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Crowdsourcing Logistics in Cities

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Preface

This thesis presents the work done during the Industrial PhD project entitled 'Crowdsourcing Logistics in Cities' in a collaboration between Atkins Denmark and the Transport Division (Transport Psychology Section) at the Technical University of Denmark. The study was conducted under supervision of Senior Researcher Sonja Haustein and Associate Professor Mikkel Thorhauge. The project was funded by the Innovation Fund Denmark (Grant number 8053-00221B). The thesis consists of the present summary report and the four papers presented below, which are included as appendices.

Paper 1:

Fessler, A., Thorhauge, M., Mabit, S., & Haustein, S. (2022). A public transport-based crowdshipping concept as a sustainable last-mile solution: Assessing user preferences with a stated choice experiment. *Transportation Research Part A: Policy and Practice*, *158*, 210–223. https://doi.org/10.1016/j.tra.2022.02.005

Paper 2:

Fessler, A., Haustein, S., & Thorhauge, M. 'Drivers and barriers in adopting a crowdshipping service: A mixed-method approach based on an extended theory of planned behaviour'. Paper submitted for publication in *Travel Behaviour and Society* (under review).

Paper 3:

Fessler, A., Cash, P., Thorhauge, M., & Haustein, S. 'A public transport based crowdshipping concept: Results of a field test in Denmark'. Paper submitted to *Transport Policy* (under revision).

Paper 4:

Fessler, A., Klöckner C., & Haustein, S. 'Formation of crowdshipping habits in public transport: Leveraging anticipated positive emotions through feedback framing'. Paper submitted for publication in *Transportation Research Part F: Traffic Psychology and Behaviour.*

The following conference paper was also submitted during the PhD period. It approaches the crowdshipping concept from an operations management perspective and is not presented as part of the thesis. However, results from this paper are included in Section 5.4: Environmental and economic savings potential.

Cheng, R., Fessler, A., Jiang, Y., Nielsen, O.A., & Larsen, A. 'Assessing the impacts of public transport-based crowdshipping: A case study in Nørrebro district in Copenhagen'. Submitted to the Transportation Research Board (TRB) 102nd Annual Meeting, Washington, D.C., USA, January 8–12, 2023

Summary

This PhD thesis presents four complimentary studies that propose and investigate the potential for a public transport-based crowdshipping concept. In an effort to alleviate environmental, economic and social issues related to last-mile parcel delivery, the 'crowd' of public transport passengers are here enabled to bring along parcels on trips that match parcel delivery routes. Instead of entering the central districts of cities, parcel delivery operators would then place the relevant parcels in automated parcel lockers (APLs) at public transport stops, from which the passengers are financially compensated for picking them up and handing them in at an APL at their matching destination stop. Together, the studies shed light on the potential to attract public transport passengers willing to bring along parcels on their trips, as well as how this potential may be enhanced by addressing relevant identified motivational and behavioural drivers and barriers. The empirical foundation of the four studies consists of (a) a range of in-depth interviews, (b) a survey distributed to a representative sample of public transport users in the capital area of Denmark and (c) pre-/post-surveys distributed in relation to a full-scale field experiment testing the proposed crowdshipping concept.

The first sub-study analyses user preferences in relation to shipment characteristics for the crowdshipping concept. Preferences are also compared in relation to sociodemographic characteristics. This is done through a stated choice experiment included in the first survey. Respondents were presented with four crowdshipping scenarios with variance in the number of parcels, the total size and weight of shipments, the monetary compensation and the extra time required to participate. Willingness to bring along a parcel was positively related to the monetary compensation. The opposite was the case for additional time use related to participation, as well as the weight, size and number of parcels. Willingness to participate decreased with age; young(er) people were more willing to bring along parcels, while individuals above 60 years of age were the least willing. The value of time was found to be slightly above the official Danish value for waiting time but below the value of travel time delay, which illustrates that participation might be considered as waiting time, but that some travel time uncertainty was introduced at the same time.

The second sub-study investigates the potential and accompanying contingencies for user uptake of the crowdshipping concept through a mixed method approach. It examines motivational drivers, barriers and socio-spatial contexts influencing the intention to participate, and includes relevant demographic, social and psychological factors. The importance of three attitudinal factors are highlighted in the results: (a) a joint factor considering the social value, the expected support from important others and positive emotions related to participation, (b) the perceived ease of use and convenience and (c) the attitude towards participating in a commercially organised crowdshipping

concept. As in the first study, younger people showed higher willingness to participate. Both the in-depth interview and survey results pointed to the importance of positive emotions elicited by participation. It would therefore be beneficial if a crowdshipping solution were set up and highlighted as a user-driven movement, where the emphasis is on helping out each other and the environment.

The third sub-study presents the main results of the field experiment testing the concept. During a two-month period, 28 automated parcel lockers (APLs) were placed at public transport stations and stops. Participating public transport passengers were rewarded for bringing along empty test parcels on their trips, from APL to APL, via an app developed for the purpose. The purpose of setting up the experiment was to achieve more realistic measures for adoption potential as well as the practical and conceptual aspects that may affect this. The study confirmed the practical viability of the concept from a user perspective, with 82% of participants stating that they, after participating in the experiment, were more motivated to participate in the concept if it should be realised. Further, the study points to the relevance of contextualising and supplementing the construct of intention from the theory of planned behaviour as a measure for adoption propensity for novel technology and services.

The fourth sub-study explores the links between anticipated/experienced positive emotions and habit formation for crowdshipping participation in the already habitualised context of public transport. It additionally explores how such links may be supported by goal framing and how existing travel routines may support crowdshipping habit formation. The study found that participants in the field experiment who anticipated to a higher degree that their participation would evoke positive feelings reported a higher degree of habit formation. Further, recipients of environmentally framed feedback at the parcel hand-in showed more conducive post-survey results – including anticipated positive emotions, habit formation and amount of parcels brought during the experiment – compared to recipients of economically framed feedback. Building upon these points, the study found that the habit formation effect of anticipated positive emotions may be strengthened by framing participation feedback towards normative goals (represented by the environmentally framed feedback) as opposed to gain-focused goals (represented by the economically framed feedback). Lastly, participants using a smartcard – and thus performing a related physical task – reported a higher degree of habit formation than monthly cardholders who simply enter trains/busses directly. Together, the results indicate that the emotional reward value of a certain behaviour may be conditioned onto situational contexts. This contributes to the establishment of cues that trigger the undertaking of the given action.

Resumé (Danish)

Denne Ph.d.-afhandling opsummerer fire komplementære delstudier, der præsenterer og undersøger potentialet for et crowdshipping-koncept baseret på offentlig transport. For at imødekomme miljømæssige, økonomiske og sociale udfordringer relateret til last-mile pakke-levering, ville passagerer med offentlig transport her få muligheden for at medbringe pakker med destinationer der matcher passagerens. I stedet for at køre ind i centrale dele af større byer, ville pakkeleverandører derfor placere de relevante pakker i pakkebokse (som kendes fra eksisterende selv-afhentningsløsninger) ved offentlige transportstationer. Herfra ville passagerer blive økonomisk belønnet for at bringe dem med til deres matchende destination. Samlet belyser studierne potentialet for at rekruttere passagerer der er villige til at deltage, samt hvordan dette potentiale kan øges ved at adressere relevante faktorer med indflydelse på motivation og adfærd. Det empiriske grundlag for de fire del-studier udgøres af 1) en række kvalitative interviews, 2) et spørgeskema der blev udsendt til et repræsentativt udsnit af borgere i hovedstadsområdet og 3) før- og efter-spørgeskemaer der blev udsendt i sammenhæng med en fuld-skala test af det foreslåede crowdshipping-koncept.

Det første del-studie analyserer brugerpræferencer i relation til forsendelses-karakteristika. Præferencerne sammenlignes også i relation til sociodemografiske karakteristika. Dette gøres igennem et stated preference-eksperiment der indgik i første spørgeskema. Respondenterne blev præsenteret for fire crowdshipping-scenarier med varierende antal pakker, samlet volumen samt vægt, den økonomiske kompensation og den ekstra tid deltagelsen ville kræve. Villigheden til at medbringe en pakke er positivt relateret til den økonomiske kompensation. Det modsatte er tilfældet for ekstra påkrævet tid for deltagelsen såvel som for vægt, volumen og antal pakker. Villighed til at deltage aftager med alder; unge/yngre mennesker er mere villige til at medbringe en pakke, imens de som er 60 år eller ældre er de mindst villige. Værdien af tid findes at være en anelse over den officielle danske værdi for ventetid, men under værdien for forsinkelsestid. Dette sandsynliggør at (tiden brugt på) deltagelse betragtes som ventetid, men at noget rejsetids-usikkerhed samtidigt opstår.

Det andet del-studie undersøger potentialet for at tiltrække brugere til crowdshipping-konceptet samt influerende faktorer hertil. Dette gøres igennem en blandet kvalitativ/kvantitativ tilgang, hvor der ses på motivationsfaktorer, barrier samt kontekster med indflydelse på intentionen om deltagelse, herunder demografiske, sociale og psykologiske faktorer. Betydningen af tre holdnings-faktorer fremhæves i resultaterne: 1) en samlet faktor der rummer positive følelser relateret til deltagelse social værdi og forventet støtte fra betydningsfulde bekendte 2) den opfattede lethed og bekvemmelighed og 3) holdningen til deltagelse i et kommercielt organiseret crowdshipping-koncept. Som det var tilfældet i det første del-studie viste yngre mennesker højere villighed til deltagelse. Både de kvalitative interviews og spørgeskema-resultaterne pegede på vigtigheden af fremkaldelsen af

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positive følelser i forbindelse med deltagelse. Dette henviser til fordelagtigheden i at opstille og fremhæve en crowdshipping-løsning som en brugerdreven bevægelse, hvor fokus er på at afhjælpe hinanden og miljøet.

Det tredje delstudie præsenterer hovedresultaterne for testen af konceptet. Over en to-måneders periode var 28 pakkebokse placeret ved offentlige transport-stationer og stop. Deltagende offentlig transport-passagerer blev belønnet for at medbringe (tomme) testpakker på deres rejser, fra pakkeboks til pakkeboks via en app udviklet til formålet. Formålet med at opstille testen var at opnå mere realistiske vurderinger af adoptionspotentialet samt af de praktiske og konceptuelle aspekter, som måtte have indflydelse herpå. Studiet understøtter fra et bruger-perspektiv at konceptet kan fungere i praksis, med 82% af deltagerne som erklærede sig mere motiverede til at deltage i et realiseret koncept efter at have deltaget i testen. Yderligere peger studiet på relevansen af at kontekstualisere og supplere Theory of Planned Behaviour's Intention-begreb som mål for adoptions-tilbøjelighed for nye teknologier og services.

Det fjerde del-studie undersøger sammenhænge imellem forventede/oplevede positive følelser og vanedannelse for crowdshipping-deltagelse in den allerede vaneprægede kontekst som offentlig transport er. Yderligere undersøger det hvorledes sådanne sammenhænge kan understøttes af goal framings samt hvordan eksisterende rejserutiner kan understøtte vanedannelse for crowdshipping. Studiet viser at der er rapporteret en højere grad af vanedannelse blandt test-deltagere der i højere grad forventer at deres deltagelse vil fremkalde positive følelser. Yderligere ses det, at der blandt modtagere af en miljø-framet feedback ved pakkeaflevering er mere befordrende efter-spørgeskema-resultater for en række nøgle-parametre, sammenlignet med modtagere af en økonomisk framet feedback. Herunder ses mere befordrende resultater for forventede positive følelser, vanedannelse og antal pakker medbragt under testen. Med udgangspunkt i disse pointer peger studiet videre på at vanedannelses-effekten af forventede positive følelser kan forstærkes ved at frame deltagelses-feedback henimod normative mål (repræsenterede ved den miljøfokuserede feedback) frem for vindings-fokuserede mål (repræsenterede ved den økonomisk fokuserede feedback). Ydermere viste resultaterne at passagerer der benyttede Rejsekort – og dermed foretog en relateret fysisk handling – rapporterede en højere grad af vanedannelse end deltagere der med månedskort o.l. blot kan træde direkte i bussen/toget uden at foretage sig yderligere. Tilsammen indikerer resultaterne at den emotionelle belønnings-værdi som en handling affører kan indlejres i situationelle kontekster. Dette bidrager til at etablere 'triggere' der udløser igangsætning af den givne adfærd.

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Contents

1   Introduction

1.1   Motivation

Increasing urbanisation and e-commerce are amongst the main drivers of the increasing social, economic and environmental challenges posed by business to consumer (B2C) goods delivery (Bretzke, 2013; Mangiaracina et al., 2019). As urban demand for parcels increases, so does the need for delivery vans to enter central city districts through infrastructure that is often already congested (Boysen et al., 2021). At the same time, novel consumption practices put pressure on delivery costs and on the traditional professional delivery chain. Customers expect fast delivery at low costs, while convenient delivery is an increasing component of e-commerce products and customer satisfaction. While freight operators are generally successful in consolidating and optimising earlier parts of delivery chains that constitute large and regular flows of goods, this is more complex and costly for the later parts (Zhou et al., 2019). Both in terms of environmental and economic costs, the last part of the delivery chain is the most critical and inefficient element, amounting to half of total delivery costs (Macioszek, 2018; Vanelslander et al., 2013). Last mile delivery has a disproportionate negative impact on (sub)urban traffic conditions, including congestion, emissions, accidents, road infrastructure depreciation and parking issues (Pourrahmani & Jaller, 2021). In line with the UN Sustainable Development Goals (SDGs) 11 'Sustainable cities and communities', 12 'Responsible consumption and production' and 13 'Climate action', there is a need to rethink the last parts of the parcel delivery system (United Nations, 2015). To accommodate this without conflicting with other SDGs, this must be done with both environmental and social sustainability in mind. Additionally, economic viability is necessary to reach scale for sufficient impact.

One approach that has gained increasing academic attention in recent years is the concept of crowdsourced logistics – or *crowdshipping* – where the delivery task is outsourced to 'the crowd' (i.e. the general public). The concept it thus related to 'the sharing economy' which refers to the peer-to-peer sharing of goods or services, usually facilitated by a digital platform (Schlagwein et al., 2020). However, the main body of prior research and practical applications has focused on private personal vehicle use, where dedicated trips or detours are more or less unavoidable (e.g. Allahviranloo & Baghestani, 2019; Paloheimo et al., 2016). Such personal vehicle-based concepts thus often entail rebound effects resulting in emission increases instead of decreases (Buldeo Rai et al., 2018). At the same time, sharing economic concepts have often been criticised for undermining the rights of workers and creating a 'gig-economy' precariat (Paus, 2018).

The application of crowdshipping to the abovementioned challenges in transport thus does not necessarily guarantee a balance of environmental, social and economic considerations. In an

exploration of potential bridging between these challenges and opportunities, this Industrial PhD project proposes a public transport-based crowdshipping concept. At least in principle, such a concept may be able to contribute to addressing the challenges posed by last mile delivery by making use of non-dedicated public transport trips in combination with automated parcel lockers (APLs).

Maintaining a critical mass of crowdshippers has been identified as an issue that is imperative to consider in previous studies on crowdshipping (Punel & Stathopoulos, 2017b). The benefits for both logistics operators and their customers will strongly depend on user uptake. The present PhD therefore explores potential user acceptance and accompanying contingencies for this.

1.2   Scope of the PhD project

1.2.1   Scientific scope

This PhD explored the potential for adoption of a public transport-based crowdshipping concept and how this potential may be enhanced by leveraging identified attitudinal and behavioural drivers and mitigating barriers. In other words, how can the potential for attracting and activating crowdshippers be maximised? In pursuing this, four complementary studies were conducted with the following aims:

- To assess the potential for user-uptake of a public transport-based crowdshipping concept in the Copenhagen region, as well as the accompanying contingencies. This was pursued through in-depth interviews and an online survey distributed to a representative sample of inhabitants in the Capital Region of Denmark.
  - o   For this purpose, willingness to accept and user preferences for shipment characteristics (number of parcels, their size and weight, the compensation and required extra time) were investigated (Paper 1). This was done with Stated Choice data from an experiment included in the online survey.
  - o   Relevant demographic, social and psychological factors were also investigated (Paper 2).
- To test the potential and contingencies for translating intentions to participate into actual participation (Paper 3). For this purpose, a full-scale real-world experiment was conducted along with distribution of pre- and post-surveys.
- To assess how participation may be supported by leveraging the identified psychological factors to strengthen habit formation (Paper 4). The data related to the experiment were also the empirical basis for this purpose.

1.2.2   Industry engagement and work towards realisation

As an Industrial PhD, the project has concurrently sought to establish a collaboration with a relevant industry actor (i.e. a logistics operator). In Denmark, the largest player in the field is PostNord.

Therefore, a collaboration with PostNord was pursued and formalised in the context of the abovementioned real-world experiment organised by the PhD student. This resulted in a collaboration agreement with the stated purpose of assessing the environmental and economic savings potential of implementing a public transport-based crowdshipping system as a supplementary delivery mode in PostNord's product portfolio. In case of sufficient potential, the subsequent purpose is to develop and test a solution.

To assess the savings potential, several datasets on PostNord's deliveries to Copenhagen were received through the formalised collaboration. A collaboration was also set up with another PhD student working in the field of operations management research, with the common aim to quantitatively analyse the impact of public transport-based crowdshipping on the operation costs of PostNord and CO_2 emissions. The methodology and results are further described in Section 5.4.

1.3   Structure of the thesis

This thesis presents the background, motivation, individual studies and the main findings and implications of the PhD project 'Crowdsourcing Logistics in Cities'. The remainder of the thesis is organised as follows:

- Chapter 2 introduces the background of the thesis, including existing research on crowdshipping and the theoretical background for the behavioural focus of the studies.
- Chapter 3 outlines the data collected and utilised in the four sub-studies of the PhD project.
- Chapter 4 describes the aims and main findings for each of the project's sub-studies.
- Chapter 5 contains a discussion and presents implications of the main findings of the project.
- Chapter 6 addresses the main limitations of the project and proposes future research perspectives.
- Chapter 7 presents the main conclusions of the PhD thesis.

After the references, the four papers are included in the appendix.

2 Background

2.1 Crowdshipping concept

2.1.1 Crowdshipping research

In the broadest sense, the term crowdshipping simply refers to the outsourcing of the task of shipping to the crowd. The crowdshipping concept considered in the present thesis shares features with several alternative logistics modes, perhaps most directly with co-modality and private vehicle–based crowdshipping. In the following, these terms and how they differ from public transport-based crowdshipping will be unfolded.

In the case of utilising existing public transport capacity, crowdshipping could also be considered a co-modal solution. Co-modal concepts – entailing the integration of goods movement into existing public passenger transport networks – have previously been studied and implemented (e.g. Arvidsson et al., 2016). However, the vast majority of research in this field has focused on earlier parts of the delivery chain, where consolidated transport is still possible, for example by placing parcel containers on (separate parts of) trams, trains or busses to be delivered at a centrally placed hub for final distribution(Masson et al., 2017; Trentini et al., 2012; Van Duin et al., 2019). To the knowledge of the present PhD project, no practically applied co-modal solutions exist that address the last mile. As such, the large savings potential of digging into the disproportionately large emissions and monetary costs through co-modality is still unexplored in practice, despite this potential being suggested by most existing studies (e.g. Bruzzone et al., 2021; Cochrane et al., 2017; Nocera et al., 2021).

At the time of writing the project proposal for the Innovation Fund Denmark in 2018, we were not able to identify any previous practical applications of a public transport-based crowdshipping concept or even theoretical considerations of such. At that time, prior research on crowdshipping had, like the existing solutions, focused on decentralised 'Uber-style' concepts, in which users offer their service by making use of their own means of transport, typically a car or bike, thus neglecting the potential of public transport infrastructure. Likewise, research on mobility behaviour that included public transport has not made connections to the concept of crowdshipping.

