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Energy efficiency in logistics through service modularity: The case of household waste

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Abstract

Purpose

Service modularity promotes efficiency at the provider end of the supply chain and customisation at the customer end. The purpose of this paper is to investigate how logistics service modularity contributes to sustainable development through the means of energy efficiency. This is analysed in the context of logistics services for household waste collection.

Design/methodology/approach

A single case study methodology with embedded units is adopted where semi-structured interviews were conducted with a waste service provider and buyers (municipalities) in Sweden, focusing on five types of logistics services for waste collection: collection of food and residual waste at apartments and one-family houses, as well as collection of gardening waste. Service modules are identified and analysed by blueprinting the service.

Findings

The findings show different service modules – standardised or customised – and their contribution to sustainable development operationalised through energy efficiency. Principles for an energy-centric service design are proposed.

Research limitations/implications

The research is limited to Swedish household waste collection setting. Promising efficiency through standardisation, logistics service modularity has a potential to improve energy efficiency as well. This neglected link between sustainability and service modularity offers fruitful research avenues.

Practical implications

This research is of practical relevance to waste logistics service providers and municipalities by suggesting principles for energy-centric service design. The service blueprint enables using logistics service modularity for improving energy efficiency in different logistics service settings.

Originality/value

This research incorporates an environmentally sustainable development perspective into logistics service modularity and contributes to logistics service literature by exploring how energy efficiency is improved by modular design of logistics services. Furthermore, the study is one of the first to use service blueprinting to analyse logistics service modularity, providing a methodological contribution to that field in general, and logistics in particular.

Keywords: Energy Efficiency, Service Logic, Service Blueprint, Logistics Service Modularity, Sustainable Development, Waste Logistics.

1. Introduction

Logistics services are energy-intensive and road transport is still mainly powered by fossil fuels (IEA, 2018), which produce high amount of greenhouse gas emissions (European Commission, 2011). Energy efficiency in logistics is strongly associated with the energy-consuming resource delivering the logistics service, namely the transport vehicle. While technological advancements may improve the current practice through means such as aerodynamic design, engine size, wheels and fuel type for vehicles (Liimatainen *et al*., 2014), logistics improvement efforts such as electrification of transport (Offer, 2015), capacity utilisation (Wehner, 2018) as well as mode of delivery (Halldórsson and Wehner, 2020) are largely concerned with the provider end of the supply chain. These improvements call for a deeper understanding of the overall logistics system and how different components are connected to each other. Following recent service literature (Heinonen and Strandvik, 2018), further attention can be paid to the consumer end of the supply chain.

Product modularity helps companies build complex products or processes from smaller subsystems (Baldwin and Clark, 1997), which are produced efficiently in mass, yet providing customised offerings. Similarly, service modularity combines efficiency at the provider end with customisation of the customer offering. Interestingly though, research on customer interfaces in service modularity is rare (De Blok *et al.*, 2014). The present paper investigates logistics services that set conditions for energy efficiency by applying service modularity. Current literature on service modularity is primarily concerned with conceptual description and characteristics of modular services and architecture (e.g. Voss and Hsuan, 2009; Bask *et al.*, 2010a, 2011a; Brax *et al.*, 2017). The present paper contributes to literature on logistics services by presenting empirical evidence on how service modularity can release energy-efficiency potential and provide sustainability improvement opportunities for logistics services. Previous literature introducing service modularity to logistics research (e.g. Bask *et al.*, 2010b; Bask *et al.*, 2011b) has associated modularity with improved operational efficiency rather environmental performance. Surprisingly, despite the energy intensity of logistics services, especially those at the consumer end of the supply chain (Halldórsson and Wehner, 2020), the relation between logistics service modularity and energy efficiency, and hence environmental performance, remains under-developed. Against this backdrop, the purpose of this paper is to investigate how logistics service modularity can facilitate environmentally sustainable development through visualisation of potential energy efficiency improvement areas in logistics service provision.

Viewing service offerings by dividing them into their modules and components allows for a deeper understanding of dimensions that can improve performance, in this case energy efficiency. Investigating logistics services and visualising the overall service delivery process achieves a deeper insight of energy-related aspects of logistics services. Service blueprinting aids in the visualisation of service modules (Bitner *et al.*, 2008), thus providing insights into their potential for sustainable development through energy efficiency. Service blueprints present the service from a customer perspective, but also include service components that are performed behind the line of visibility by the provider. The study maps the architecture of five logistics services for waste collection using service blueprinting. The scope of the service ranges from the point of consumption to the first recycling and/or sorting facility along the waste supply chain.

By analysing logistics service modularity with respect to energy efficiency, this paper's contribution is four-fold: (1) Conceptualizing logistics as a service, (2) identifying improvement potential through modularity, (3) providing insight into components, interfaces and actors through service blueprinting, and based on these first three, (4) analysing energy consuming components of logistics services. Due to the intangible characteristics of services, and the nascent nature of the phenomena (Edmondson and McManus, 2007), a qualitative approach is chosen to analyse the energy efficiency improvement potential of different waste logistics service modules. Service blueprinting can be seen as means to identify the energy efficiency potential at various stages of the waste logistics service provision.

The remainder of the paper is organised as follows. Section 2 provides an overview of service logic, blueprint and how modularity can enable energy efficiency in logistics services. Section 3 introduces the method, including sampling, data collection and analysis, as well as the research quality. Section 4 presents the findings, visualised through the service blueprint. Section 5 discusses the findings and Section 6 presents conclusions.

2. Frame of reference: Sustainable logistic services

This study explores sustainable development operationalised through energy efficiency. Herein, "development" is regarded as a process of improvement that leads to a favourable outcome (Robèrt *et al.*, 2002); in this study by focusing on the service delivery of providers to their customers. The framework of the study departs from a service logic that focuses on the provider-customer interface and combines it with service blueprinting as a practical method to visualising this interface. The second part of the framework relates service modularity to energy efficiency.

2.1. Identifying potential: Service logic and blueprint

Service logic refers to services as a process whereby value co-creation builds on the assumption that the customer creates value and the firm facilitates value creation (Grönroos, 2011). In parallel, Vargo and Lusch (2004, 2008) developed service-dominant logic, stating that value is always co-created between provider and customer. Both logics have their roots in marketing (Edvardsson and Olsson, 1996; Grönroos, 2006) and build upon the value-in-use meaning of value (e.g. Vargo *et al.*, 2008; Grönroos, 2006, 2011) which addresses the phase beyond market exchange. Although the two logics overlap, the present study builds on service logic by Grönroos (2011). Herein, co-creation of value can occur on the co-creation platform which is where the provider and customer interact.

