them with autonomy over their food purchases (Hirdrobo et al., 2014).

Costs

No paper in this literature review has addressed the operational costs of food banks. The closest reference points are provided by Hidrobo et al. (2014) and Gentilini (2016), who compare the operational costs of food transfers with cash and vouchers. Hidrobo et al. (2014) included a cost overview showing the expenses for different food aid modalities (see Table 2). For all the modalities, the transfers took place once a month. The cost calculation excluded the food purchasing costs and the value of the vouchers and cash ($40,-), as that was the same in their study. The major expenses for food transfers were food storage, parcel preparation and food distribution. For vouchers, the collaboration with supermarkets, design of the vouchers and the voucher liquidation carried major expenses. For cash, the production of the debit cards was the biggest expense. The total costs of food transfers came down to $11.46 per transfer. The total costs of vouchers and cash were $3.27 and $2.99 per transfer. The studies reviewed by Gentilini (2016) showed a similar pattern, with food transfers commonly being 2 to 3 times more expensive than vouchers or cash transfers due to operational and logistical costs.

Table 2: *cost overview per food aid modality by Hidrobo et al. (2014) ($)*

Cash		**Voucher**		**Food**	
Travel preparation	74	Travel preparation	85	Travel preparation	53
Meetings and contracts with bank	912	Supermarket selection	2,492	Food storage	26,956
Operations (travel, staff time)	4,843	Contracts and meetings with supermarkets	3,283	Ration preparation	18,764
Production of debit cards	13,219	Design of vouchers	11,857	Food distribution	16,109
Transfer bank	215	Voucher liquidation	6,857		
Execution of payments	2,794	Execution of payments	2,604	Execution of payments	282
Data monitoring	1,014	Data monitoring	1,078	Data monitoring	884
Total cost	23,070		28,256		63,048
Total number of beneficiaries	1,284		1,441		917
Total cost per beneficiary	17.97		19.61		68.75
Total cost per transfer	2.99		3.27		11.46

Food banks have a high amount of operational and logistical activities just like food transfers as mentioned by Hidrobo et al. (2014) and Gentilini (2016). The biggest difference is that food banks work with donated products. These have to be picked up, sorted, stored, and distributed (Byrne & Juste, 2022b). This makes the food bank system more complex. However, the advantage of working with donated food is that there are no food purchasing costs, while the value attached to vouchers does require notable financial inputs. Next to that, in food banks, all of the work is done by volunteers, mostly eliminating labour costs. Therefore, the cost difference between the food bank system and the food voucher system could be smaller than the differences found by Hidrobo et al. (2014) and Gentilini (2016).

2.2.3 Food aid comparison models

Ryckembusch et al. (2013) and Sahinyazan et al. (2021) have created tools to analyse what the best food aid modality would be in different scenarios. The model by Ryckembusch et al. (2013) looks into the cost-effectiveness of commodity-based food vouchers compared to food transfers, taking into account nutritional objectives. To decide which of the two modalities would be the most cost-effective, they use a measure that minimizes costs and maximizes nutritional benefits. This measure is calculated by dividing a nutrient value score by the full costs. This measure is also used in the manual for cash and voucher systems by the World Food Programme (2014).

Sahinyazan et al. (2021) designed a model looking into food transfers, vouchers, and cash. They also consider the option of the optimal food aid system being a combination of multiple food aid modalities. In addition to costs and nutritional value, the beneficiaries' preferences and market conditions were considered. Beneficiaries may prefer basic food, tasty food, or "temptation" food. When looking at the market conditions, food vouchers are the preferred option when there is a stable economy and secure access to products. In the case of unstable economies and markets, food transfers offer a more robust source of food aid than vouchers. Taking into account all these factors, the model by Sahinyazan et al. (2021) calculates the most fitting food aid modality for each household in each market.

Both studies used costs as a key indicator to decide which system would be preferable, similar to this thesis. However, these models used commodity-based vouchers in their calculations, while the voucher system considered in the Netherlands uses value-based vouchers. Commodity-based vouchers are significantly more restrictive than value-based vouchers (Gentilini, 2013; Sahinyazan et al, 2021). This means that the calculations by Sahinyazan et al. (2021) and Ryckembusch et al. (2013) would not be representative for the current study. Next to that, it is also the question of how representative the costs of food transfers are for the costs of food bank parcels. Food banks generally have no food purchasing or labour costs. Therefore, new cost calculations would need to be made to get the best picture of the food bank and food voucher system in the Netherlands.

2.3 Conclusion

Whether food banks or food vouchers are a preferred system depends on the circumstances and the goals one would like to achieve (Gentilini, 2013; Sahinyazan et al, 2021). Food vouchers can be used to encourage healthy eating behaviour and they give more freedom to the beneficiaries in terms of product choice and getting fresh produce (Hidrobo et al., 2014), while food banks reduce food waste by redistributing donated food (Byrne and Just, 2022b). However, it is less clear how significant the role of food banks is in the overall prevention of food waste. In terms of the effectiveness of both systems, the stability of the country and the economy, the nutritional value, the beneficiaries' preferences, and the operational costs should be considered (Ryckembusch et al., 2013; Sahinyazan et al, 2021; WFP, 2014). A cost comparison based on the literature is less straightforward. Food voucher systems require significantly fewer

operational activities than food banks, making this system very cost-efficient according to Hirdrobo et al. (2014) and Gentilini (2016). However, food banks have the benefit of obtaining free food and having very low labour costs due to the practice of working with volunteers (Byrne and Just, 2022b). To find out how the systems would compare in the Netherlands, information on retail value, costs, and food waste would need to be obtained.

3. Food banks and food vouchers in the Netherlands

To get a full understanding of which systems are compared in this thesis, this section will go into more detail on what the food bank and the food voucher system are and how they operate. The food voucher system is a newly introduced system and therefore requires some explanation. The food bank system is a more familiar concept, but how the food banks operate in the Netherlands may differ from other countries. Therefore, this chapter provides the necessary background information for the scenario analysis. The following information was gathered via the website of Voedselbanken Nederland and personal communication with Voedselbanken Nederland and Buyproxy.

3.1 Food banks

Food banks in the Netherlands operate under the Dutch food bank organisation Voedselbanken Nederland (Voedselbanken Nederland, 2023). Voedselbanken Nederland raises funds for food banks and provides guidelines and protocols for the intake of beneficiaries, but also for the collection and storage of food to ensure food safety. Roughly 40% of the food is raised by Voedselbanken Nederland on the national level and gets delivered to local food banks through distribution centres. The other 60% of the food is gathered by food banks themselves.

Food commonly gets collected from supermarkets and food-processing companies. This tends to be leftover food as a result of the overestimation of demand, but could also be food containing factory defects or food that is going to be taken out of a company's assortment. Additionally, food donations also come from individuals, community gardens, and from food collection initiatives by churches, schools, and associations. The food coming from those initiatives tends to be basic products with a long shelf life, which the food bank can store and use over a longer time. In case of food shortages, some food banks choose to purchase extra food. Other food banks, based on the principle that food banks should only operate with donated food, choose to only work with donated food.

Food products normally get distributed in one of two ways. First, they are distributed in the form of food parcels at the food bank itself or at one of its distribution points. Second, some food banks operate social supermarkets. At these social supermarkets, the donated food is presented in a supermarket format and beneficiaries can pick their own products, normally with limitations based on household size and product availability. The majority of food banks still work with the parcel system, but the number of social supermarkets is increasing (Voedselbanken Nederland, 2021).

All of the labour at food banks is provided by volunteers. The most important operational activities are the acquisition of food and funds, transportation of food, intake of beneficiaries, and parcel preparation (or running the social supermarket). To cover their costs, local food banks commonly receive subsidies from the local municipality, donations and sponsorships from local businesses and organisations, and an annual contribution from Voedselbanken Nederland.

3.2 Food voucher system

The food voucher system currently considered in the Netherlands is a collaboration between companies, foundations, and municipalities in which beneficiaries receive a food debit card instead of food. This debit card is developed by Buyproxy. On this debit card, beneficiaries get weekly payments which they can use to buy food. They are free to use this card at any supermarket. The weekly budget is based on the household composition and the food budgets established by Nibud (Dutch National Institute for Family Finance Information). The exact calculation method can be found in Appendix B.

