Collaborative innovation of sociotechnical systems: Exploring transport system opportunities through off-peak delivery tests

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ABSTRACT

Transitions of transport systems are necessary to meet climate targets and reach sustainable development goals. Sustainable transport needs to be equitable, efficient, safe, and green. Transport systems need to become less resource-intensive, whereby sharing and utilising resources more efficiently can be a route forward. However, for well-functioning sharing, the involved stakeholders need to collaborate. Thus, sharing resources can mean sharing material and physical resources, such as vehicles and places, but it can also mean sharing immaterial and intangible resources, such as time and responsibilities. Through an interview study exploring shared resources in goods deliveries at off-peak hours in Stockholm-based trials, opportunities for organising transport system innovations have been investigated. Interviews were carried out with thirteen respondents involved in, or related to, off-peak logistics, and trigger materials were used to deepen the conversation when discussing the logistics service systems. Off-peak trials can be seen as innovation processes affected by several conditions. Innovation processes are collaborative, and collaborative innovation involves decision-making coordination across organisational boundaries. The concepts of sensemaking and sensegiving are used to analyse the studied collaborative innovation processes. However, stakeholders engaged in innovating sustainable transport systems must find new ways to collaborate as ambiguity and uncertainty are more extensive than in their day-to-day business development or the incremental development of new services. This study shows that conditions for such collaborative innovation processes vary between different types of collaborative settings, as innovation depends on the transformative capacity to alter types of stakeholder agreements and roles and agree on how to share resources and design such sharing. Designing for resource sharing requires understanding how to design tangible and intangible buffers and for the involved stakeholders to make sense of such new designs.

KEYWORDS

Collaborative innovation, Sensemaking, Sustainable transport systems

INTRODUCTION

Urban areas contribute to an increasingly large share of global greenhouse gas emissions (IPCC, 2022), and systemic transitions to ensure more efficient resource management in such areas are considered opportunities to work towards net-zero emissions (IPCC, 2022). While technological development is crucial, emissions continue to increase even though existing technologies already have sufficient capabilities to provide more sustainable services. It is thus clear that technological development on its own will not enable sustainability and cannot be the sole driver for sustainable transport to develop. Also, re-organisations and re-configurations of how technologies are implemented and used in sociotechnical systems are needed. However, this requires collaborative efforts of involved stakeholders, such as system operators and users, to negotiate and renegotiate any system change's intended value and desirable outcomes.

Freight transportation is necessary for urban areas to provide goods to retail stores, supermarkets, or restaurants. The vehicles used for deliveries contribute to many negative externalities, including greenhouse gas emissions, pollution, noise, and accidents. This is especially true during rush hours when they reinforce congestion and share roads with vulnerable traffic groups such as pedestrians and cyclists. To mitigate some of these externalities, off-peak deliveries can be implemented whereby deliveries are performed at night and thus put less strain on the transport system during peak hours. While there are clear societal benefits and environmental sustainability gains from shifting to off-peak deliveries, the potential business cases need to be clarified and the understanding of how such sociotechnical system innovation could be enabled. Thus, in this study, we investigate the conditions for implementing off-peak deliveries and how private and public actors co-create value. Furthermore, we learn why some stakeholders re-configure and re-organise their sociotechnical systems and how their negotiation and renegotiation processes emerge.

BACKGROUND

This study is part of a research project that was a cooperative initiative by stakeholders in several transport, logistics and retail related industries, as well as from academia and the public sector. The initiative aimed to build knowledge on designing cleaner and safer cities by developing efficient transport solutions, assuming that current solutions contribute to the many problems caused by urban logistics.

The initiative's public and private actors participated in co-creation processes where new technologies and services were piloted. One such service that was tested in Stockholm, Sweden, in 2022 was off-peak deliveries, which has been described as a solution for some problems that urban transport systems are facing (Pernestål Brenden et al., 2017; Sánchez-Díaz et al., 2017). Although off-peak deliveries have been tested many times, the service has failed to become standard practice. Therefore, there is a continued need to study off-peak pilots.