A service design concerns interactions with customers and the organisation, both internally and in a wider network (Avlonitis and Hsuan, 2017; Bitner *et al.*, 2008). In line with the service-logic, the service blueprint is a useful tool to visualise provider-customer interfaces and modules of a service. It is a practical technique, originally developed for providers to visualise their contact with the customers through illustration of a service process (Bitner *et al.*, 2008). Furthermore, the blueprint is a tool for designing or improving a service as well as a service innovation (Bitner *et al.,* 2008; Fließ and Kleinaltenkamp, 2004). The blueprint divides the service delivery process into actions and components, but holds on to the notion "that a total service is greater than the sum of its parts" (Bitner *et al.*, 2008, p. 88). The components of the service blueprint are physical evidence, consumer action, front office, back office, and support process (see lower part of Figure 2.1). Figure 2.1 summarises Grönroos' (2011) provider- and customer-spheres together with the service process along the components of the service blueprint by Bitner *et al.* (2008).

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2.2. Releasing potential: Energy efficiency through logistics service modularity

Modularity seeks improvement of operational efficiency through standardisation. A modular design of services makes it possible to provide customised offerings while maintaining lower cost operations. Building upon this, the framework extends the notion of performance to also consider energy efficiency of the service delivery process and combines it with the principles of modularity.

2.2.1. Modularity and performance

Modularity in manufacturing has been widely discussed (e.g. Baldwin and Clark, 1997) and can be described as "building a complex product or process from smaller subsystems that can be designed yet function together as a whole" (Baldwin and Clark, 1997, p. 84). In logistics, modularity enables the cost-efficient mass customisation (Bask *et al.*, 2011a) of a customer offering; the breakdown of a product or process into modules makes it replicable, the components replaceable and the system manageable (Bask *et al.*,2010a). Modularity promotes performance and cost efficiency (Voss and Hsuan, 2009; Bask *et al.*, 2010a; Brax *et al.*, 2017; Schilling, 2000), as well as standardisation, which improves efficiency and effectiveness together with overall profitability for the provider organisation (Voss and Hsuan, 2009).

2.2.2. Service modularity and efficiency

Similar to manufacturing sectors, service industries respond to requests for improved performance and efficiency. A key characteristic of a service is that it is produced and consumed at the same time and cannot be stored as a physical product, hence, involving the customer in the service delivery process has to happen while the service is produced. As service modularity is regarded as an enabler to meet various customer service requirements more efficiently (Bask *et al.*, 2010a), the provider-customer interface becomes a core area of focus. In this respect, a service module can be defined as "a system of components that offers a well-defined functionality via a precisely described interface and with which a modular service is composed, tailored, customized, and personalized" (Tuunanen *et al.*, 2012, p. 101).

Modularity is still an emerging area in service management, and a consensus on the definition of this concept has yet to be established (Avlonitis and Hsuan, 2017). Frandsen (2017) identified three topics – platform, architecture and activities – as key points of reference for modularity. Pekkarinen and Ulkuniemi (2008) developed a platform-based approach for developing services. Voss and Hsuan (2009) emphasised the importance of service architecture when designing services and established that modularity builds the foundation for service customisation and customer choice, effective product development, and outsourcing. Bask *et al.* (2010a) presented a case study in the logistics industry illustrating service modularity with the example of a delivery process that consists of activities like order handling, procurement, production planning, testing, warehousing and transporting. Warehousing, for example, can be divided into further standardised, invisible process steps (Bask *et al.*, 2010a). Here, service modularity builds upon process modularity rather than product modularity. The present study adopts a similar process perspective on modularity. A process module is a standardised and indivisible process step (Pekkarinen and Ulkuniemi, 2008), making a service offering available to a customer (Rahikka *et al.*, 2011). Process modularity makes it possible to break a large service process down into sub-processes, both to reorganise the standard ones to achieve efficiency in service production and also to customise some of them to achieve customisation at the customer end (Bask *et al.*, 2011a). It follows, involvement of customers in early stages of production is a prerequisite to achieve customisation benefits with modularity (Duray, 2002). Doing this requires organisational modularity to combine resources from different providers or business functions (Pekkarinen and Ulkuniemi, 2008) which are operating or belong to the different components of a service blueprint. Engaging multiple providers in a service delivery creates a fragmentation problem (Vähätalo, 2012) which can hinder the benefits of service modularity. Furthermore, excessive emphasis on service modularity can result in inflexible services delivered by a system with high division of labour and lack of coordination, which in turn risk to fail addressing customer needs effectively (Rajahonka, 2013).

2.2.3. Service modularity and energy efficiency

Energy efficiency is defined as any provision that "delivers more services for the same energy input, or the same services for less energy input" (OECD/IEA, 2014). Departing from this definition, it is common to measure energy efficiency in quantitative terms. However, energy efficiency of services is a combination of multiple variables that interact to deliver the service. In logistics services, energy efficiency has been defined qualitatively as the interaction between distribution structure, transportation execution, customer logistics capability (Colicchia *et al*., 2013; Halldórsson and Wehner, 2020). Following from the second definition, service modularity is helpful in showing services in detail as they break each module down into smaller components, illustrating the interactions between them and the service process subunits that surpass these components.

Service modularity enables standardisation, which improves efficiency and effectiveness together with cost reduction and overall profitability (Voss and Hsuan, 2009). Building upon Pohjosenperä *et al.* (2019), who used service modularity for enabling value creation in healthcare logistics facilitating more efficient patient treatment, this paper regards service modularity as an enabler to create more energy-efficient logistics services. Use of energy resources as a key input to power logistics services such as transport are expected to be improved by applying standardisation principles of service modularity. To this end, environmentally sustainable development of logistics services is addressed with respect to energy efficiency, improvement of which can be enabled through modularity. Table 2.1 presents key terms used in this study, adapted from De Blok *et al.* (2014) and Rahikka *et al.* (2011).

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These key terms represent the components and actors that are used to illustrate the logistics service provision within the waste collection context. They help explain the smallest units of the service and how they can improve the energy efficiency of the overall service.

3. Method

The exploratory nature of the purpose and the qualitative approach to energy efficiency requires a qualitative research design. To describe and explore service modularity within the waste logistics context, a single case study is adopted as research methodology. Case study is an appropriate research method when the purpose of a study is to investigate a contemporary phenomenon within its real-life context (Yin, 2014). Eisenhardt and Graebner (2007, 25) add that "case studies are rich, empirical descriptions of particular instances of a phenomenon that are typically based on a variety of data sources" which points out the requirement to collect data from multiple sources.

