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New Opportunities for Smart Urban Logistics - Results of a Field Study

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Purpose: *Sustainability and customer service of urban last mile logistics are lacking behind the expectations of today's society. This paper provides a holistic framework and empirical evidence of a field study ("Kiezbote") on evaluating smart urban logistics concepts with the purpose to increase customer service and improve ecological and economic sustainability of smart urban logistics concepts.*

Methodology: *The smart urban logistics concept "Kiezbote" was tested in a 12-months field study in Berlin-Charlottenburg. We consolidated parcels in a micro-hub and delivered by cargo bike within 2h-time windows. Based on multiple quantitative and qualitative criteria, we developed a holistic framework to study feasibility, profitability, customer-centricity and effects on the environment.*

Findings: *The findings indicate that our smart urban logistics concept outperforms the service-level of conventional parcel delivery by far. C02 emissions could be significantly reduced. The additional costs generated need to be covered by receiver, parcel logistics service provider and online-shops in order to enable economic implementation.*

Originality: *This work closes the gap between many studies available in the literature dealing with smart urban logistics concepts and their missing practical implementation. This is one of the first completed field studies that provides an empirically grounded framework regarding environmental-friendly, economic viable AND customer-centric last mile delivery.*

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1 Introduction

The problems of urban logistics have not been finally solved yet, but are becoming more crucial due to various trends. On the one hand, e-commerce continues to grow, so that the number of parcels increases significantly. The ongoing COVID19 pandemic intensified this trend (BIEK, 2021), but even without this global event, parcel deliveries would have increased (BIEK, 2019). Another trend that has a strong impact on urban logistics is the intended reduction of traffic in city centers to both offer more quality of life in inner cities and to contribute to the reduction of greenhouse gases, which is demanded in all areas of industries and society. Furthermore, parcel recipients are increasingly dissatisfied with the service provided by parcel service providers. Various studies have shown that almost 50 per cent of all deliveries do not reach the recipient, but are left with neighbors, parcel shops, parcel stations or other pick-up businesses. (Seeck and Göhr, 2018; GS1 Germany GmbH, 2019)

There are several reasons for the poor service by parcel service providers: On the one hand, the highly competitive pressure in the industry causes a need for efficiency, on the other hand, parcel service providers do not see the recipients as their customers, as they are mostly paid by the shippers. The shippers are becoming increasingly aware that their customers - the parcel recipients - project the poor service and thus their dissatisfaction with the delivery onto the shipper. Therefore, the pressure to provide a much better service, especially from the large shippers (e-commerce player), will increase on the parcel service providers.

In addition to the dissatisfaction of the recipients, the increasing parcel volumes exacerbate the problem of the highly stressed infrastructure of urban centers. Neither the increasing number of parcel vehicles nor the environmental pollution caused by the diesel-powered vehicles play the decisive role here. This is because parcel vehicles do not drive very much, but stand still for the majority of their operating time, namely about 90 per cent, as various studies on delivery tours in urban areas show (Schäfer, et al., 2017; Seeck and Göhr, 2018). During this time, the parcel vehicles are parking on the lanes in the second row, in violation of traffic regulations. Thus, parcel vehicles are a source of danger and, above all, a source of congestion in inner-city traffic. In order to cope with this problem and to make city centers more attractive for the people living there and the businesses located there, many municipalities - especially in Germany - are planning several restrictions on traffic. This will mainly affect diesel-powered vehicles, but even e-cars will be impaired in the future due to entry and passage restrictions.

Therefore, smart solutions are required for urban logistics that both guarantee deliveries at times and locations when and how the recipients are demanding it and contribute to relieving the urban infrastructure. Technical solutions such as the use of drones or robots have not yet been able to establish themselves, because although the technology is available, both safety aspects and customer acceptance have not been sufficiently clarified. This type of delivery will probably be limited to special cases such as the transport of urgent medical products. Solutions such as the delivery to parcel stations and collection by the recipient relieve the infrastructure, but often do not meet the wishes of the recipient; most of the online-shoppers expect the service of home delivery, as they could otherwise also visit a shop (Seeck and Göhr, 2018; IFH Köln GmbH and Hermes Germany GmbH, 2019).