Cities worldwide are experiencing population growth as people are relocating from rural areas. How this urbanisation is managed affects efforts for sustainable development (UN, 2019). With increased urbanisation, transport systems are primarily affected due to higher demands for personal transport and goods deliveries, which result in negative externalities such as congestion, CO_2 emissions and noise. For sustainable transport development, e.g. transport of people and goods in a manner that is safe, affordable, accessible, efficient, and resilient while minimising emissions and environmental

impacts, increased demand cannot be met only by providing added infrastructure, but instead, several strategies are needed as outlined by the 'Avoid-Shift-Improve' approach (UN, 2016). Such approaches include avoiding unnecessary travel by, for example, improving urban planning, establishing less complex supply chains, and increasing remote work. Furthermore, strategies for improving environmental transport performance include transport solutions that are more energy-efficient and less carbon-intensive. Moreover, these approaches also include shifting transport to improve efficiency and reduce environmental impacts by using, for example, combinations of transport modes and off-peak transport solutions. Off-peak delivery concepts have been extensively trialled and can contribute to mitigating some of the negative environmental impacts (Pernestål Brenden et al., 2017; Sánchez-Díaz et al., 2017). Furthermore, off-peak deliveries can benefit businesses, including increased delivery reliability and traffic safety (Sánchez-Díaz et al., 2017).

Off-peak deliveries can be performed in several ways, among which the most common are staffed or unassisted at locations such as individual stores, shopping malls or offices. Staffed off-peak deliveries require either added or extended shifts for workers at receiving locations. When adding shifts, labour costs increase, whereas extending shifts leads to smaller time slots for delivery. Unassisted deliveries require access to facilities. The provider can be given full access, controlled access through a designated area for unloading, or separate access to a delivery point outside or inside the facilities. Locations that gather several actors and have a high demand for traffic activity, such as shopping malls, office buildings or universities, are considered to have good conditions for implementing off-peak delivery concepts since there is a business interest in maintaining attractiveness for present and future tenants (Sánchez-Díaz et al., 2017). However, there are many barriers to implementing off-peak deliveries, for example, noise levels and labour expenses (Pernestål Brenden et al., 2017). Furthermore, there are challenges to creating relevant value for all actors involved in the urban delivery systems (Holguín-Veras et al., 2005; Planing et al., 2020).

Organising off-peak delivery systems is a challenging task, and for successful implementation, it is necessary to understand these as sociotechnical systems. Sociotechnical systems are hybrid systems that include concrete, tangible components, like various technical solutions, and abstract parts, such as operators performing multiple roles (Vermaas et al., 2011). For successful coordination of sociotechnical systems, the operators and users of such systems need agreements and rules. Agreements can, for example, be business contracts, and rules can be both legal directives and norms of how to act and behave. When developing and implementing new sociotechnical systems, the involved operators need to agree on their respective roles and the system rules to know how to act according to the agreed rules. Thereby, the roles of the operators could shift, and new agreements would have to be made. When there is uncertainty and ambiguity about the system components, rules and operator roles, or insufficient knowledge about any of these, it becomes challenging for system operators to agree on how to develop or shift these sociotechnical systems. Furthermore, adding to the challenges of implementing new sociotechnical systems, these systems always have emergent properties. Thus, predicting or controlling sociotechnical systems is complex, and the risks involved with any system change are hard to assess. Thereby, stakeholders such as operators and users of sociotechnical systems need to negotiate and sometimes continuously renegotiate their roles and agreements. Consequently, collaboration stands out as a critical feature of innovation activities in changing these systems, even more so if the innovation aims at imposing changed or new values, as this has been seen to constitute a significant problem in the pursuit of disruptive innovations (see, e.g. Christensen and Rosenbloom, 1995; Christensen and Raynor, 2015).

THEORETICAL FRAMEWORK

For this study, we consider the implementation of off-peak deliveries as innovation processes that are collaborative, organised in different ways, and, when implemented, either framed as problem-solving processes or as processes of generative interpretations and envisioning meanings. Innovation occurs when involved actors make sense of it or give it some meaning. To understand off-peak delivery tests as developments, implementations, and organisations of sociotechnical systems, we have chosen to address the research question using theories from innovation management, the broader field of organisation studies, and science and technology studies. This section thus outlines theories on collaborative innovation and actors' sensemaking in such processes aiming to shift sociotechnical systems.

Collaborative innovation of sociotechnical systems

The idea of sociotechnical systems as a particular type of system has been well established in organisation studies, spanning from earlier more micro-level applications of, e.g. work design (Oldham and Hackman, 1980) to, later on, include also macro-level shifts towards e.g. sustainability (Geels, 2002). Transport systems can be regarded as a particular sociotechnical system since such systems include both technical components such as buildings, roads, railways, cars, trucks, trains, bicycles, signal systems, etc., as well as human actors in their roles, for instance as drivers, passengers, and pedestrians, whose actions may be individual, or as part of organisations. These systems tend to be complex, as they include a significant number of components with both individual and collective logics and objectives; these components are closely interconnected and also undergo substantial changes over time, in terms of, e.g., the introduction of new technologies and changes to what is considered acceptable and desirable system performance.