The context of this study is defined as waste logistics context but to understand the service modularity phenomenon within this context, it is necessary to investigate multiple services. Different waste logistics services are selected as units of analysis which calls for an embedded single case study design (Yin, 2014). Adopting a single case study methodology with embedded units allows to investigate service modularity in-depth and enhance the insights extended to the waste logistics context.

3.1. Sampling

Energy efficiency through service modularity requires views from different actors in the logistics system, hence data was purposively collected by interviewing different actors working with waste collection logistics services. Two different municipalities (MUN) were chosen, along with one waste service provider (WSP) contracted by both MUNs. Both MUNs hold shares in the WSP, but the WSP can be regarded as an independent organisation. Waste collection is organised in a highly regulated setting (Halldórsson et al., 2019), which provides the opportunity to depict the whole system with a small but effective sample. Sampling strategy was purposive (Flick, 2014) to include the individuals who have an in-depth knowledge and understanding of the services in question. Individuals that had been involved in the new service development, service improvement or other service design activities within the selected case context were selected among employees of MUNs and WSP.

3.2. Data collection and analysis

The first round of interviews (I) concerned descriptions of different services and selection of services to be investigated in detail. The second round (II) entailed in-depth descriptions via service blueprinting – mapping the components that together constitute service modules and their relation to energy efficiency. Data was collected on five different services (see Figure 3.1). By choosing to investigate the waste logistics system, a mundane but also important service was investigated. This setting was chosen since the regulated setting of actors in waste logistics makes it possible to depict the waste system holistically (Halldórsson *et al.*, 2019). Because of national regulations, the collection of residual and food waste is provided according to the ratio of households within the borders of a municipality, but that number can easily be scaled up to households nationwide. Thus, the studied services are representative for the collection of residual and food waste at apartments and one-family homes in Sweden and transferable to similar settings around the world.

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The collection of residual and food waste was chosen as a traditional service that has been offered for many years and could be described in detail. However, many interviewees did not know how and why the service came about because they had not been part of the process. The collection of gardening waste is a relatively new service, which had only been offered for a short while, arising from a demand from households. Interviewees could answer well how and why this service was developed since they had been part of this process.

In line with the embedded single case study design, multiple rounds of data collection with multiple respondents was carried out. Furthermore, the data collection process required active involvement of the sample for drawing the blueprints and revising as well as validating them. This is reflected in the triangulation of data collection methods, i.e. semi-structured interviews, brainstorming sessions and a validation round. Data was collected from 8 different participants on 12 occasions (see Table 3.1).

--Insert Table 3.1 in here, please—

The following steps of service blueprinting were undertaken during the data collection process (Bitner *et al.*, 2008): (1) Clearly articulate the service process or sub-process to be blueprinted and specify which segment of customer it focuses on, (2) delineate actions of customer, (3) establish contact employee actions, both frontstage and backstage, (4) add links that connect customer to contact employee activities, (5) add physical evidence as last component, and (6) if desired, add more boxes for details. The first round of interview data was used to draw the first drafts of service blueprints which were later revised and validated during the second round. While drawing the blueprints, interview data representing different blueprint components were coded by two researchers independently. A "matching" approach was adopted to coding interview data (Dubois & Gadde, 2002) where the researchers went back and forth between the data sources and service blueprint components to match service descriptions with specific components and to refine the labels for each process step. The service blueprints' components functioned as the "tight and pre-structured framework" (Miles *et al.*, 2020) that guided the data analysis process in the first round. The initial coding of process steps by individual researchers was compared together with their labels and refined where necessary.

For the second round of interviews, data was collected through service blueprinting to map out the components that constitute a service module. Service blueprinting is a service modelling approach to describe and sketch service process steps which enables the participants to visualise them (Lee et al., 2015). In this study, service blueprinting is used as a tool to both collect the data but also to present the findings at the end of data analysis process. The service blueprints show where the customer might interact with the organisation; however, to map the whole service design, it is crucial to also focus beyond those touchpoints (Avlonitis and Hsuan, 2017; Tax *et al.*, 2013; Rawson *et al.*, 2013).

The service blueprints were analysed in regard to the four levels of service architecture developed by Voss and Hsuan (2009). Furthermore, the blueprints were used to identify service process modules and interfaces guided by the service logic by Grönroos (2006, 2008). Mapping the different service offerings helped comparing the modules across the services and identifying customised as well as standardised components and modules that impact energy efficiency.

3.3. Research quality

The evaluation of quality and trustworthiness of the research was guided by the four criteria of credibility, transferability, dependability and confirmability (Halldórsson and Aastrup, 2003). Table 3.2 lists all the criteria and actions taken to ensure research quality. Generalisation of one in-depth case study is enhanced through an analytical process (Dubois and Araujo, 2007), through causal relationships that can be found within the case rather than comparing attributes between cases.

--Insert Table 3.2 in here, please--

4. Findings: Modules of five logistics services

The five logistics services are described in detail below. Figure 4.1 visualises Services 1 a and b, which was selected to illustrate the mapping of improvement potential through service blueprinting.

Service 1 – Collection of (a) residual and (b) food waste at apartment housing: The service is initiated in a first module (**M1**), referred to as "service ordering" in Figure 4.1. The first contact with the municipality to acquire services is initiated by the houseowner in case of rental apartments, or by the board of the housing association in case of privately-owned apartments (both actors are referred to in the following as houseowners). For newly built apartment houses, this contact is initiated before inhabitants move in. The municipality provides advice on the right number and size of bins, and in special cases even visit the premises. The houseowner makes the final decision on number of fractions (two fractions meaning (a) residual and (b) food waste are sorted, or they can order a mixed bin in case they do not wish to sort), the number and sizes of bins and the time interval of collection. This data is booked by the municipality's customer service into a customer database.

In **M2** ("implementation"), all information is shared with the WSP. This is also part of the interface between M1 and M2. When bins are kept in a waste room, houseowners transfer keys to the WSP. Next, new bins are delivered from the WSP together with a pallet of paper bags that the inhabitants use to collect the food waste in the apartments, as well as possible information material to the premises. The bins are equipped with an ID tag (RFID-tag read by the WSP during emptying) and a sticker that makes the relevant address visible to everyone.