The need to understand the acceptance of crowdshipping has been deemed crucial by researchers within transportation, as only a fraction of crowdshipping companies (using private-car deliveries) succeed in establishing a lasting market by attracting and maintaining users within the system (Punel & Stathopoulos, 2017a). A system needs to be integrated with the professional transport systems upstream if it is to play a relevant role in the final parts of the delivery chain. Attempts to crowdsource package transport and delivery may therefore often prove ineffective, as lacking integration with the

existing infrastructure of delivery chains leads to high transaction costs. Efficiency is further worsened compared to traditional delivery systems when coupled with concepts that do not solely make use of non-dedicated trips, which is difficult to avoid when relying on mobility modes other than public transport. These difficulties do match well with the small economic margins of transport, where customers expect delivery at low cost (Chen et al., 2018). To illustrate, few people are probably willing to act as a crowdshipper if they need to spend a lot of time coordinating with a parcel sender, drive somewhere in their car they would not otherwise go to pick up a parcel at a specific place at a specific time and then drive somewhere else they would not otherwise go to deliver the parcel somewhere at a specific time. Most people would probably at least expect a better compensation than what is usually possible to provide. This is where the use of non-dedicated trips – trips that would be taken anyway – with public transport might, at least on paper, be able to balance the economic, social and economic challenges of last mile delivery.

In a literature review, Le et al. (2019) divided existing crowdshipping literature into three categories: supply (crowdshippers), demand (customers) and operations management. The focus of this PhD project is on the crowdshipper, although the parallel work on industry engagement and work towards realisation (as described in Section 1.2.1) employs operations management approaches to evaluate potential and viability (Cheng et al., 2022). The focus on the crowdshipper has been chosen due to the novel and untried nature of the proposed concept. The experience and expectations of the customer are not expected to vary much from those related to other crowdshipping concepts where demand-side attributes have been investigated in, for example, stated choice (SC) experiments (Punel & Stathopoulos, 2017b). It is expected that the most important attributes identified here, such as delivery cost, receiving the package in its integrity and speed of delivery are relevant for customers, independently of whether the crowdshipper delivers by car or public transport. In contrast, the experience, barriers, needs and preferences of the crowdshipper will be very dependent on the mode of transport.

Since the time of writing the project proposal, some academic work on public transport-based crowdshipping has surfaced. With a conference paper (Serafini et al., 2018) and a range of papers on the subject (Gatta et al., 2018, 2019; Simoni et al., 2019), a group of authors connected to Roma Tre University were amongst the first to discuss a crowdshipping system based on public transport. They analysed the willingness to act as a public transport crowdshipper in Rome through SC scenarios, as well as the demand-side willingness to receive goods through this type of crowdshipping service. On this basis, they assessed economic and environmental impacts in a first exploration of effects. They identified substantial savings potential; however, as scenario analyses were only based on the SC results, operations management research approaches are needed to reach more reliable evaluations,

taking into account variables such as vehicle capacity and routing based on actual parcel flow. As mentioned, this is a task that the industrial PhD project in a broader sense has aimed to facilitate in a subsidiary manner. In the following section, the crowdshipping concept imagined and proposed in the present thesis is described in more detail.

2.1.2   The proposed crowdshipping framework

In the typical current B2C delivery flow, parcels for delivery in a given city are gathered in a distribution hub located in the outskirts of the city, after having undertaken the journey from sender through the hub-network of the logistics operator. From the hub, a fleet of vans and trucks undertake the last stretch of the transport chain to parcel recipients, either through home delivery or to pick-up points such as post-offices, parcel shops or automated parcel lockers (APLs). This last part of the transport chain is what the present Industrial PhD project initially seeks to address through public transport-based crowdshipping. However, as will be discussed in Section 7, the possibility for the concept to undertake the entire transport chain from sender to recipient is not ruled out.

The use of APLs has in itself shown potential to address last mile challenges, with operational and service-related benefits compared to traditional delivery options (Zurel et al., 2018). In the PhD project's proposed crowdshipping concept, the flow of public transport passengers is utilised to supplement the abovementioned fleet of vans; on trips in which matching parcel/passenger-itineraries allow it, passengers are offered compensation for bringing along parcels from and to APLs placed at the public transport stations/stops. This is facilitated by an app that presents registered users with the opportunity to 'book' the parcel(s) when identifying a parcel/passenger-match. Subsequently, the app allows passengers to open the relevant APL-locker through a Bluetooth connection upon pick-up and hand-in at, respectively, departure and transit/destination points.

Ideally, crowdshippers will receive the financial compensation for bringing a parcel along on the trip in the form of credit for the transit system (as opposed to ready money). This is to ensure that participation is not done as a precarious job and, at the same time, that parcels are only brought on trips that would be taken anyway.

2.2 Theoretical background

2.2.1 Theory of planned behaviour

The theory of planned behaviour (TPB; Ajzen, 1991) is one of the most frequently applied frameworks for explaining both environmental and transport-related behaviour (e.g. Schwenk & Möser, 2009; Vlassenroot et al., 2010). Its wide scope and adaptability to additional relevant constructs also makes the framework suitable as a theoretical point of departure for exploring novel behaviour such as crowdshipping. In TPB, the main determinant of behaviour is the intention to undertake a given behaviour. Intention is formed by three factors. The *attitude* towards a behaviour refers to the valuation (positive or negative) of the action. *Subjective norm* (SN) refers to the perceived judgement of the behaviour from a person's important others. *Perceived behavioural control* (PBC) is the person's perceived ease or difficulty of performing the behaviour.

For the purposes of this PhD project, inspiration for extensions was sought from multiple approaches to transport and environmental behaviour. This included habit (Klöckner & Blöbaum, 2010; Verplanken & Aarts, 1999; Verplanken & Orbell, 2003), goal framing (e.g. Lindenberg & Steg, 2007; Steg et al., 2014; Westin et al., 2020), symbolic motives (Schuitema et al., 2013; Steg, 2005; Steg et al., 2001) and self-identity (e.g. Cook et al., 2002; Fallah Zavareh et al., 2020; Sparks & Guthrie, 1998; Van der Werff et al., 2013), as well as anticipated emotions (e.g. Steg, 2005; Taufik et al., 2016; Venhoeven et al., 2013).

2.2.2 Habits

Frequency of performance has been shown to moderate the influence of intentions on behaviour. In a metastudy (Ouellette & Wood, 1998), it was shown that past behaviour is a strong predictor of future behaviour when it comes to behaviour that is performed frequently, while intentions have only a small influence. On the other hand, intentions were a strong predictor of behaviour performed infrequently (e.g. annually or bi-annually), while past behaviour lost nearly all significance. In other words, these results indicate that people tend to 'automatically' repeat their everyday behaviours, but make more deliberate decisions when it comes to questions that are faced infrequently. However, frequency alone is insufficient to determine habits, as it lacks consideration for central components of habit development such as stability of context and intentions.

Habits have been defined as 'cognitive structures that automatically determine future behaviour by linking specific situational cues to (chains of) behavioural patterns' (Klöckner & Verplanken, 2018, p. 239). In the domain of transport behaviour, the inclusion of habit has added significant value as an extension of TPB (e.g. Klöckner and Blöbaum, 2010). In fact, it is one of the most important concepts to include on mobility-related issues (e.g. Klöckner et al., 2003; Lanzini & Khan, 2017).

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There are two commonly applied approaches to measure habits. The Response Frequency Measure (Verplanken et al., 1994) measures the consistency with which different travel modes are made across various presented travel scenarios (the approach was originally developed for measuring travel mode habits). The Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003) assesses both frequency and strength of cognitive association through application of items focusing on automaticity. With their approach to habit, Orbell and Verplanken (2015) highlight the convergence of three elements from different accounts of habit: a history of repetition, a high degree of automaticity and cued in stable contexts. The easy application of SRHI to other domains than travel mode choice, as well as its applicability to questionnaire studies, means that this PhD will draw inspiration from the SRHI approach to habit measurement.

The results of prior studies (e.g. Aarts et al., 1997; Verplanken & Wood, 2006) present both barriers and opportunities for behaviour change interventions targeting (potential) public transport users. On the one hand, frequently performed behaviour with context stability (e.g. making the same trip every day) forms strong habits that leave little room for (changes in) intention to guide action. On the other hand, habits' sensitivity to changes in this context opens room for intervention. By changing the otherwise stable context in which habitual behaviour is usually performed, guidance can be encouraged through social beliefs and evaluations such as those expressed in TPB (Danner et al., 2008). However, regarding technology, previous research has also described how existing habits may be leveraged to 'stack' on novel habits, also known as habit chaining (e.g. Judah et al., 2013; Labrecque et al., 2017; Pinder et al., 2018). Inspiration is thus drawn from several approaches in the exploration of existing habits and how their influence on public transport behaviour may be mitigated/leveraged to induce crowdshipping participation.

2.2.3   Goal framing

Goal framing theory (GFT; Lindenberg & Steg, 2007) argues that the way individuals process and act upon information is framed by three types of general goals: hedonic, gain and normative goals. Hedonic goals focus on immediate satisfaction – to feel good right here and now. Gain goals emphasise personal gains or minimising losses of resources such as money, time or status. Finally, normative goals focus on 'doing the right thing' – to act appropriately and in line with one's own values and beliefs. According to GFT, one of the three goal frames will be dominant at a given point in time, and will then influence how and which information is processed. Normative goals are expected to be the strongest basis for pro-environmental behaviour, such as participating in the crowdshipping concept. If people act pro-environmentally with a basis in hedonic or gain goals, this is only due to the behaviour being profitable or comfortable, and they will then only undertake the behaviour as long as this is the case (Steg & Nordlund, 2018). In the context of the crowdshipping concept, an emphasis on the

economic remuneration for carrying a parcel can thus be imagined to foster engagement by highlighting gain goals. A focus on the concept's environmental and societal benefits towards which participation contributes can be thought to incentivise participation by highlighting normative goals. The emotional or economic benefits could be strategically amplified through the design of the system and accompanying app to trigger hedonic goals as well, where the previously experienced positive emotions are brought to mind and linked to a present opportunity to participate.

GFT served as a natural extension of the applied TPB framework, which focuses primarily on gain goals. It was evident from the second study that anticipating emotions related to compliance with ideas of 'doing good' was a strong predictor of intention to participate in the crowdshipping concept. Thus, the need for an approach further encompassing normative goals was highlighted as well as the hedonic goal in cases where 'doing the right thing' is connected with positive emotions.

2.2.4 Symbolic motives and emotions

The inclusion of symbolic motives was deemed relevant, as previous work on, for example, mode choice has shown travellers' choices are not only based on functional and instrumental benefits. Transport behaviour is also a signifier to ourselves and to others of who we are, who we wish to be or who we think we should be. Symbolic motives thus also influence choices, such as mode choice (e.g. Hunecke et al., 2007; Lois & López-Sáez, 2009; Steg et al., 2001). People may ascribe different symbolic values to the same behaviours, depending on how they see themselves and their peers, and thus the same environmentally relevant behaviour, such as driving electric vehicles, may for some result in positive emotions and for others result in embarrassment (Graham-Rowe et al., 2012).

Previous research also shows how the degree of belief that the performance of a given behaviour will elicit positive emotions can act as a strong predictor of the given behaviour. Referred to as anticipated emotions, such anticipations have, for example, been shown to increase intention to use public transport when anticipating feeling good from using it (positive anticipated emotions) and bad when not using it (negative anticipated emotions) (Carrus et al., 2008). Whether positive or negative, anticipated emotions are shaped through a combination of previous emotional outcomes and current affect. Positive emotional outcomes may be psychological rewards for living up to ideals of 'doing the right thing', for example, performing an environmentally friendly action (Venhoeven et al., 2013). These feelings can result in a 'warm glow', that may also entail a social dimension, such as a sense of belonging or living up to social norms (Cabo et al., 2020; IJzerman et al., 2012; Taufik et al., 2015).

3 Method

As a whole, the aims of the PhD project have been pursued through a mixed method approach. The applied qualitative and quantitative methods are argued to strengthen the results, as they complement each other in their strengths and weaknesses. In aiming to assess the potential for adoption at a societal level, a representative sample is needed. However, if we do not measure the right aspects in the survey's standardised phrasing of questions, this sample will be of little use. Further, as the crowdshipping concept is novel in nature, participants in both interviews and surveys cannot ground their evaluations in any practical experience, but must instead rely on hypothetical scenarios. This has been shown to be a troublesome basis for realistic indications of future adoption in studies of future mobility services. Instead, actual hands-on experience can uncover practical limitations and lead to more accurate assessments of future use (Millonig & Haustein, 2020). For this reason, a practical experiment simulating the experience to participants was conducted. The various sources of data (depicted in Fig. 1) are described further in the following sections.
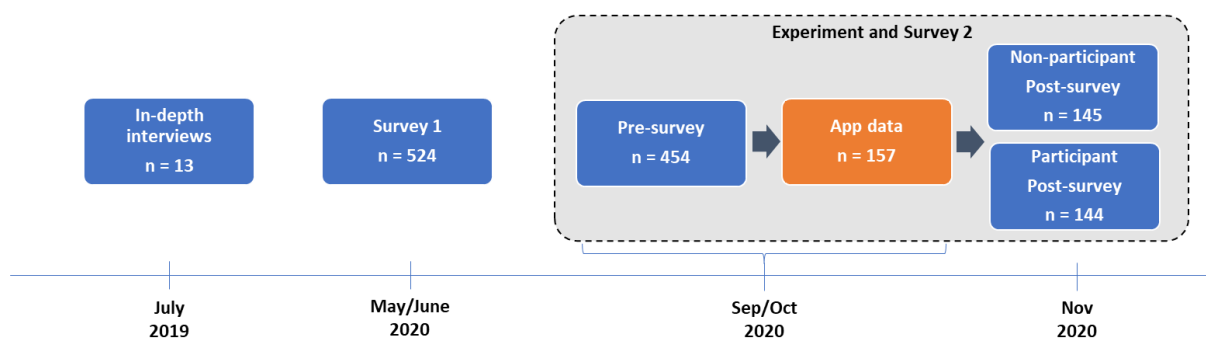
Figure 1: Data collection timeline

3.1 Qualitative interviews

In-depth interviews were conducted as the first exploratory step in identifying motivational drivers of and barriers to participation in public transport-based crowdshipping. As the proposed crowdshipping concept is novel in nature, with very limited prior knowledge to consult, this was deemed necessary to ensure that the scenarios described and assessed quantitatively in the subsequent survey made sense to respondents and that all potentially relevant (de)motivational factors were included. This is one of the key strengths of the in-depth interview – the ability to capture nuanced descriptions and accompanying reasonings (Kvale & Brinkmann, 2009).

Interviews were conducted with a semi-structured interview guide to ensure certain themes were covered while staying receptive to themes that may appear during the data-gathering process. Thirteen interviews were completed. Respondents were between 19 and 55 years of age. Both

inhabitants of outskirts and central districts of Copenhagen were represented. Their use of public transport in Copenhagen ranged from daily to rare use. The mean interview duration was 49 minutes.

The interviews covered all factors of TPB: what aspects of the crowdshipping concept the interviewee would like/dislike (attitude), potential challenges (PBC), expected views of others (social norms) and if they could imagine participating (intention). They also covered the potential for evoking feelings of community and engagement (relatedness). Lastly, transport habit compatibility was covered. Further details on the method, sampling, interview-guide and analysis are provided in Paper 2, Section 3 (See Appendix). Although effective in identifying relevant themes, the findings of the in-depth interviews cannot be generalised to the whole population of interest (public transport users in the Copenhagen Region). For this purpose, a quantitative approach was applied.

3.2   Survey 1

A survey was distributed to a representative sample of inhabitants in the Capital Region of Denmark in May/June 2020. Requirements for participation were use of public transport on at least a monthly basis and residence in the included area codes of Copenhagen and its catchment area. The sample was drawn from the online panel of a market research institute (EPINION) and took gender, age, education (for the general population) and geography (within the included range of area codes) into account for representativity. After cleaning the data,[1] the final sample consisted of 524 respondents. As the country was in lockdown at the time of data collection, respondents were instructed to answer based on their lives and transport habits prior to the pandemic. The main part of the survey covered attitudinal, practical and sociodemographic aspects. The attitudinal factors were informed by the qualitative interviews (see Section 3.1) and an extended version of the TPB (Ajzen, 1991) covering the psychological constructs described in Section 2.2. Items to measure these constructs were assessed on 5-point Likert scales. The full list of included items can be found in Paper 2, Table 2.

Survey 1 also included an SC experiment. This choice of method was inspired by the only existing research on user preferences for public transport-based crowdshipping (Serafini et al., 2018), which was also based on an SC experiment. The experiment assessed preferences for shipment characteristics in crowdshipping scenarios that included five attributes: compensation, extra time, number of parcels, size and weight. By applying these, the aim was to enable more precise estimates of appropriate monetary compensation levels for various shipment characteristics. The inclusion of the time component further allowed a comparison with average values of travel time as well as values of travel delays for Danish public transport commuters.

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[1] Responses that were completed in less than 40% of the median duration as well as responses with suspicious answer patterns were removed.

Using the software package Ngene (ChoiceMetrics, 2012), the attributes were combined in different ways to produce 40 choice tasks that were divided into ten blocks, of which one was randomly assigned to each participant. Participants were thus presented with four choice tasks requesting that they choose between options A, B or 'No choice', as shown in Figure 2. Attributes and their levels were determined from several preceding inputs. First, the qualitative interviews (Section 3.1) had included an imagined scenario to highlight practical preferences and barriers for participation, which qualified the selection of relevant attributes and levels. Additionally, existing information on last-mile costs (Gevaers et al., 2009) was used to set upper boundaries for compensation. The experiment design was iterated based on a pilot-test (n=77) before being validated in a final test (n=59) prior to distribution. The experiment design is described in further detail in Paper 1, Section 3.1.

Figure 2: Choice task example.

A weakness of the SC method is the hypothetical nature, and thus potential lack of realism of the SC questions (Ortúzar & Willumsen, 2011). The method could also be accused of relying on the assumption that we generally make deliberate, conscious and rational decisions when we go about our daily lives. Such assumptions have been heavily questioned in the recent decades (e.g. Kahneman, 2011). Further, for habitual behaviour such as public transport travel, it has been demonstrated that intentions do not necessarily translate easily into action (Danner et al., 2007; Kim et al., 2017; Légal et al., 2016). The SC method is nonetheless useful for the overall aims of the thesis, as its findings can provide indications of appropriate compensation levels and the relevance of various attributes. To accommodate the fact that both SC and general survey results entail a considerable amount of uncertainty as to whether people will actually participate in practice, a real-life field experiment was conducted. This is described further in the following section.

3.3   Experiment and Survey 2

In September 2020 a full-scale field experiment testing the crowdshipping concept was launched. In relation to this, a pre-survey based on Survey 1 and a post-survey was distributed. 28 APLs were placed at public transport stations and stops for the S-train, Metro, Bus and Train. The majority (22) were placed in the Greater Copenhagen area to imitate the imagined operational area and direction of a crowdshipping solution managing deliveries from city outskirts to central districts. To test in more

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rural surroundings and at greater distances, six APLs were placed in Northern Jutland, of which four were placed in small municipalities and two in the larger municipality of Aalborg (120,000 inhabitants). Empty test parcels were placed in the lockers to be moved around by participants. The experiment was organised in collaboration with several relevant actors, to obtain the relevant approvals and access needed to make the experiment as realistic as possible. These included municipalities, DSB (the Danish national rail company), Metroselskabet (Metro company) and the APL-operator Nærboks (at the time partly owned by the Danish national postal service PostNord, but at the time of writing, fully owned by PostNord).