We consider innovations of transport systems, as for sociotechnical systems in general, to occur in ecosystems where actors collaborate in different constellations. While ecosystems can take many forms (Aarikka-Stenroos and Ritala, 2017), we focus on one type in particular – service ecosystems (Vargo et al., 2015), as transport systems can fruitfully be considered as providing a set of services to its stakeholders. Following a service-dominant logic (Vargo and Lusch, 2004), value is seen as co-creational, not something produced by one party and provided to another. Similarly, innovation is considered a collaborative process (Vargo et al., 2015). Moreover, collaborative innovation is an open innovation (Chesbrough, 2003) process where resources are drawn across organisational boundaries (Davis and Eisenhardt, 2011), and thereby, the goals and purposes of such a process are continuously changing (Rindova and Kotha, 2001). Sometimes, collaborative innovation refers to co-creating with users (Baldwin and von Hippel, 2011), but other times, it refers to coordinating decision-making across organisational boundaries (Lavie et al., 2012; Ollila and Yström, 2016; Tihanyi et al., 2014).

Collaborative innovation spanning organisational boundaries arguably poses particular challenges to the ones involved, as organisational distance leads to difficulties in sharing information in the way needed to reduce or eliminate uncertainty purposefully. Moreover, distances in terms of knowledge and perspectives may make collaboration difficult as shared information can be interpreted differently. On the one hand, these cognitive biases have the potential for innovation as they offer potentially fruitful interpretive ambiguities (Spender, 1996) where new combinations of knowledge sets and resources can be found. At the same time, these ambiguities may constitute obstacles to joint decisions and actions due to misunderstandings caused by lacking absorptive capacity (Cohen and Levinthal, 1990; Zahra and George, 2002) and exaggerated cognitive distance (Nooteboom et al., 2007).

Sensemaking and sensegiving in collaborative innovation

Collaboratively innovating in ecosystems by establishing new services and sociotechnical systems, such as implementing off-peak deliveries, can be challenging since the number of outcomes and the means to achieve them can be both plentiful and ambiguous. Furthermore, recent research has revealed that this is further complicated by existing biases between, for instance, public and private actors in terms of their knowledge focus in terms of disciplines and applications, respectively (Asplund et al., 2021), and the need for distributed governance and coordination an ecosystem (Olk and West, 2023). To study how actors deal with this ambiguity when entering new environments and collaborating across boundaries, we have chosen to employ the concepts of sensemaking and sensegiving (Gioia and Chittipeddi, 1991; Hill and Levenhagen, 1995; Weick and Sutcliffe, 2005).

Sensemaking, or causation (Sarasvathy, 2001), is a process in which actors recognise a sensible outcome and, if desirable, decide how it can be reached most efficiently through a set of available means (Sarasvathy, 2001). Whereas sensemaking is a process for understanding through which means an outcome can be reached or why something has occurred, sensegiving (Gioia and Chittipeddi, 1991; Hill and Levenhagen, 1995; Weick and Sutcliffe, 2005) or effectuation (Sarasvathy, 2001) aims at understanding what possible outcomes that can be generated using a known set of means (Sarasvathy, 2001). Sensegiving is also essential for communication when actors motivate decisions to others, such as business partners or consumers (Gioia and Chittipeddi, 1991; Hill and Levenhagen, 1995). Sensemaking and sensegiving processes are co-dependent, often co-occur (Höllerer et al., 2018) and can be either retrospective or future-oriented (Stigliani and Ravasi, 2012). Theory about these processes has been used to study, for example, high-level topics such as strategic changes in organisations (Gioia and Chittipeddi, 1991) and how individual employees collaborate and create knowledge together when using specific tools or artefacts (Kaplan, 2011).

When actors, individually or collectively (Stigliani and Ravasi, 2012), take part in sensemaking and sensegiving processes, they attach meaning to innovations (Verganti and Öberg, 2013). This meaning can even be an innovation in itself. Innovation processes can be framed as a process of problem-solving, ideation or interpreting and envisioning (Verganti and Öberg, 2013). Radically new meanings can be considered results of interpretation and envisioning processes. Interpreting refers to actors moving from finding optimal solutions to finding new meaning, while envisioning refers to generating new or alternative scenarios not already asked for by consumers (Verganti and Öberg, 2013). Thus, innovating services that create meaningful experiences can change why a service is used rather than just how it is used or what it is (Verganti and Öberg, 2013). For users, a service's meaning is deeply connected to their socio-cultural context, which dictates what innovations make sense. Radical innovations of meaning expand beyond these contexts, which is why they require actors to envision alternative futures (Verganti and Öberg, 2013).