An interesting alternative for the delivery of parcels in urban areas is the concept of a micro-hub with subsequent delivery by cargo bike. This concept relieves the urban infrastructure, as cargo bikes strain it less than parcel vehicles and, above all, do not cause any traffic jams while they are standing. At the same time, the concept makes it possible to deliver to recipients in desired time windows and thus, guarantee attended deliveries. Additional advantages of the concept are the physical proximity of the micro-hub to the recipients, which allows for easy pick-up, and the bundling of all parcel deliveries from different parcel service providers. Furthermore, by locating the service in the middle of the neighborhood – that is where the name "Kiezbote" comes from - creates a close emotional relationship to the recipients that leads to high identification potential of the recipients with *their* Kiezbote.

The research question arises of how such a concept can be comprehensively evaluated in order to prove its economic implementation, to determine its effects on emissions reduction and to investigate effects on customer satisfaction. A 12-month field trial was conducted for this purpose. In a selected area ("Kiez") in Berlin-Charlottenburg with approx. 15,000 inhabitants, the service described - desired time window delivery of bundled parcels by cargo bike - was offered free of charge.

After a brief outline of the basics of Smart Urban Logistics (SUL) and the prior work in chapter 2, the evaluation criteria for the concept are developed in chapter 3. Then, the data collection methods during the field trial are described and the results are presented and discussed in chapter 4 followed by the conclusion in chapter 5.

2 Prior Work

Smart Urban Logistics (SUL) solutions can be grouped in two categories:

1. *cooperative logistics* (e. g., transshipment and consolidation facilities, home deliveries systems, intelligent transportation systems for freight monitoring and planning/routing, cargo bikes for Business-to-Business (B2B) and Business-to-Consumer (B2C), city lockers) and
2. *administrative & regulatory schemes and incentives* (e. g., access restrictions, (un)loading zones, off-peak deliveries and enforcement and intelligent transportation system adoption for control and traffic management) (NOVELOG, 2016; Karakikes and Nathanail, 2017; Korczak and Kijewska, 2019).

Several pilot studies have been conducted and evaluated containing different SUL solutions in the past few years, an extract of them is presented in the following. Patier and Browne (2010) developed a methodology for the evaluation of urban logistics innovations and applied it on two pilot studies in Paris (mail and small packages) and Bristol (Urban Consolidation Center (UCC) for retailers). The evaluation framework contains a broad range of categories, e. g., logistics data, economic, environmental and social indicators, regulation and also customer satisfaction. However, looking at the application of the framework customer satisfaction as an important aspect of urban logistics was not included anymore. In the EU-project CITYLOG (2010-2012) the SUL solution of provider-opened parcel lockers has been tested in Berlin, Lyon and Turin and evaluated especially regarding traffic impact and CO2 emissions (Rybarczyk, 2019). The system has been further developed and is currently (2020-2022) being tested and evaluated in the German project STADTQUARTIER 4.1 with respect to environmental criteria (Leibniz-Institut für Raumbezogene Sozialforschung, 2020). The EU-project NOVELOG (2015-2018) tested many SUL pilot projects that have been conducted in

Gothenburg (UCC), Athens (intermodal transport), Graz (cargo bike), Mechelen (lockers, UCC, cargo bike), Turin (multi-users lane, (un)loading lots), Reggio Emilia (UCC in parking house, e-vans, cargo bikes), Venice (connect islands to core urban areas), Barcelona (cargo bike), and Pisa (parking slot software) (NOVELOG, 2017). Even if they developed a holistic evaluation framework containing criteria like air quality, greenhouse gas emissions, noise pollution, level of service (i. a. customer satisfaction), safety and security (e. g., accidents), vehicle (e. g., load factor) the pilots were only assessed using a few of the 25 criteria of the framework. Comprehensive data collection seems to be an important challenge in evaluating SUL pilots. In the EU-project CITYLAB (2015-2018) pilot studies have been conducted in London (UCC, electric vehicle), Amsterdam (floating depot, micro hub, cargo bike), Brussels (utilizing spare van capacity), Southampton (joint procurement and consolidation), Oslo (joint logistics for shopping centers), Rome (integration direct and reverse logistics), and Paris (logistics hotels) (CITYLAB, 2018). Environmental and economic effects have been assessed individually for each pilot and not following a standardized approach (e. g., total distance travelled, CO2 emissions, shipments per day), customer satisfaction was not considered. Furthermore, Leonardi, Browne and Allen (2012) conducted a before-after assessment of a logistics trial with micro consolidation center and cargo bikes in London and evaluated the total distance travelled (-14 per cent) and CO2 emissions (- 55 per cent), financially the case was proofed successfully by the company but the financial data is not accessible. Verlinde, et al. (2014) investigated in a Brussels trial as part of the EU-project STRAIGHTSOL, if mobile depots make urban deliveries faster, more sustainable and more economically viable with the result that the savings of diesel-kilometer doubled the costs for the operator. Navarro, et al. (2016) studied economic, operational, energy efficiency, environmental and social perspectives of urban freight transport via cargo bike for smart cities in Barcelona, Bologna, Piraeus, Rijeka and Valencia and concluded that the economic viability is hard to reach. They found out that the total number of shipments is important to become profitable – what we can also see in our pilot study. Table 1 summarizes the results found in prior works.