The smartphone app 'CrowdShip' was developed for the experiment by Atkins under the instructions of the PhD student. The app was developed for both IOS and Android. The app facilitated the interaction with the placed APLs through a Bluetooth connection. Using the app, participants could (a) book a parcel with a matching route by entering their departure and destination station, (b) open the APL at their departure station (one of the 28 included stations/stops) through Bluetooth and (c) open the APL to hand the parcel in at their given destination (another of the 28). Participants were financially rewarded for each time they transferred a parcel. Further details and screenshots are provided in Section 4.1.1, Paper 3.
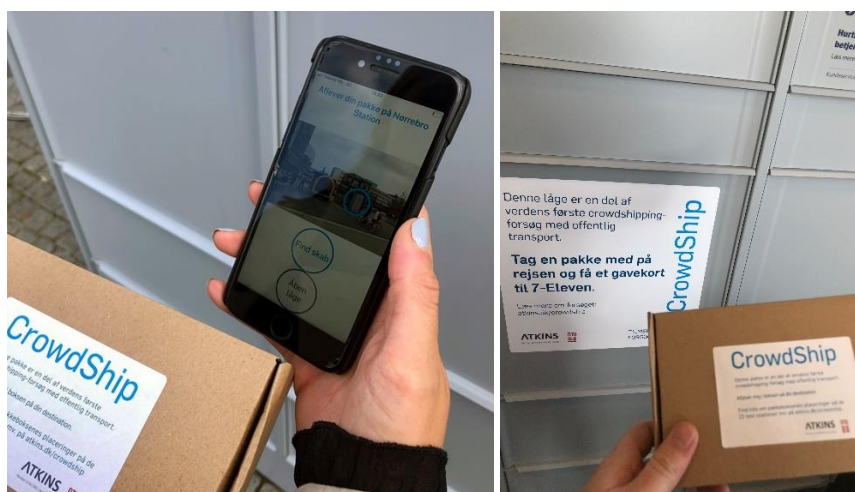
Figure 3: Hand-in of a test parcel and APL as presented to participants

Participation in the practical test was possible from September 2nd 2020. Due to a national COVID19-lockdown announced on September 18th the originally planned one-month experiment period was doubled, to compensate for the vastly diminished public transport use (as people were sent home from work, etc).

A pre- and post-survey was distributed in relation to the experiment. The pre-survey was a slightly distilled version of Survey 1, where the number of items in a few selected factors was reduced to decrease participant workload. The post-survey measured the participants' experience in the

experiment, as well as the same attitudinal variables included in the pre-survey. To qualify as a participant, individuals were required to transfer a parcel a minimum of two times. Respondents of the pre-survey who did not participate in the practical test received a short separate post-survey covering their reasons for not participating.

A total of 454 pre-surveys were completed (64% women, 34% men) from respondents between 16 and 73 years of age (see Section 4.2, Paper 3, for details). Of these, 157 (35%) participated in the practical test; 144 of those who did so (92%) also completed the post-survey (60% women, 38% men). The separate post-survey for non-participants was completed by 145 of the pre-survey respondents.

The use of the various data sources in relation to the papers of the PhD are displayed in Table 1.

Paper	Data source
Paper 1	Survey 1 (incl. SC experiment)
Paper 2	Qualitative interviews + Survey 1
Paper 3	Survey 2 (Pre- and post-survey)
Paper 4	Survey 2 (Pre- and post-survey)

Table 1: Papers and data sources

4   Findings

4.1   Paper 1: A public transport-based crowdshipping concept as a sustainable last-mile solution: Assessing user preferences with a stated choice experiment

4.1.1   Aim

The objective of this study was to analyse user preferences for the public transport-based crowdshipping concept through an SC experiment. This was pursued to provide a greater level of detail on service and shipment characteristics to allow for more precise estimates of appropriate compensation levels. Further, sociodemographic characteristics were included to identify the population segments most prone to participate.

4.1.2   Main results

Mixed logit models were estimated to assess user preferences. As expected, it was found that the utility of bringing a parcel is positively related to the monetary remuneration offered, while the opposite is the case for additional time use related to participation, as well as the weight, size and number of parcels. Regarding sociodemographic differences, it was found that students, the working population and young(er) individuals (below 40 years of age) were more prone to take part in the crowdshipping concept, while the opposite was the case for individuals above 60 years of age. Further, it was found that the marginal disutility of additional time spent (the disadvantage of spending time) on participating was higher for old(er) individuals and individuals in the high-income group, while the opposite was the case for individuals with a lower level of education. The profiles of most participation-prone individuals seemed to match typical public transport commuters. It was hypothesised that this is due to the ease with which regular commuters might participate if they get into the habit of participation, in opposition to the irregular user whose initial mental effort might not pay off. The willingness to accept (WTA) was found to be just below 200 DKK per hour (~26 Euro/h). This is between the value for waiting time of approx. 183 DKK per hour (16 Euro/h) and the value for travel time delays of approx. 274 DKK per hour (37 Euro/h). This seems plausible if one considers participation as waiting time and at the same time introducing some travel time uncertainty, as participation may cause the individual to miss the next train or bus.

4.2   Paper 2: Drivers and barriers in adopting a crowdshipping service: A mixed-method approach based on an extended theory of planned behaviour

4.2.1   Aim

The aim of this study was to assess the potential and accompanying contingencies for user-uptake of the crowdshipping concept by examining the motivational drivers, barriers and socio-spatial contexts

that influence the intention to participate. In pursuing this, relevant demographic, social and psychological factors were investigated through in-depth interviews and an online survey. In addition to the qualitative data itself, the in-depth interviews informed the design of the subsequent survey. With very limited research on the topic, this served to include as many influential factors relevant to potential users as possible.

4.2.2   Main results

Results pointed to the need to consider three attitudinal factors: perceived ease of use and convenience (PBC), the attitude towards participating in a commercial crowdshipping concept (concept attitude) and – clearly the most relevant – the social value of participation and expected support from important others and positive emotions related to participation, which was captured in one joint factor. The importance of positive emotions elicited from participation was highlighted in both the interview and survey results. As in the first study, age was found to be of significant importance, with younger people showing higher intention to participate. Male respondents showed a slightly higher intention to participate, but this was only significant when controlling for the higher scores identified amongst women in the joint factor for the social value, expected support from important others and positive emotions related to participation. Also, monthly public transport expenses were found to influence participation intention. Findings suggest that a public transport-based crowdshipping platform could advantageously be highlighted as a user-driven movement, where the purpose of doing something good for the environment is supplemented with the goal of helping each other. This message seems proportionately important to convey the younger the audience is. The quantitative results showed that the social aspects of the service also resonated significantly better the younger the age group, meaning that young(er) people to a higher extent expect participation to elicit positive feelings and support from their social surroundings. Concerning communication efforts to those aged 65 and above, results indicated that focus should be on addressing the group's higher PBC concerns, by reassuring them that participation is easy and that they are capable of participating.

4.3   Paper 3: A public transport based crowdshipping concept: Results of a field test in Denmark

4.3.1   Aim

Based on data from the practical experiment and the accompanying pre-/post-surveys, the aim of this study was three-fold: first, to achieve a more realistic measure for intention to participate in a realised public transport-based crowdshipping concept by providing practical experience; second, to examine what worked from a practical perspective and what should be iterated in a future concept; and third,

to model how psychological constructs related to TPB affect different evaluation criteria: post-intention, acceptance and engagement in the trial (behaviour). In addressing these aims, we sought to portray (de)motivational aspects related to the crowdshipping concept.

4.3.2   Main results

In the study, we confirmed the practical viability of a public transport-based crowdshipping concept from a user perspective, with 82% of participants stating that they, due to test participation, were more motivated to participate in the concept if it should be realised. After participating, 47% and 68% of participants would often or always, respectively, bring a parcel on their most used outbound and return trips. Ease of interacting with the APLs had a significant positive effect on acceptance of the service. Further, they should be placed in the immediate vicinity of where passengers naturally pass by. Placement of APLs at the participants' departure point had a higher and significant correlation with acceptance of the service compared to the APL at destination point, which could be caused by a (perceived) risk of missing the next train/bus if the parcel is not retrieved swiftly. A general preference for bringing parcels on home-bound trips presents a challenge to the required outskirts-to-city flow of parcels, where the capacity of commuters going the same direction to work is utilised. Efforts are thus needed to make participation as easy and rapid as possible, as well as to communicate this, to avoid fear of being delayed due to participation. The approach and results highlighted the relevance of contextualising and supplementing evaluations of intention. A range of constructs, including intention, showed less favourable results in the post-survey compared to the pre-survey. Given the high level of motivation as result of participation, we argue that participants, by trying out the service in practice, to a higher degree are enabled to bring situational constraints into consideration for their post-evaluations of participation intention, in line with previous research showing that situational constraints are underrated in predictions of own future behaviour, which is prone to 'optimistic bias'.

4.4   Paper 4: Formation of crowdshipping habits in public transport: Leveraging anticipated positive emotions through feedback framing

4.4.1   Aim

The aim of this study was to explore links between anticipated/experienced positive emotions and habit formation in the context of public transport use which is already highly habitualised. On this basis, the study assessed the potential to leverage intrinsic motivations in establishing contextual cues to initiate action (in this case participation in the crowdshipping concept) through respectively gain- and normative-focused goal framings. Lastly, the study investigated whether different existing travel routines (actively checking in/out with a smartcard or not) facilitated or hindered crowdshipping habit formation.

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4.4.2   Main results

In the study it was found that the construct 'anticipated social value and positive emotions' (ASP) was significantly positively related to habit formation; participants who to a higher degree anticipated having positive feelings evoked in relation to engaging in the service reported a higher degree of habit formation. Second, the study found that recipients of the environmentally framed feedback showed more conducive results on ASP, concept attitude, habit formation and quantity of parcels carried during the experiment. The study also found that the provision of environmentally framed feedback strengthened the habit formation effect of ASP: a significant effect on habit formation was found for participants with high pre-survey ASP who received the environmental feedback – not for any of the other ASP/feedback groups (low ASP/environmental feedback, high ASP/economic feedback, low ASP/economic feedback). The results suggest that behavioural cues may be formed through the conditioning of emotional reward value onto situational contexts. The results also support the findings of the previous studies that a crowdshipping concept may benefit from appealing to altruistically and socially oriented values. Finally, the study found a significantly higher degree of habit formation reported amongst public transport passengers using the Danish smartcard 'Rejsekort'. This group has the cognitive and practical task of paying for their trips by physically checking in and out at placed cards readers. The results suggest that they may gain an advantage in novel habit formation through chaining to this related existing routine.

5   Discussion and implications of findings

The following part of the thesis discusses the main findings and considers the accompanying implications.

5.1   Idealistic and instrumental motives; finding a balance

The findings of the sub-studies lead to potential implications that are relevant to consider for the design and promotion of potential future crowdshipping concepts. Paper 2 points to the potential benefits of strategically highlighting different aspects of the service to different population segments. The results showed that the crowdshipping concept could advantageously be presented as a bottom-up user-driven movement. Here, focus should be on the users' drive to support each other and the community in addition to the environmental contribution of participation. In particular, this focus seems important to emphasise towards younger users (below the age of 26). In addition to having higher participation propensity, they expect – to a significantly higher degree – their participation to elicit positive feelings and social resonance. This is also the case for the second youngest group of potential users (the 26–39 year olds), although to a lesser degree than the youngest. For recruitment efforts targeted towards participants at age 65 and above, the results point to the need to demonstrate the ease of use and reassurance of their efficacy; the group's concerns regarding the ease of use (perceived behavioural control) can be addressed by assuring them that they are capable of crowdshipping when travelling with public transport.

Although the results of both Survey 1 and the qualitative interviews indicated the benefits of highlighting the environmental and social aspects of the service, they also pointed to the risk of a backlash if these values are not perceived as genuinely embedded in the concept, but simply applied manipulatively as a 'share-washing' varnish. The risk here is that the organisation behind the concept would be accused of exploiting the positive emotions (e.g. warm glow) associated with the sharing economy (Curtis & Lehner, 2019). According to the interviewees, the best strategy for avoiding this is to be fully transparent about the organisation of the concept in general and about the cost and compensation structure in particular. As the compensation available for participants is relatively small, a certain goodwill towards the purpose and organisation behind the concept would likely be necessary for many participants. However, for users more driven by instrumental motives – which were also represented in the interviews – this may be less influential. It has previously been shown that community and altruistically driven users react with scepticism towards a for-profit turn of a former non-profit sharing economic platform, while it was perceived as unproblematic or even favourable by users with more instrumental attitudes (Mikołajewska-Zając, 2016). In general, the economic aspect should not be underestimated in relation to a wider roll-out of a crowdshipping concept. Previous studies have shown the high importance of economic incentives (e.g. Hamari et al., 2016; PWC, 2015).

However, in considering such indications of the relative importance of economic versus more idealistic motives, it should be kept in mind that the sharing economy should not be perceived as one coherent phenomenon. Instead, the relative importance of economic, social and environmental motives varies across its sectors and across cultural contexts (Böcker & Meelen, 2017).

5.2 A need for predictability

In Paper 3, we found a preference for carrying a parcel on return trips, as opposed to bringing them on outbound trips. The regression results also showed that participants who most often brought parcels on their outbound trips brought significantly more parcels during the experiment. This is in line with previous research, where predictability has been shown to affect the stress levels of mass transit morning commuters (Evans et al., 2002). This is a potential challenge for a crowdshipping concept intended to serve as a last-mile delivery solution for central city districts, where the relative advantage is biggest (for the reasons described in Section 2.1). The solution should ideally utilise the city-bound passenger flow to make optimal use of outskirt commuters on their way to work or school in central districts of the city. This points to the need to address any (perceived) issues of added trip unpredictability related to participation. Although participants were generally seen to be able to distinguish between their participation in the experiment (measured as acceptance) and participation in a realised concept (measured as intention), the perceived issues of added unpredictability during the experiment will have been most pronounced for the relatively high number of participants who experienced connection issues (54% of participants agreed or strongly agreed to having experienced issues connecting to the lockers through the app). This was also emphasised by many participants to be the most negative aspect of participation via text entry fields of the post-survey, and in some cases it was a reason for hesitation to carry a parcel. It was pointed out that this was especially the case in instances with time constraints, such as going to work or transferring to other public transport. A realised solution should obviously address the connection issues that establish a perceived barrier to participation, as well as ensure that participation is generally an easy and smooth experience which integrates well into existing routines. This would, for example, be by including GPS functionality to facilitate APL localisation and providing an indicator of next departure to the app interface to help inform the decision of whether to carry a parcel. The issues of (un)predictability, however, may not be entirely within control of an operator of a crowdshipping concept, but are also affected by the transit system context in which it is embedded. In the regression results, satisfaction with travel was found to have a significant effect on behaviour during the trial, where those with higher satisfaction with travel carried more parcels. This points to the importance of a well-functioning public transport system as a pre-requisite for implementing a public transport-based crowdshipping service. This could be interpreted as an expression of the need for predictability and a certain mental surplus in the

relevant situational travel context, if the user is to actually perform the action of bringing along a parcel as he/she intended.

5.3 Anticipated emotions and motivated cueing

Anticipated positive emotions' facilitating potential for habit formation was illustrated in Paper 4, where 'Anticipated social value and positive emotions' (ASP) were found to be significantly positively related to habit formation. The results indicate that a higher degree of anticipated positive emotions might positively influence the participant's immediate evaluation of the behaviour (the automatic affect), which would subsequently guide him/her towards pursuing it. This process would be akin to 'motivated cueing'; the (emotional) reward value of carrying a parcel is conditioned onto contextual cues in the relevant transit situation (Wood & Neal, 2007). An alternative interpretation to this is that the higher degree of anticipated positive emotions directly leads participants to carry a parcel more often, which would then lead to stronger habits. To test this alternative interpretation, an additional linear regression was performed with habit formation as the dependent variable. Amongst the independent variables, this regression included the number of trips taken with a parcel and pre-survey ASP as a separate continuous variable. The results supported the first interpretation – that motivated cueing is established – as ASP was also highly significant in this model.

Along the same lines, it was found that an environmentally framed feedback further supported the habit formation effect of ASP in comparison to the economically framed feedback. This might also indicate that the emotional reward value can become conditioned onto situational contexts to establish behavioural cues. This could be viewed through the lens of Bamberg's (2013) stage model of self-regulated behavioural change, which consists of a predecision, preaction, action and postaction stages. In the predecision stage, the creation of 'goal intention' (an element in the formation of a new behaviour according to the model) is supported by positive emotions that are anticipated to be evoked with goal progression. In this light, the anticipated positive emotions (included in ASP) could be interpreted as being redeemed to a higher degree for participants who received the environmental feedback. This was further supported in the regression results; the positive relation between ASP and habit formation was more pronounced for high-ASP participants who received the environmentally framed feedback. The in-app feedback would thus make salient the norms and values (the normative goals) which the participant had successfully lived up to, thus evoking positive emotions. New behaviour – and eventually habit formation – is thus supported (Carver & Scheier, 1990). Seemingly, recipients of the economically framed feedback did not have their behaviour formation supported in the same manner. It has previously been shown that the activation of financial symbols leads to activation of egoistic values (e.g. Lindenberg, 2018). Appealing to economic self-interest has in some

cases been shown to be less effective in supporting behaviour change within the environmental domain, as it may undermine intrinsic moral motives (Bolderdijk et al., 2013). The results are thus in line with the findings of the other sub-studies, which indicate that the public transport-based crowdshipping concept might increase chances of success by highlighting altruistically and socially oriented values in its promotion and design.

5.4   Environmental and economic savings potential

As mentioned in Section 1.2.2, concurrent work has been done to engage and collaborate with the industry, with the aim of quantitatively analysing the impact of public transport-based crowdshipping on the operation costs of PostNord and CO_2 emissions, as a first step towards a possible realisation of the concept. This work (Cheng et al., 2022) has been submitted during the PhD thesis period, but is a parallel stream of work focussing on the system performance of crowdshipping, and thus not presented as part of the PhD. However, to put the content of the thesis into perspective, it is relevant to describe the savings potential identified in this work.

Cheng et al. (2022) utilised real-world delivery data from PostNord's operations in Copenhagen to generate four scenarios for delivery: 0% crowdshipping (current/baseline), 10% crowdshipping, 20% crowdshipping and 30% crowdshipping. By solving the vehicle routing problem, savings are thus calculated for scenarios where, respectively, 10%, 20% and 30% of randomly selected parcels from the dataset are removed from the current delivery flow and undertaken by crowdshippers. The postal code of 2200 Nørrebro was selected as a test case sample for the study, as it is a densely populated area of Copenhagen, illustrative of the inner city districts. The study period was October 11th-15th, an average period in terms of shipment quantity. On average, around 850 parcels were delivered to the postal code each day. The parcels randomly selected for crowdshipping were drawn from all delivery types: home delivery, deliveries to APLs, deliveries to collect shops and to post offices. In the crowdshipping scenarios, the randomly selected parcels were instead delivered to APL facilities at Brøndbyøster and Glostrup S-train stations, which are the closest to the PostNord distribution hub in Brøndby that serves western Zealand, including Copenhagen. In the three crowdshipping scenarios, the total route length reduction amounted to, respectively, an average of 6.3%, 13.9% and 23.9%. In other words, transferring 10% of parcels for Nørrebro to crowdshippers would result in around a 6.3% reduction in the number of kilometres driven by the last mile van delivery fleet. The reduced working time for the three scenarios amounted to, respectively, 8.3%, 16.5% and 18.9%. Together, these numbers give an indication of the potential savings in both environmental and economic terms.

In very simplified terms, to meet the savings potential for the 10%, 20% and 30% scenarios, sufficient adoption by crowdshippers would be needed to bring along approximately 85, 170 and 255 parcels

per day to serve the postal code of Nørrebro. Size and matching destinations permitting, these may be 'bundled', allowing one crowdshipper to carry several parcels. Based on data from the Danish Rejsekort and the national Danish traffic model (LTM) there are around 300-400 daily trips made from the two stations of Brøndbyøster and Glostrup to the zipkode of Nørrebro. Although this gives an idea of the size of the passenger flow, more work is needed to identify the amount of trips to specific stops within the zipcode, and how the matching of passengers and parcel recipients could be increased by, for example, including workplaces as destinations.