METHOD

In this study, we have used a phenomenon-based approach (von Krogh et al., 2012) in which a study begins by identifying a specific phenomenon rather than starting with an established theory or hypothesis. The phenomenon is then described, analysed, and theorised. In this study, the phenomenon examined was the implementation of off-peak deliveries. Moreover, the conditions for sensemaking and sensegiving in the collaborative innovation process of configuring such transport systems were investigated.

The first step was understanding when, how and why off-peak deliveries were implemented. For this, 13 semi-structured interviews were conducted online in the spring of 2021. The selected respondents were employees at organisations that provide, carry, or receive goods, as well as property firms and public organisations. The respondents had implemented, tested or considered implementing off-peak deliveries and were connected to the research project. The interviews were held in either English or Swedish. The authors translated quotes that were gathered from interviews conducted in Swedish. In this process, the goal was to maintain themes and meanings rather than translate directly (van Nes et al., 2010). Information about the respondents is presented in Table 1.

Table 1. Information about respondents, including the type of organisation and role.

Respondent	Organisation	Role
1	Provider	Quality and sustainability manager
2	Provider & receiver	Head of logistics
3	Provider	Head of transport structure
4	Provider	Head of section
5	Receiver	Chief of operations
6	Provider	Head of transports
7	Provider	CEO
8	Receiver	Contact person
9	Provider	Owner and CEO
10	Receiver	Responsible for food purchasing
11	Receiver	Regional manager
12	Property owner	Regional manager
13	Public actor	Urban freight strategist

We consider the delivery tests to be prototypes of sociotechnical systems, and we used design methods to understand the experiences gained through the iterative prototype testing. Furthermore, and more specifically, service design methods were used to explore the experiences of the delivery test and collaboratively gain insights from these. As a first task in the interviews, respondents were asked to describe the process of delivering or receiving goods. A trigger material (Stickdorn and Schneider, 2011) showing a timeline and empty notes supported the respondents' storytelling. During the interview, the respondents' answers were written on the notes, and these were used collaboratively to create a journey map (Stickdorn and Schneider, 2011) where the activities involved in off-peak deliveries were mapped out. The purpose of using this service design tool was twofold: on the one hand, creating the journey maps was used to ensure we understood the respondents, and on the other hand, we used them as trigger materials to deepen the conversations. Hence, the visualisations acted as trigger material for the respondents to answer subsequent questions, which included the topics of day-to-day activities, perceived pains and gains concerning conducting the activities, value generation, operations, networks, risks, and innovation opportunities. The topics and examples of questions concerning each are presented in Table 2.

Table 2. Interview topics and examples of questions

Topic	Examples of questions
Day-to-day activities	Can you please describe the process of receiving goods at off-peak times?
Pains and gains	How do you perceive the pains and gains regarding off-peak deliveries?
Value generation	What value do you get from receiving goods at off-peak times? What are the shared benefits for providers and receivers through off-peak deliveries?
Operations	What did you need to adapt to receive goods at off-peak times?
Network (system)	Are there other actors that are (indirectly) part of off-peak deliveries that are affected by off-peak deliveries? Are there any legal, regulative or business issues or barriers that impact your company in delivering goods at off-peak times?
Risks	What kind of business risks are involved in off-peak deliveries?
Innovation opportunities	Do you see any innovation opportunities within off-peak that can possibly change and alter the system in the future?

To analyse the qualitative data gathered from the interviews, these were transcribed and coded in MAXQDA, a software for qualitative data analysis (MAXQDA, 2021). For us, coding is a process in which relevant quotes are highlighted, grouped as second-order themes, and categorised into first-order concepts. This analysis was based on the methodology described by Gioia, Corley, and Hamilton (2013). The coding was performed separately by members of the research team. A total of 52 first-order concepts were identified and subsequently grouped into 8 second-order themes, including "Flows", "Adapting to off-peak", "Safety and security", "Barriers", "Collaboration", "Value", "Innovation and change", and "Buffers". The complete result of the coding process is presented in Appendix A. Finally, the theoretical framework was utilised to theorise and draw conclusions about how and why off-peak deliveries were implemented and how and why collaborative innovation took place.