M3 ("disposal") is provided by the household themselves, who put bags in the paper-bag-holders in their kitchens. Here, waste is mostly sorted into two fractions – residual and food waste – and then moved to bins in a waste room. Residual waste is disposed of in plastic bags approximately once a week, and food waste is disposed of in paper bags approximately two to three times a week. The number of bins, sizes or intervals can change at the request of the houseowner, in cases the sorting behaviour of the inhabitants is different than anticipated. This allows for a degree of customisation. Furthermore, the houseowner is responsible for ordering a refill of paper bags.

In **M4** ("pulling"), full bins need to be pulled to the property line by the houseowner (for example, through a facility manager) or the houseowner orders this service from the WSP. When the WSP pulls up bins, they must be located within 25 metres to the property line. In **M5** ("routing"), the route planning is conducted by the WSP to allow for the most efficient route with respect to time and energy consumption. WSPs can change their route only a certain number of times during the year; inhabitants would need to be informed and changes are perceived to be inconvenient. In **M6** ("collecting and monitoring"), the bin is weighed when being lifted and emptied by the waste truck. This data is linked to bin-ID and recorded in the WSP's IT system. Deviations such as bad sorting, overly high weight or a possible non-emptying because of non-accessibility or wrong sorting are also recorded.

--Insert Figure 4.1 in here, please--

In **M7** (“informing”), the recorded data is shared with the municipality’s customer data system, an interface for information flow. For deviations, the municipality or the WSP sends a letter or text message to the houseowner, who in turn informs the inhabitants. In case of a failed attempt to empty the bins, the houseowner orders an extra collection. The WSP returns the bins where they were placed at the property line or, in the case of extra pull, returned to the exact location. Residual and food waste do not need to be collected at the same time since they are based on different collection intervals.

In **M8** (“transport”), the waste is transported to a reloading station (use of small trucks) or to an incineration facility for residual waste or to a biological waste preparation facility for food waste (use of larger trucks). The service ends with **M9** “invoicing”, where the municipality charges the houseowner by the weight of residual waste.

Service 2 – Collection of (a) residual and (b) food waste at one-family housing: S2 is initiated in a first module (**M1**) “service ordering”. Similar to M1 of S1, residents of the one-family house establish the initial contact with the municipality to order and buy the service.

M2 (“implementation”) is also equivalent to M1 from S1. After the implementation phase, the third module (**M3**, “disposal”) is provided by the household themselves. Households provide the same activities as in M3 of S1, with the difference that one-family houses normally have no waste room and bins are located outside the house in the garden.

In **M4** (“pulling”), the full bins need to be pulled to the property line, which is either done by the household or can be ordered as a service. In **M5** (“routing”), the WSP plans the transport to ensure the most efficient route with respect to time and energy consumption, but the routing can only change a limited number of times during the year. In **M6** (“collecting and monitoring”), when the bin is emptied, they are weighed when lifted by the waste truck; this data is connected their ID. It is saved in the WSP’s IT system, and deviations are noted down. In **M7** (“informing”), all information is shared with the municipality’s customer data system, an interface of information flow. In cases of deviation, the municipality or the WSP informs the household via letter or text message. In case of a failed attempt to empty the bins, the household needs to order an extra occasion of waste collection. The WSP returns the bins where they were placed. Residual and food waste do not need to be collected at the same time since they are based on different collection intervals.

The transport of the collected waste in **M8** (“transport”) is conducted the same way as in M8 of S1. Because of the small amount of waste collected per individual household, the collection is rather energy-inefficient, which can lead to low fill rates. The service ends with **M10** “invoicing” when the municipality charges the household for the weight of residual waste. This is an incentive for households to sort waste better to all other fractions (not only food waste, but also packaging material) to pay a low-weight bill on collection of residual waste.

Service 3: Collection of gardening waste at one-family housing: The service is initiated in a first module (**M1**), “service ordering”, when the resident of the one-family house establishes the first contact with the municipality to order and buy the gardening waste collection service. There is one standard size of bin available, fixed intervals, and the collection period is between April and October when most gardening waste is generated. Customer can order the service via phone and the municipality’s customer service enter the data into the customer data system. Alternatively, the household can order this service online over the municipality’s website.

In **M2** (“implementation”), all information is shared with the WSP. Then, the WSP delivers the new bin from its bin storage to the premises. When the bin is delivered, it is equipped with an ID tag (a RFID-tag that can be read by the WSP every time they empty the bin and is connected to their IT system) and a sticker showing the relevant address. After the implementation phase, the third module (**M3**, "disposal") is provided by the household themselves. The household disposes gardening waste into the bin. Limitations are the maximum volume and maximum weight, so the bin can still be lifted and rolled. As the service is used by the houseowner for a while, the required number of bins can be adapted. In **M4** ("pulling"), the full bins need to be pulled to the property line. For the gardening waste there is no alternative and a pulling service cannot be ordered. In **M5** ("routing"), the route planning is conducted by the WSP to allow for the most efficient route in terms of time and energy consumption. However, the WSP can change the route only a certain number of times during the year, to avoid inconvenience for the households. Since a relatively small number of households currently order this service, the truck must drive long distances between each collection point.

In **M6** ("collecting and monitoring"), the bin is emptied, and possible deviations are recorded, such as bad sorting, overly high weight or a possible non-emptying because of non-accessibility. In **M7** ("informing"), all information is shared with the municipality's customer data system. In cases of deviation, the municipality or the WSP sends a letter or text message to the houseowner, who informs the residents. In case of a failed attempt to empty the bins, the household must order an extra waste collection occasion or drop off heavy gardening waste themselves at a nearby recycling centre. The WSP returns the bins to where they were placed on arrival, and the household needs to return them themselves to their spot.

In **M8** ("transport"), the waste is transported directly to a recycling centre without reloading. The service ends with **M10** "invoicing", when the municipality charges the household with a fixed price for the gardening waste.

5. Discussion

This study sets out to investigate how logistics service modularity contributes to sustainable development through the means of energy efficiency. The results structures around service blueprints that depict the individual service process modules of the logistics service offerings in the context of household waste collection. A detailed account of waste collection logistics services is provided, showing that improvement potential can occur in components and interfaces, here presented as a sequence of inter-related modules.

5.1. Logistics services modularity

In the service offering, several service components were grouped into a *module* that was offered to a customer in itself or together with other modules creating customer value. The grouping of several components to a logistics service process module was based on components trying to achieve the same goal or a variety of the service offering (Rahikka *et al.*, 2011). The *interfaces* connecting individual components, both within and in between modules, relate to information flow, collaboration or indicate a sequence of components. Derived from the analysis of the five services and their underlying modules, three constituent components of *logistics service modularity* became apparent.