Based on the results of the sub-studies, we argue for the realism of attracting a sufficiently large proportion of Danish public transport passengers to meet the savings potential identified in the most conservative scenario calculations. Around 27% of respondents in Survey 1 stated that they would 'Always' or 'Often' carry a parcel on their most used route in the Copenhagen area. In addition, trying the concept in practice did not seem to deter many experiment participants from acting as crowdshippers in a potential realised concept, although the sample of experiment participants should not be conflated with the representative sample of Survey 1. After the experiment, 82% of participants stated that they had become more motivated to participate in a realised concept by participating. Counterintuitively to this result, they also adjusted their expectations for how often they would bring a parcel significantly downwards in the post-survey compared to the pre-survey. As we still saw high numbers for expected participation amongst experiment participants (47% and 68% stated that they would 'Always' or 'Often' carry a parcel on respectively their most used outbound and return trip), we argue in Paper 3 that the post-survey results show a supportive but reality-checked indication of the adoption potential. However, more work is needed on how the potential identified in the scenarios could most optimally be realised through matching passenger and parcel flows.

6 Limitations and future research perspectives

The approach and the findings of the PhD are subject to a range of limitations which are addressed here. Concerning the experiment and associated data collection, there are several aspects worth noting. The second national COVID-19 lockdown was announced halfway through the originally scheduled experiment period, which resulted in implications for the results and their interpretation. First and foremost, people were sent home from work, and thus there were fewer people who were able to participate, which was clearly seen in non-participants' reasonings in the post-survey results. This was also illustrated by the substantial drop-out rate of 65% from 454 completed pre-surveys to 157 who eventually took part in the practical experiment. Also, the gradual process of gathering public attention about the experiment had only just started at the time of lockdown. The PR resources of DSB − the national Danish train operator − were not available for promotion as originally planned, as they had to be fully dedicated to the COVID-19 situation, also before the lockdown. The small sample size means that generalisability is limited and that findings related to sub-groups should, in particular, be regarded as exploratory.

The − at that time still − extraordinary conditions for passengers represent a bit of a black box in terms of the effects on those still using public transport who were able to participate in the experiment. Some research on the changing circumstances suggests that the disrupted habitual behaviour resulting from the novel situation would actually leave more room for intentionally induced action, and that passengers consequently may in fact have been more prone to (remember to) participate (Wood et al., 2005). Other research, however (e.g. Przybylowski et al., 2021), indicates that having to cope with the circumstances and perhaps nervousness of public transport travel under COVID-19 may have caused an opposite effect. It has previously been shown in the context of transport behaviour how divergence from habitual responses is difficult under conditions of cognitive load, which this added layer of pandemic complexity may represent (Aarts & Dijksterhuis, 2000). Future research would thus add value by setting up public transport-based crowdshipping experiments under more normal conditions.

The setup of the experiment is also worth considering. The parcels used in the experiment were small, empty and weighed close to nothing. As such, they were less of a burden to carry. This may, however, have made it harder for participants to remember to hand in the parcel. If, for example, the participant would need to return to the station as a result of forgetting to the hand in the parcel, this would be a nuisance. The fact that parcels were empty was also demotivating to some participants, who elaborated in the post-survey's text entry fields that it could feel pointless to carry them. However, for the results of Paper 3, we argue that we addressed many potentially related validity issues by

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including two motivational measures: acceptance and intention. Participants were seen to have the ability to distinguish between their test participation (measured through acceptance) and their expectations of participating in a realised concept (measured through intention). Regarding the attitudes towards the service, it is likely that a realised concept operating on market terms would face a higher degree of scepticism compared with the concept of the PhD project that was presented as a research project undertaken by both a university and a company.

Considering the general lack of practical experiments and field work in the sphere of crowdshipping, these limitations can arguably be considered as minor, though, in comparison to the validity issues of studies based on hypothetical scenario descriptions and stated preference studies alone. Nonetheless, future research could benefit from analysing data based on any realised concepts that may arise to enrich findings with the added complexities facing participants. These would, for example, be related to the real contents and value of the parcels as well as the accompanying liability issues.

There are also limitations to consider when interpreting the results for habit formation. The relatively short experiment period was briefer than the time which is often considered necessary to establish novel habits (Lally et al., 2010). Many participants did also not take as many public transport trips as usual due to the COVID-19 lockdown, further exacerbating this issue. The habit formation construct was formed by retrospective and prospective items in an attempt to compensate for this, but despite the construct being empirically formed and having acceptable internal consistency (Cronbach's alpha of .73), this may complicate comparison of the results to previous research. Future research on the topic could benefit from taking a longitudinal approach to improve conditions for evaluating habit-related aspects of participation. To get a more detailed understanding of how cues are conditioned onto the situational contexts of public transport travel, future studies could also benefit from research designs that prompt participants to reflect on their participation immediately following their parcel hand-in. This could allow for more precise descriptions of when and how the opportunity to bring a parcel was cued and acted upon. This was possible within the technical setup of the conducted experiment, but was not pursued as this 'burden' of evaluation could become associated with participation itself (picking up and handing in the parcel). This was deemed a risk, as it might, first, demotivate participation and, second, affect post-survey evaluations if the tasks of bringing a parcel and reflecting on the experience where mentally merged by the participants.

In paper 4, the ASP construct was intended to measure the anticipated positive emotions stemming from social value, feelings of community and living up to own ideals. The construct has acceptable internal consistency (Cronbach's alpha of .72). However, the range of sources for these anticipated positive emotions is broad. It could be argued that this complicates the interpretation of related

results. The same paper also includes the constructs of context stability and habit automation measuring habit strength for public transport and a concept attitude construct. With Cronbach's alphas ranging between .62 and .71, some of these reliability scores are rather low, which must be considered as a limitation.

For findings related to the two feedback framing conditions, the lack of a control group (with no feedback framing) is also a limitation. Related results can therefore only be interpreted as a comparison between environmental and economic framings. Yet, given the small sample size, it was not considered advisable to split up the sample into more than two feedback conditions.

7 Conclusions

In its current form, the last part of business-to-consumer delivery contributes disproportionately to issues such as pollution, congestion and traffic safety, as well as being the most costly part of the transport chain. With the ever-increasing growth of e-commerce, this makes it relevant to explore alternative modes of delivery such as crowdshipping. In crowdshipping, (parts of) the delivery task is outsourced to 'the crowd' rather than undertaken by traditional professional couriers.

The summarised sub-studies in this thesis have proposed and explored the potential for a public transport-based crowdshipping concept from a user perspective. At least in principle, the concept represents an opportunity to balance the environmental, economic and social challenges which has proven difficult for existing crowdshipping concepts. The aims of the PhD were pursued with basis in three main data sources: First, a range of in-depth interviews. Second, a survey distributed to a representative sample of public transport users in the capital area of Denmark. Third, a setup of pre-/post-surveys distributed in relation to a full-scale field experiment testing the concept. This concluding section reflects upon the findings of the individual studies in relation to the overall aims of the PhD project.

Upon briefly being introduced to the crowdshipping concept, around 27% of public transport passengers in the vicinity of the Capital Region of Denmark stated that they would 'Often' or 'Always' carry a parcel on their most used route in the Copenhagen area (respectively values 4 and 5 on the provided 5-point frequency scale). Three attitudinal factors were found to be especially relevant for the formation of intention to participate in the service: perceived ease of use and convenience, the attitude towards participating in a commercial crowdshipping concept and, in particular, the emotional value (consisting of positive emotions related to participation and the social value from participation as well as expected support from important others). Students and the working population were found to be more likely to participate. Young(er) people were found to be the most participation-prone age group, while the opposite was the case for the other end of the age spectrum.

To overcome issues of hypothetical bias, a full-scale real-world experiment was conducted in which the crowdshipping service was tried out in practice by public transport passengers in the Copenhagen area and Northern Jutland. Here, the practical viability of the service was validated from a user perspective, with 82% of participants becoming more motivated to participate in a realised concept as a result of participating. The results of the experiment confirmed the relevance of considering perceived ease of use and convenience as well as positive emotions related to participation as key factors for adoption propensity. Results across the sub-studies also highlighted the importance of predictability and the accompanying need for crowdshipping concepts to integrate smoothly into the

existing routines of public transport passengers. The need for a well-functioning public transit system was illustrated by an effect of satisfaction with travel on the number of parcels carried during the experiment, which indicates that a mental surplus is conducive for participation. The habit stability of public transport use – which may also contribute to such surplus – was found to have a positive effect on crowdshipping habit formation. The same sub-study found a higher degree of reported habit formation amongst participants using smartcards. With the cognitive and practical task of paying for their trips by physically checking in and out at placed card readers, they may have an advantage in establishing the new crowdshipping habit, through chaining with pre-existing routines. Results of the first sub-study indicated that participation is mentally associated with waiting time with some added uncertainty, with a willingness to accept (the opportunity to crowdship) found to be between the value for waiting time and the value for travel time delays.

As the crowdshipping concept is set to operate in the highly habitualised domain of public transport travel, existing routines may pose as barriers to the concrete Monday morning translation of intentions into action. This is illustrated in the results of the fourth sub-study, where habit automaticity for public transport use was found to have a negative effect on crowdshipping habit formation. Results stemming from the experiment also illustrated how anticipated social value and positive emotions may play a facilitating role in habit formation for participation, by leveraging intrinsic motivations to establish environmental cues that initiate action. Anticipated social value and positive emotions are shown to have a positive effect on habit formation. Moreover, in addition to showing more conducive results for a range of attitudinal and behavioural variables, the provision of an environmentally framed feedback is found to further support the habit facilitating effect of anticipated positive emotions; recipients of the environmentally framed feedback who to a higher degree anticipated participation would elicit positive emotions, reported a higher degree of habit formation than those with lower expectations, as well as recipients of the economically framed feedback (both those high and low in anticipated positive emotions). This suggests that the formation of behavioural cues may be supported by emotional reward value being conditioned onto situational contexts.

The anticipated positive emotions that are shown to have strong conducive effects for participation cannot simply be a conceptual varnish applied to the concept in communication efforts, but must have a basis in actual environmental and social benefits. The interview results indicated the risk of a backlash if the service is perceived as a greenwashed precarisation of delivery that capitalises on the good intentions of people. An actual positive environmental effect to accommodate this is seen in the results of the concurrent work with the largest Nordic freight operator. Calculations of the savings potential of the concept show a substantial beneficial basis; in addition to the economic savings,

simulation results show substantial van fleet reductions and fewer vehicle kilometres driven by implementing a public transport-based crowdshipping system in Copenhagen. As such, the potential for and of introducing a public transport-based crowdshipping concept has been substantiated by the present work. A realisation of the concept may not in itself be *the* solution to solve the issue of the delivery chain's last part; however, it may serve to illustrate how socially founded solutions based on new ways of enabling cooperation may supplement technically based solutions, as a part of the multitude of efforts that are needed to address the current challenges of pollution, congestion and liveability.

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8 Appendix: The papers

A public transport-based crowdshipping concept as a sustainable last-mile solution: Assessing user preferences with a stated choice experiment

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A public transport-based crowdshipping concept as a sustainable last-mile solution: Assessing user preferences with a stated choice experiment

Abstract

In this study, we analyse user preferences for a public transport based crowdshipping concept, where users carry parcels along on their ride. The concept offers potential economic, environmental and social benefits over other last-mile solutions. We set up a stated choice experiment in which respondents indicate whether they would be willing to bring a parcel along on their ride, while varying the number of parcels, their size, weight, the compensation and required extra time. Based on data from 524 public transport passengers in the Greater Copenhagen Area, we estimate a mixed logit model and find all main effects to be significant. Our results indicate that young(er) individuals, students and (to a lesser extent) employed and self-employed individuals are more likely to participate in the crowdshipping concept, while old(er) individuals (60+) are less willing to participate. Our findings further show that the marginal disutility of time spent retrieving and dropping off parcels is higher for old(er) respondents and individuals with high(er) income, while it is lower for individuals with a short-term education. Finally, we find the value of time to be slightly higher than the official Danish value for waiting time but lower than the value of travel time delay. Findings can inform the design of a crowdshipping system as well as related engagement efforts.

Highlights

- User preferences for a PT crowdshipping concept is explored using a SC experiment
- The monetary compensation is positively associated with the willingness to crowdship
- Time use, weight, size and number of parcels are negatively associated
- Students, workers and young(er) individuals are more likely to bring parcels
- Value of time to bring parcels is slightly higher than value of waiting time

Keywords

Crowdshipping, last-mile parcel delivery, discrete choice models, user preferences, stated choice experiment

1 Introduction

The growth of e-commerce gives rise to increasing environmental and social costs (Viu-Roig and Alvarez-Palau, 2020). In particular, last-mile delivery poses a challenge, as high customer expectations for delivery time, lacking possibilities of consolidation, and dispersed destinations make it the most inefficient and expensive part of the delivery process (Macioszek, 2018). Last-mile delivery leads to increasing environmental problems caused by emissions from stop-and-go traffic by diesel-powered delivery vans, while second-row parking and blocking of cycle and pedestrian paths challenge road safety (Groth *et al.,* 2019).

Co-modal solutions have been applied and studied as part of the delivery chain, where parts of trams, trains or busses are used for freight transport (e.g. Arvidsson, Givoni and Woxenius, 2016), but final delivery to customer address or pick-up point is not addressed in such solutions.

In recent years, crowdshipping has received increasing attention in the search for solutions to mitigate challenges posed by these developments. Crowdshipping refers to the distribution of delivery tasks to "the crowd", typically through an online platform. However, its application does not guarantee a solution balancing the environmental, economic and social challenges. Many crowdshipping concepts make use of private vehicles resulting in rebound effects from dedicated trips or detours, and thus increased fuel consumption (Paloheimo et al., 2016). At the same time, the sharing economy, under which crowdshipping could be labelled, has raised concerns for the rights of workers. The 'gig economy' is here seen by critics as a dystopic scenario where 'platform capitalists' profit and leave the on-demand workers fighting over the crumbs (Paus, 2018). Such applications of the crowdshipping term are accordingly not necessarily in line with the visions of the UN's sustainable development goals.

The use of non-dedicated public transport trips in combination with automated parcel lockers (APLs) represents an opportunity that at least in principle has the potential to mitigate the three-faceted challenge of last-mile delivery. APLs already serve as a delivery option to address pressure on the last mile, with a range of operational and service-related benefits in themselves compared to traditional last mile delivery (Zurel et al., 2018). By supplementing the vans delivering to these APLs, public transport trips could reduce the amount of van deliveries to city centres, instead allowing them to drop off at city outskirts. In the concept proposed and investigated in the present paper, public transport passengers are offered compensation for bringing along parcels from APL to APL on their trips in which matching itineraries allow it. When compensation for bringing a parcel along on the trip is provided in form of reduced travel expenses (as opposed to ready money), the service does not qualify as a precarious (side) job, and the potential to prevent negative social effects becomes evident. This concurrently ensures that only public transport trips that would be taken anyway are utilised.

However, both academically and practically, public transport based crowdshipping has received very little attention. A few papers (all connected to Roma Tre University's 'TRE Lab') have described and explored such a crowdshipping concept (Gatta et al., 2019; Marcucci et al., 2017; Serafini et al., 2018; Simoni et al., 2019). To our knowledge, no practical examples exist (the closest perhaps being the 'Ritzen Koeriers' operating in the 90's, where students were employed to deliver parcels via public transport [University of Groningen, 2021]).

The efficiency and economic benefits for the freight provider will highly depend on user acceptance. The present paper therefore assesses contingencies related to the willingness to act as a crowdshipper on public transport trips. This is done through a Stated Choice (SC) experiment which was conducted as part of a survey distributed to a sample of citizens of the Capital Region of Denmark.

The main contribution of this paper is a greater level of detail on service and shipment characteristics, giving an improved starting point for work on realising a public transport based crowdshipping

concept. More specifically, the included attributes will allow for a more precise estimate of appropriate compensation levels for various shipment characteristics and a comparison with average values of travel time as well as values of travel delays for Danish public transport commuters. In addition to shipment characteristics, also demographic characteristics of the potential crowdshippers are taken into account and will reveal which population segments are most likely to engage in the concept.

The remainder of the paper is structured as follows: Section 2 reviews the literature on last-mile crowdshipping solutions, service and shipment characteristics and sociodemographic characteristics of crowdshipping participants. Section 3 presents the design of the SC experiment, the data-collection procedure as well as sample characteristics and lastly the modelling methodology. In Section 4, the main results are presented and a policy analysis is performed. Section 5 concludes the paper with the main findings and implications for research and practice.

2   Literature review

Starting with an overview of previous work on last-mile crowdshipping solutions (Section 2.1), the scarce work on relevant attributes for the assessment of potential of a public transport based crowdshipping solution is highlighted in Section 2.2. Finally, Section 2.3 discusses sociodemographic characteristics of crowdshipping participants identified in previous work.

2.1   Last-mile crowdshipping solutions

As is the case for a major part of realised crowdshipping concepts, the main body of literature within transport research has dealt with concepts based on private vehicles. Le *et al.* (2019) review the literature on crowdshipping from the three-fold division of *supply* (crowdshippers), *demand* (customers), and *operations and management*. The focus of the present paper will be on the crowdshipper side. The results of previous research on the importance of customer side attributes are assumed to be more applicable to the case of public transport based crowdshipping than for the crowdshipper side. SC experiments have been deployed to identify influential service attributes on the acceptance of options faced by the customer side of private vehicle based crowdshipping platforms (Punel and Stathopoulos, 2017). As such, it is assumed that the most important attributes identified here, e.g. "Delivery Cost", "Package Received in its Integrity" and "Speed" (p. 27) are relevant for customers, independently of the crowdshippers' mode of transport.

As the private vehicle based crowdshipping delivery mode shares many features with more traditional last-mile solutions relying on road vehicles, a large part of research on crowdshipping has concerned itself with operations and management issues, such as formulating logistics optimisation problems (e.g. Wang *et al.*, 2016; Devari, Nikolaev and He, 2017) or matching supply and demand side (e.g. Ermagun and Stathopoulos, 2018, 2020; Ermagun, Punel and Stathopoulos, 2020). Most trips undertaken as carrier in such crowdshipping platforms will not precisely match any originally planned trips. To accommodate the probabilistic nature of the uncertain user behaviour, dynamical models have been applied in the matching of demand and supply side in such optimisation efforts (Allahviranloo and Baghestani, 2019). The environmental sustainability of crowdshipping initiatives has been shown to be heavily influenced by the trip type – dedicated or existing – being utilised (Qi et al., 2018). Private vehicle based crowdshipping concepts that often result in additional trips or detours will therefore often result in higher emissions (Buldeo Rai et al., 2018). By contrast, Gatta *et al*. (2019) found substantial emission reduction potential of a public transport based crowdshipping service in Rome. Results were obtained from scenario analyses building upon results from a SC survey.

2.2 Service and shipment characteristics

Investigating a public transport based crowdshipping system, SC experiments have been used in several studies by the same research group to assess potential for user uptake on both crowdshipper and customer side (Serafini *et al.*, 2018; Gatta *et al.*, 2019). On the crowdshipper side, these studies identified APLs' location (inside metro station) as the most relevant feature, followed by bank credit mode (single delivery) and remuneration. Real-time booking was preferred over offline, but was found to be the least required feature. However, more evidence of the viability of a crowdshipping concept is still needed, as many aspects of a potential crowdshipping framework remain unclear. The usefulness of quantitatively treating the attributes such as remuneration, to calculate robust Willingness To Accept (WTA) measures, was highlighted for future work on public transport based crowdshipping (Gatta et al., 2019). As another example, parcel size has been shown to influence the willingness to act as a crowdshipper, but has not been included as an attribute in their SC experiments (Marcucci, 2017). In fact, no one has explored in detail how the characteristics of shipments impact the willingness to act as a crowdshipper and what tradeoffs are made with regard to the size, weight and number of parcels, which is essential information for potential crowdshipping providers.

2.3 Sociodemographic characteristics of crowdshipping participants

Punel *et al*. (2018, 2019) investigated the determinants of crowdshipping use. They found young people, men and full-time employed people to be more prone to partake in crowdshipping initiatives. Furthermore, they found higher willingness amongst individuals with a strong sense of community and environmental concern.

A comparison of demographic characteristics of drivers of the ride-sharing company Uber in the US with the general workforce and taxi drivers/chauffeurs based on two surveys and census data (Hall and Krueger, 2018) revealed that Uber drivers are overrepresented in the age group 30-39 and underrepresented among older age groups. Uber drivers more often have a college degree than the other two groups. The main motivation for their job was "to earn more income to better support myself or my family'' suggesting that people did not earn enough in their current job – one third of drivers worked for Uber in addition to a part-time, one third in addition to a full time job.