RESULTS

This section presents the main findings from analysing the interviews. To highlight differences in how actors had reconfigured and (re-)organised their sociotechnical systems when implementing off-peak deliveries, we first introduce three service ecosystems and how the respondents in each of them engaged in sensemaking and sensegiving processes when collaborating. Additionally, we summarise the identified barriers to further implementation of off-peak delivery concepts.

Ecosystem 1: Internal collaborations

The first ecosystem was primarily characterised by limited co-innovation across organisational boundaries. In our study, off-peak deliveries were implemented by single actors who delivered goods to their business locations from a central warehouse in what was referred to as a closed-loop delivery system. Nevertheless, their transport systems had to be reconfigured to change into such deliveries. When off-peak deliveries had been implemented, drivers could access business locations regardless

of the presence of store employees through what the respondent described as "person-independent zones". One respondent argued that:

"One condition that has made it easy for us to [implement off-peak deliveries] is that we have a closed-loop. I can imagine that letting many different people in a person-independent zone at night without a signature supply chain was considered a beneficial condition for unmanned deliveries, such as control or caution, which makes the system increasingly vulnerable. Regarding responsibility, something disappears, and something is missing. […] However, it becomes a more vulnerable system the more open you make it."

Due to the closed-loop system, collaboration with external actors was unnecessary to perform off-peak deliveries. However, one respondent stated that their organisation had previously participated in collaborative projects with academia and other businesses. Furthermore, how off-peak operations were implemented varied across cities in Sweden and depended on regulations set by the city administrations.

Most respondents in this ecosystem perceived a more efficient use of resources as the principal value that could be generated by implementing off-peak deliveries. One such resource is road space. Several carriers mentioned that drivers did not need to share streets or parking spots with other users if deliveries were performed at night, which was referred to by one respondent as *"congestion-free deliveries"*. Furthermore, trucks could be utilised more so that hourly ownership costs decreased and less fuel was required.

Ecosystem 2: Partnership collaborations

The second ecosystem involved a partnership between two independent actors. The partnership consisted of one actor who provided goods and one who received them. In our study, two cases of such a partnership ecosystem showcased different types of formal and informal collaborations.

In the first case, the receiver purchased all goods and transports from the provider through a synchronised ordering system. The partnership involved contracts, although the receiver suggested that *"the contracts are important, of course, but still, the teamwork between the driver and the crew member is still very important to get this to work"*. Similarly, the provider discussed how close teamwork between the driver and the crew member benefited the coordination of the delivery process. Furthermore, close cooperation of this kind was considered to enable trials and implementation of new technologies and concepts. As stated by the provider:

"And I mean, the partnership between [us] is really tight. So, we also have the benefits of reducing emissions and testing this type of technology together with electrification. So that is done in like more of a partnership scope. So, if you would not have them as part of the project, then we cannot do it at all."

In the second case, off-peak deliveries were discussed but not tested or implemented. The receiver stated that their organisation generally was willing to try new technologies and solutions. Collaboration between these partners mainly occurred through contracts and the processes of writing and revising these. However, the receiver mentioned that writing contracts took a long time and could sometimes be challenging. About the revision process, the receiver stated that:

"There are continuous dialogues constantly with proposed improvements and how we can work together, with all types of forums from our purchasing and operations departments. We conduct monthly checks with their logistics and transport department to see what is happening and if we can do anything better."

The respondents in this ecosystem also argued that the main value was the higher efficiency of transport operations. However, in addition to better resource management, the carriers also mentioned the value of possible improvements to drivers' work environments due to less stressful surroundings, more predictable time management, and route setting. This was another type of business value described by some of the respondents. On the receiver side, operational efficiency was mentioned as the main benefit. For example, having goods delivered at night meant that staff could unpack before opening in the morning and spend the rest of the workday focusing on core activities. Some meant this could improve customer experience, but not everyone agreed.

Ecosystem 3: Platform collaborations

In the third ecosystem, platforms for collaboration were established where several actors were engaged in the innovation processes. It was found that collaborating and sharing resources through these platforms entailed specific challenges, such as the need for all stakeholders to gain economic benefits. One respondent, representing a property owner, suggested that a new perspective on value could be necessary to enable sustainable urban development. The respondent stated that:

"To me, it is, in some way, about the sharing economy. That is what we do with many technological solutions in the properties. Apps and gadgets, how to book and charge. So we have to start working together somehow. […] We have gone from staying within the facades and renting out square metres to thinking about the whole, taking a leap outside, and starting to work with the city in an entirely different way."