The intake of beneficiaries would take place at the applicant's home. To ensure beneficiaries only purchase healthy food with the food aid debit card, beneficiaries need to install an app on their phone in which they scan their food receipts. The system will recognize which foods are healthy and which ones are not and will only reimburse the healthy products. Whether a product is considered healthy, is based on the 'Wheel of Five'(Schijf van Vijf) by the Netherlands Nutrition Centre (Voedingscentrum Nederland).

The main operational activities of this system are the intake of beneficiaries, distribution of the debit cards, and software maintenance. The work could be carried out by paid professionals or volunteers, or a combination of both. Since the system is still in its development phase, this has not been clearly defined yet. Similarly, it needs to be investigated how the system would exactly be financed when it gets implemented on a national level. This is currently a major challenge according to Buyproxy. Municipalities and businesses provided the majority of the resources needed for the pilot in Rotterdam. Additional sources of funding would be required if the system would be implemented throughout the whole Netherlands.

4. Methodology

4.1 Research design

The food voucher system is compared to the food bank system in the form of a quantitative scenario analysis, providing insights for the food aid debate in developed countries. Scenario analysis specifically is an appropriate method to support strategic decision-making because it can take into account different conditions and decisions (Postma & Liebl, 2003). Scenarios can be defined as alternative futures resulting from a combination of trends and policies (Amer et al., 2013; Fontela & Hingel, 1993). In the current study, there are two main scenarios: the food bank system and the food voucher system. The food bank system is currently in place in the Netherlands and is largely run by Voedselbanken Nederland and its local food bank members (Voedselbanken Nederland, 2023). The voucher system is based on project 'Beter Eten' in Rotterdam. Table 3 provides an overview of both scenarios.

Table 3: *overview of main scenarios: food bank and food voucher system*

	S0: food bank	**S1: food vouchers**
Product	Food, to be picked up once a week	Food debit card, receiving payments once a week
Main operational activities	□ Intake of beneficiaries □ Food acquisition □ Preparing the parcel / filling the supermarket shelves □ Transportation of food □ Distribution via parcels / social supermarkets	□ Intake of beneficiaries □ Food debit card distribution □ Software maintenance

Table 4: *measurements of the key indicators for the food bank and food voucher system*

Key indicator	**S0: food bank**	**S1: food vouchers**
Food waste	□ Kgs of food saved from going to waste □ Kgs of food wasted at consumer level	□ Kgs of food waste ending up at alternative destinations □ Kgs of food wasted at consumer level
Retail value	□ Value of parcel in euros □ Number of products per parcel	□ Value of food voucher in euros
Costs	□ Cost price of parcel □ Fixed costs and variable costs	□ Cost price of voucher □ Fixed costs and variable costs

To compare the two systems, this thesis specifically looks at several key operational indicators. There are many other relevant issues that do not make this a straightforward comparison between alternatives. It is also important to note that this analysis should also not be interpreted like that: the two systems might also be used in a complementary manner. The indicators that are going to be analysed in this thesis are food waste, retail value, and costs. Food waste and retail value represent the two main objectives of the food bank: preventing food waste and providing food aid (Voedselbanken Nederland, 2021). Costs give an indication of an organisation's efficiency and is therefore an essential factor in strategic decision-making (Hansen et al., 2021). The key indicators are expressed in measurements in Table 4.

To take into account the uncertainties in the calculations of the key indicators, sub scenarios have been created based on the available data. See Table 5. For both the food bank and the food voucher system, the consumer waste levels are uncertain. Therefore, 3 sub scenarios have been set for both systems: high, medium, and low consumer waste levels. Additionally, the costs of the food bank parcels turned out to vary significantly per food bank location (as show later in this thesis). For the food bank system, 3 cost price levels are therefore taken into consideration: high, medium, and low. The cost price and consumer waste level calculations do not affect each other, therefore the different sub scenarios in S0 can be combined in any way (for instance, scenario S0b3 would represent a scenario for a food bank with medium consumer waste levels and low food bank costs).

Table 5: *overview of main scenarios with sub-scenarios*

	S0: food bank			**S1: food vouchers**		
Consumer waste levels	a	b	c	a	b	c
	high	medium	low	high	medium	low
Cost price	1	2	3	-		
	High	medium	low			

4.2 Definitions

To clarify some of the concepts used in this thesis, Table 6 provides an overview of definitions. The definition of food waste considers the Dutch definition and measurement of food waste, which is later on used in the calculations. This means that human food turning into products like biogas, animal feed, and compost, is still considered waste (Southoudt & Vollebregt, 2020). Furthermore, for food bank system, the retail value indicates how much the contents of a food parcel would cost in the store. In case of the voucher system, the retail value of the purchased products would be equal to the weekly payment the beneficiaries receive on their debit card.

Table 6: *terms and definitions used in this thesis, with their corresponding source*

Term	Definition	Reference
Food waste	When food intended for human consumption, is not used for that purpose.	Soethoudt and Vollebregt (2020)
Consumer waste level	The proportion of food wasted at the consumer level.	Yu and Jaenicke (2020)
Waste valorisation	The recovery of waste materials, in which waste gets turned into useful products.	Galanakis (2019)
Retail value	The value of an item or load based on retail prices.	Grewal et al. (2012)

4.3 Data collection

4.3.1 Food waste

The website and annual reports of Voedselbanken Nederland provided estimations of the percentage of the total food waste in the Netherlands that is saved by the food bank on an annual basis. The total food waste in the Netherlands is estimated by Soethoudt and Vollebregt (2020) and also used by Voedselbanken Nederland in their calculations. Voedselbanken Nederland was contacted via email and phone to collect more information regarding the number and type of products that are being donated. Data on what type of food is typically saved is not available. Therefore, data from food waste at Dutch supermarkets (Vollebergt, 2020) was taken to represent the food that gets saved by the food bank. Supermarkets work together with food banks on a regular basis and therefore tend to be a significant contributor to the number of donations (Voedselbanken Nederland, 2022). Furthermore, data on food parcel usage (Neter et al., 2016) and consumer food waste statistics (Ooijendijk et al., 2019) were combined to estimate the food waste on the consumer level in the food bank system and the food voucher system. Additionally, food waste also occurs at the food banks themselves. They often receive highly perishable products and follow quality and storage procedures according to the food safety regulations handbook by Voedselbanken Nederland. This means that donated products might not always make it to beneficiaries. However, no data is available on what proportion of donations gets thrown away. Therefore, food waste at the food bank itself will not be considered in the calculations.

In the food voucher system, food streams that normally go to the food bank would have to go to alternative destinations. Rijkswaterstaat (2020) describes common valorisation options based on different types of waste streams in the Netherlands. Their waste processing statistics were used to portray food waste in the food voucher system.

An overview of all the data used can be found in Appendix C.

4.3.2 Retail value

Voedselbanken Nederland (2021) provided an estimation of the average retail per parcel, accounting for a household size of 2-3 people. The retail value of the food debit card can be calculated using the approach in Appendix B. A household consisting of a man and a woman, both in age range 14-50, was chosen to calculate the food budget and to compare with the retail value of the average food parcel. To get an idea of the variation in food parcel value between different food banks, the food banks in the cost analysis were contacted to give estimations of how many products their average food parcel contains. Additionally, Voedselbanken Nederland (2021) also gives an average number of products per food parcel across all food banks.

4.3.3 Costs

Food bank	Type	Number of households
Groningen	Supermarket	450
Lelystad	Supermarket	274
Utrecht	Parcels	593
Nijmegen	Parcels	700
Goes	Parcels	221
Enschede	Parcels	350
Rotterdam	Supermarket and parcels	1662
Ede	Parcels	93
Deventer	Parcels	237
Purmerend	Parcels	99
Assen	Parcels	228
Arnhem	Supermarket and parcels	1239

***Figure 2**: food bank sample with distribution type and average number of households in 2021 according to the websites and annual reports*

The costs of the food voucher system were provided by Buyproxy via personal communication. To get more insights on the costs of food banks, financial reports of 12 food banks were collected and analysed. These reports are available on the food banks' websites. The 12 food banks were selected based on data availability. Criteria for selection were that the food bank had to have financial reports of the years 2020 and 2021, and also information on the number of households served in those years. The financial reports had to be detailed enough to differentiate between fixed and variable costs. shows the food banks that were chosen.
Together, these food banks served 19% of the total food bank beneficiaries in 2021. The distribution of the food is done via parcels or social supermarkets. Additionally, Groningen, Rotterdam, Deventer, and Arnhem also serve as regional distribution centres. So, next to providing food aid in their own area, they also distribute food to other food banks in the Netherlands.