While both the spectrum of solutions that have been piloted and the developed evaluation methods are versatile, the application of the evaluation methods mostly only focus on single aspects, especially on environmental impact, partly on economic performance and rarely on customer satisfaction. Thus, our work is a first attempt to develop *and* apply a comprehensive approach how SUL pilots can be evaluated. The underlying study is one of the first completed field studies that provides empirical evidence regarding environmental-friendly, economic viable *and* customer-centric SUL solutions.

Table 1: Summary of Prior Work

Project	SUL pilots	Evaluation criteria	Criticism or shortcomings
Patier and Browne (2010)	UCC (Bristol), Mail and small packages (Paris)	Environmental economic, social; regulation; satisfaction; operational	Customer satisfaction not considered in application
Rybarczyk (2019)	Parcel lockers (Berlin, Lyon, Turin)	Environmental	Main focus only on environmental impact or technical aspects
NOVELOG (2017)	UCC, intermodal transport, cargo bike, locker, etc. in 9 EU cities	Environmental and economic; customer satisfaction; safety and security	Pilots were only assessed using a few of the 25 developed criteria

Project	SUL pilots	Evaluation criteria	Criticism or shortcomings
CITYLAB (2018)	UCC, cargo bike, floating depot, micro hub, etc. in 7 EU cities	Environmental and economic	Different evaluation approaches applied; customer satisfaction not considered
Leonardi, Browne and Allen (2012)	micro consolidation center, cargo bikes (London)	Environmental and economic	Financial data is not accessible, customer satisfaction not considered
Verlinde, et al. (2014)	Mobile depots (Brussels)	Environmental and economic	Customer satisfaction not considered
Navarro, et al. (2016)	Cargo bikes in 5 EU cities	Environmental economic, social; operational	Customer satisfaction not considered

3 Evaluation Framework

The purpose of the framework is to provide a foundation for comprehensive evaluation of SUL solutions regarding their impact on customer satisfaction, profitability and environmental impact. After developing criteria, the framework is summarized in 3.2.

3.1 Development of Criteria

3.1.1 Customer Satisfaction

Customer Satisfaction can be understood "as post consumption evaluation of a product/service in terms of positive/neutral/negative attitudes toward the product/service" (Day, 1977). The customer satisfaction approach is theoretical grounded by the *confirmation/disconfirmation paradigm* that defines satisfaction as a reaction on the subjectively perceived discrepancy between expected and experienced performance (Töpfer, 2020). According to Haller (1995) satisfaction is setting in when expectations are met.

Satisfaction can be measured using objective criteria like revenue or market share, but the validity of this approach can be questioned because a purchase does not inevitably imply satisfaction, in addition to that, the indicators occur at a later date (Töpfer, 2020). On the other hand, subjective approaches (e. g., customer surveys) are fitting well for measuring customer satisfaction because only by asking the customer it can be found out, if the product matches the customer needs (Lingenfelder and Schneider, 1991). Subjective approaches can be divided into attribute-oriented and event-oriented approaches. Attribute-oriented approaches consist of indirect measurements that imply customer satisfaction by measuring suitable indicators and direct measurements where customers are asked explicit for their perceived satisfaction (Töpfer, 2020). For SUL solutions the indirect criteria are developed based on the following logistics service performance targets:

- "Delivery reliability" indicates customer satisfaction by stating the ratio of deliveries on time compared to the overall numbers of deliveries.
- "Delivery flexibility" by explaining the ability to change an already arranged delivery order.
- "Information transparency" gives the receiver information about the delivery, e. g., by Track & Trace functions.
- "Shipment quality" states the share of damages of all shipments that also is relevant because the additional handling step in a micro hub is an additional damage risk cause.

The first three criteria are, especially in an urban environment with an increasing share of B2C deliveries, highly relevant for customer satisfaction due to the increasing customer requirements regarding individualized and flexible delivery.