First, *standardised and customised service modules allow for variety in service offerings;* the blueprint reveals a range that is partly related to operational efficiency, i.e. allowing the provider to deliver the same offering to different customer groups (Bask et al., 2010a). Interestingly, the service blueprint provides an insight into modules that allows the provider to offer different types of waste logistics services to the same group of customers, i.e. customize the offerings (Voss and Hsuan, 2009). When comparing the modules across the service offerings, several standardised and customised modules can be identified. For example, “service ordering” modules (M1) are similar across all service offerings, but certain components within those modules are customised (e.g. customer can choose how often bins should be emptied). A comparison between service offerings S1 and S2 – both of which resemble a standardised service customised to different customer groups (i.e. inhabitants of apartments versus residents of one-family houses) – shows standardised components that are exchanged while used to deliver services to different customer groups. Comparison of service offerings S2 and S3 shows that the customer group stays the same but the offering changes from the collection of residual and food waste to gardening waste. Here, many components and modules again are unchanged while others are adapted, e.g. the service that the bin is pulled to the property line is not available in S3.

Second, *blueprints enable the provider to involve the customer-end as an integrated part of the logistics service delivery.* Service modularity entails a sequence of dimensions that move *horizontally* in the service blueprint (as can be seen in Figure 4.1) allocating components to different modules. In the *vertical dimension* of Figure 4.1, these components appear in either the provider or customer sphere, or at the intersection of these (Grönroos, 2011). This follows the service logic in that services are produced and consumed in a provider-customer exchange process. Building on the process module definition provided by Rahikka *et al.* (2011), the modules described above illustrate the process modules that are indivisible waste collection service process steps and enable the waste collection offering to be available to the households. As a tool, service blueprints are an alternative to the service platform concept suggested by Pekkarinen and Ulkuniemi (2008). However, blueprints also extend the service modules to the customer end of the service process. Carlborg and Kindström (2014) emphasised the importance of customer resources in understanding the modular structure of different service types. The findings in the present study extend this view by providing in-depth information about the customers’ involvement in process modules through household actions with the help of service blueprints.

Finally, the service blueprint enables *capturing the dual role of providers and customers*. The result provides evidence for the *dual role* of the customer/consumer in service production. More specifically, in line with the traditional service literature (Grönroos, 1982) and more recent studies on logistics services (Halldórsson *et al.,* 2019), the customer in the waste collection service case – the houseowner – takes an active role in service production during M1 and M2. Such involvement impacts the service that the customer receives in return. Individual households, namely the inhabitants of apartments, impact the service through their co-production and consumption actions, such as proper sorting or consumption frequency. The “informing” module (M7) is required to facilitate the feedback loop to enable the required change in the service. Furthermore, the service modules that are illustrated through blueprinting provide a useful tool with which to understand the compiled resources, in form of physical evidence, and the facilitation processes for customers’ value co-creation (Grönroos, 2006). These components of the blueprint are also reflected in the service logic, in which another important proposition is the value-creation spheres composed of the provider, customer and joint spheres (Grönroos and Voima, 2013). By using service blueprinting, Figure 4.1 exhibits an operationalisation opportunity to understand the individual actions and processes that take place in all spheres. Components of service modules that take place as a support process or invisible employee action contribute to potential value formation and facilitation of value creation by the customer. Components that take place at the visible contact or household action stages represent the joint sphere because it is in these stages that the majority of interaction between the provider and customer occurs. However, this sphere is very dynamic and depending on the extent of interaction the boundaries of the sphere can extend both ways. Then, part of household action and physical evidence stages represent the customer sphere, where the provider is passive. At this point, the customer interacts with resources that are obtained from the provider and these can be physical goods such as bins or garbage rooms. Here, the blueprint reveals – vertically – the depth of interaction and illustrates where the customer socially creates value-in-use.

Whilst this account presents an advantageous view of logistics service modularity, there are also some drawbacks to consider. Service modularity is, for example only applicable to services with a certain level of complexity and size. As complexity increases, the interface requirements will increase which makes it difficult to describe, yet to manage, the modules. Furthermore, using a modular approach to services requires an adaptation of the business model, training for the organisation and investment in modules. Confirming what Duray (2002) has argued for product modularity, if customer involvement is not achieved in early stages of service production, then customisation advantages might be lost. However, Pekkarinen and Ulkuniemi (2008) state that it is difficult to illustrate or describe a service to a customer prior to the actual delivery. Service blueprinting is a helpful visualisation tool for addressing this drawback. Finally, being a regulated industry, waste logistics is not as fragmented as other service industries, which reduces the coordination problem of module interfaces across multiple organisations (Vähätalo, 2012). Managers must be aware of the inflexibility trap that might emerge as a result of over-emphasis on modularity (Rajahonka, 2013).

5.2. Energy efficiency through logistics service modularity

Based on the findings of this study, the authors argue that energy efficiency can be understood as an operant and intangible resource (Lusch, 2011) that holds value by capturing both the economic and environmental dimension of sustainable development. The second part of the analysis relates logistics service modularity to energy efficiency, offering three important insights.

First, energy efficiency through service modularity can be defined with respect to the desired results. On one hand, the operational efficiency feature of modularity enhances the achievement of both the economic and environmental aspect of services, hence creating conditions for energy efficiency improvements. On the other hand, service modularity helps to explain how increased variety in customer offering (i.e. customisation) can be achieved by either preserving or increasing energy efficiency of services. Whilst, this confirms notion held by the traditional service operations literature (Voss and Hsuan, 2009) and the emerging logistics services modularity literature (Bask *et al.,* 2011b), the use of the blueprinting adds to current body of knowledge the how of undertaking such analysis.

Second, as conceptualized in this study, the service blueprint offers a two-dimensional approach to energy efficiency through logistics service modularity; a horizontal scope of a service delivery process (Bitner *et al.,* 2008) and a vertical dimension representing the provider and customer sphere (Grönroos, 2011), respectively. The novelty of the results refers in particular to the second dimension. The decision of size of bins and collection interval in M1 directly impacts how often a waste truck of the waste management provider will have to visit to empty the bins, which in turn impacts the energy consumption of modules M3 to M8. The "routing" module (M5), commanded by the service provider, has direct impact on energy consumption. While being limited to a maximum to four route schedule changes a year to avoid inconvenience for houseowners, who then would need to adapt their time of pulling the bins to the property line to a different day, energy inefficiencies are accepted. This module "routing" (M5) shows a clear movement across the vertical levels of the blueprint, between the service provider and the customer. In a rapidly developing urban environment, where new collection points need to be added to the waste collection system to improve the so-called first-mile logistics (Halldórsson *et al.,* 2019), non-flexible routing, i.e. not modular, can be counterproductive to energy efficiency.