Serafini *et al*. (2018) also found older people to be less interested in acting as crowdshippers using public transport. Young people have previously been shown to be more open to try new services and are as digital natives more familiar with the digital tools needed for participation. In general they also show higher flexibility in terms of travel mode choice (Dias *et al.*, 2017). In particular, millennials have shown higher attraction to sharing economy (Hwang and Griffiths, 2017). Males were also found to be more willing to participate in crowdshipping by Miller *et al*. (2017), while they found that both low-income and high-income earners as well as individuals with a graduate degree were less inclined to participate. The U-shaped income effect is suspected to be related to lacking schedule flexibility and work pressures in the extreme income classes, while demands and rewards of crowdshipping might be more aligned with the medium income classes.

3 Method

3.1 Design of the SC experiment

This section describes the process, considerations and decisions regarding the SC experiment. As mentioned in the introduction, very few studies have analysed the topic, so creating a suitable design is to some extent a pioneering task. To our knowledge, the only previous study that used a SC experiment for assessing public transport based crowdshipping effects is Gatta *et al*. (2019). They constructed an experiment, where four attributes were measured with two levels each. With an A, B

and a 'No choice' option, using a Bayesian D-Optimality efficient design, four different questionnaire blocks were produced, each consisting of three SC questions, resulting in twelve different attribute level combinations. The four attributes were 'Location of APL' (Inside metro stations / Outside metro stations or by adjacent buildings), 'Remuneration' (1/3 € per delivery), 'Delivery booking' (Real-time booking / Offline booking) and 'Bank crediting modes' (Single delivery / Every 5 deliveries).

The motivation for this study is to move towards a more detailed concept description compared to Gatta *et al*. (2019), which can lead to more realistic scenarios. In the crowdshipping concept described to participants, APLs are placed directly at stations/stops (Danish stations are – in contrast to the metro stations of Rome – not closed off by ticketing facilities, and the inside/outside-distinction is thus more blurry). All interaction with the service – including the booking of parcels, the opening of APLs and immediate remuneration – is facilitated by an app. Having already defined these functionalities, we include characteristics of the shipment in the SC design. Thus, similar to Gatta *et al*. (2019) our SC design will include compensation to closely reflect the actual practical tasks that participants face. To improve the realism of the scenarios, we add four new attributes to the SC experiment. This gives a total of five attributes: compensation, extra time (in total), number of parcels, size (in total) and weight (in total). The addition of a specific time component allows for an assessment of the valuation of travel time in the sample.

The attribute levels were set based on several preliminary investigations. Firstly, 13 semi-structured interviews about the crowdshipping concept had been conducted prior to the SC design process (Fessler et al., 2021b). The interviews included men and women aged 19-55 living in outskirts and central districts of Copenhagen. The interview guide included a broad range of topics related to the service, including an imagined scenario with point of departure in their own use of public transport, which highlighted practical preferences and barriers for participation. Responses informed the selection of both relevant attributes and levels.

Secondly, upper boundaries for compensation levels were informed by existing data on last-mile costs, which have been shown to constitute from 13% up to 75% of supply chain costs (Gevaers et al., 2009). In order to increase the span available for interpretation, the time attribute was set relatively high, considering that the APL interaction itself can be handled in less than 30 seconds with an app developed for a subsequent real-life experiment (Fessler et al., 2021a). The time attribute was iterated from an earlier pilot-tested design (N=77), where an interpretable range of time of 1-5 minutes was shown to be too narrow. The final design was based on the attribute levels shown in Table 1 (tested in pilot with N=59).

ATTRIBUTES	LEVELS				
Compensation (DKK)[2]	5	10	20	30	50
Extra time (minutes)	1	2	4	6	8
Number of parcels	1	2	3	4	5
Total size (litre)	0.5	1	2	4	8
Total weight (kg)	0.5	1	2	3	5

Table 1: Levels for the attributes in the SC experiment.

The design was constructed using the software package Ngene (ChoiceMetrics, 2012). An efficient design was chosen in the construction of the SC experiment, where participants were asked to choose between two shipment options, 'A'/'B', and a 'No Choice' option: 'I would not choose either of the

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[2] This corresponds to the compensation ranging between 0.67-6.72 EUR. Date of currency conversion: January 4th 2021.

two'. While efficient designs were originally motivated by their higher efficiency in maximising effects in smaller sample sizes in comparison with orthogonal designs (Rose and Bliemer, 2009), we use them to allow for the insertion of 'conditions', in order to avoid dominated alternatives. The design rejected choice tasks where 1) one of the alternatives had 4 advantageous attributes or 2) both Compensation and Time was advantageous for the same alternative and 3) an attribute had the same level in both alternatives. No constraints were imposed on combinations of number of parcels, size, and weight within each alternative. In total 40 choice tasks were constructed and divided into 10 blocks, resulting in 4 choice tasks presented to each respondent. The scenarios appeared as shown in Figure 1:

Figure 1: Choice task example.

3.2 Procedure and participants

The data was collected in May and June 2020 through an online survey. The survey was distributed by Epinion, a private data analytics enterprise. We aimed for a representative sample for the Capital Region population in terms of age, gender and level of education. Criteria for inclusion in the survey were residence in the Capital Region of Denmark and using public transport at least monthly. The respondents were explicitly instructed to answer from the context of their own lives and transport habits prior to the COVID-19 outbreak, that had brought the country to a lockdown at the time of data collection.

In Table 2, the sample characteristics are compared with weighted values from the Danish National Travel Survey (Transportvaneundersøgelsen, TU) (Transport DTU, 2020a). The TU sample includes respondents from the same region with public transport use on the sample day and/or with an active public transport season ticket. As this extraction favours more regular public transport users compared to our sample, this may explain the higher proportion of young people, students and employed people in the TU sample[3].

In the crowdshipping concept presented to survey participants, APLs were placed at public transport stations and stops. Through a smartphone app, registered users[4] were offered the possibility to bring one or several parcels along on their public transport trip from departure point to the matching end- (or transit-) point. Crowdshippers were compensated with public transport fare credits.

Apart from the four choices related to the SC experiment (see Section 3.1), socio-demographic information was requested including age, gender, household type, income, level of education, employment and working hour flexibility. The terms 'Lower education' and 'Higher education' used in

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[3] Due to differences in income-registration (after vs before taxes), this variable is not included from TU.
[4] This paper does not involve the demand (customer) side, and references to *users* therefore relate to crowdshippers.

the paper refer to respectively 'Short-term further education or below' (below 2 years education after high school) and 'Medium-term further education or above' (2+ years education after high school). On average, it took 10-15 minutes to complete the survey (the survey collected other information not relevant for this paper).

The data – consisting of 567 respondents - was cleaned by removing responses from participants who completed the survey in less than 4 minutes (=less than 40% of the median duration) as well as participants with suspicious answer patterns. After data cleaning, the final sample consisted of 2096 observations collected from 524 respondents. In approximately half of the choice tasks (46%), the "no-package" option was chosen. Table 2 presents descriptive statistics of the final sample, while Figure 2 presents the attribute level distribution in the data, and Figure 3 shows the correlation among attribute differences between alternative A and B.
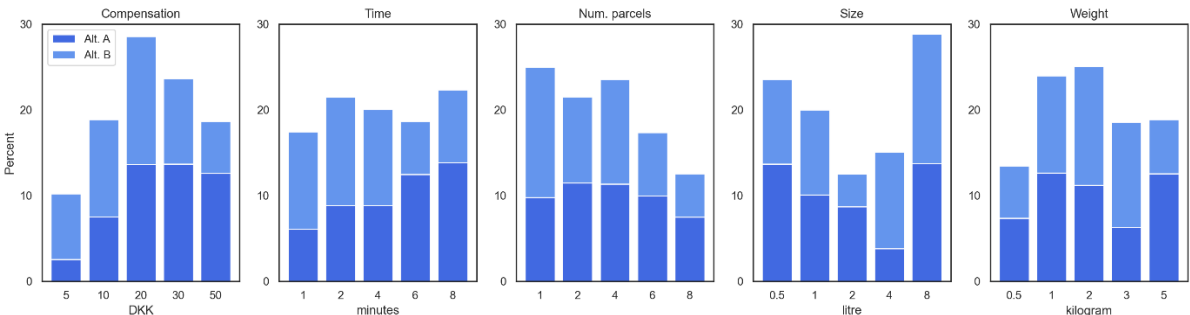
Figure 2: Distribution of level values across alternative A and B for all five attributes
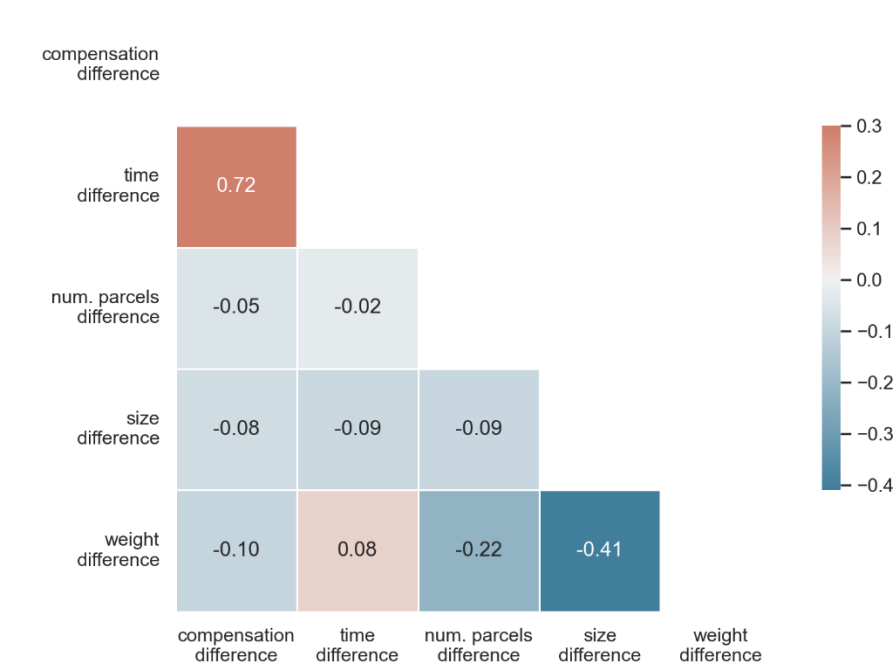
Figure 3: Correlogram of attributes differences between alternative A and B.

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VARIABLES	#	%	TU
Gender			
Female	261	49.8%	45.9%
Male	259	49.4%	54.0%
Other/Do not wish to answer	4	0.8%	
Age			
18-39 years	188	35.9%	56.9%
40-60 years	153	29.2%	20.8%
Above 60 years	183	34.9%	22.4%
Employment status			
Employed/Self-employed	266	51.0%	45.3%
Student	60	11.5%	28.9%
Not working	196	37.5%	25.8%
Education			
Higher education	257	49.0%	56.5%
Lower education	267	51.0%	43.5%
Income			
High: ≥ 50,000 DKK/month	86	16.4%	-
Medium	187	35.7%	-
Low < 20,000 DKK/month	171	32.7%	-
Unknown	80	15.2%	-

Table 2: Descriptive statistics of the sample.

3.3   Modelling methodology

In order to estimate user preferences, we rely on discrete choice models based on random utility maximisation (RUM), see e.g. Train (2009). We define a Mixed Logit (ML) model, in which the utility U_{nti} for individual n, alternative i, and choice task t takes the form:

$$U_{nti} = V_{nti}(\beta_n, x_{nti}) + \varepsilon_{nti} \tag{1}$$

where V_{nti} is the systematic part of the utility, β_n is a vector of taste parameters that follow a density $f(\beta)$ in the population, and ε_{nti} is the standard i.i.d. extreme value type 1 error term. The inclusion of random taste parameters that only vary across individuals allows the model to account for potential panel effects across observations from the same respondents. The probability P that individual n chooses a series of alternatives $i = \{i_1, \dots, i_T\}$ over T choice tasks is then given as:

$$P_{ni} = \int \prod_{t=1}^{T} \frac{\exp\left(V_{nti}(\beta_n, x_{nti_t})\right)}{\sum_j \exp\left(V_{ntj}(\beta_n, x_{ntj})\right)} f(\beta) d\beta \tag{2}$$

In this notation, we use j to sum over the alternatives in choice task t for individual n. We suppress this to keep the notation simpler. Since the integral does not have a closed form, we rely on simulation in order to estimate the parameters that maximise the loglikelihood function:

$$LL = \sum_{n=1}^{N} \sum_{i} \ln \left(P_{ni}^{\;y_{ni}}\right) \tag{3}$$

where y_{ni} is 1 if the series of alternatives i is chosen by individual n, 0 otherwise.

The base utility specifications are presented below where the two unlabelled options (i.e. options A and B) are defined based on five attributes. Since the SC design also include a "no choice" option, which has no characteristics, we model this on the basis of an alternative-specific constant (ASC). More specifically, we define the systematic part of the utility V_{int} as shown below. Note that for the final model specification we also test non-linear effects as well as systematic and random preference heterogeneity, which are omitted here for simplicity.

$$V_{nti}^{A} = \beta_{Compensation} * Compensation_{nti}^{A} + \beta_{Time} * Time_{nti}^{A} + \beta_{Detour} * Detour_{nti}^{A} \\ + \beta_{Size} * Size_{nti}^{A} + \beta_{Weigth} * Weigth_{nti}^{A} \tag{4a}$$

$$V_{nti}^{B} = \beta_{Compensation} * Compensation_{nti}^{B} + \beta_{Time} * Time_{nti}^{B} + \beta_{Detour} * Detour_{nti}^{B} \\ + \beta_{Size} * Size_{nti}^{B} + \beta_{Weigth} * Weigth_{nti}^{B} \tag{4b}$$

$$V_{nti}^{No\ Choice} = ASC^{No\ Choice} + \eta_{ni} \tag{4c}$$

4 Results

4.1 Model estimation

Models are estimated in PandasBiogeme (Bierlaire, 2020) using 10,000 MLHS-draws (Hess et al., 2006) and the CFSQP-algorithm (Lawrence et al., 1997). A model summary and comparisons among various models are presented in Table 3, while the final parameter estimates are presented in Table 4 (base models are included in appendix for completeness). Table 4 shows that all parameters have the expected signs, thus an increase in monetary compensation increases the utility – and thus the probability – for bringing a parcel. Contrary, an increase in time, size, weight, or number of parcels decreases the utility – and thus the probability – for bringing parcels.

We tested for socio-demographic differences and heterogeneity in preferences, and in the final model kept the effects found to be significant. Note that all main effects are included in alternatives A and B ('No choice' is used as reference). More specifically, younger respondents (below 40 years of age) have a higher base utility for bringing parcels, while older respondents (above 60 years of age) have a lower base utility for bringing parcels. These findings are similar to the results of Gatta *et al.* (2019) who also found interest in participating in public transport based crowdshipping to decline with age. With respect to primary occupation, we see that both students and (to a lesser extent) individuals in jobs are more likely to pick up a parcel compared to individuals not studying or working. This seems plausible as both students and workers would usually/frequently commute to the location of their main occupation. Furthermore, older respondents and respondents in the highest income groups (50,000 or more DKK/year) have a higher marginal disutility for time, which is in line with existing literature (Börjesson et al., 2012; Mackie et al., 2001), while individuals with a higher education are more willing to accept extra time used for picking up parcels. We also tested for income effects in

compensation in various ways [beta*compensation*(income/mean income)^gamma], but did not find any significant effects in our data.

The ML models include a normally distributed error component which accounts for correlation among observations from the same respondents (panel effect). The error component is seen to be significant across all four specifications, and while the mean ASC coefficient is highly dependent on specification, the variation (ASC_NoChoice_S) is rather stable.

We tested for non-linear effects in all attributes, and found compensation to possess non-linear effects, while the remaining attributes were not significantly different from a linear specification. In Table 3, we have compared the linear specification with models with a log and BoxCox transformation of compensation. We find that lambda in the BoxCox transformation is significantly different from 1 (i.e. a linear specification) and that the BoxCox model overall has a significant improvement in fit compared to the model with a linear specification for compensation. However, we find that lambda in the BoxCox model is not significantly different from 0 (i.e. a log-transformation) and that the BoxCox model overall does not have a significant improvement in fit compared to the model with log specification. For completeness, we also tested a model that included compensation with both a linear and log-transformed component, and find that only the parameter for Log(compensation) is significantly different from 0 (rob T-test = 3.82), while the parameter for compensation is not (rob. T-test = 1.01). The final loglikelihood is -1461.0, which yields that the model is not significantly better than the Log-model at 1 degree of freedom. Hence we disregard this model for further investigation.

We cannot directly compare the linear and log specifications using a Likelihood Ratio (LR) test, but we can compare their behavioural effects. More specifically, in the non-linear specification the marginal utility is a function of the attribute. In the linear specification, the marginal utility remains unchanged for the full range of compensation, however, for the log-specification the marginal utility halves when the attribute doubles, which in turn means that the WTA doubles when compensation doubles. We believe this could lead to some unrealistic effects and an undesirable interpretation of the behaviour, and therefore we prefer the linear specification as the differences in model fit to data are relatively small. For comparison, we present the linear, log, and BoxCox specification below, and it can be seen that results remain fairly stable across the three models.

We also tested for unobserved preference heterogeneity. More specifically, we specified normally distributed preferences in the sample. We found that all attributes had unobserved preference heterogeneity. However, the assumption of normal distributed preferences is not without issues. Firstly, a portion of the sample will due to the tails of the distribution end up with a counterintuitive sign. Secondly, simulation of WTA measures and marginal rates of substitution becomes highly unstable when draws are included in the denominator both due to draws with a "wrong" sign and – in particular – draws close to 0, which will make the WTA measures explode. To alleviate these issues, we tested both lognormal and triangular distributions, which both solved the first issue, however, the lognormal distribution also provided highly unstable WTA measures during simulation, while the triangular distribution provided stable WTAs, but this came at the cost of forcing the spread of the distribution to be equal to the midpoint of the distribution to avoid draws with a wrong sign. In the end, we decided to stick with the model including normally distributed preferences on all attributes except for compensation. This allowed us to compute stable WTAs because we did not have draws in the denominator (a similar approach is found in Basu and Hunt, 2012), however, the marginal rates of substitution still remained unstable, and thus are not presented here. The model with unobserved preference heterogeneity is presented alongside the other models in Table 3, 4, and 5. As mentioned, due to the assumption of normally distributed preference heterogeneity, some respondents will

inherently have a counterintuitive sign. In Table 4, we computed the percentage with the expected sign within each segment.

	ML1 (Linear specification)	ML2 (Log specification)	ML3 (BoxCox specification)	ML4 (Linear specification, unobserved preference heterogeneity)
Model Summary				
Number of parameters:	17	17	18	21
Sample size:	524	524	524	524
Observations:	2,096	2,096	2,096	2,096
Number of draws:	10,000	10,000	10,000	10,000
Algorithm:	CFSQP	CFSQP	CFSQP	CFSQP
AIC:	2972.2	2957.4	2958.1	2877.7
BIC:	3044.6	3029.9	3034.8	2967.2
Final log likelihood:	-1469.1	-1461.7	-1461.1	-1417.9
Model Summary				
LR-test against BoxCox-model:	ChiSq = 16.05 > 3.84 => BoxCox-model significantly better	ChiSq = 1.31 < 3.84 => BoxCox-model not significantly better		
T-test of λ against 1:			-5.033	
T-test of λ against 0:			1.222	
MU of Compensation:	$\beta_{Compensation}$	$\dfrac{\beta_{Compensation}}{Compensation}$	$\dfrac{\beta_{Compensation}}{Compensation^{(1-\lambda)}}$	$\beta_{Compensation}$
MU of Compensation = 10:	0.045	0.110	0.172	0.067
MU of Compensation = 20:	0.045	0.055	0.098	0.067

Table 3: Model summary and comparison.