4.4 Food waste analysis

Total food saved by food banks

To find out how many kgs of food are saved by food banks per year, the percentages of food saved by food banks were multiplied by the food waste estimations for the Netherlands, according to the formula below. To find the most realistic estimation, the total amount of food saved by the food bank was compared to the number of products this accounted for. Further explanation and calculations are provided in Appendix D.

$$SF = P_s * W \quad (1)$$

SF= total food saved by food banks (kg)
P_s= % of food saved by food banks, according to Voedselbanken Nederland (2019, 2020, 2021)
With s(1) = 2.3, s(2)= 2, s(3)=1.5 and s(4)= 1
W= total food waste in the Netherlands, including food that goes to the food bank (kg) (Southoudt & Vollebregt, 2020)

Consumer waste

Table 7: *consumer food waste levels for the food bank and food voucher system, split in 3 scenarios (based on Neter et al., (2016) and Ooijendijk et al. (2019))*

Consumers who use all products in the food parcel		Consumer food waste percentage		
		a. high	b. medium	c. low
Always	39.4%	0%	0%	0%
Sometimes	57.0%	4.75%	2.38%	1.19%
Never	3.6%	9.50%	4.75%	2.38%
Total waste percentage		3.05%	1.52%	0.76%

The consumer waste levels for both systems were estimated with food parcel usage data by Neter et al. (2016) and consumer waste statistics by Ooijendijk et al. (2019). An overview of the waste percentage per parcel per scenario can be found in Table 7. It is assumed that people who sometimes use all the products in their food parcel, waste half of what people who never fully use their food parcel would waste. The same percentages were applied for the food voucher system, because there is no reliable data on how much food voucher beneficiaries waste. Since the food voucher system and the food bank have the same target group, it is likely the consumer waste percentages are very similar. The above percentages were multiplied with the quantity of food that beneficiaries receive, to find out the amount of kgs that gets wasted at the consumer level:

$$CW = W_l(SF + RF) \quad (2)$$

CW= total consumer waste (kg)
W_l = consumer waste level (based on Nether et al., (2016) and Ooijendijk et al., (2019)) with l(a)=3.05%, l(b)=1.52% and l(c)=0.76%
SF= total food saved by the food banks (kg)
RF= regular food (kg)

It is assumed that in both systems, the beneficiaries receive the same quantity of food. In these calculations, a distinction was made between saved food (SF) and "regular" food (RF). Saved food is food saved by food banks that would otherwise be thrown away. Regular food is food that is donated, but not saved from going to waste, meaning this food would most likely end up for regular human consumption (e.g. being sold on the supermarket shelves) if it were not donated. In the case of the food bank system, 50% of the food beneficiaries receive is saved and 50% is regular (as was stated by Voedselbanken Nederland in personal communication with the author). In the food voucher system, 100% of the food would be considered regular food, since all of the food would be newly purchased by the beneficiary. This represents the difference in how much extra waste is created in the food voucher system, because there is no saved food stream in this system.

In the food voucher system, it is assumed the food that is normally saved by the food bank goes to different waste valorisation options. The total food waste saved by the food bank was multiplied by waste processing plant statistics by Rijkswaterstaat (2021) to get an overview of how many kgs of food end up at which valorisation options:

$$WP_x = SF * M_x \quad (3)$$

WP_x= total food waste processed with method x (kg)
SF= total food waste saved by food banks (kg)

M_x= waste processing method (Rijkswaterstaat, 2021)
with x(compost)=95%, x(bio-digestion)= 27.5% and x(incineration)=5%

4.5 Cost analysis

Cost distribution

To get an overview of which cost items take up the most amount of resources in each system, costs were sorted into categories. For the food banks, the categories were: facility, machines and installations, inventory, volunteers, distribution, office, communication, purchasing of food, and general costs. For the food voucher system, the costs could be attributed to software, transaction and general costs. For both systems, the costs were classified as 'fixed' or 'variable', to get an indication of the agility of both systems and as a base for the cost price calculation. The purchasing of food by food banks and the value of the food vouchers are not included in any of the calculations, to focus purely on the systems' activities. This is in line with the method used by Hidrobo et al. (2014). Similarly, incidental costs, like food banks' costs related to Covid-19, were also not included since these are not considered relevant in cost analyses (Drury, 2017).

Cost price calculation

The cost price in the food voucher system is already given. For the food bank system, fixed and variable costs were used to calculate the cost price per parcel according to absorption costing, also known as traditional costing or full costing (Benjamin et al., 2011). Absorption costing provides the most complete picture of the overall costs because direct, indirect, variable, and fixed costs are all included in the cost price (Drury, 2017). Therefore, this is an appropriate method to compare the total costs of the food bank system to the total costs of the food voucher system. The following cost price formula, based on Drury (2017), is used:

$$\text{Cost price per parcel} = \frac{total\ fixed\ costs}{normal\ activity\ level} + \frac{total\ variable\ costs}{actual\ activity\ level} \quad (4)$$

For food banks, the actual activity level was based on the average number of households served in that year. The normal activity level was based on the average number of households served in 2020 and 2021.

The low, medium, and high cost price scenarios were calculated by taking the average of the the 8 lowest, 8 medium, and 8 highest cost prices of all food banks in 2020 and 2021. Appendix E provides an overview of all the data and calculations associated with the cost analysis.

5. Results

5.1 Food waste

Food bank system

The food that is saved by the food bank is estimated to be 19,666,667 kg. This accounts for 24,284,580 products, with the average product weighing 810 grams. This would mean the food bank saves approximately 1% of the total food waste in the Netherlands, when the total food waste in the Netherlands is 1,966,666,667 kg. However, since the food waste numbers in the Netherlands are also estimations and fall into a wide range, it could be this percentage is slightly higher (when considering a lower total food waste) or lower (when considering a higher total food waste) in reality.

The type of products that tend to be saved by the food bank can be seen in Table 8. By far the majority consists of fresh products with a short shelf life.

***Table 8**: food waste streams divided into categories with percentages and kgs, based on food waste levels in the supermarket sector by Vollebergt (2020)*

Food category	Share	Kg
Potatoes, vegetables, and fruits	34.5%	6,785,000
Bread, part-baked bread, and pastry	31.5%	6,195,000
Dairy, eggs, chilled convenience products	13.3%	2,615,667
Fresh meat and fish	7.5%	1,475,000
Other fresh products and shelf-stable products	13.2%	2,596,000

This food stream makes up 50% of donations, the other 50% are products that are donated but not necessarily saved from going to waste. These tend to be the products with a longer shelf life.

Food voucher system

In the food voucher system, the 19,666,667 kg of food that is saved by the food bank, would have to go to other destinations. In the Netherlands, organic waste like leftover food commonly gets turned into compost and biogas in waste processing plants (Rijkswaterstaat, 2020). See Table 9. The majority of waste gets turned into compost, with 29% first going through bio-digestion before getting turned into compost (bio-digestion barely affects the size of the compost). A 5% share of the waste stream also gets rejected and sent to incineration plants.

***Table 9:** food waste streams processing methods, with percentages based on Rijkswaterstaat (2020)*

Processing methods	Product	Share	Kg
Composting	Compost	95%	18,683,334
Bio-digestion	Biogas		5,418,167
Incineration	Electricity and heat	5%	983,333

Consumer waste

The average Dutch consumer wastes 9.5% of their purchased food (Ooijendijk et al., 2019). Food bank and food voucher beneficiaries waste considerably less, estimating from 3.05% to 0.76%. The total consumer waste in both systems is the same if you consider that food bank and food voucher recipients waste the same percentage of food. However, it needs to be taken into account that, while food voucher beneficiaries buy fully new products of which they might waste a certain percentage, half of the food that food bank beneficiaries receive exists out of saved food that would otherwise likely go to waste anyway. Therefore, in Table 10, a distinction has been made between saved food and regular food that goes to waste. This reflects that the food voucher system creates 50% new waste on the consumer level, in case the food waste percentages in both systems are the same.