Other logistics performance targets like “lead time” and “delivery capability” are not considered because last mile carriers do not have a significant influence on product availability or speed in the upstream supply chain. As one direct criterion, “satisfaction quantification” is used with the aim to investigate individual perceptions of customers of the SUL solution by conducting quantitative online-surveys asking for the importance and performance of single aspects of the offered service (SERVIMPERF).

In contrast to the attribute-oriented criteria, event-oriented criteria do not survey single attributes, but they deal with experiences of a specific event. One event-oriented criterion is “satisfaction exploration”. The customer is asked to talk about his or her pleasant and unpleasant experiences with the product or service along different touch points (Stauss and Hentschel, 1990). Another event-oriented criterion is „customer complaints“ that deals only with the critical negative moments of truth and is used for problem identification (Stauss, 2000). Quantifying and classifying those points is the starting point to derive action fields (Töpfer, 2020).

3.1.2 Profitability

Profitability can be measured based on “revenues” and “costs”. Only if SUL solutions are profitable, a sustainable implementation is realistic. Therefore, either being profitable or pointing out how to become profitable is crucial for all SUL pilots. For SUL solutions the typical revenue streams can be either the “sender” that benefits through a better delivery service that builds closer customer relationships and increases retention rates, the “receiver” who benefits by saving time while receiving parcels conveniently or a “logistics service provider” that outsources parts of its last mile operations. For each of the players, we chose the “willingness to pay” as the criterion to calculate the revenue potentials as we cannot test real prices on the market. Furthermore, the criterion “amount of freight units” is required to calculate potential revenues of each revenue stream.

On the other hand, in order to describe the costs, they can be divided into “fix costs” (e. g., micro hub rent) and “variable costs” (e. g., delivery staff). The costs for SUL solutions are evaluated on this general level and not further specified because the single cost elements depend on the individual characteristics of each SUL concept, e. g., on the chosen operating model (degree of automation or outsourcing) so that the costs always need to be interpreted with respect to the associated processes and services. In addition, there are some relevant process KPIs that influence the variable costs (especially the delivery costs per parcel) that need to be considered in an overall assessment on profitability because those KPIs provide levers for improvement of the productivity. The KPIs are the following:

- "Consolidation factor" states the amount of freight units that can be delivered to one customer at a time.
- "Service time" is the time the driver is off the vehicle to handover the parcel.
- "Stop density" describes the average distance between two stops.
- "Driving speed" is the average speed a vehicle is driving between the stops.
- "Driving-service ratio" describes the shares of overall driving time, and the overall service time and indicates where to focus to increase productivity and thus, reduce costs per freight unit.

The (re)loading time is not considered as a criterion because it has no relevant impact on productivity (Breitbarth, et al., 2021).

3.1.3 Environmental Impact

The environmental impact can be evaluated based on the produced "CO2 emissions" that can be calculated according to the standard EN 16258 "Methodology for calculation and declaration of energy consumption and greenhouse gas emissions of transport services". Furthermore, parking of transportation vehicles on the driving lane produces indirect emissions by generating mini-congestions. Thus, the second criterion regarding environmental impact is "parking on driving lane" that describes the share of stops that are made on the driving lane in the second row. For more differentiated analysis of environmental impact, see (Patier and Browne, 2010; NOVELOG, 2017; CITYLAB, 2018).

3.2 Summary of Criteria

Based on the aforementioned criteria *Table 2: Evaluation Framework for Smart Urban Logistics Solutions* presents a holistic evaluation framework for SUL solution pilots. It is divided into the three evaluation areas customer satisfaction, profitability and environmental impact which are further divided into several evaluation sub areas that are again further divided into specific qualitative and quantitative evaluation criteria.

Table 2: Evaluation Framework for Smart Urban Logistics Solutions

Evaluation area	Evaluation sub area	Evaluation criteria
Customer satisfaction	Indirect satisfaction measurement	Delivery reliability Delivery flexibility Information transparency Shipment quality
	Direct satisfaction measurement	Satisfaction quantification
	Event-oriented satisfaction measurement	Satisfaction exploration Customer complaints
Profitability	Freight volume	Amount of freight units
	Revenue streams	Willingness-to-pay sender Willingness-to-pay receiver

Evaluation area	Evaluation sub area	Evaluation criteria
		Willingness-to-pay logistics service provider
	Cost structure	Fix costs
		Variable costs
	Cost driver	Consolidation factor
		Service time
		Stop density
		Driving speed
		Driving-service ratio
Environmental impact	Emissions	CO_2 emissions
		Parking on driving lane

4 Field Study “Kiezbote”: Application of Framework

In the following, the field study “Kiezbote” is described in chapter 4.1 because the developed evaluation framework is applied on this case. Chapter 4.2 explains the data collection approach and chapter 4.3 presents and discusses the results within the three dimensions “customer satisfaction”, “profitability”, and “environmental impact” of the SUL field trial “Kiezbote”.