Estimated parameters	ML1 (Linear specification) Value	Rob. t-test	Rob. p-value	ML2 (Log specification) Value	Rob. t-test	Rob. p-value	ML3 (BoxCox specification) Value	Rob. t-test	Rob. p-value	ML4 (Linear specification, unobserved preference heterogeneity) Value	Rob. t-test	Rob. p-value	% right sign
ASC, NoChoice	0.739	1.007	0.314	2.635	3.390	0.001	1.974	2.222	0.026	0.191	0.196	0.845	
ASC, NoChoice, S	-5.841	-11.220	0.000	-5.875	-11.221	0.000	-5.885	-11.217	0.000	-6.647	-9.601	0.000	
Age: 18-39 years**	2.483	3.081	0.002	2.519	3.104	0.002	2.517	3.099	0.002	2.813	2.700	0.007	
Age: Above 60 years**	-1.945	-2.343	0.019	-1.920	-2.295	0.022	-1.932	-2.306	0.021	-2.022	-1.944	0.052	
Employment: Employed/Self-employed**	1.474	2.049	0.040	1.462	2.026	0.043	1.469	2.031	0.042	1.658	1.751	0.080	
Employment: Student**	2.923	2.359	0.018	2.943	2.366	0.018	2.943	2.362	0.018	3.814	2.132	0.033	
Compensation	0.045	10.121	0.000							0.067	9.046	0.000	
Log(Compensation)				1.097	9.845	0.000							
BoxCox(Compensation)							0.622	2.012	0.044				
BoxCox(Compensation, λ*)							0.195	-5.033	0.000				
Number of parcels	-0.120	-3.448	0.001	-0.170	-4.845	0.000	-0.158	-4.421	0.000	-0.275	-4.220	0.000	73.6%
Number of parcels, S										0.435	3.746	0.000	
Total size	-0.127	-7.641	0.000	-0.128	-7.649	0.000	-0.127	-7.581	0.000	-0.216	-6.818	0.000	90.6%
Total size, S										-0.164	-3.314	0.001	
Extra time	-0.088	-2.390	0.017	-0.112	-2.880	0.004	-0.114	-2.953	0.003	-0.148	-2.408	0.016	62.9%
Extra time, Age: Above 60 years	-0.137	-2.677	0.007	-0.143	-2.736	0.006	-0.143	-2.726	0.006	-0.303	-3.727	0.000	84.3%
Extra time, Income: High	-0.160	-2.753	0.006	-0.169	-2.805	0.005	-0.168	-2.807	0.005	-0.277	-2.940	0.003	82.9%
Extra time, Income: Unknown	-0.107	-1.564	0.118	-0.110	-1.617	0.106	-0.110	-1.607	0.108	-0.202	-1.913	0.056	78.3%
Extra time, Education: Higher education	0.062	1.559	0.119	0.059	1.479	0.139	0.060	1.501	0.133	0.082	1.221	0.222	55.9%
Extra time, S										0.447	7.573	0.000	
Total weight	-0.330	-6.360	0.000	-0.350	-6.635	0.000	-0.346	-6.537	0.000	-0.602	-6.412	0.000	94.2%
Total weight, Income: Low	0.224	3.280	0.028	0.215	3.188	0.001	0.220	3.222	0.001	0.310	2.830	0.005	77.7%
Total weight, Income: High	0.183	2.202	0.001	0.198	2.314	0.021	0.196	2.311	0.021	0.289	2.314	0.021	79.3%
Total weight, S										0.383	3.861	0.000	

Table 4: Parameter estimation. * T-test and p-value against 1. ** Main effects included in the crowdshipping alternatives using the "No choice" as the reference alternative. For ML4, the column indicating the percentage with the right sign is computed for the relevant group in the sample.

4.2 Willingness To Accept and marginal rates of substitution

Table 5 presents the WTA measures and marginal rates of substitution among attributes. Table 5 presents average values of WTA and marginal rate of substitution in the sample, which takes into account the socio-demographic distribution in the sample. For all non-linear effects (i.e. compensation in ML2 and ML3) the WTA measures are functions of the attribute values, hence for these we simulate the WTA for both alternative 1 and 2, and present the average value to circumvent outliers. Furthermore, for completeness, Figure 4 plots the raw WTA measures as a function of compensation.

In the following, we focus on the linear specification, but the other models show similar values, and are all well within the confidence interval. The WTA related to time is found to be slightly below 200 DKK/h (~26 Euro/h). For comparison, the official Danish values of time (Transport DTU, 2020b) for commuters are 91 DKK/h (~12 Euro/h) for (in-vehicle) travel time, 183 DKK/h (~25 Euro/h) for waiting time, and 274 DKK/h (~37 Euro/h) for travel delays. Our WTA for time is fairly close to the value of waiting time, albeit slightly higher. We believe this value is indeed realistic as the time for retrieving the parcel would (in many cases) otherwise be spent waiting for the next departure. One possible explanation for our WTA to be higher than the waiting time value could be that it also introduces an element of uncertainty, which could lead to missing the next departure while picking up a parcel, and thus ultimately facing a delay.

We also segmented the value of time based on various socio-demographic characteristics found to be significant in the model. We note that the WTA increases for the segment above 60 years and with high income. The value of an additional parcel, litre, and kg is found to be 2.67, 2.83 and 5.07 DKK respectively. The marginal rates of substitution indicate how individuals (on average) value certain characteristics against each other. For example, Table 5 shows that respondents are willing to bring one additional parcel if they can reduce the total weight by 0.69 kg (or vice versa), or increase the total parcel size a litre if they can reduce the pickup time with 1.74 min (or vice versa).

	Unit	ML1 (Linear specification)	ML2 (Log specification)	ML3 (BoxCox specification)	ML4 (Linear specification, unobserved preference heterogeneity)
Willingness To Accept (WTA)					
Time/Compensation	DKK/min	**3.26 (1.14, 5.34)**	**3.88 (1.75, 6.05)**	**3.60 (0.30, 15.52)**	**4.24 (1.97, 6.65)**
Lower Edu. & Age≤60 & Low-Medium Inc.	DKK/min	*0.61 (-0.88, 1.97)*	*1.18 (-0.30, 2.66)*	*1.12 (-0.58, 4.54)*	*0.98 (-0.72, 2.49)*
Lower Edu. & Age≤60 & High inc.	DKK/min	*4.18 (1.46, 6.76)*	*4.90 (2.18, 7.46)*	*4.52 (0.37, 19.11)*	*5.15 (2.29, 8.28)*
Lower Edu. & Age≤60 & Unknown inc.	DKK/min	*2.98 (0.14, 5.90)*	*3.63 (0.94, 6.79)*	*3.35 (-0.62, 15.02)*	*4.03 (0.99, 7.21)*
Lower Edu. & Age>60 & Low-Medium Inc.	DKK/min	*3.69 (1.51, 5.88)*	*4.31 (2.16, 6.60)*	*3.99 (0.48, 17.46)*	*5.52 (3.42, 8.15)*
Lower Edu. & Age>60 & High inc.	DKK/min	*7.25 (4.00, 10.58)*	*8.85 (5.42, 12.40)*	*8.07 (1.62, 36.12)*	*9.69 (6.46, 13.78)*
Lower Edu. & Age>60 & Unknown inc.	DKK/min	*6.06 (2.36, 9.63)*	*6.25 (3.05, 9.83)*	*5.84 (0.71, 27.93)*	*8.55 (4.92, 12.70)*
Higher Edu. & Age≤60 & Low-Medium Inc.	DKK/min	*1.97 (0.39, 3.45)*	*2.55 (0.90, 4.06)*	*2.39 (0.21, 9.48)*	*2.20 (0.46, 3.87)*
Higher Edu. & Age≤60 & High inc.	DKK/min	*5.56 (3.10, 8.19)*	*6.30 (3.82, 8.94)*	*5.80 (1.11, 23.00)*	*6.33 (3.47, 9.22)*
Higher Edu. & Age≤60 & Unknown inc.	DKK/min	*4.36 (1.50, 7.11)*	*5.10 (2.22, 8.13)*	*4.71 (0.33, 20.08)*	*5.23 (2.16, 8.54)*
Higher Edu. & Age>60 & Low-Medium Inc.	DKK/min	*5.05 (2.84, 7.27)*	*5.74 (3.36, 7.97)*	*5.30 (1.10, 24.64)*	*6.74 (4.48, 9.43)*
Higher Edu. & Age>60 & High inc.	DKK/min	*8.63 (5.74, 11.62)*	*9.07 (6.15, 12.30)*	*8.40 (2.17, 37.22)*	*10.89 (7.67, 14.89)*
Higher Edu. & Age>60 & Unknown inc.	DKK/min	*7.43 (3.71, 11.08)*	*7.87 (4.46, 11.73)*	*7.29 (1.22, 35.01)*	*9.75 (6.10, 14.00)*
Num. Parcels/Compensation	DKK/#	**2.67 (1.02, 4.34)**	**3.80 (2.31, 5.55)**	**3.23 (0.64, 13.79)**	**4.10 (2.39, 6.14)**
Size/Compensation	DKK/L	**2.83 (2.04, 3.71)**	**2.86 (2.06, 3.77)**	**2.61 (0.74, 11.99)**	**3.23 (2.35, 4.19)**
Weight/Compensation	DKK/kg	**5.07 (2.53, 7.88)**	**5.55 (3.03, 8.43)**	**4.96 (0.45, 22.12)**	**6.78 (4.02, 9.90)**
Marginal rates of substitution (MRS)					
Num. Parcels /Time	min/#/	1.64 (-9.82, 14.52)	1.47 (-3.65, 7.74)	1.33 (-3.41, 7.43)	
Size/Time	min/L	1.74 (-10.34, 14.26)	1.10 (-2.96, 5.80)	1.07 (-2.23, 5.87)	
Weight/Time	min/kg	2.95 (-18.56, 27.20)	2.11 (-4.67, 10.75)	2.00 (-4.65, 10.77)	
Num. Parcels/Size	L/#	0.94 (0.40, 1.55)	1.33 (0.80, 1.99)	1.24 (0.69, 1.88)	
Num. Parcels/Weight	kg/#	0.69 (-0.77, 3.23)	0.84 (0.42, 3.03)	0.82 (0.38, 3.01)	
Size/Weight	Kg/L	0.73 (-0.73, 3.17)	0.63 (0.39, 2.13)	0.66 (0.38, 2.34)	

Table 5: WTA measures and marginal rates of substitution. Numbers in brackets represent a 95% confidence interval.
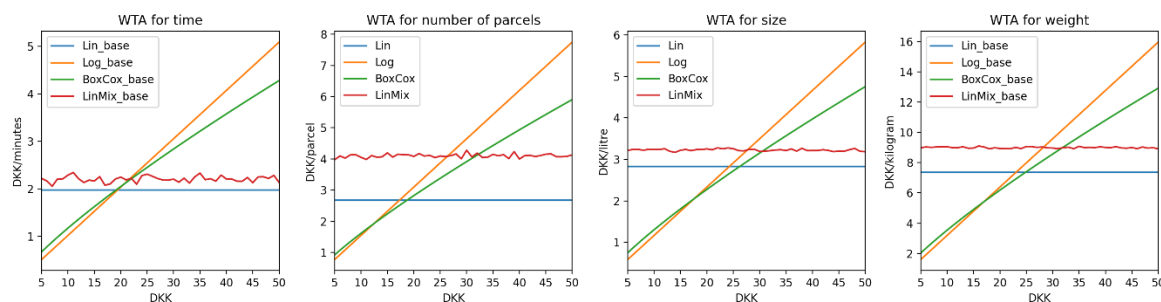
Figure 4: WTA as a function of compensation. Note for the attributes time and weight (for which we found systematic preference heterogeneity) we present only the base WTA for simplicity.

4.3   Policy analysis

In order to evaluate the sensitivity of various groups in the sample towards the measured attributes we perform a policy analysis. However, since the data is based on a SC experiment it does not make sense to assess policy measures directly using the model and data from the previous section. In order to approach a somewhat realistic policy analysis we:

1) Define a binary outcome: bring parcel vs. do not bring parcel.
2) Update all attribute values in the sample for the "bring parcel" alternative to values from a full scale field experiment testing the concept (Fessler et al., 2021a)[5]. Those values were: compensation = 10 DKK, time for retrieving/dropping off parcels = 1 min, number of parcels shipped = 1, size of parcel = 1 litre, and weight of parcel = 1 kg.
3) Calibrated the ASC so that the model reproduced "actual" market shares. The best real life information we had available to calibrate the model was a full scale field experiment undertaken shortly after the current data was collected (Fessler et al., 2021a). This field test showed that parcels were taken on ~40% of the trips. Note that in the field test participants (who can be characterised as 'first-movers') did not receive reminders about bringing parcels, which would likely be the case in an actual realised crowdshipping concept.

Please note that the abovementioned adjustments were done with the same sample as used in the model estimation, thus the socio-demographic distribution in the policy analysis is the same as in the model estimation, see Table 2. Figure 5 presents the probability that various segments would bring a parcel as a function of the five attributes (compensation, time, number of parcels, size, and weight) in the SC design using the level range as bounds. For the income groups, we see that the probabilities to crowdship are similar across income groups, however for time and weight it is visible that the low and high income groups have respectively the highest and lowest probability to bring a parcel. This tendency is more visible as the compensation levels increase. For segmentation based on age and occupation, we see an even clearer distinction in the probability to bring a parcel. More specifically, younger individuals have the highest probability to be a crowdshipper, while older individuals have the lowest. And in line with our expectations, we see that students have the highest probability to bring a parcel. The fact that individuals with a job have a higher probability to be a crowdshipper seems intuitive as they would have a natural commute to and from work (unlike retired/non-employed individuals).

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[5] In a full scale field experiment conducted after data of the current paper was collected, the concept was tested by public transport passengers in Denmark. APLs were placed at selected stations and a smartphone app was developed, allowing participants to collect/hand in small (19 x 12 x 4 cm) empty test parcels in less than 30 seconds per interaction. They were rewarded with 10 kr. per transported parcel.

We also computed the probability for bringing a parcel as a function of compensation for various levels of time, number of parcels, size, and weight (graphs not presented). In line with our expectations, lower levels of time, number of parcels, size, and weight have higher probabilities to crowdship that increase as compensation increases.
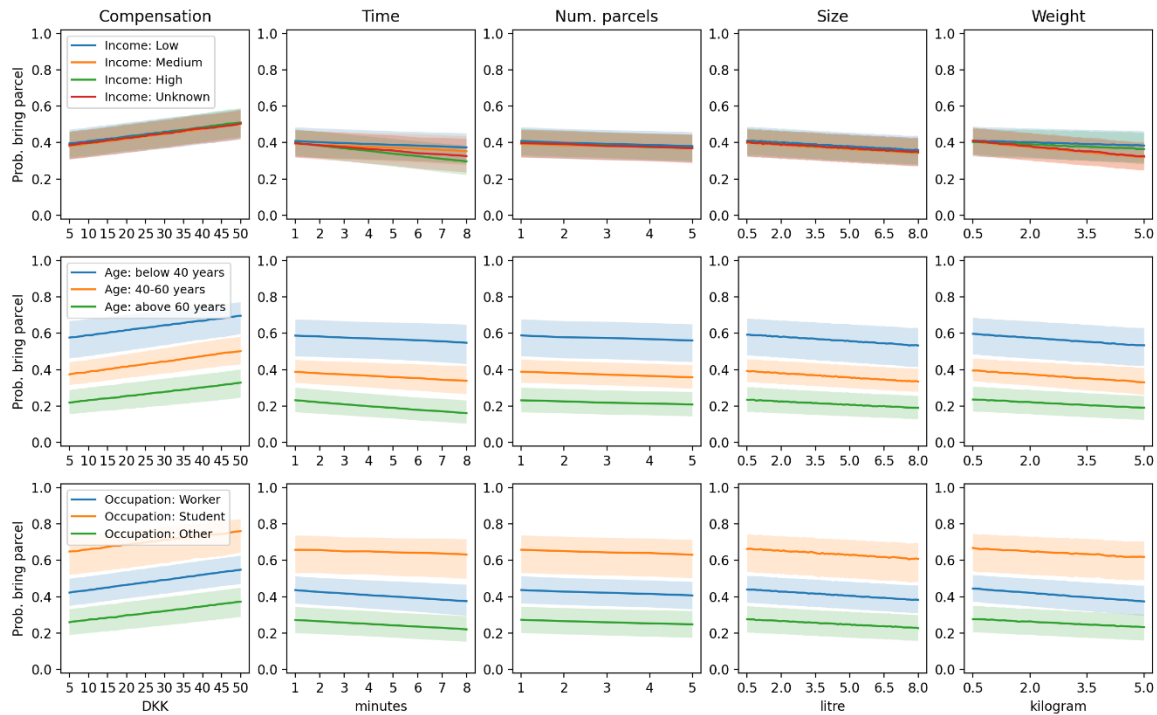
Figure 5: Segment probability of bringing parcel as function of attribute.

Despite entailing many characteristics of the most positively rated service-level combinations of Gatta *et al.* (2019), our resulting probabilities are generally lower than the highest rated crowdshipping concepts of this previous work. However, with the greater level of detail on service and shipment characteristics and calibration based on a full scale field experiment, the results may be less prone to hypothetical bias issues, which often leads to optimistic evaluations of future behaviour (Ajzen et al., 2004). Further, Gatta *et al.* (2019) measured the probability of adopting the crowdshipping concept in a broader sense, whereas our results are based on the acceptance of more specific trips, which could be assumed to yield lower acceptance probabilities.

5   Conclusion

Due to growing e-commerce, last-mile delivery brings increasing environmental and social challenges. On this background, this paper investigated the acceptance of a public transport based crowdshipping concept that is suggested as a sustainable alternative to existing last-mile solutions. In the suggested concept, public transport passengers can bring parcels along their trip and get automatically compensated by reduced travel expenses. This ensures that the system solely makes use of non-dedicated trips and does not become a catalyst for unregulated precariat jobs lacking workers' rights.

We explored user preferences by developing a five-attribute SC experiment in which respondents were presented with four choice tasks containing two crowdshipping alternatives as well as an 'opt-out'-alternative. The survey was distributed through an online panel to a sample of regular public transport users in the Greater Copenhagen Area. We estimated mixed logit models in order to assess user preferences while accounting for panel effects across observations from the same respondent.

In line with our expectations, we found that utility of bringing a parcel is positively associated with the (monetary) compensation provided to individuals, while utility is negatively associated with the (additional) time usage as well as the weight, size, and number of parcels. We tested all attributes for non-linear effects, but found it to be relevant only for the compensation attribute. For comparison, we presented the results with linear, logarithmic and BoxCox transformations of compensation, and despite differences in the assumption of the marginal utility of compensation the overall results remained reasonably stable. Although the model with a linear compensation specification is not statistically superior, we argue that it is more sensible from a behavioural point of view as the marginal utility is constant for all values of compensation within the range covered in our data.

We also tested for socio-demographic differences and heterogeneity in user preferences and found:

- Students, the working population and young(er) individuals (below 40 years of age) are more likely to participate in public transport based crowdshipping.
- Old(er) individuals (above 60 years of age) are less likely to participate in public transport based crowdshipping.
- Old(er) individuals and individuals in the high-income group have a higher marginal disutility of time spent retrieving the parcels, while individuals with a lower education show a lower marginal disutility.