Table 10: *waste created by food bank and food voucher beneficiaries according to high (a), medium (b), and low (c) consumer waste levels, expressed in SF (saved food) and RF (regular food), in kgs. Percentages based on Neter et al., (2016) and Ooijendijk et al. (2019).*

		S1: food vouchers		
	Waste level	a 3.05%	b 1.52%	c 0.76%
S0: food bank	a 3.05%	SF: 599,735 RF: 599,735 RF: 1,199,470	SF: 599,735 RF: 599,735 RF: 599,735	SF: 599,735 RF: 599,735 RF: 299,868
	b 1.52%	SF: 299,868 RF: 299,868 RF: 1,199,470	SF: 299,868 RF: 299,868 RF: 599,735	SF: 299,868 RF: 299,868 RF: 299,868
	c 0.76%	SF: 149,934 RF: 149,934 RF: 1,199,470	SF: 299,868 RF: 299,868 RF: 599,735	SF: 299,868 RF: 299,868 RF: 299,868

5.2 Retail value

The retail value of an average food parcel in the food bank system is €43 (Voedselbanken Nederland, 2021). This accounts for a household size of 2 to 3 people. The value of the weekly food debit card payment for a similar household size is €44.31. So, the two systems provide similar values when looking at the average household size.

In both systems, the provided value is based on the household composition. The food voucher system has a standard procedure for this. In the food bank system, it is up to the individual food banks to decide how they account for different households. Additionally, the value food banks can provide also heavily depends on the donation stream. Figure 3 illustrates the variation between the 12 different food banks in terms of the number of products per parcel. While the average number of products in a parcel in Groningen ranges between 30 and 50 products, the parcels in Deventer contain a maximum of 25 products. The national average across all 172 food banks in the Netherlands is 25 products per parcel (Voedselbanken Nederland, 2021).

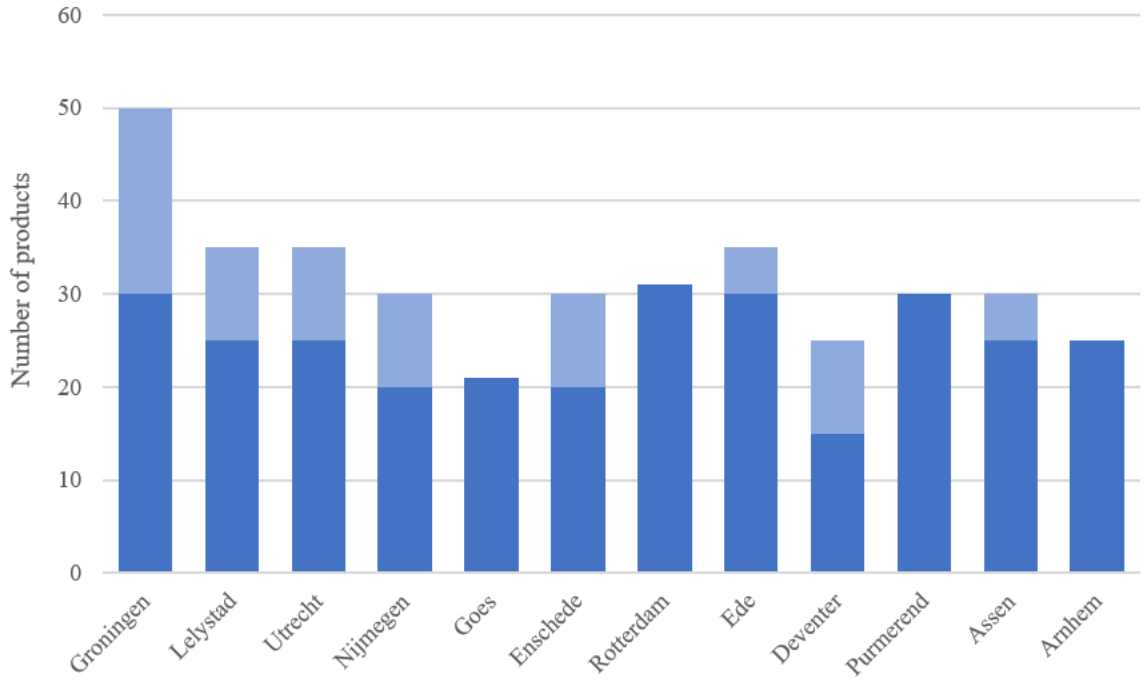

Figure 3: *average number of products per parcel per food bank, retrieved in February 2023 (if the food bank gave a range instead of a single number for the number of products per parcel, this range is represented in light blue).*

5.3 Costs

5.3.1 Cost distribution

The food bank and food voucher system have vastly different cost structures due to their different operational activities. Figure 4 shows the total costs and how they are distributed across the 12 different food banks in 2021. Figure 5 gives the average cost distribution of food banks in percentages. As can be seen, the majority of costs are related to the facility and distribution. In the food voucher system (see Figure 6), the majority of the costs are related to software and transaction. Transaction costs are the costs associated with the electronic payments that take place on the food debit card.

Additionally, it was found some food banks spend a notable amount of their budget on purchasing food. Since these costs were not intended to be included in the main analysis, a cost distribution overview including the food purchasing costs is provided in Appendix F.