4.1 Description of the Field Study "Kiezbote"

The SUL solution "Kiezbote" was implemented and tested in a 12-months field study in Berlin-Charlottenburg within the postal codes areas 10585, 10587, 10589, 14059 from 13.07.2020 to 30.06.2021. We consolidated B2C parcels of all senders and parcel logistics providers in a micro-hub and delivered by cargo bike within 2h-time windows between 4 and 10 pm. The parcel volume was not generated by cooperation with parcel logistics providers or online shops. Instead, the recipients decided to use "Kiezbote" by (voluntarily) change their delivery address during online shopping to the address of the "Kiezbote" micro-hub ("c/o Kiezbote"). As soon as the parcel arrives at the "Kiezbote" micro hub, the recipients get notifications via mail and app and can choose their preferred time window for parcel delivery. The technical infrastructure mainly consists of two cargo bikes ("Bullitt", "Citkar Loadster"), apps for B2C communication and micro-hub management ("Pickshare") as well as mobile devices for delivery drivers. Feasibility of all processes and resources was proven during the pilot study.

4.2 Data Collection

Within the field trial several internal data was collected regarding customer satisfaction, profitability and environmental impact that was enriched with external data from literature about conventional parcel delivery in order to interpret the results better. Three databases build the basis for data collection: The customer database, the parcel database, and the delivery database. The customer database contains all relevant information regarding customers (name, email, address, registration date, using behavior data). The parcel database tracks meta data (date, time, sender, parcel service provider, receiver, weight, size and volume, comments) and handover data (booked time window, address, date, and time of handover). The delivery database consists of date, transport mode, action (drive, handover), start time, duration, number of parcels, target address.

4.2.1 Customer Satisfaction

Customer satisfaction data is collected in the customer data base ("delivery reliability", "shipment quality", "customer complaints") and by conducting qualitative and quantitative research with "Kiezbote" customers (”satisfaction exploration", "satisfaction quantification"). "Delivery flexibility" and "information transparency" is qualitatively assessed based on the developed processes and used IT systems (that does not foresee any flexibility or tracking and tracing transparency).

For "satisfaction exploration" two focus groups of 2h each with group sizes of 4-5 participants were conducted in February 2021 in order to gain a deeper understanding of why customers use "Kiezbote", how satisfied "Kiezbote" customers are, their thoughts of willingness-to-pay and improvement potentials where also additional data regarding the criteria "delivery flexibility" and "information transparency" could have been collected. The focus groups were transcribed using f4 transcript and analyzed using the qualitative content analysis after Mayring with a deductive-inductive approach (Mayring, 2015).

"Satisfaction quantification" was investigated by conducting a quantitative online survey with "Kiezbote" customers in June 2021 to get a broad understanding of how satisfied they are with "Kiezbote" service and conventional delivery using 5-point scales with equidistant verbal anchors after Rohrmann (1978). Furthermore, the customers are asked for their preferred payment model (per delivery or monthly flatrate) and their willingness to pay for the related payment model.

4.2.2 Profitability

To assess profitability data was collected regarding freight volume, revenue streams, cost structure and cost driver. The freight volume was generated out of the parcel database. The willingness-to-pay of customer was gained with help of surveys as described in chapter 4.2.1, whereas the willingness-to-pay of parcel logistics provider was put out of literature. The sender willingness-to-pay could not be collected due to the reasons described in chapter 4.3.2. Overall daily revenue (rev_daily) calculation is shown in (1) and considers the following factors:

- daily amount of parcels (dp = 12.4 parcels per day)
- share of willingness-to-pay of recipients (swtp_r = 0.83)
- willingness to pay of parcel service provider (wtp_p = 0.50 € per parcel)
- share of pay per delivery of recipients (sdel_r = 0.68)

- average pay per delivery of recipient (adel_r = 2.32 € per delivery)
- consolidation factor (cf = 1.97 parcels per delivery per customer)
- share of pay per flatrate of recipients (sflat_r = 0.32)
- average monthly pay per flatrate of recipients (aflat_r = 8.50 €)
- number of working days per month (wd = 21 days).

$$rev_{daily} = dp * swtp_r \left(wtp_p + sdel_r * \frac{adel_r}{cf} \right) + swtp_r * sflat_r * \frac{aflat_r}{wd} \quad (1)$$

The fix cost could be calculated based on real bills (micro hub rent and equipment, cargo bike leasing, marketing, insurance, staff equipment) while micro hub staff was calculated based on the experience that only 1h per day is needed to handle the parcels in the hub. Prerequisite is that the parcel service provider can keyless access the micro depot to deliver the parcels. The variable delivery costs were calculated based on the assumption that 13 parcels can be delivered in one hour at costs of 15.50 € per hour and the variable IT costs were calculated based on the assumption that 10 per cent of the revenues need to be payed to the revenues.