Another respondent, representing a public organisation, further discussed the need for collaboration:

"So, my role is to initiate and participate in innovation projects and develop new solutions with other stakeholders. Moreover, in the field of freight transport, I believe that it is particularly necessary to work in that way since there are so many different stakeholders that need to be involved. It is quite a complex system. So, we have developed a way of bringing different stakeholders together and trying to facilitate development for sustainable transport."

Some respondents in this ecosystem claimed that off-peak delivery concepts could contribute to more liveable cities and fulfil several sustainable development goals. For them, the value could be generated for society at large. Many suggested that traffic safety would increase since fewer cyclists and pedestrians would share road space with heavy vehicles at night. Furthermore, negative externalities such as pollution and noise were expected to decrease. The property owner who collaborated with the platform also employed a holistic perspective. The property owner argued that working towards a more liveable city positively affected their business since properties in safe and pleasant areas are more attractive to prospective tenants.

Barriers to further implementation

Even though almost half of the respondents utilised off-peak delivery concepts at the time of the interviews, barriers to implementing off-peak deliveries further were still found. These can be categorised as uncertainties regarding the following interdependent factors:

- Investments and costs
- Regulations and rules
- Trust and safety

An illustrative example where these were combined was described in several interviews and involved a night-time ban on heavy traffic in Stockholm from 10 p.m. to 6 a.m. Due to this policy, carriers needed to apply for an exemption to perform off-peak deliveries. The city office assigned these exemptions to specific vehicles on an annual basis. To be eligible, vehicles needed to be either hybrid or electric and designed so that noise emissions were lower than a legislated limit. Other than running the vehicles, significant noise sources include drivers talking or playing loud music and carts and forklifts used for unloading goods. Due to these requirements, investing in off-peak eligible vehicles was considered costly. Furthermore, being dependent on annual exemptions added a dimension of uncertainty. As a result, while there were significant motivations for many respondents, one receiver did not consider off-peak deliveries a viable business alternative, even though agreeing that these could have environmental benefits.

Another mentioned barrier was nightly access to business locations. Some businesses could not receive goods at night due to their location in metro stations or shopping malls, both closed at night. For unmanned receiving, drivers had to be able to enter business locations without an employee of the receiver to open doors or deactivate alarms. However, several solutions to these problems were brought up during the interviews. The respondent in Ecosystem 1 described that their drivers were given a tag to turn off the alarm to enter a person-independent zone. These zones were prepared with areas with specific temperatures where the driver could unload goods without breaking the so-called cold chain (i.e., sustaining the required temperature of the goods). Other respondents solved this by having the driver unload goods directly into refrigerators or freezers.

One provider was sceptical about implementing unmanned reception since it would not be possible to control that the right type or amount of goods was delivered or that it was in good condition. Furthermore, they saw potential problems with responsibility if something would get damaged. Another expressed similar concerns, stating that they would be unlikely to implement unmanned receptions. To deal with these types of concerns, one provider mentioned that their drivers took photos of the delivered goods when no one was there to receive them. Later, these photos were sent to the receiver for control.

Finally, while many respondents mentioned increased safety for cyclists and pedestrians as a positive consequence of off-peak deliveries, some carriers expressed concerns regarding the safety of drivers while working alone at night. During the daytime, support functions were generally perceived to be more available. Also, with more people present in the urban environment during the daytime, it was considered safer in case of accidents, robberies, or incidents.

DISCUSSION

In our study, it is clear that certain conditions determine the implementation of off-peak delivery services. For actors to innovate collaboratively and, in our case, implement off-peak deliveries, they need to make sense of the opportunities to generate and capture value. Identifying the presence or lack of value can be considered a combination of sensemaking and sensegiving, where actors weigh potential value generation against actions needed to achieve it. In this final section, we draw on the theoretical framework previously introduced to further explore the sensemaking and sensegiving processes and understand the conditions for innovation within the three categories of service ecosystems. These perspectives are discussed in the context of the three service ecosystems. Moreover, we outline the identified conditions that need to exist for collaborative innovation to take place.