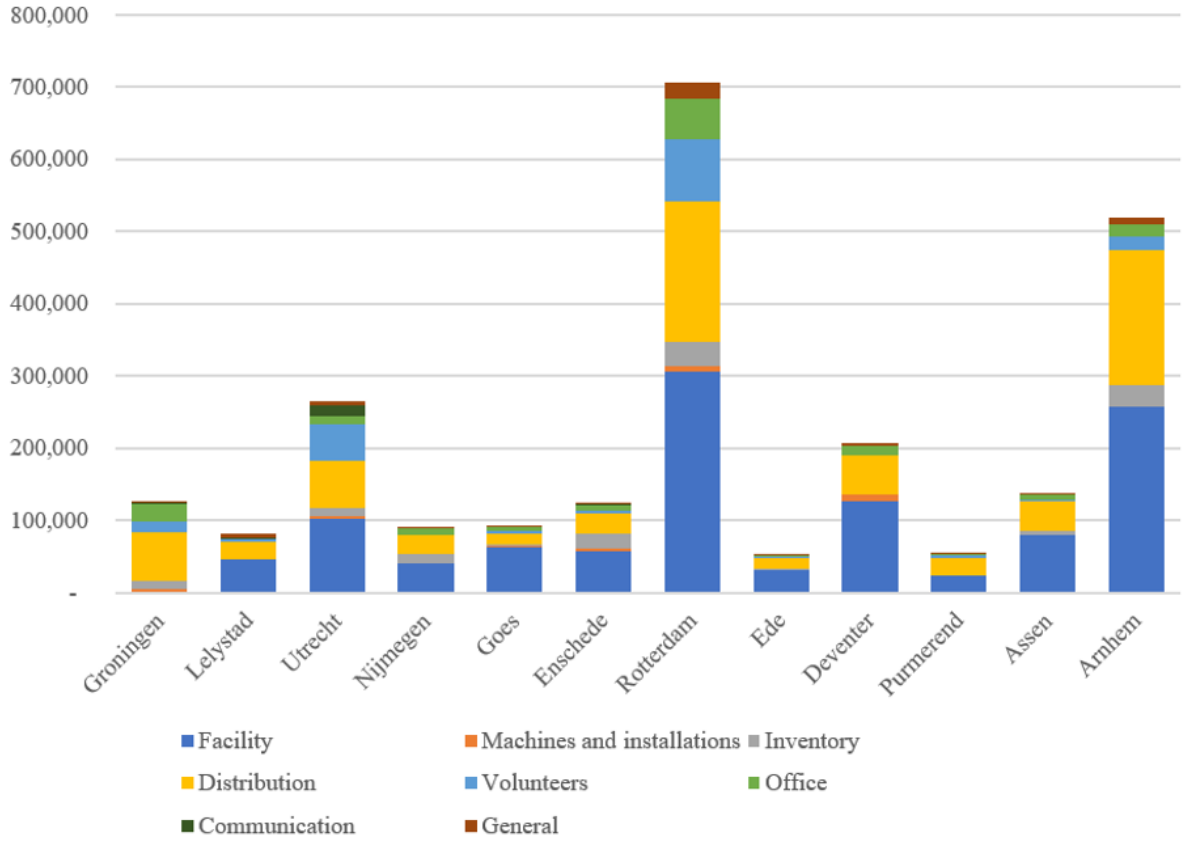

Figure 4: *cost distributions of food banks in 2021 (€)*

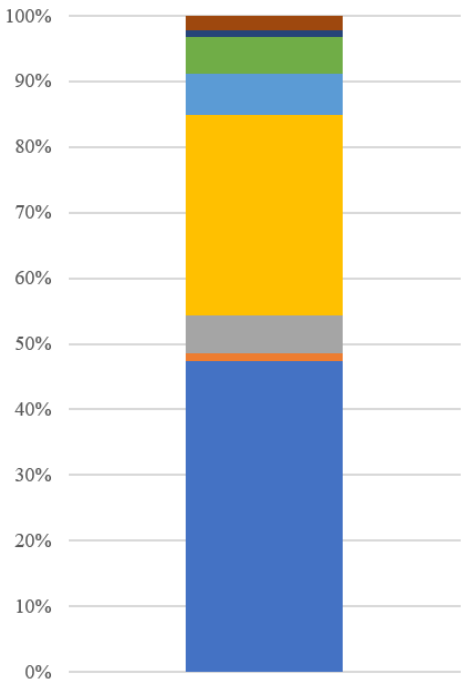

Figure 5: *average cost distribution of food banks in 2021*

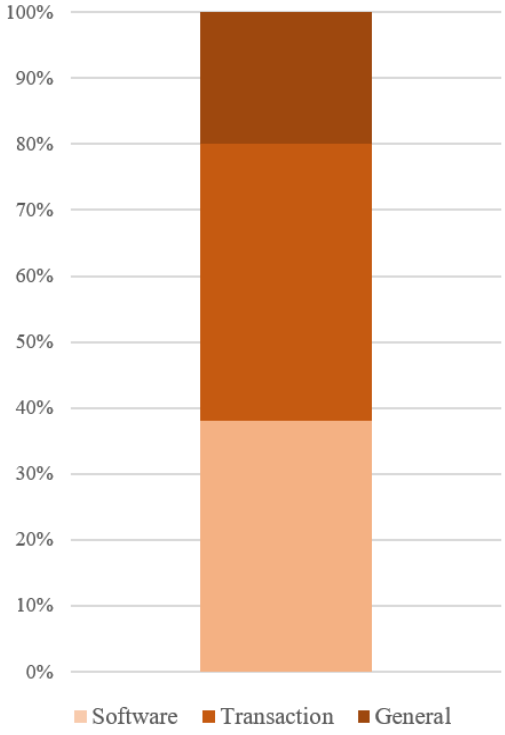

Figure 6: *cost distribution of food voucher*

When comparing the cost distributions of different food banks, it can be seen that Groningen barely has any facility costs (€1755, but not visible in Figure 4). This is due to the fact that the building they use is subsidised by the municipality. Similarly, other food banks also have costs that are covered by municipalities or companies. Sometimes they receive free equipment and services. As a result, it is not possible to obtain a complete picture of all the costs incurred by a food bank. Therefore, the cost prices in the following paragraph represent the costs that are made by food banks, but do not include costs incurred by third parties on behalf of food banks.

5.3.2 Cost price

Figure 7 depicts the cost prices of all 12 food banks in 2020 and 2021. It also displays the proportion of fixed and variable costs. As can be seen, there is a lot of variation between different food banks. Nijmegen has an exceptionally low cost price of €2.16 in 2020, while Deventer has a cost price that is nearly 8 times as much: €16.76 in 2021. The high cost prices of Deventer could be explained by them also being a distribution centre. They incur higher facility costs because they require more space for storage and distribution activities. They also spend more on machinery and equipment. However, this does not always result in a higher cost price. Rotterdam and Arnhem are also distribution centres and their cost prices are comparable to regular food banks. Groningen also has a distribution centre; however, the distribution centre costs were kept separate from food bank expenses in their financial reports.

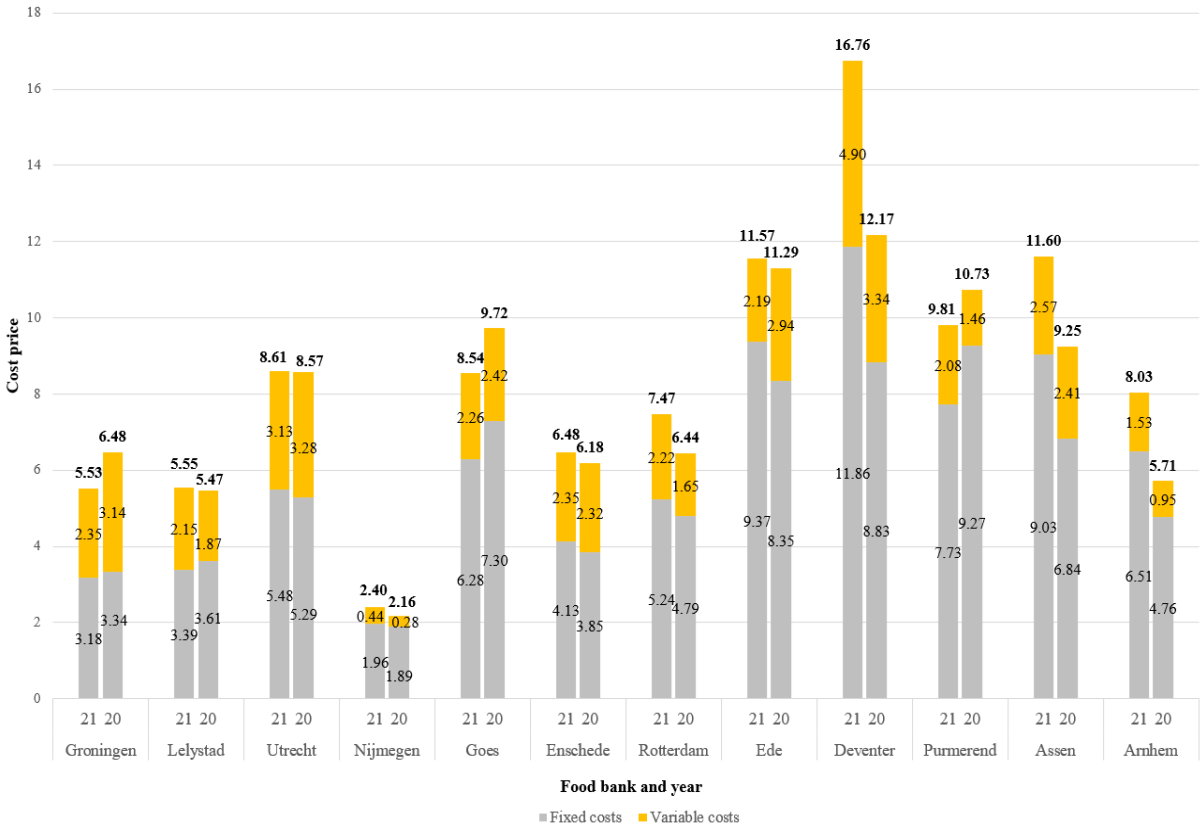

Figure 7: *overview of food bank cost prices in 2021 and 2020, split up into fixed and variable costs (€)*

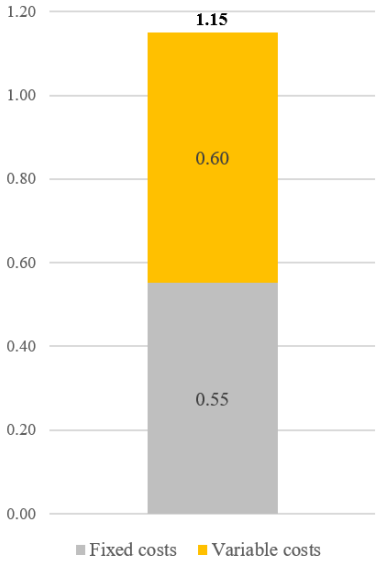

Figure 8: *cost price of food debit card, split up into fixed and variable costs (€)*

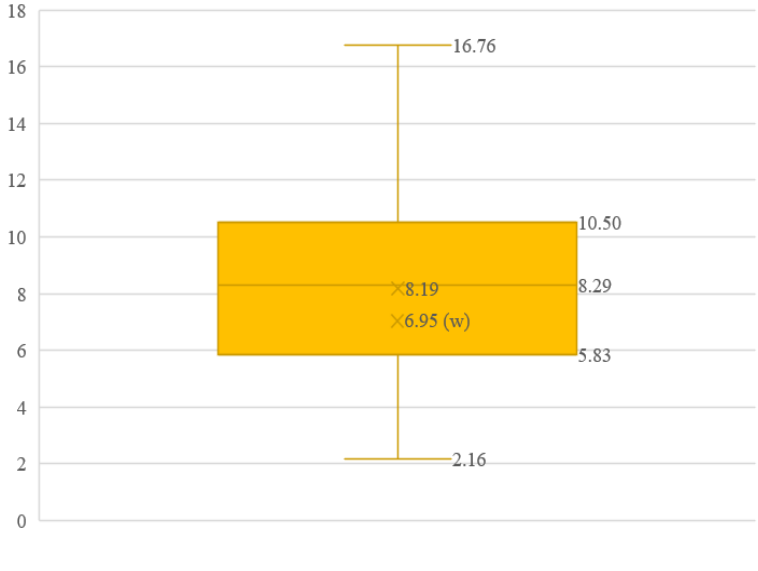

Figure 9: *distribution of food bank cost prices – boxplot (€), including average and weighted average (w)*

All of the food banks have more fixed costs than variable costs. These are costs that remain constant regardless of whether the number of beneficiaries increases or decreases (Drury, 2017). This means that cost prices can differ more depending on how many food parcels are distributed. When the number of beneficiaries decreases, the costs per parcel may become very high; however, when the number of beneficiaries increases, economies of scale may be realized, resulting in a lower cost price. Food vouchers, on the other hand, have a higher proportion of variable costs (see Figure 8). This means that the cost price is relatively stable and that the system can easily adapt to changes in demand.