Third, energy efficiency has a distinct appearance with respect to the dual role of providers and customers as a feature of logistics service modularity. For example, the modules "routing" and "transport" (M5 and M8) have the highest energy consumption because they are the modules where large trucks move to collect waste, but this also implies that changes to those modules can save the most energy in absolute numbers. Notably, however, improvement potential is not limited to the modules within which they occur, as changes in other modules along interfaces can also improve energy consumption. For example, using a truck that collects two fractions at the same time (occurs in "transport" M8), will have an impact on possible options during service ordering (M8), the rhythm of collection and, with that, customers' pulling (M4) and providers routing (M5). Illustrating the entire waste collection service through the service blueprint allows not only for identification of components and interfaces, but moreover analysis of how modules relate to each other and where energy efficiency can be achieved.

Derived from the findings and analysis, the following principles for energy efficiency in logistics through service modularity are proposed:

1. *Energy as a resource:* In modular logistics service design, modules, where energy use could be combined, are used to provide customised services in a more energy-efficient manner.
2. *Duality -- energy efficiency at provider–customer interface*: Energy-centric service design should include both the provider and customer.
3. *Energy efficiency through service blueprinting:* It is vital to visualise the whole service process, including invisible actions and back office activities, to see where improvement potential of energy efficiency is available.
4. *Energy efficiency through convenience:* Visualisation of the customer–provider interface helps to illustrate both energy-efficient and convenient actions of customers that can be duplicated in another service offering.
5. *Energy efficiency in line with customisation:* Providing a modular logistics service where customers can combine different components to form their customised environmentally friendly service package, yet constituted of standardised components, can improve the overall energy efficiency of logistics services and customer satisfaction.

6. Conclusion

Derived from the results and the discussion, the study suggests a three-step approach to sustainable development of logistics services, conceptualizing *logistics* as a *service*, using *modularity* (components and interfaces) to operationalize improvement potential of logistics services, and using *energy efficiency* as an analytical construct to explain how the potential may be released with respect to the service level attained. Provided the energy-consuming nature of logistics services, and their important role in the transformation of the transport sector towards increased use of renewable energy sources, and the promising potential of co-creative effort of providers and customers, such an insight into the micro-foundations of services is essential. The work with service modularity is approached by borrowing the service blueprint from service marketing literature and to illustrate the service modularity concept of operations management literature in the context of logistics services. The contributions of this study are four-fold. In combination, the contributions propose a hands-on approach to

First, logistics offering is conceptualized with respect to the service logic of the service marketing literature. Service blueprints are used to provide an in-depth understanding of the modular composition of logistics services and the role of the provider and customer in the service co-creation is explicated. This provides a novel insight into how individual service components, standardised and customised, allow for variety in service offering. By this, the study represents an initial contribution to theory of logistics services focussing on a module as unit of analysis by combining service logic (Grönroos, 2006, 2008; Grönroos and Voima, 2013) with service modularity that is analysed through service blueprinting and logistics that is conceptualized as a service.

Second, the applicability of service blueprints as a hands-on method needs to be combined with a process perspective to capture interactions and identify potential between modules. Following the notion of dual-actor nature of services, the blueprint captures the service "components" by mapping the collaborative and dialogical process between providers and customers by the "line of visibility" in the blueprints. In addition, "interfaces" between modules provide opportunities to explore other interactions between provider and customer networks. For example, connections between the "service ordering" (M1) and "implementation" (M2) modules illustrate the provider network composed of municipality and the WSP.

Third, the study confirms emphasis on service modularity as being derived from process rather than product modularity (Bask *et al.*, 2010a). The results of service blueprinting depict an insight into the specific steps in processes, but as a method it can be used to illustrate type of logistics services beyond the waste management context studied here. The generic components refer to interactions across different modules, the two key actors and their actions within different modules, and how a standardisation of those can increase efficiency while also achieving customisation.

Finally, service modularity is used to show how energy efficiency can be improved in service provision. The break-down of components through the service blueprint allows for a better understanding of energy consuming parts of logistics services, and how improvement of energy efficiency as means of sustainable development can be achieved through changes of individual components whilst still preserving a holistic perspective of the potential implications for other components of the service. This contribution relates service modularity to environmental sustainability operationalised through energy efficiency. The concept of modularity has been an improvement opportunity for both goods manufacturing and service production (Bask *et al.*, 2011a). It enables the standardised production of smaller components and varied configurations of these components through standardised interfaces where this variance enables an increased degree of customisation. Similarly, dividing a service system into standard components and configuring them in various ways improves both efficiency and performance (Voss and Hsuan, 2009) because it enables more efficient use of standardised inputs. Considering energy as a resource or input for various modules and their components, the authors propose that dividing logistics services into modules makes it possible to increase energy efficiency in a similar manner, thus improving environmental sustainability.

6.1. Practical implications

Regarding practical implications, logistics managers are given insights into the applicability of service blueprints to identify hot spots of energy efficiency improvement potential in various components of the service process of their organisation. Furthermore, principles for energy efficiency in logistics through service modularity, as provided in the end of Section 5.2, can guide managers when developing their service processes. One other advantage of service blueprinting is visualisation of customer involvement at different stages of service provision. This would introduce customisation opportunities for waste logistics service providers and also allow for working together with customers to improve sustainability of logistics services. Service blueprint is a hands-on tool that would facilitate modular thinking for logistics service organisations which, due to the nature of the industry, lack the standards that manufacturing industry enjoys and therefore, face many difficulties in switching to a modular design. This also directly relates to effects for society, since the waste collection logistics services is a service used by every resident in Sweden. By configurating the service, every resident will be affected, either because a higher degree of customization might make customers more satisfied, a better routing might reduce the number of large trucks driving around residential areas, or by a higher level of energy efficiency, emissions are reduced and air quality improved.

Based on the effects of service modularity suggested by Carlborg and Kindström (2014), this study proposes that using standardised modules in the provision of various service offerings is expected to reduce the energy inputs required by an independent service sub-process. A modular perspective enables the re-use of a module for different service offerings, thus providing opportunities to combine different services. Furthermore, it is easier to improve energy efficiency at a modular process level than at the whole service level. By looking at modules and interfaces, it is easier to see the impact of a change in one module on another.