The cost driver data for "consolidation factor", "service time", and "driving-service ratio" was collected in the delivery database. "Stop density" and "driving speed" could not be measured because we only documented the time, not the distances between two stops. The data of conventional parcel deliver companies were collected out of literature as it is stated in Table.

4.2.3 Environmental Impact

Breitbarth, et al. (2021) calculate CO2 emissions for "Kiezbote" compared to conventional parcel delivery based on the standard EN 16258 and vehicle routing models. A well-to-wheel emission calculation consisting of fuel emissions of the transport services (tank-to-wheel) and emissions of fuel production, vehicles manufacturing, streets construction and transport network maintenance (well-to-tank) is used (Schmied and Knörr, 2012). The data of parking on driving lane was collected by the delivery data base for "Kiezbote" and by literature for conventional parcel delivery (Seeck and Göhr, 2018).

4.3 Results and Discussion

4.3.1 Customer Satisfaction

The findings indicate that our SUL solution “Kiezbote” outperforms the service-level of conventional parcel delivery by far. The “satisfaction quantification” shows that “Kiezbote” customer are very satisfied with the “Kiezbote” service (4.7 / 5 points on a 5-point Likert scale) while they are rather not satisfied with the service of conventional parcel companies (2.7 / 5). These findings are supported by the results of the “delivery reliability”, where 99.6 per cent of the parcels have been personally delivered within the customer-defined 2h-time windows. In the rare cases when the parcel could not be delivered, the customers were not at home, even if they chose the time window, but it has never been an operative bottleneck of “Kiezbote”. Compared to a “delivery reliability” of parcel companies of 95.0 per cent incl. handover to neighbors etc. and about 50 per cent when only personal handovers are counted (Seeck and Göhr, 2018), “Kiezbote” does not only offer a greater service, but also gains efficiency because a “second try” is practically not necessary. The “shipment quality” is 100 per cent, parcels have not been damaged by “Kiezbote”, but only 98.8 per cent of the parcels arrived without damage at the “Kiezbote” micro hub, what customers see as failure of the parcel companies. Exploring customer satisfaction further resulted in the findings that customers especially like the reliable personal parcel handover within a time window from a friendly and service-oriented driver. Furthermore, parcel consolidation over parcel companies and time, environmental-friendly delivery by cargo bike and the trouble shooting activities in case of customer complaints have been seen as main drivers for satisfaction. The only few “customer complaints” reached us through different channels (mail, nebenan.de, Facebook, Instagram, phone, in person) and they mostly contained complaints about the registration process and the time window booking via the app at the beginning of the pilot trial, what was also confirmed in the customer interviews. The following improvement potentials could be derived:

- better general functionality
- tracking and tracing of the whole upstream process
- announcements of the expected time of arrival (ETA)

- flexibility in cancelling or rebooking of time windows
- additional value-added services: courier service within the neighborhood (this idea was tested in the pilot but was not demanded in real-world, whereas bulky waste collection as one idea out of the interviews was tested and well demanded)

As mentioned above, “delivery flexibility” plays a crucial role to increase customer satisfaction. In the pilot, this was possible through individual communication by phone or mail, at scale this needs to be implemented in the app. In addition, “information transparency” needs to be integrated into the app to further increase the trust in the service and enable capacity planning for “Kiezbote”. While larger parcel companies do not offer delivery flexibility, information transparency is a strength in terms of tracking & tracing across the whole delivery process and not yet realized at “Kiezbote”.

Table 3 summarizes the quantitative comparison of Kiezbote and conventional parcel service provider regarding customer satisfaction and underlines that “Kiezbote” outperforms the large parcel companies. At this point, the question arises what effect the increasing service performance has on the overall costs of last mile delivery. The following chapter 4.3.2 will address this question.