Figure 9 shows how the cost prices of food banks are distributed. The average cost price over all food banks in 2020 and 2021 is €8.19. When taking into account the number of parcels distributed per food bank, the average food parcel would cost €6.95. Food banks with a higher number of beneficiaries tend to have a lower cost price. The costs of the food voucher system are €1.15 per household per week. This is lower than the food bank system, even in the lowest cost price scenario (see Table 11).

Table 11: *overview cost prices in the food bank and food voucher system, with 3 cost price levels for the food bank system*

S0: food bank		**S1: food vouchers**
S01. Low	€4.93	€1.15
S02. Medium	€7.93	
S03. High	€11.70	

6. Discussion

Various studies have researched food aid in the form of transfers and vouchers (Gentilini, 2016; Hidrobo et al., 2014; Ryckembusch et al., 2013; Sahinyazan et al, 2021). In experimental settings, vouchers seem to get the upper hand due to their operational simplicity and freedom of product choice for beneficiaries (Gentilini, 2016; Hidrobo et al., 2014). The systems in these studies had similar conditions, allowing a fairly straightforward comparison. However, when comparing a voucher system with a food bank system, the comparison becomes more complex. Unlike most food transfer systems, food banks are run entirely by volunteers (Byrne & Just,

2022b). Additionally, they rely on donated food, which consequently affects the costs and the content of a food parcel. Furthermore, the role of the food bank in food waste prevention also needs to be considered. Taking these factors into account, this thesis aimed to realistically represent both scenarios, involving the complexities of each system as much as possible in the context of this research: food waste, retail value and costs. The research findings are further discussed below.

It was found the food bank saves around 1% of the total food waste in the Netherlands, or 19,666,667 kg. This is the lowest estimate by Voedselbanken Nederland (2020), which had estimates ranging from 1 to 2.3%. This is also lower than the estimations from the United States (Byrne & Just, 2022b), claiming food banks save 3 to 5% of food from going to waste. However, it needs to be considered organisations do not all use the same method for measuring food waste (Bellemare et al., 2017). For example, the U.S. Environmental Protection Agency (EPA) only considers food ending up in landfill as food waste, while the Food And Agriculture Organization (FAO) of the United Nations considers food waste the sum of landfill and food "recovered for non-food use" (such as compost, biogas and animal feed). Then, organisations also vary in whether or not they include the inedible parts of food in the total food waste sum. Due to these different definitions and measuring methods, it is challenging to draw comparisons between countries.

Food banks may be able to increase the share of food they save, but not all food waste in the Netherlands is suitable for redistribution. For example, a large share of the food waste exists out of failed crops (Soethoudt & Vollebregt, 2020). So, certain waste streams are only suitable for animal feed, bio-digestion, compost, incineration, or landfill. In the case of the food voucher system, this 1% of food that is saved by the food bank would largely end up in bio-digestion and compost. These options do create valuable products (compost and biogas), however, they are lower on the food waste hierarchy than redistribution (Samen Tegen Voedselverspilling, 2023). Redistribution is considered the best way to handle food waste, right after prevention. In addition to the previous mentioned methods, there are also other ways to valorise food waste streams, like converting waste into biobased products. There are initiatives for this in Europe, but they are not applied on a large scale yet (Pant et al., 2019).

The food bank and food voucher system offer a similar retail value to beneficiaries when looking at the average household. However, while the food voucher system offers a stable value to the beneficiaries in the form of weekly payments based on a fixed formula, there is a lot of variation in the provided value of the food bank system. One food bank receives a lot of donations and can offer 30 to 35 products per parcel, while another food bank may only be able to offer 15 products in certain weeks. So, the number of products a beneficiary receives highly depends on the food bank, with food banks also having internal variations based on the number of beneficiaries and the number of donations they receive. This problem was also acknowledged by Byrne and Just (2022b). Food banks highly rely on independent initiatives, causing certain food banks to have a higher donation stream than others. Additionally, food bank organisations tend to not prioritise equity in distribution due to the additional operational complexities.

In terms of costs, the two systems highly differ. The food bank has a high fixed cost structure, while the food voucher system has a higher proportion of variable costs. The food voucher system is therefore easy to scale up and down. Food banks, on the other hand, have a higher share of fixed costs. They need to invest in buildings, vehicles, machines and installations. The high share of fixed costs means that their cost price will be heavily affected by changes in the number of beneficiaries (Drury, 2017). This could also partially explain why there is such a variation in cost prices between different food banks. When looking at the cost price, the food voucher system is 2 to 14 times cheaper than the food bank system. This is in line with research

by Hidrobo et al. (2014) and Gentilini (2013, 2016): the distribution of food requires significantly more resources than the distribution of vouchers. However, in these calculations, the value of the vouchers was not considered. When you take into account the value of these weekly payments (e.g. €44.31 for an average household), the cost price of the food voucher system becomes higher than that of the food bank system. Thus, the food voucher system may be more adaptable to change in demand and require fewer resources, but the food bank system is still more cost-efficient overall.

Finally, during the cost analysis, it was observed that certain food banks spend a notable proportion of their budget on purchasing food. In the sample of food banks that was taken in this thesis, it gets as high as €4.24 per parcel. This could be an effect of Covid-19, which caused an increase in demand, a decrease in food donations and an increase in monetary donations (Dekkinga et al, 2022). However, Dekkinga et al. (2022) also mentioned that the food donation streams rapidly recovered after the initial shock in 2020. The decrease in food donations seems to be a general trend, as mentioned by food banks' annual reports, FEBA (2021) and Akkerman et al. (2023). The number of donations is decreasing as businesses implement more waste prevention strategies.

While this thesis has highlighted some key factors in comparing the two systems, additional factors need to be taken into account for decision-making, as showcased in related literature in Section 2. The effectiveness of a food aid system heavily depends on the setting (WFP, 2014; Gentilini, 2013). Additionally, it is important to note that the food bank and food voucher system do not have to be mutually exclusive. It may be possible, that combining the two systems could lead to the optimal food aid system. This has also been mentioned before by Sahinyazan et al. (2021). A combination of different food aid modalities could potentially solve the unfavourable effects of any food aid modality used on its own (WFP, 2014). The voucher system could be implemented as an addition to the food bank system, especially in the case of insufficient donation streams. The average number of products per parcel reveals certain food banks are more negatively impacted by declining donation streams than others. Therefore, a voucher system could be strategically implemented to provide beneficiaries with additional food aid and also make up for variations in the number of products per food parcel. This would diminish the need for food banks to purchase additional food, and make the food bank system more adaptive to changes in demand and donation streams.

7. Conclusion, limitations, and future research

This thesis provides a quantitative perspective on the food bank and food voucher system in the Netherlands. This is a new addition to the food aid debate in developed countries, giving insights on food waste, retail value, and the costs of two different food aid modalities. Of these two systems, the food voucher system is still relatively unknown since it is not implemented in many developed countries (Byrne & Just, 2022b). This thesis gives an indication of what the practical implications of this system would be compared to the current food bank system. The following paragraphs will discuss the main conclusions, with the limitations of the study and recommendations for further research.

The first aim was to find out what the food bank's role is in the prevention of food waste, and what would happen if the food voucher system would fully replace the food bank. This study found that the food bank saves around 1% of the total food waste in the Netherlands. Food banks may be able to increase this number, but not all of the food waste in the Netherlands is fit for redistribution and businesses are also actively decreasing their own food waste. In the food voucher system, the food saved by the food bank would largely go into compost and bio-

digestion. Additionally, there would be more potential food waste on the consumer level, because beneficiaries would not consume the saved food by the food bank and only purchase new food. However, it is not known how accurate the consumer waste percentages used in this thesis are. Due to the lack of research on this topic, consumer waste percentages were estimated based on a combination of different statistics. In addition to that, it is also not known how much food waste takes place at the food banks themselves. It would be necessary to conduct research on how much food waste is produced by food banks and beneficiaries to obtain a complete picture of the total food waste in the food bank system.