6.2. Future research

Whilst this research is a first attempt to combine service blueprinting with service modularity from the theoretical perspective of service logic, this provides opportunities for future studies focusing on environmentally sustainable development of logistics service providers. Illustration of how standardised modules could be used across different service offerings and their impact on the energy efficiency levels of these offerings would present many practical insights for further motivation of using this approach. To further this development, at least three venues of further research should be considered. First, settings other than waste collection may offer greater variety in customer needs, hence allow for further scrutiny of boundaries of logistics services modularity vis à vis customization. One such setting is home deliveries, or last-mile logistics, which can take various forms, and offer different opportunities for energy efficiency improvements (Halldórsson and Wehner, 2020). Related to this, implementing the modular service design to various logistics service settings for measuring the impacts on cost, time and energy consumption before and after implementation would complement this study's discussion on the benefits of such an approach to logistics service design. Second, whilst a service logic suggests a more active role of end-users as logistics service value co-creators (Halldórsson et al., 2019), the incentives that encourage them in doing so are not well understood. Third, future research should investigate how service modularity allows managers to convert goals of improved energy efficiency into actions through logistics service development and -innovation (Halldórsson, 2019). Herein, a modular perspective could support the process of energy efficiency service design from the beginning for new services by using the standardised components that have the greatest impact on energy efficiency. Finally, the dynamic roles of various actors (Wagner et al., 2017) in this modular service setting deserve further attention. With reference to wider provider and customer networks, an actor may play both roles depending on the relationship in the service process. Hence, an actor can be in the provider sphere when performing in one module, but in the customer sphere when performing in another module. Exploring this dynamism and its impacts on service design could provide important insights. Value as a concept is not the main focus in this study, but service logic provides an important lens to understanding locus and creation of value. Keeping this lens and using service modularity on service blueprints might provide insights into value facilitation, co-creation and in-use formulation processes by different modules.

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Figure 2.1 Service logic and service blueprint combined

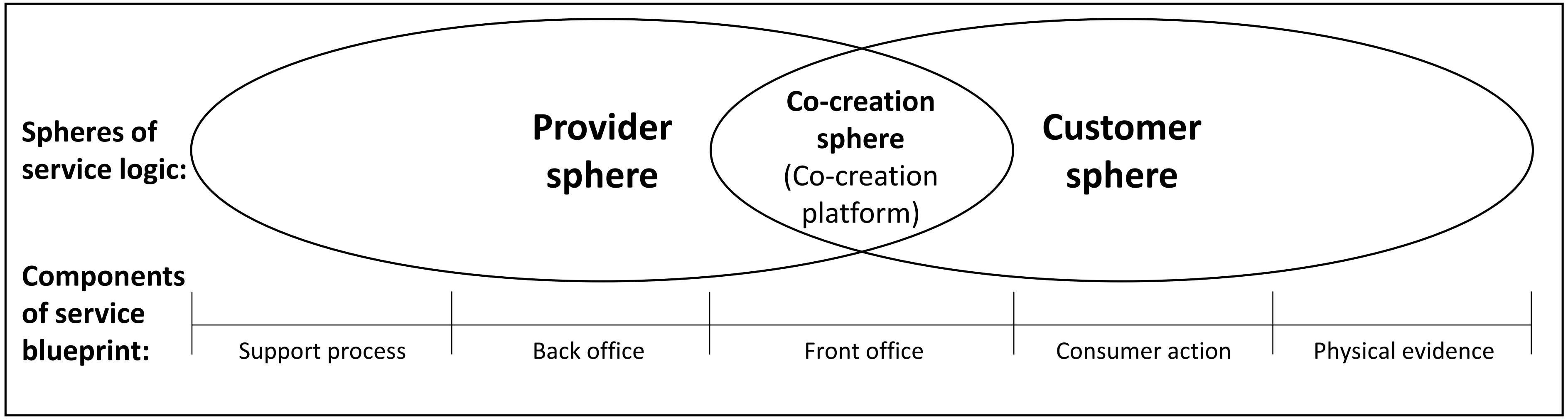
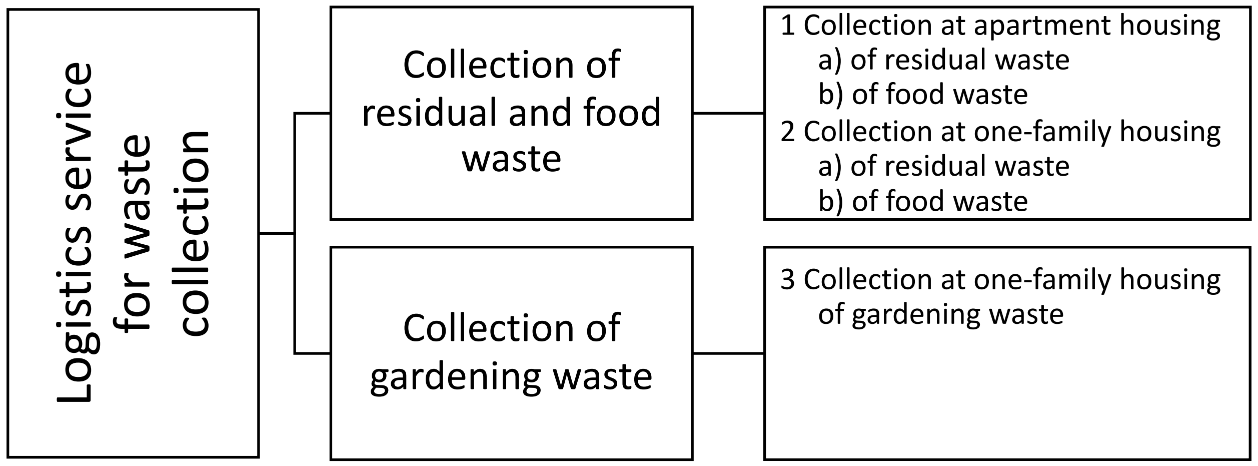
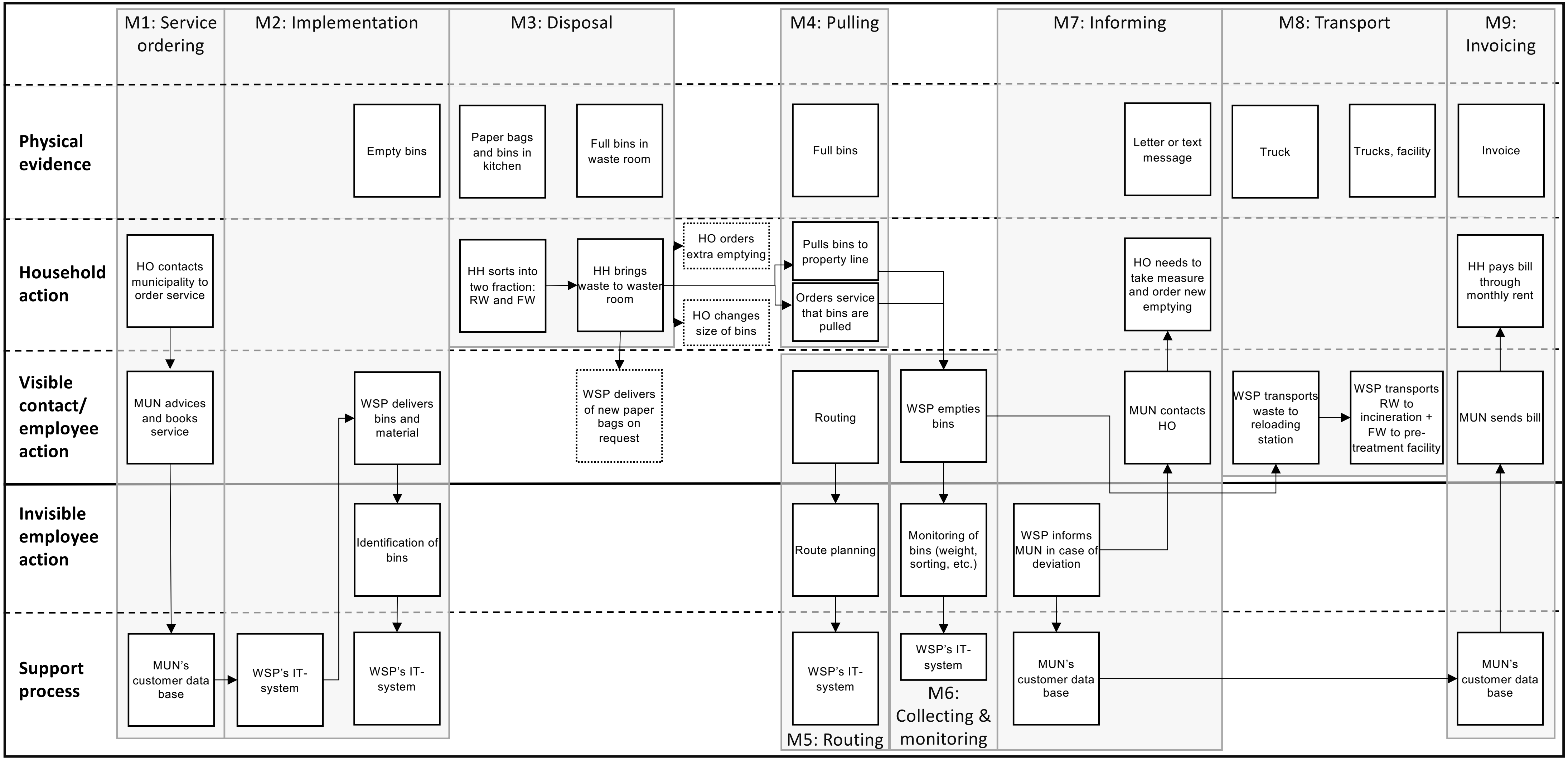