Individuals in the low- and high-income groups have a lower marginal utility of the total weight of the parcels. From the demographic profiles, people interested in the service do not belong to the typical profile of early adopters of new transport technologies, who are mostly found to be male, young/middle aged, with high education and income (Haustein and Jensen, 2018; Nielsen and Haustein, 2018). Their characteristics differ from sharing economy service providers like Uber drivers (Hall & Krueger, 2018) but to a large extent match the profiles for sharing economy users and seem to be typical public transport commuters. This is not surprising as it makes most sense for people with regular public transport trips to participate in the service, as the mental effort will be comparably low when they get into a habit of taking a parcel along compared with irregular users, where the initial effort is less likely to pay off. We found the WTA (for the linear model) to be slightly below 200 DKK/h (~26 Euro/h), which is between the value for waiting time of approx. 183 DKK/h (16 Euro/h) and the value for travel time delays of approx. 274 DKK/h (37 Euro/h). This seems reasonable, as the time spent retrieving a parcel can be considered as waiting time while also introducing some travel time uncertainty, i.e. there is a risk of missing the train while retrieving the parcel. The model also provides information about how individuals rank attributes (such as non-monetary) against each other. On average respondents are willing to:

- Carry an additional parcel in order to 1) reduce time usage by 1.64 minutes, total parcel weight by 0.69 kg or total parcel size by 0.94 litres (or vice versa) or 2) increase the compensation by 2.67 DKK (or vice versa).
- Increase the total parcel size by 1 litre in order to 1) reduce time usage by 1.74 minutes or total parcel weight by 0.73 kg (or vice versa) or 2) increase the compensation by 2.83 DKK (or vice versa).
- Increase the total parcel weight by 1 kg in order to 1) reduce time usage by 2.95 minutes (or vice versa) or 2) increase the compensation by 5.07 DKK (or vice versa).

While a payment through reduced transport costs is in the first instance expected to prohibit unnecessary trips, rebound effects cannot be totally ruled out, as it is possible that saved travel expenses are reinvested in additional trips or in other areas of consumption. More importantly, travellers may feel that they – by bringing parcels along their way – have "done their bit" and feel

licensed to consume more in other areas of consumption. Likewise to these negative spillover effects, also positive spillover effects are possible; that people feel more motivated to also act more environmentally-friendly in other areas of consumption (see, e.g. Sorrell *et al*., 2020). Generally, more knowledge about the potential users that goes beyond demographic variables is highly relevant, as well as a segmentation that also includes psychological factors and could be used for tailored measures (e.g. dos Reis *et al.*, 2020), both to motivate potential crowdshippers as well as to optimise the achievable environmental effects. More knowledge on the transferability to other contextual, geographic and cultural settings would also be relevant scopes for future work on the subject.

The findings of the present study could help inform the design of a public transport based crowdshipping system in several ways, and add plausibility to the economic feasibility of the service; that sufficient financial incentive for crowdshippers is possible within the current economic margins of goods delivery. Engagement efforts could benefit from the results on differences between various demographic profiles, while the identified marginal rates of substitution might further the setup of the most optimal and attractive delivery "bundles", in order to design the most efficient delivery system.

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Appendix

Estimated parameters	Base model (MNL)			Base model (ML)		
	Value	Robust t-test	Robust p-value	Value	Robust t-test	Robust p-value
ASC_NoChoice	0.027	0.194	0.847	-0.384	-1.059	0.290
ASC_NoChoice_S				-6.357	-11.342	0.000
B_Compensation	0.027	9.784	0.000	0.042	9.669	0.000
B_NoPack	-0.083	-3.243	0.001	-0.113	-3.229	0.001
B_Size	-0.105	-8.692	0.000	-0.125	-7.791	0.000
B_Time	-0.053	-3.211	0.001	-0.111	-4.339	0.000
B_Weight	-0.181	-7.323	0.000	-0.214	-5.905	0.000
Model Summary						
Number of parameters:	6			7		
Sample size:	2,096			524		
Observations:	2,096			2,096		
Number of draws:				10,000		
Algorithm:	CFSQP			CFSQP		
AIC:	4,261.0			3,075.4		
BIC:	4,294.9			3,105.2		
Final log likelihood:	-2,124.5			-1,530.7		

Table 6: Parameter estimates and model summary for base models.

	Unit	Base model (MNL)	Base model (ML)
Willingness To Accept (WTA)			
Time/Compensation	DKK/min	1.95 (0.81, 2.89)	2.66 (1.67, 3.56)
Num. Parcels/Compensation	DKK/#	3.04 (1.16, 5.05)	2.71 (1.07, 4.57)
Size/Compensation	DKK/L	3.87 (2.84, 5.17)	3.00 (2.16, 4.02)
Weight/Compensation	DKK/kg	6.63 (4.41, 9.19)	5.15 (3.14, 7.59)
Marginal rates of substitution (MRS)			
Num. Parcels/Time	min /#/	1.56 (0.54, 4.40)	1.02 (0.38, 2.04)
Size/Time	min/L	1.98 (1.14, 5.00)	1.13 (0.73, 2.03)
Weight/Time	min/kg	3.39 (1.79, 9.56)	1.94 (1.08, 3.70)
Num. Parcels/Size	L/#	0.79 (0.31, 1.32)	0.90 (0.36, 1.54)
Num. Parcels/Weight	kg/#	0.46 (0.18, 0.77)	0.53 (0.22, 0.92)
Size/Weight	L/kg	0.58 (0.44, 0.79)	0.58 (0.44, 0.82)

Table 7: Simulated probabilities, WTA and marginal rate of substitution for the two base models.

Drivers and barriers in adopting a crowdshipping service: A mixed-method approach based on an extended theory of planned behaviour

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Drivers and barriers in adopting a crowdshipping service: A mixed-method approach based on an extended theory of planned behaviour

Abstract

Increasing traffic from last mile delivery related to e-commerce adds to issues of congestion, carbon emissions and liveability in cities worldwide. The present study investigates the potential and accompanying contingencies for user-uptake of a crowdshipping solution that combines automated parcel lockers with public transport, allowing users to bring along parcels on their trips, in an attempt to reduce last mile traffic and associated challenges. We apply a mixed method approach , using in-depth interviews and an online survey based on an extended version of the Theory of Planned Behaviour, to examine the motivational drivers, barriers and socio-spatial contexts influencing the intention to participate in the proposed crowdshipping concept. To this end, relevant demographic, social and psychological factors are investigated. Results point to the importance of three attitudinal factors: (1) the social value from participation and expected support from important others, (2) perceived ease of use and convenience and (3) the attitude towards participating in a commercially organized crowdshipping concept including the potential negative associations tied to this. Age was found to be an influencing factor; younger people showed higher intention to participate. The resulting opportunities for increasing user uptake and motivation that could be pursued through communication and the design of the crowdshipping service, are discussed.

Highlights

- Motivations and barriers for a public transport based crowdshipping concept are explored
- A mixed method approach was applied, using in-depth interviews and an online survey
- Social value and expected support from important others is a strong motivational driver
- Concerns about participation complexity is strongest demotivator

Keywords

Crowdshipping, Public Transport, Last Mile logistics, Theory of Planned Behavior, Sharing economy

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1 Introduction

Cities worldwide experience growing congestion, which in turn negatively affects the economy, the environment and liveability. Continued growth in E-commerce compounds the problem, as freight vehicles account for a significant share of traffic and contribute to congestion (McKinsey 2017, Taniguchi et al. 2016, Allen *et al.*, 2018). Additionally, last mile delivery undermines road safety through second-row parking and the blocking of cycle and pedestrian paths (Groth et al., 2019).
New consumption patterns put pressure both on delivery costs as well as on the traditional professional delivery chain. Customers expect delivery at a low cost, while convenient delivery is a growing part of e-commerce products and customer satisfaction. The demand for fast deliveries reduces the possibilities for consolidation and thereby reduces stocking efficiency, accelerating the problem even further (Chen, Mes and Schutten, 2018). Transport companies are relatively effective in consolidating and optimizing large and regular flows of goods (e.g. port-to-port, port-to-delivery central, central-to-central) but consolidation of the later parts of the delivery-chain is a complex and costly process, which does not harmonize with the aforementioned requirements of the new consumption patterns and with the extremely low value of transport in the actual system (Zhou, Lin and Lin, 2019). This results in inefficient and environmentally taxing delivery patterns based on a system that has difficulties with accommodating this new demand. The 'last mile' of delivery therefore accounts for up to 50% of total delivery costs (Rodrigue, Comtois and Slack, 2016) and is the most inefficient, pollutive stage of the e-commerce supply chain (Zhou *et al.*, 2016).

More resource and space efficient solutions might lie in utilizing spare transport capacity in cities through new technologies in order to organize the use of resources differently, as it has been done by a vast amount of sharing economy concepts in a broad range of fields within the last decade (Heinrichs, 2013). Within the field of personal transportation, this has resulted in car- and ridesharing concepts that have been broadly adopted for years by now (Hartl *et al.*, 2018). Within the domain of freight transport, the fact that people travel within and around cities on a daily basis for commuting, leisure and social purposes is being utilized. They represent a significant and relatively cheap transport capacity, in particular if they make use of non-dedicated trips. At the same time, the possibility for rethinking the divide between freight and passenger transport expands, in parallel with the development, towards more intelligent mobility systems and ICT use. Influenced by the sharing economy paradigm, this has resulted in terms such as 'crowdsourced logistics', or 'crowdshipping' (e.g. Le *et al.*, 2019).

This paper aims to investigate the potential and accompanying contingencies for user-uptake of a crowdshipping solution that combines the concept of Automated Parcel Lockers (APLs) with public transport. Such a solution has recently been tested in practice in Copenhagen (www.atkins.dk/crowdship), but so far no knowledge is available on the psychological determinants affecting (potential) users' intention to participate in such a concept. A theoretically efficient and well-designed service is of little help if it is not accepted by its intended users. This paper addresses this issue by exploring the factors related to the intention to participate in the concept with point of departure in an extended version of the Theory of Planned Behaviour (Ajzen, 1991). The following section provides more details on the concept (Section 2.1), describes the theoretical framework (Section 2.2), and specifies the contribution of the paper further (Section 2.3).

2 Background

2.1 Crowdshipping as last mile solution
Possible solutions to the abovementioned challenges might lie in designing delivery chains that can incentivize individuals to offer their transport capacity in order to address the increasing number of

deliveries produced by e-commerce business models, while accommodating for lower delivery costs and avoiding the creation of a proletariat of delivery workers, like Uber has done for taxi services. Public passenger transport is one domain in which the possibilities for utilizing existing transport capacity through sharing economy principles represent an opportunity for assessment.

In the solution proposed in this study, APLs are placed at public transport stations and stops, in the immediate vicinity of where passengers naturally pass by. In connection with public transport trips, registered passengers are then offered the possibility to bring a parcel (or several if their size allows it) along with them. Through a mobile app, passengers can book the parcel(s) that match(es) their route. Before departure, they can then use the app to open the relevant locker through bluetooth connection to bring along the parcel on their trip. Upon arriving at their stop, the passenger hands in the parcel at the designated APL in the same way. With the test-app and APLs used in the Copenhagen-based test of the concept, booking and collecting a parcel could be performed in less than 20 seconds in total. Crowdshippers are compensated with credit for the transit system. Only registered and validated crowdshippers can participate in the imagined concept. Likewise, only approved commercial senders (Webshops etc.) can send their goods through the system, in order to ensure safety and legality of shipments. There are several models for how liability issues could be handled; one being that the crowdshipping platform covers damaged or lost parcels, while monitoring and managing suspicious/problematic crowdshippers (e.g. losing a parcel). To start off, only shipments of relatively low value would be sent through the system.

Most prior research on crowdshipping – as well as the implemented solutions thus far - has focused on transport capacity of private car drivers and other transport forms where dedicated trips in the form of detours are to a smaller or greater extent unavoidable (e.g. Punel and Stathopoulos, 2017; Allahviranloo and Baghestani, 2019). For this reason, such concepts based on private vehicle use often result in higher emissions (Buldeo Rai, Verlinde and Macharis, 2018). As the only example to our knowledge, Gatta and colleagues (Gatta *et al.*, 2018, 2019; Serafini *et al.*, 2018; Simoni *et al.*, 2019) assessed the potential for and of a public transport based crowdshipping concept in a series of papers. In a theoretical case study of Rome, they investigated the willingness to act as crowdshippers (supply side) and to receive parcels delivered by a crowdshipper (demand side) as well as how the features of a potential service affects this. In a stated preference survey they identified the most important features influencing the inclination to participate in a crowdshipping service and used discrete choice models to study the underlying behaviour (Serafini *et al.*, 2018). They found young people to be significantly more inclined to participate than the average population, and older people correspondingly less inclined. The location of the APLs (inside metro station) was identified as the most important feature of the service, followed by bank credit mode (single delivery) and remuneration. The least important feature was shown to be booking options (where real time booking was preferred over offline). The authors point to the need of investigating further, the social and psychological factors that might affect the adoption of a public transport based crowdshipping solution.

2.2   Theoretical framework

To examine the psychological factors of participation in the suggested crowdshipping solution, we use the Theory of Planned Behaviour (Ajzen, 1991) as a point of departure. The theory has been successfully applied to explain and predict a wide variety of behaviours, including mode choice (e.g. Bamberg, Ajzen and Schmidt, 2003; Donald, Cooper and Conchie, 2014), departure time choice (Thorhauge et al., 2016), as well as the intention to use or re-use car sharing (Zhang and Li, 2020; Mattia, Guglielmetti Mugion and Principato, 2019).

An additional reason for choosing the Theory of Planned Behaviour (TPB) as an explanatory framework is its wide scope, rendering it able to encompass additional relevant factors for the concept.

TPB is derived from the Theory of Reasoned Action (Ajzen & Fishbein, 1980). Like its predecessor, the main determinant of behaviour in TPB is the intention to act (Ajzen, 1991). Intention is here shaped by (1) Attitude toward behaviour, (2) Subjective Norms and (3) Perceived Behavioural Control. The *Attitude toward behaviour* is the valuation (positive or negative) of the performance of a given behaviour. *Subjective Norm* (SN) is the perceived judgement of the behaviour from one's important others. *Perceived Behavioural Control* (PBC) refers to the individual's perceived ease/difficulty of performing the behaviour. In addition to predicting intention, PBC is also assumed to be a direct predictor of behaviour. In the context of mode choice, PBC has mostly referred to infrastructural barriers, while perceived constraints or needs resulting from the personal living circumstances have been neglected. The construct of Perceived Mobility Necessities (PMN) has therefore been added and proven a relevant addition of PBC in the context of mode choice (Haustein & Hunecke, 2007). In the context of the examined service, PMN could inhibit the uptake of the service for people who already perceive their life as requiring a (too) high level of mobility and therefor prefer individual transport modes (Thorhauge et al, 2020). However, for public transport commuters with high PMN it could also be easier and more efficient to integrate it into their daily commuting habits.

With regard to the measurement of attitudes in the context of mode choice, it has proved relevant not only to focus on functional and instrumental benefits, such as convenience and saved time or money, but also to take symbolic-affective user motives - such as autonomy, excitement and status - into account (e.g. Hunecke *et al.*, 2007; Lois and López-Sáez, 2009). Reviewing the motives related to the participation in sharing economy concepts, Andreotti et al. (Andreotti *et al.*, 2018, p. 12) concluded that "instrumental motives (economic/monetary, sometimes in combination with functional motives, such as convenience), normative motives (primarily geared towards sustainability, but also altruism), and social-hedonic motives (including enjoyment as well as community/social motives)" are found most relevant in previous research. In the context of TPB, normative motives are covered by SN – but in the context of environmental behaviour, it has been found relevant to additionally consider personal norm.

The construct of personal norm (PN), derived from the Norm Activation Model (NAM) (Schwartz, 1977), has often been applied to supplement TPB models in case the given behaviour is assumed to be influenced by a perceived personal obligation to help (others or the environment). The NAM has also in itself proven to be a useful framework for understanding the circumstances of when and why the personal obligation to protect the environment leads to behaviour in accordance with this personal norm or not (Møller, Haustein and Bohlbro, 2018). The key assumption of NAM is that personal norms function as direct causal determinants of pro-social (or environmental) behaviour. However, whether a PN is activated depends on several preconditions.; a first being the awareness of a need for action. Kim et al. (2018) recently integrated assumptions of the TPB and NAM in a joint framework to explain the use of sharing services and showed a significant effect of PN in addition to the TPB constructs Attitude, SN and PBC.

In earlier studies, car use has been found to be most strongly related to benefits for the car user (Garvill, 1999). Reduction of use, on the other hand, was shown to be more strongly related to pro-social motives (Nordlund and Garvill, 2003). Even though a crowdshipping-concept would ideally be constructed in a manner which makes the direct rewards versus inconvenience of participation incentivizing enough in itself, it is relevant to draw parallels to and seek guidance from work that circles around the same problem; discovering drivers behind the intentions of people to go out of their way to form new behaviours that might be of greater social than personal benefit. Drawing on this

earlier work, pro-social motives for behaviour change become central for our study of a concept in which the personal benefits may be small.

To cover the "social-hedonic motives (including enjoyment as well as community/social motives)" that Andreotti et al. (2018) found relevant for participation in sharing economy, it seems relevant to consider the concept of *Relatedness* (Alderfer, 1969).

As a development of Maslow's hierarchy of needs, Clayton Alderfer's ERG Theory categorizes human needs into Existence (functional needs), Relatedness (belonging/togetherness) and Growth (self-esteem/self-actualization) (Alderfer, 1969). In contrast to Maslow's hierarchy, ERG Theory works from the premise that it is possible to satisfy each of the three domains independently. Support for the relevance of considering the emotional needs represented in ERG theory in a mobility context has recently been provided in the context of mode choice (Bláfoss Ingvardson *et al.*, 2020) and the intention to adopt MaaS (Schikofsky, Dannewald and Kowald, 2020).

Mobility choices are not simply determined by evaluations of functional utility (e.g. Steg, 2005). They are also an expression of how we see ourselves and how we relate to the world. Within ERG Theory, the satisfaction of the need for Relatedness is characterized by being dependent on processes of sharing or mutuality (Alderfer, 1969). In a study that examined the intention to share public transport information through a collaborative transit app, aspects of Relatedness had by far the highest effect on the intention to share information with other travellers (Sarker *et al.*, 2019). With an increase in climate change-focused activism and participation in social movements (Fisher and Nasrin, 2021), there is arguably a greater potential for studying how feelings of Relatedness to likeminded people affect intentions within a broad range of mobility choices, including the intention to participate in the proposed crowdshipping concept.

2.3 The present study

This paper aims to add to the field of research on crowdshipping by employing constructs derived from an extension of the Theory of Planned Behaviour in order to assess relevant demographic, social, and psychological factors for user uptake of a public transport based crowdshipping concept.
The challenges and opportunities described in the previous sections, point to the need for an understanding of the preconditions for implementing crowd-based solutions to current and upcoming transportation-problems in a feasible manner. To make the outlined crowdshipping solution as appealing to take part in - and thus as effective - as possible, it is important to understand the motivations, barriers and socio-spatial contexts that exist among and around the potential users of such solutions. This is a necessary first step towards applying relevant behavioural interventions.

To examine the motivational drivers and barriers influencing the intention to participate in public transport based crowdshipping, we use a mixed methods approach. First, the breadth of relevant motivational factors is explored through qualitative interviews (Part 1). These explorative findings are then, in combination with existing work on relevant constructs, sought quantitatively validated through a survey and subsequent linear regression analysis (Part 2). Finally, findings and implications for public transport based crowdshipping concepts specifically - and sharing economy concepts more generally - are discussed.

3 Part 1: Qualitative Interviews

3.1 Method

In an initial exploration of motivational factors and barriers relevant for assessing the acceptance of the crowdshipping concept, in-depth interviews were conducted. As research on the topic of public

transport-based crowdshipping is very limited, this explorative phase was crucial in ensuring that scenarios described and assessed quantitatively in the subsequent survey, make sense to possible users and that all relevant motivations and barriers are included. The interviews were conducted as semi-structured interviews in order to make sure that certain themes were being covered while ensuring an openness to the themes that appeared during the data-gathering process.

3.1.1   Sampling

The applied sampling was based on the broadest possible target group for the service and was accordingly inclusive; all potential public transport users in the Copenhagen area aged 18 and above. In line with the grounded theory approach that has been applied to explore motivations behind travel mode choice (e.g. Gardner & Abraham, 2007; Schikofsky et al., 2020), data collection was stopped when saturation was achieved (Francis *et al.*, 2010). Despite the quite heterogeneous sample presented in Table 1, the relatively narrow focus of the interview-guide meant that saturation was relatively quickly achieved. This resulted in 13 interviews of respondents aged 19-55 with a geographical distribution encompassing both outskirts and central districts of Copenhagen. The spectrum of public transport use ranged from those using public transport in Copenhagen on a daily basis to those using it very rarely. The interview-length averaged 49 minutes.