The second aim was to find out how the systems compare in terms of retail value. It was found the retail values in the food bank and food voucher system are almost equal. This was based on the average household of 2-3 people. Given that the retail values for different household sizes within the food bank system are unknown, this thesis was unable to take into account varying household sizes in its analysis. More data would have to be collected to find out how the retail value compares in the two systems for different household sizes. Next to that, it should be noted that retail value might not be the most accurate indicator of how beneficiaries value the systems. For a beneficiary, having the option to buy almost anything they want with their food debit card, may be more valuable than receiving a food parcel with a high retail value.

The final aim was to find out how the systems compare in terms of costs, specifically looking at cost distributions and cost prices. It was found that the food bank and food voucher systems have vastly different cost structures, with the food bank having high fixed costs and the food voucher system having higher variable costs. This means the cost price in the food bank system is more easily affected by changes in demand, while the cost price in the food voucher system is mostly stable. Also, more investments would need to be made in the food bank system. This makes the food voucher system more adaptable to change. When looking at the cost price, the food voucher system is less expensive when it comes to the operational costs. However, when you take the value of the payments into account that get distributed on the food debit cards, the food bank system is the more cost-efficient option. A limitation of the cost price calculation in this research is that these cost prices may not reflect the full cost price, since some costs would be covered by external parties. This is specifically the case for the food bank system. It was observed in the cost analysis that food banks frequently collaborate and share expenses within the food bank system, which compromises the accuracy of the cost price even more. This can be seen in the food banks that are a food bank and a distribution centre at the same time; next to providing food aid in their own region, they also distribute food to other food banks. Getting a proper overview of what the actual costs of a food bank are, is therefore a complicated task. This requires an in-depth analysis of the financial reports in collaboration with the related food banks, in which they properly classify the costs and look at the value of the services and equipment received from externals. This would also allow the introduction of more sophisticated cost systems, like Activity Based Costing (ABC) (Drury, 2017). ABC makes indirect costs traceable and tends to provide more accurate product costing than the traditional method. Finally, it needs to be noted that the cost price in the food voucher system is not fully certain and should therefore be seen as an indication, since the system is still in its development phase.

Furthermore, it needs to be mentioned that the complexity of both systems is not fully represented by the key indicators used in this scenario analysis. Further research to identify and measure other relevant indicators is encouraged and would provide a more thorough comparison of the food bank and food voucher system. Nevertheless, the importance of the key indicators used in this thesis should not be underestimated. The results of this thesis offer an operational perspective with quantitative indicators, providing a new and practical addition to

the food aid debate. This new information can be used by policymakers and food aid organisations to improve food aid in developed nations.

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Appendix A: Literature review approach

Search strategy

Table A1: *literature search keywords with synonyms*

Keywords	Synonyms
Food bank	Food transfer, food basket, food parcel, food package, food pantry
Food voucher	Food stamps, EBT, food pass, SNAP

Table A2*: literature search query and number of articles found and considered relevant*

Search query	Articles found	Relevant articles
TITLE-ABS-KEY ("food bank" OR "food transfer" OR "food basket" OR "food package" OR "food pantry" AND "Food voucher" OR "food stamp" OR "EBT" OR "food pass" OR "SNAP") AND (LIMIT-TO (DOCTYPE , "ar"))	91	9

Table A3: *article selection inclusion and exclusion criteria*

Inclusion criteria	Exclusion criteria
Covers food aid in the form of food parcels/transfers and food vouchers. Contains food waste, retail value, operations and/or cost-related perspectives. Published in English or Dutch. Published after 2010.	Only covers the sociological perspective of food aid. Only covers nutritional intake. Covers food aid in the context of emergency relief like natural disasters or conflict situations. Food aid initiatives too dissimilar from food banks or voucher programmes, like soup kitchens or cash transfers.

A literature review was done to get an overview of the current state of research on food bank and food vouchers. The aim was to find out how these two systems compare and what the advantages and disadvantages of each system are. Therefore, a search query was formed which included food bank, food voucher, and their synonyms. See Table A1 and Table A2. The search was limited to only include articles. The search strategy resulted in 91 articles. 9 were considered relevant according to the inclusion and exclusion criteria of Table A3.

Overview papers

Table A4: *summary papers literatures study*

Study	Country	Methodology	Main findings	Topics included			
				Food waste	Retail value	Costs	Operations
Byrne and Just (2021)	USA	Data analysis	Food pantries are found to be the second-best option after SNAP benefits. Recipients turn to food pantries when their SNAP benefits have been exhausted (average $129.83 per person). This means SNAP benefits are likely insufficient for most people as many recipients rely on the food pantry in later days of the month.		X		
Byrne and Just (2022a)	USA	Mathematical model	This study presents a valuation approach using revealed preference and travel cost modelling, to estimate food pantry value. It was found that in the food bank in Colorado, the annual value of pantry access to pantry client households is between $600 and $1000, and the value per pantry visit is between $40 and $60.		X		
Byrne and Just (2022b)	High-income countries	Literature review	Food banks and food pantries are the most common form of food assistance in high-income countries. However, they are not as efficient as they could be, mainly due to them being independent initiatives and having a complex supply chain. Furthermore, it is unknown what the economic value of private food assistance is.	X			X
Gentilini (2016)	Developing countries	Literature review	Costs for cash and vouchers tend to be significantly lower than food transfers. When it comes to the effectiveness of different food aid modalities, individual studies cannot be generalized. Although there are some differences in terms of food consumption and dietary diversity, in general, the impacts tend to depend on context, specific objectives, measurement, and program design.		X	X	
Gentilini (2013)	Developing countries	Literature review	This report analysed 12 experimental studies comparing different food aid modalities. It shows effectiveness varies by indicator and tends to be moderate. The performance per food aid modality depends on the program design and objectives, the beneficiaries and the capacity of local markets. Costs for cash and voucher programs were substantially lower than food transfer programs.		X	X	

Study	Country	Methodology	Main findings	Topics included			
				Food waste	Retail value	Costs	Operations
Hidrobo et al. (2014)	Ecuador	Experimental design	This study compared food, cash and vouchers. Food transfers were found to be significantly more expensive due to the cost of transport to distribution sites and the rental of storage facilities, making cash and vouchers the most cost-efficient. If the objective is to increase calories or dietary diversity, vouchers are the most cost-effective means of doing so, followed by cash. Cash gives recipients autonomy while vouchers restrict their choices in order to achieve specific objectives.		X	X	X
Mabli & Worthington (2017)	USA	Survey	It was found SNAP benefits are sufficient for some households. However, 76% of households that enter the program while using pantries, still do so 6 months later. Therefore, the adequacy of SNAP benefits should be assessed on whether it is sufficient enough to provide recipients with enough means to live a healthy, active life.		X		
Ryckembusch et al. (2013)	USA	Mathematical model	This article presents a new analytical tool for ex-ante comparison of the cost-effectiveness of two food aid modalities (food and vouchers) in pursuing specific nutritional objectives. It combines costs with nutritional value to find the optimal food aid modality.			X	
Sahinyazan et al. (2021)	General	Mathematical model	This study presents aims to determine the optimal approach for allocating modalities and quantities of aid to beneficiaries, considering the beneficiaries' needs and preferences. There are 3 objectives to assess potential solutions: program costs, beneficiaries' nutrition levels, and economic contributions to the local economy. A modality's effectiveness depends on the population and market characteristics.			X	

Appendix B: Food voucher value calculation

Table B1: *daily food budget based on age, gender and household size according to Nibud (2021)*

	1 person	2 persons	3 persons	≥ 4 persons
Child age 1-3 **A**	€2.75	€2.50	€2.00	€1.75
Child age 4-8 **B**	€3.72	€3.38	€2.70	€2.37
Child age 9-13 **C**	€6.08	€5.53	€4.42	€3.87
Male age 14-50 **D**	€7.36	€6.69	€5.35	€4.68
Female age 14-50 **E**	€6.57	€5.97	€4.78	€ 4.18
Male age 51-69 **F**	€7.00	€6.36	€5.09	€4.45
Female age 51-69 **G**	€6.59	€5.99	€4.79	€4.19
Male and female age 70+ **H**	€6.95	€6.32	€5.06	€4.42