Figure 3.1 Chosen waste collection services





Component   Interface   Module

RW: Residual Waste   FW: Food Waste   MUN: Municipality   WSP: Waste Service Provider   HH: Household   HO: Houseowner

Table 2.1 Key terms and definitions

Key terms and definitions as used in this study
Component: The smallest unit, a sub-system of a module, like physical evidence, household or employee action or part of a support process (the small boxes in the service blueprint depicted in Figure 4.1). *Module:* Smallest meaningful element offered to a customer, either in itself or as part of a service offering creating the value perceived by the customer. Composed of at least one component but normally a combination of components. *Interface:* Essential for connecting components within a module or between modules; an interface ensures a smooth flow of information, coordination and successive actions (shown as arrows on the service blueprint depicted in Figure 4.1). *Service offering:* A final service that is offered to a customer, such as a gardening waste collection service. *WSP:* Waste service provider, which provides the logistics service for waste collection and plays a role in the modular service provision. *MUN:* Municipality, which acts as supplier and provider to the household, as a buyer to the WSP, and plays a role in the modular service provision. *HH:* Household, which plays a role in the modular service provision and is the final customer of the service.

Table 3.1 Data collection

No.	Interviewee	Form of data collection	Date	Duration
1	Logistics development manager, WSP	BS	Mar 2017	90 min
2	Logistics development manager, WSP	BS	April 2017	70 min
3	Logistics development manager, environment and quality manager, WSP	SSI	Nov 2017	90 min
4	Strategic advisor and unit manager, MUN1	BS	Nov 2018	80 min
5	Process leader waste collection, MUN1	SSI I	Jan 2019	75 min
6	Service developer waste collection, MUN1	SSI I	Jan 2019	85 min
7	Sanitation manager, MUN2	SSI I	Jan 2019	90 min
8	Strategic advisor, MUN1	BS	Jan 2019	60 min
9	Strategic advisor, MUN1	BS	Feb 2019	60 min
10	Process leader, MUN1	SSI II	Feb 2019	75 min
11	Service developer, MUN1	SSI II	Feb 2019	85 min
12	Waste service consultant	Validation	Mar 2019	40 min

Note: BS: brain-storming sessions; SSI semi-structured interviews; I: round one; II: round two

Table 3.2 Research quality

Criteria/Meaning	Approach
Credibility (internal validity): There is no single objective reality; reality exists only in the minds of the participants (Erlandson *et al.*, 1993). Reality is seen by the researcher and validated through the participants (Halldórsson and Aastrup, 2003).	Interview guide is based on theory; data collection is based on robust tool; findings are validated with interviewees
Transferability (external validity): The extent to which general claims can be made from findings (Halldórsson and Aastrup, 2003).	Data collection with multiple respondents; multiple rounds of data collection with different key actors
Dependability (reliability): Describes how reliable the data is and if it is stable over time, meaning the study and its results could be reconstructed (Halldórsson and Aastrup, 2003).	Data collection with several different actors; documentation of all methodological decisions, records of all collected data
Confirmability (objectivity): Ensures the researcher's objectivity and that results are free of bias (Halldórsson and Aastrup, 2003).	Discussion of findings among authors and peers; triangulation of data; presentation of findings to practitioner networks (municipality, waste logistics service providers).