Table 3: Quantitative Results Customer Satisfaction

Criteria	Field trial "Kiezbote"	Parcel service provider
Delivery reliability	99.6 per cent (only personal handover)	50.0 per cent (only personal handover) (Seeck and Göhr, 2018) to 95,0 per cent (incl. handover to neighbours)
Shipment quality	100.0 per cent	98.8 per cent
Customer satisfaction quantification	4,95 / 5	2,70 / 5

4.3.2 Profitability

The increased service level of consolidated time window deliveries by cargo bike leads to additional costs that needed to be covered by receiver, parcel logistics service provider and online-shops in order to enable economic implementation. The main question is under what circumstances profitability of the mentioned SUL concept can be reached. Therefore, "freight volume" and "willingness to pay" of different revenue streams are used to calculate the revenue potentials. Compared to the fix and variable costs in a break-even analysis the required number of parcels per day to be profitable can be identified. Furthermore, relevant cost drivers are presented and productivity issues are discussed comparing "Kiezbote" with conventional parcel service providers.

The number of parcels account for an average of 7.5 parcels per day over the 12 months trial. While in the first month an average of only 2.1 parcels per day is reached, the last month shows an average of 12.4 parcels per day. The number of parcels is rising steadily from month to month due to high service level and customer satisfaction. At the same time, three factors limit the growth trend. First, during the COVID-19 pandemic a lot of people have had to work from home and could attend parcel deliveries of conventional parcel service providers. For those people, there was no need for the time window delivery. Second, the number of parcels was acquired by convincing parcel receivers to change the delivery address of their online orders to the “Kiezbote” micro hub. Having the first point in mind, this “convincing process” requires much more marketing and communication efforts and expertise as we would have expected. Third, we have had some challenges with the registration process and the app functionality as mentioned in chapter 4.3.1, so that an unknown part of the people in the neighborhood did not even use the service even if they were interested.

The customers that used “Kiezbote” were almost all willing to pay for the experienced service (83 per cent). Thereof, 68 per cent prefer to pay for each delivery (Ø 2.32 €), 32 per cent for a monthly flat rate (Ø 8.50 €). The willingness to pay of online shops cannot be quantified yet because after an initial discussion with a leading online shop it has become clear, that for a cooperation SUL services needed to be rolled out at scale so that the process changes justify the benefits. The willingness to pay of online shops is a topic that should be studied further. The willingness to pay for parcel logistics provider is theoretically set to be about 0.50 € as this is the amount that parcel shops are receiving. In practice, those companies are not willing to cooperate on the last mile with consolidation services for brand strategic reasons because they do not want to lose the “face to the customer”. Nevertheless, we calculate with 0.50 € due to the high efficiency improvements, a parcel company gains when multi-dropping parcels at one place instead of delivering to the front door.

Considering the willingness to pay of receivers and parcel logistics providers and the number of daily parcels that is covered by the willingness to pay of receivers (83 per cent ~ 10 parcels per day) “Kiezbote” could currently generate revenues of 13.50 € per day or 283.50 € per month delivering 210 parcels per month.

On the other hand, there are the fix and variable costs for operating “Kiezbote”. Monthly fix costs consist of micro hub rent and equipment (527 €), micro hub staff (400 €; 1h per day for parcel handling), cargo bike leasing (300 €), marketing (150 €) insurance (89 €), staff equipment (18 €) and total 1,484 € per month. Variable costs contain the driver costs (1.17 € per parcel; delivering 13 parcels per hour at 7 stops at labor costs of 15.50 € per hour) and IT costs (0.09 € per parcel ~ 10 per cent of receiver fee) so that the variable costs total 1.26 € per parcel.

At this point it becomes clear, that a parcel volume of 10 parcels per day and the resulting revenue of 283.50 € per month cannot cover the overall costs of 1,749 € per month. The productivity could be increased from the empirically reached 13 parcels at 7 stops per hour up to 20 parcels at 10 stops per hour – what is realistic according to bike delivery experts – variable costs could be reduced to 0.87 € per parcel. Based on this data a break-even analysis is conducted an presented in Figure 1. Furthermore, there are several opportunities to reduce fix costs regarding the parcel handling process in a micro hub (automation, outsourcing) or on the transport process (purchasing advantages of cargo bikes at scale).