Food debit card covers 50% of the household food spendings

Example calculation:

Household with parents and 3 children
(B+C+D+E+F)*50%= (2.37+3.87+4.68+4.18+4.45)*50%= 9.78 per day
Weekly payment= 9.78*7= 68.43

Appendix C: Data collection food waste streams

Table C1: *food waste data collection*

Data	Specifics	Source
Total food waste in the Netherlands	1.514-2.380 kiloton	Southoudt and Vollebregt (2020)
Percentage of total food waste saved by the food bank	1%, 1.5%, 2%, 2.3%	Voedselbanken Nederland (2019, 2020, 2021)
Number of products collected per year on a national and a local level	National (40%)= 19.427.664 products Local (60%)= 29.141.496 products	Personal communication with Voedselbanken Nederland
Percentage of total donated food that is saved from becoming waste	50%	Personal communication with food bank De Bevelanden, confirmed by Voedselbanken Nederland
Food waste levels per category	34.5% potatoes, vegetables and fruits 31.5% bread, part-baked bread and pastry 3.3% dairy, eggs, chilled convenience products 7.5% fresh meat and fish 13.2% Other fresh products and shelf-stable products	Vollebergt (2020)
Food parcel usage	Use of all products from food parcel 3.6% never 57% sometimes 39.4% always	Neter et al. (2016)
Food waste average Dutch consumer	9.5%	Ooijendijk et al. (2019)
Food waste processing methods of “gft afval” (fruit, vegetable and garden waste), “swill” (leftover food and kitchen waste) and “organic waste” (biodegradable household and industrial waste) in the Netherlands	95% compost 29% bio-digestion 5% incineration (rejected waste)	Rijkswaterstaat (2022)

Appendix D: Food waste calculations

Total food saved by the food bank

Table D1: *estimations of food waste in the Netherlands in kgs, excluding food that goes to the food bank (Southoudt & Vollebregt (2020))*

min	Mean	Max
1,514,000,000	1,947,000,000	2,380,000,000

Table D2*: kgs of food saved by the food bank in 2021, using the mean of the total food waste in the Netherlands*

% saved by the food bank	Total food waste in the Netherlands*			Kgs saved by the food bank
	min	mean	max	
2.3%	1,549,641,760	1,992,835,210	2,436,028,659	45,835,210
2%	1,544,897,959	1,986,734,694	2,428,571,429	39,734,694
1.5%	1,537,055,838	1,976,649,746	2,416,243,655	29,649,746
1%	1,529,292,929	1,966,666,667	2,404,040,404	19,666,667

** food waste in the Netherlands including the food that goes to the food bank*

The food bank collected a total of 48,569,160 products in 2021. 50% of the food that they collected were products that would otherwise go to waste. This translates to 24,284,580 products. To decide which estimation from Table D2 is the most realistic, the amount of kgs saved by the food bank is divided by 24,284,580. This gives the following product weights:

Table D3*: kgs of food saved by the food bank in 2021, with the average weight per product*

Kgs saved by the food bank	Weight average product (g)
45,835,210	1887
39,734,694	1636
29,649,746	1221
19,666,667	810

It is assumed an average food product does not weight more than 1 kg. Therefore the estimate of 19,666,667 is considered the most realistic and taken as the reference number for the further calculations.

Appendix E: Cost calculations

Food banks

The cost calculations for the food banks can be found in the Excel file below. The first 2 sheets provide summaries of all 12 food banks and their corresponding cost prices and cost distributions in 2020 and 2021. The remaining 12 sheets show the cost overviews of every individual food bank in detail, together with the corresponding cost classifications (fixed/variable and facility/machines and installations/…). The fixed costs are split up into regular fixed costs and depreciation costs.

Kostenanalyse voedselbanken Neder

Food voucher system

Table E1: *cost overview food voucher system, with the corresponding cost classifications (€)*

Data Buyproxy			**Cost classifications**	
Month	**Week**	**Cost items**	**Category**	**Fixed/variable**
1.15	0.26	Usage of systems	Software	Fixed
0.75	0.17	Depreciation (software)	Software	Fixed
1	0.23	Operational costs	General	50% fixed 50% variable
2.10	0.48	Transaction costs	Transaction	Variable
5	1.15	Total		

For the food voucher system, Buyproxy provided a cost overview. The monthly costs of the food debit card are €5,-, which is €1,15 per week (5/30.437*7). The cost items could be categorised into software, general, and transaction costs. See the overview in Table E1.

Appendix F: Food purchasing costs

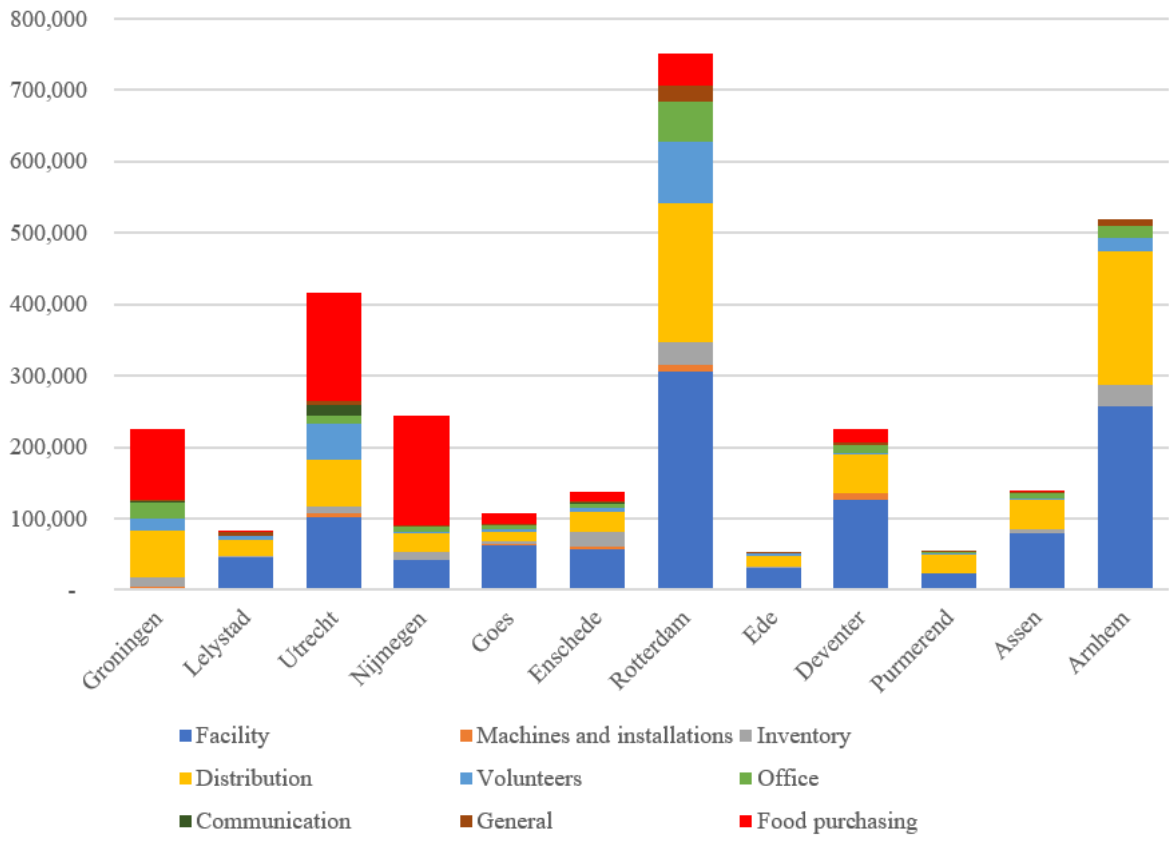

Figure F1: *cost type distributions of food banks in 2021, including purchasing costs*

Table F1: *purchased food per parcel (€)*

Food bank	**2021**	**2020**
Groningen	€4.22	€3.18
Lelystad	€0.07	€0.39
Utrecht	€4.91	€2.16
Nijmegen	€4.24	€3.21
Goes	€1.34	€3.17
Enschede	€0.69	€0.49
Rotterdam	€0.51	€0.65
Ede	€0.00	€0.00
Deventer	€1.53	€1.49
Purmerend	€0.00	€0.20
Assen	€0.13	€0.55
Arnhem	€0.00	€0.00