Sensegiving occurs when the purpose of an innovation or re-configuration of a sociotechnical system is explored, and the innovation is given meaning. In this study, innovation occurred when the purpose of off-peak deliveries was interpreted as value-generating. To capture value from off-peak delivery concepts the actors had to overcome barriers by re-configuring their delivery systems When asking themselves whether or not it was reasonable to perform these re-configurations, actors were engaging in sensemaking processes in which the amount and magnitude of barriers (which varied) affected the decisions. The types of sociotechnical system re-configurations are presented below (see Table 3), where we distinguish between technological and organisational re-configurations.

Table 3. Summary of types of re-configurations discussed in the interviews.

Technological re-configurations		**Organisational re-configurations**	
Vehicles	**Business locations**	**Internal**	**External**
Noise reductions	Space make-overs	Work routines	Collaboration
Alternative fuels	Access allowances	Work roles	Sharing
	Cold chain assurances	Support functions	

Technological re-configurations could be necessary for vehicles (shifting to alternative fuels and reducing noise) and business locations (making space for deliveries, giving drivers access to this space and maintaining intended temperatures for goods). From an organisational perspective, internal re-configurations in the form of new work roles and routines and enabling support functions for the driver were sometimes required. For example, drivers needed to take on the responsibilities of the receiving staff when delivering to unmanned locations, and re-configurations required the most effort to perform varied tasks for different actors.

Collaborating in service ecosystems

In our study, collaborating around urban deliveries involved sharing resources – physical (such as access to business locations) and digital (such as information and data). Collaboration was also affected by the systems the actors operated in, where, for example, factors such as the level of formality and trust between the business partners varied. Ultimately, these ecosystem characteristics affected the outcomes of sensegiving and sensemaking processes. The mapping of such variations concerning the service ecosystems is presented in Table 4.

Table 4. Summary of sensegiving and sensemaking in different types of ecosystems.

Service ecosystem	**Characteristics**	**Sensegiving outcome**	**Sensemaking outcome**
Internal collaborations	Limited co-creation Single actor with complete control over supply chain Good conditions to try new technologies and concepts	Synchronising delivery systems with those used in other countries Value that can be used for marketing purposes	Full control of the supply chain makes off-peak deliveries easy to implement
Partnerships	Two actors with a customer-supplier relation Clear division of responsibilities	Actors share common goal of increased efficiency for cost savings Trust could be established for future innovation	Case 1: Collaboratively defined potential value from off-peak deliveries Case 2: Current service was deemed sufficient and changing to off-peak would be too costly and inconvenient
Collaborative platforms	High degree of sharing resources Sharing economy and system thinking	Value closely related to core business Insights for future development	Control of properties and clear goals makes it easy to test innovations

In the first type of ecosystem, *Internal collaborations*, reconfiguring their transport systems was considered a problem-solving process where the involved actors made sense of trying off-peak deliveries since they saw possibilities to gain economic value through efficiency in the logistic system. In this ecosystem, the reconfigurations of the sociotechnical system were seen as straightforward. Since the actors involved in the system were already coupled with each other, the economic value gained by more efficiently organising their transports could easily be shared by all involved. Furthermore, collectively making sense in this ecosystem was mainly focused on the here-and-now business.

Within the scope of the second ecosystem, *Partnerships,* two cases were identified. The first involved a close partnership where the two actors collaborated through informal and formal means. Formal in that responsibilities were made clear by contracts, and informal since the contracts were complemented by teamwork between drivers and receivers. Regarding sensegiving, the actors shared a common goal of increasing efficiency and establishing new services. The high level of trust established through continuous collaboration allowed for an environment where they could test

innovations. Learning was considered a generated value since insights from trials could help when scaling up off-peak deliveries in the future; due to the collaboratively defined value generation and the possibility of capturing it, performing the necessary re-configurations and implementing off-peak deliveries made sense. However, in the second case of this type of ecosystem, the barriers, such as required investments, were considered too substantial, and this partnership did not implement off-peak delivery tests. Even so, in this type of ecosystem, innovating was a collective future-oriented sensemaking process (Stigliani and Ravasi, 2012). When tackling wicked problems (Rittel and Webber, 1973), design methods can support the sensemaking and sensegiving processes and facilitate the involved collaborators to realise future prospective value. This can even be considered a radical innovation of meaning (Verganti and Öberg, 2013).

The *Collaborative platforms* involved a property owner who had realised how societal value generation would benefit their operations and re-configured their business model to capture it. As property developers operating in city centres, sustainable urban development had a clear connection to their core business. Thus, it made sense to perform the necessary re-configurations. The barriers to doing so were relatively small since it would not require actions from any other actors, as in the previous ecosystem.