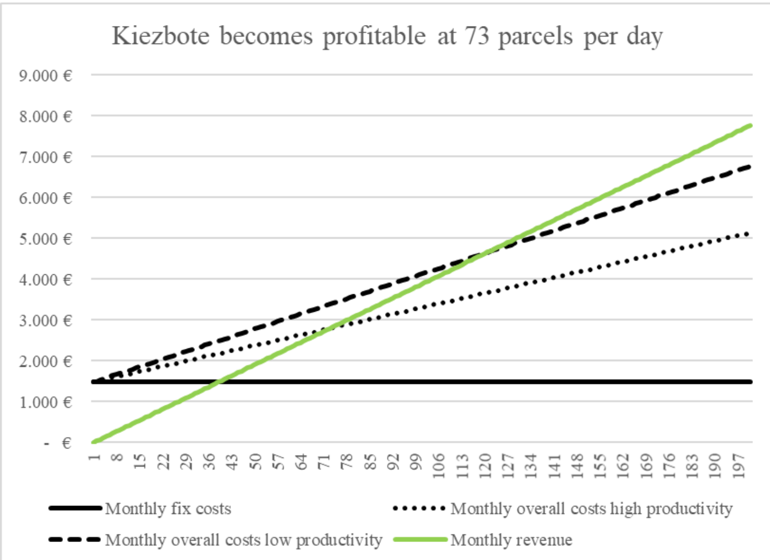

Figure 1: Results Profitability: Break Even Analysis

For further improvement of the delivery productivity, several cost drivers can be analysed. Empirical “Kiezbote” results already show some advantages over parcel logistics companies regarding driving and handover of parcels, see Table 4.

Table 4: Results Profitability: Improvement Levers KPI of Last Mile Productivity

Criteria	Field trial “Kiezbote”	Parcel service provider
consolidation factor	2.08	1.2 (Brabänder, 2020)
service time	02:35 min	02:26 min (Sesam GmbH, 2020)
service time per parcel	01:14 min	02:01 min (calculated based on references above)
driving-service ratio	35:65	10:90 (Seeck and Göhr, 2018)

While the consolidation factor and therefore the service time per parcel is significantly better at “Kiezbote”, driving takes a much higher share on the overall time due to the lower stop density caused by the yet low parcel volume. Thus, “Kiezbote” should reduce the driving time by optimizing their routes using an intelligent route planning software that incorporates the advantages of cargo bikes over conventional transporter.

4.3.3 Environmental Impact

C02 emissions can be significantly reduced of about 60 ex micro depot and of about 12 per cent on the last mile ex depot out of the city (Breitbarth, et al., 2021). The long distance from depot to micro depot cannot be eliminated; therefore, new sustainable solutions for this distance should be further investigated. Parking on driving lane could be reduced to 0 per cent of stops while we see a number of 30 per cent of stops at conventional parcel delivery companies (Seeck and Göhr, 2018).

5 Conclusion

The aim of the report was to show how SUL solutions pilots like “Kiezbote” can be comprehensively evaluated in order to prove its economic implementation, to determine its effects on emissions reduction and to investigate effects on customer satisfaction. Therefore, a holistic evaluation framework was developed containing 20 criteria. The results show that the customer satisfaction can be strongly increased when using “Kiezbote” from 2.7 / 5 (satisfaction rate conventional parcel delivery) up to 4.96 / 5 (satisfaction rate Kiezbote). The increased service – the consolidated parcel delivery within time windows by cargo bikes – produces additional costs that raise the question of how the concept can be implemented profitable as a prerequisite for sustainable and independent operations. However, the break-even analysis has shown that profitability can be reached from 73 parcels per day when the delivery staff reaches productivity of 20 parcels at 10 stops per hour. The CO_2 emissions on the last mile starting from micro depot can be reduced by 60 per cent.

This work provides empirical evidence as one of the first completed field trial on SUL solutions that considers profitability, environmental impact, *and* customer satisfaction. This work provides not only a comprehensive evaluation framework focusing on customer satisfaction, but also delivers some input data for further simulations and optimization of SUL solutions. Practically the results are relevant for last mile startups to inspire and validate their business models in terms of customer satisfaction, profitability, and environmental impact and thus, opens up new opportunities for SUL.

The work underlies the following limitations: First, the empirical data was collected during the COVID-19 pandemic when consumer behavior was changed. It is expected that the results would differ when conducting the trial after the crises due a higher need for time window delivery caused by more out-of-home-time. Second, the comprehensive framework consists of all relevant areas to evaluate SUL solutions pilots. However, when setting the target focus in a specific direction (e. g., environmental impact), the criteria should be individually enriched to get a more differentiated picture (e. g., not only evaluating CO2 emissions reduction). Third, the evaluation framework was only applied to one pilot. It should be validated with further pilots of a different nature (e. g., lockers, intermodal transportation) and also with SUL trials that include the distance from depot to micro-depot.

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