Conditions for organising collaborative innovation

As a final contribution, we outline three conditions for organising collaborative innovation based on the previous discussion on value generation and sensemaking. However, it is important to acknowledge the study's limitations and the data it is built on. First, there are clear boundaries in terms of scope. We have only considered the city of Stockholm and interviewed actors who operate there and are involved in off-peak deliveries. Furthermore, the actors represented a limited number of organisations connected to a joint research project. This can have several implications for the results, and the conclusions drawn may not reflect mainstream perspectives on off-peak deliveries. Thus, many questions remain regarding economic viability and sustainability contributions, as well as the generalisability of the study.

However, we found that as a first condition for collaborative innovation, the ecosystem actors must understand what *value* can be generated. The respondents we interviewed in this study had done so to various extents. Off-peak deliveries were shown to be closely associated with sustainability, which was considered value-adding in itself by some, if not for environmental or societal benefits, at least for public relations. Creating disruptive value (Christensen, 2015) is not necessarily easy, and addressing sustainability can be a way to find new value. However, such value can also conflict with existing value.

A second condition relates to *sensemaking*, as actors need to agree that their business could capture value (Verganti and Öberg, 2013). For most respondents, there were no apparent benefits. The main exception was the property developer in Ecosystem 3, whose activities depended on attractive urban areas. Without this explicit connection to an actor's principal business activities, performing necessary re-configurations was not motivated, and it was thus more challenging to capture value. However, some had chosen to test off-peak deliveries regardless, and by doing this, they had learned and made sense of the benefits that off-peak could have for their businesses.

Finally, we argue that collaboration in the context of urban deliveries occurs through the *sharing* of buffers. However, the interviews showed that buffers were not only affected by innovation – but also formed conditions for it. This was especially apparent in one case, where access to business locations

(in metro stations) was regulated by opening hours set by the regional public transport operator. Thereby, this buffer was not available for the actors in question. Another example that affected all actors was the general ban on heavy vehicle operation in Stockholm after 10 p.m. Thus, we can conclude that limiting conditions are built into the sociotechnical landscape, according to Geels' (2002) terminology. Such conditions leave some actors unable to tweak buffers and subsequently less incentivised to perform system re-configurations.

CONCLUSIONS

In this study, we have investigated the conditions necessary for co-innovating and implementing off-peak delivery concepts for actors based in Stockholm, Sweden. This was done through a qualitative interview study using additional service design methods.

Conditions for innovation are present if actors perceive an opportunity to generate value and if re-configurations needed to capture it are reasonable. When actors identify what value can be captured by their business, they engage in a sensegiving process. Through the interviews, we found that actors perceived value generated by businesses, society or both. In the latter case, the synergetic value was created. However, several barriers to collaborative innovation were also found. To overcome these, actors had to agree on and perform technological or organisational re-configurations. When deciding to do so, sensemaking processes took place.

The sensemaking and sensegiving processes were also affected by the service ecosystems in which the actors collaborated. We identified three categories of such ecosystems, and the perspectives on value and re-configuration found from the interviews were analysed in these contexts. The ecosystems differed in factors such as the level of formality and to what extent resources were shared. Two such resources were space and time, which we have considered buffers that were intervened in through the off-peak deliveries. However, we have also noticed that for actors to innovate collaboratively, the ability to tweak buffers influenced their capacity to re-configure the sociotechnical systems.

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APPENDIX A

Results from MAXQDA coding

First-order concepts	Second-order themes
Flows	Recycling/waste
	Order placements
	Reception
	Returns
	Off-peak trials and utilisation
	Planning
	Reporting
	Congestion-free deliveries
Adapting to off-peak	Additional support functions
	Business models
	Organisational change
Safety and security	Safety of goods
	Work environment
	Driver
	Traffic safety
	Staff safety
Barriers	Noise
	Costs
	Regulations
	Receiving and storage space
	Access
	Keys, codes and tags
	Cold chain
Collaboration	Property owners
	Cooperation
	Contracts
	Responsibility
	Trust
Value	Efficiency
	Congestion-free deliveries
	Delivery efficiency
	Business efficiency
	Cost benefits
	Vehicle utilisation
	Transport system efficiency
	Viable neighbourhoods
	Sustainable development
	Delivery reliability
	Environment
Innovation and change	Charging
	Geofencing
	Autonomous vehicles
	Vehicles

	Co-loading hubs
	Policies and regulations
	Unmanned deliveries
	Further opportunities
	Sharing economy
Buffers	Space
	Time

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