Sample

Cover name	*Gender*	*Age*	*Main transport mode*
Victor	M	18	Metro
Daniel	M	23	Metro
Michael	M	29	Bike
Pierre	M	34	Bike + S-train
Kristian	M	39	S-train
Jonas	M	53	S-train & Metro
Rebekka	F	19	S-train + bus
Line	F	23	Bike
Didde	F	27	Bike
Karen	F	28	Bike + S-train
Henriette	F	46	Bike + S-train
Lotte	F	55	S-train
Lone	F	55	S-train

Table 1: Sample characteristics

3.1.2   Interview-guide

The interview guide covered all factors of the TPB – asking about what aspects people would like or dislike about the concept (Attitude), what potential challenges they saw (PBC), how they expected others to view the concept and their participation in it (SN) and if they could imagine to engage in the service themselves (Intention). The potential for feelings of community and engagement (Relatedness) was also brought into the interviews on this basis. Furthermore, transport habits and their compatibility to the concept were covered. The interview guide was divided into five sections.

(1) *Public Transport*. The first section covered the respondents' use and preferences concerning public transport in the Copenhagen area. This provided insight into their regular as well as occasional transport needs and choices. Starting with broad questions about their daily mobility choices and habits, the focus shifted towards public transport options and their respective (dis)advantages. To avoid bias, the crowdshipping concept and focus of the research project was not introduced until after this section.

(2) *Concept introduction and initial thoughts*. Participants where asked about their initial thoughts on it and who they expected to be the most frequent users. The open(ing) question was intended to inform a correspondingly broad range of items, such as attitudinal variables concerning personal advantage and symbolic motives.

(3) *Practicalities*. Interviewees were then asked about possibilities and preferences for receiving information about available parcels matching their route. They were then given the opportunity to pinpoint practical preferences and barriers through an imagined scenario with point of departure in their own use of public transport.

(4) *Concept, users and motivation*. To elevate the focus from practicalities of using the service to what the participants thought of the overall concept, they were asked questions on whether they thought others might use the service and why. This projective technique was intended to facilitate considerations about possible motivations to use the service, without having to take point of departure in themselves, allowing for a broader range of themes, some of which might have been difficult to articulate in an interview setting (Donoghue, 2010). For example, some participants might feel uncomfortable or embarrassed about mentioning the economic compensation as their primary driver. These insights on the participants' assessment of the service were also sought by asking them to relate the concept to a number of existing sharing economic companies with similar characteristics.

(5) *Receiving parcels though crowdsourced logistics*. Interviewees were asked about their thoughts on the mode of delivery, with themselves being the recipient of the parcel.

3.2   Analysis

The interviews were transcribed and analysed using qualitative content analysis (Mayring, 2007). The data was thematically coded based on the themes that emerged from the interviewees. As the topic of the interviews was very new, this inductive data-driven approach was applied to allow openness for novel and unexpected aspects. However, to make sure all theory-relevant themes were discovered, a deductive analysis was included alongside the inductive analysis, an approach that has been proposed by Mayring (2007). As proposed by for example Marquart et al. (2020), this was done to facilitate links to the relevant theory presented in the previous section. The outcome of this was an empirical underlining of the relevance of many concepts of the behavioural theories under consideration, as well as a range of new themes that emerged as a natural consequence of the novelty of the crowdshipping concept in question.

3.3   Results

3.3.1   The task of first-time use

The interview results highlighted the relevance of considering the whole context in which participation would take place. A link to travel satisfaction, especially concerning comfort, is underlined in the following interview quote:

"It sounds really cool, really smart. But in the case of the metro, I'm also thinking whether it should be excluded, maybe at certain hours. Because even if it is small parcels, if 30 students are bringing one, it will be hard. Also, the busses in the morning. You are standing up, cause there is no room. And people use all the doors, because they just have to get on the bus. It's a fight for survival." (Daniel, 23)

Evaluations of transit experience concerning both time and comfort were correspondingly related to the interviewees' envisioned inclination to use the service, as illustrated in the above quote. Participation in a crowdshipping service would add complexity to a ride. The experienced contextual

time pressure and stress-level would then easily influence the extent to which participation would 'tilt' passengers towards feelings of restlessness and unpleasantness.

"I don't know if I would do it myself. I think Rejsekort [Danish ticketing card] *works pretty well. One would have to do it for idealistic reasons. My motivation wouldn't be to save a small amount of kroner* [Danish currency] *on public transport. But it would be to help minimize traffic in the city."* (Lone, 55)

The need to accommodate the often habitual nature of public transport was therefore often indicated:

"The less you have to do other than bring a parcel, the more realistic it is. If it becomes routine. And that's probably the easiest. That daily trip, that they know 'I'm taking that'." (Lone,55)

Signing up for the service and using it for the first time is a task that must compete heavily for a piece of potential user's limited attention span. In the domain of travel mode choice, habits have been shown to both reduce active search for choice-relevant information as well as the use of the information, leading to form barriers towards perceiving and processing counter habitual information (Verplanken, Aarts and Van Knippenberg, 1997). One interviewee, who misunderstood the concept and thought parcels were to be delivered directly to the recipient rather than the destination APL, expressed such initial barriers:

"If you only hear about it shortly, you think 'oh, that sounds troublesome, I'm not doing that (…). As with everything, once you find out how it works, I believe that you just think 'that's pretty smart'." (Line, 23)

Though this was not commonly addressed directly by the interviewees, we here see an expression of how lacking Perceived Behavioural Control can influence the intention to participate. Establishing the first time use of new mobility solutions has previously been documented as a trying task (e.g. Gao *et al.*, 2020). Such initial troubles may be caused by the fact that similar concepts are not widespread. Participants might then have a correspondingly harder time drawing on associations to help understand the concept, as this interviewee does when asked if it reminds her of any existing sharing economic concepts:

"When you first introduced the project to me, I met it with greater scepticism than I do with a lot of other concepts. Because I think logistics are hard to imagine. And it's a part of the city I don't know yet. But something like GoMore [Danish ridesharing service] *is an extension of hitchhiking. This [participating in the concept] is something you don't already do at all. It's more difficult for me to imagine than a GoMore lift. Or renting out your apartment (…) So it's all concepts for something that exist. And this feels more like a concept for something that doesn't exist. So I associate it with these things, but I still meet it with a greater mental blockade."* (Karen, 28)

Though very few explicitly mentioned this as a problem, the majority of participants had a hard time directly associating the service with any existing sharing economic concepts. Almost all interviewees mention ease of use as the key to the concept's success. In the below quote, it is seen how previous negative experiences with novel mobility solutions might add mental blockades:

"It's all about how easy it is. For me to use it myself, it would be that it runs smoothly. I would spend two minutes extra to be at the station at some time and deliver it. But if I knew that it was like with the city bikes, that every second time it's flat, and every second time it won't open and this and that, then I would just think that I won't bother" (Michael, 29)

There were roughly three mentioned main types of mental barriers to participation, understood as the concerns given when prompted. The first concern mentioned by many of the respondents is liability if the parcel is damaged or lost:

"What if you lose the parcel underway? How would I ever prove that I didn't just bring home with me? Would it be with an insurance?" (Victor, 18)

"Just one concern, and that is the insurance issue. What if the parcel gets lost underway or stolen." (Jonas, 53)

The second concern is about safety and risk of transporting something illegal:

"Those organizing should of course guarantee that you aren't running around with a hand grenade or something like that." (Lone, 55)

"The only thing should be if there was a gun or something… So if I was stopped with it, I (need to be sure I) *could say that I just brought it from her and transported it."* (Michael, 29)

"Then you get a little paranoid. What's in the parcel, haha. Do you suddenly become a drug smuggler, because someone saw an opportunity, or are you bringing a bomb on the S-train…" (Henriette, 55)

The third concern is about practicalities, such as not being able to hand in the parcel at the destination due to technical issues, or the phone running out of battery:

"I would also have some concerns about what if you can't hand in the parcel? For various reasons. And then have to run around with the parcel." (Jonas, 53)

"… or the app should know that you are low on battery or something, where it can then recommend you not to do it. " (Rebecca, 19)

The diverse range of concerns raised during the interviews illustrate the importance of communicating effectively to potential users in order to address the mental barriers to participation in a novel concept such as public transport based crowdshipping.

3.3.2 For money or environment?

For some participants, the economic aspect served as a clear primary motivator, and they also believed this to be the case for others, even though they might not be open about it:

"90% (of people's motivation would be to) *save money I would say. We talk so much about 'green' behaviour, but really how many people bother to do anything about it… It's the money in it. I'm assuming it is for all."* (Kristian, 39)

Environmental awareness was mentioned by many interviewees as a possible motivation for early adopters of the service. The possibility to contribute towards a reduction in congestion and carbon emissions also underlined the need to address positive emotions that might be activated in response to living up to one's own moral standards. The contribution of emission reduction was often mentioned in relation to intrinsic motivations and personally felt responsibility to mitigate environmental issues through own actions, such as in the following part of a response regarding imagined typical users of the service:

"Of course it would be nice to get some kind of subsidy to my commuter-card, but it is not essential for me that the price gets reduced… (Typical users could be) *People who are advocates for sharing economy, who give importance to the climate challenges, that we need to bring down our CO2 emissions."* (Lotte, 55)

When asked directly, none of the interviewees mentioned that they would be embarrassed to participate. This contrasts prior research on workers in the "traditional" sharing economy, where it was found that (perceived) stigma and a simple focus on money rather than sharing lies in stark contrast to the presented idealistic and empowering visions of many sharing economic platforms (Ravenelle, 2017). This seems to mark a significant perceptual difference between 'need to' and 'choose to', as one interviewee also touches upon:

" (…) but I still think that there would be some who wouldn't find it so nice. Especially, if they didn't have that much money. If it became a necessary evil." (Didde, 27)

Adding to this, a possible explanation for the contrast to earlier work might be that the proposed crowdshipping concept cannot be utilized as a 'gig economy'-alternative to traditional employment, and accordingly is less significant for identity construction. This difference has also been shown amongst Uber drivers, who showcase *identity discrepancies* by highlighting how they merely take part in the sharing economy as opposed to having their identity defined by their occupation as is the case for regular taxi drivers (Phung *et al.*, 2020). The difference between transport credit and money and positive effect on perception of the concept was addressed by several interviewees, such as in the following:

"Discount is definitely better than money." (Karen, 28)

For many interviewees, the reduced fare of the ride or a discount, seems to evoke and be more in line with the positive feelings of doing good for others and other idealistic values, where they associate ready money with a colder and transactional nature, with potentially accompanying negative influence on own and others' valuation. The sharing economy's idealism/rationalism-duality, as found in Ravenelle's (2017) work, is seen in expressions such as these:

"I would feel best about discount… whether they give me the money or the trip, it's exactly the same but there would just be something about me not receiving anything as such, other than a trip that I took." (Didde, 27)

"I don't think in monetary terms, but I think it is nice if I can get out of having to pay for things" (Karen, 28)

More importantly, however, for the interviewees' valuation of the potential evoking of such self-conscious emotions in relation to their own participation, seems to be the environmental aspect of the service.

"This is part of the education you want to give to your children. What kind of message. Because I don't need my ticket reimbursed, right. For me, now that I'm a full time employee in a company, it doesn't cost so much. So the money wouldn't be the only attraction here. The idea of making some small gesture for the environment and also it's nice to have less trucks in your city." (Pierre, 34)

Most of the interviewees (n=8) also explicitly point to the societal benefit as a mitigator when asked about possible embarrassment of participating. Even if this is not the actual main motivation, the positive environmental effects can then seemingly serve as a legitimization.

"But of course you can also just, if you don't want to say that it is because of your financial situation, say that you do for environmental reasons." (Line, 23)

This discrepancy between actual main personal motivation and the one she might present to peers, is expressed by this middle-aged interviewee:

"I might say that it (participation) was for the environment, but I would probably mostly do it for the money… My generation might think that it is a bit embarrassing to do it for the money, but if we can cover it up in it being for the sake of the environment, then it's okay." (Henriette, 46)

This mirrors findings of earlier work in which differences are indicated between reported attitudes and actual behaviour; perceived sustainability was found to be an important factor in the formation of positive attitudes towards sharing economy, while economic benefits were found to be a stronger motivator for intentions to participate (Hamari, Sjoklint and Ukkonen, 2016). *"If it becomes the "save money" context, I think it would become more stigmatized. If (it talks to) the idealist, I think it will become more exalted… If you want to create a positive atmosphere around it, I wouldn't talk to the monetary-incentive"* (Karen, 28)

Quotes such as the abovementioned on one side touch upon the theme of social approval and following social norms. Without many participants addressing it directly, the backside of the theme circled in the quotes, could equivalently be argued to be potential negative evaluations or social stigma. As the above examples and related literature illustrates, such fear of negative evaluations by one's peers could both be related to being labelled a "discount hunter" and with being associated with delivery workers, which may for some be an issue. However, this may be alleviated by the positive environmental gesture that participation represents, and the divergent effect for identity construction of work undertaken in the sharing economy sphere.

3.3.3 Part of something bigger – for better or worse

The participants were not only drawn to the idea of participating by the monetary and environmental gains. Many participants explicitly mentioned the social aspect of the service and the idea of becoming part of a larger movement as motivating factors:

"I think it would be really appealing to the segment I belong to, young people between 18 and 26, students… Because I know they would do it to save money, but it also looks extra good, that you are helping the environment and you are part of a new thing… I think people would think it is pretty cool. In that way, it would also work well that the project has a clear thought on sustainability. When joining, you are made aware that you are actually supporting something bigger." (Rebecca, 19)

Though many participants had a hard time associating the practical participation with other concepts, the social/sharing aspect seems clear and in line with what many see as a positive movement:

"I think it is pretty cool. Also fits well with this wave of sharing. You carpool, eat together and repurpose food." (Line, 23)

"I don't think of it as scary to go along with such a concept. Because people who sign up for something like that, they must have some idea about that we should help each other out." (Lotte, 55)

This also pointed out by some participants as an opportunity for attracting new participants amongst parcel recipients, by making both recipient and crowdshipper feel included in a community:

"(…) Something that pulls you to also become a transporter. 'Now you have ordered a parcel, which others help get to you. You will get double credit for your trip next time'. So it feels like you become part of a network instead of just clicking a button and thereby having bought a CO_2 compensation. It has to feel social." (Karen, 28)

For some of the participants, the social aspect takes precedence over the environmental one:

"I think people would think it is cool, but not because of the environment. Because you would like your own parcels faster. Then you think 'that's a pretty good deed'. I would be happy myself, if someone transported my parcel… So I hadn't even thought of the environmental aspect." (Kristian, 39)

For some participants the underlining of the social aspect at the same time expresses clear divisions in their sympathy between involved people and enterprises.

"It's kind of cute. Like a 'we help each other out' vibe. I am contributing to someone getting support in their everyday life. I like that. That it goes to people in my everyday life, rather than a company. It of course also goes to a company, but it is more measurable to me how it affects people's life. And I trust people more than I trust [Freight provider]". (Karen, 28)

This division has potential influence on these participants' willingness to participate and for what:

"You also can't help but wonder whose parcels it is in some way. There might be ones I would be more willing to bring. Who actually profits from this. Of course there are congestion issues that are reduced, but there is also some commercial goal in this for someone… for companies sending sports clothing is like okay it's about congestion issues, but its also a way you could save money as a company. Then it becomes commercial… and kind of a job… then you should maybe receive more money... Then I would feel kind of stupid, if I were hauling a load of parcels every day, without knowing to who" (Didde, 27)

For this reason, transparency is important, as another interviewee points out:

"It would be very good if there is transparency in which companies are involved… What am I supporting? Is there a profit dropping in someone's pocket? Which pockets? Is it a governmental organization, something where we are all a part of it. Or into some Amazon-ish pocket. Transparency would be nice… If the delivery companies save money, I would be annoyed having to donate to their surplus. Either I should get as much of my travel covered as possible, or there should be full transparency on why I get so little money per parcel." (Karen, 28)

As such, there are seemingly several balances that must be struck in the design and communication of a public transport based crowdshipping concept. The social aspect of the concept seemingly has potential to evoke positive feelings, but at the same time some fragility is seen in such non-economic motivations, as the positive associations risk being perceived as fake commercial extortion with a tint of 'greenwashing', if the concept and the organization around it is not perceived as transparent.

3.3.4   Conclusions

The interviews supported the relevance of the constructs of TPB and its suggested expansions. The results in particular highlight the relevance of Relatedness, Subjective Norms, and Perceived Behavioural Control. Results on the interviewees' travel routines also suggest that it is relevant to consider travel satisfaction as a factor influencing the uptake of the service. A need to consider three main barrier types (liability, safety, and practical) for user uptake was also found. Additionally, the identified potential for evoking positive feelings as a result of helping others through one's effort, indicated the relevance of adding the construct of 'Warm Glow' (Taufik, Bolderdijk and Steg, 2015), which has previously been utilized to take into account the moral satisfaction associated with an environmentally friendly contribution (e.g. Kahneman and Knetsch, 1992; Bagozzi, Gopinath and Nyer, 1999; Hartmann *et al.*, 2017). Finally, the results highlighted the need to address the significance and influence of the potential perceived contrast between the idealistic motives of a crowdshipping concept and underlying profit motives of an operator.

4 Part 2: Survey

4.1 Method

4.1.1 Procedure and participants

The data for the second part of this study is based on an online survey coded in Qualtrics. It was distributed in May/June 2020 to inhabitants of the Capital Region of Denmark. Besides residing in one of the included area codes in and around Copenhagen, use of public transport on at least monthly basis was a requirement for participation. The representative sample was drawn from EPINION's (a market research institute) online panel. The sampling took gender, age, education (for general population) and geography (within the area of interest) into account. In total, 1989 surveys were initiated, of which the majority were screened out for not fulfilling the participation requirements. After cleaning the data by removing completed responses finished in less than 40% of the median duration as well as removing responses from participants with suspicious answer patterns, the final sample consisted of 524 respondents.

The respondents were explicitly instructed to answer based on their lives and transport habits prior to the COVID-19 outbreak, as the country was in lockdown at the time of data collection.

4.1.2 Measures

In the operationalization of theoretical constructs, validated items were adapted from the literature and new items were created, informed by the results of the qualitative interviews (Study 1). The selection of items was additionally informed by the result of a pre-test and a principle component analysis (PCA), in which some theoretical constructs fell on the same factor. We aimed to measure the previously identified factors reliably, rather than all single theoretical constructs separately, as the latter would have resulted in a too long survey. Therefore, several theoretical constructs were measured with a limited number of items.

Intention was measured with six items, of which each participant answered four (see Table 3 for item list). Firstly, all participants responded to "*How often would you make use of the opportunity to check in and out with packages if there were always packages to bring?*" with two items that cover different trip-types (most used route in Copenhagen area and other public transport trips in Copenhagen area). Secondly, the participants responded to one of two separate two-item sets of questions (compensation presented to participants as '% discount on trip fare' or cash). These two sets were based on a presented example with more details as well as an accompanying photo of the parcel in question as illustrated in Figure 1. Each participant was randomly assigned one of these two-item sets, and thus only answered four of the six intention items.

Figure 1: Intention-item (% discount)

Social aspects around participations seems of particular relevance for participations and were covered by the constructs Subjective Norm and Relatedness. *Subjective Norm* was represented by an item on whether participants imagine their friends to participate. *Relatedness* was represented by two items that measured the potential positive feelings of being part of a movement/community (both adapted from Schikofsky 2019). Similar as in Sarker et al. (2019), we expected both constructs to load on a joint factor.

The construct *Warm Glow* (three items) was added to additionally cover whether participation was thought to elicit positive emotions derived from the contribution towards a societal need and environmental protection (Venhoeven, Bolderdijk and Steg, 2013; Taufik, Bolderdijk and Steg, 2015).

Personal norm was measured by one items on the personal obligation to take the environmental into consideration in transport choices. In addition, *Awareness of need* with regard to climate action was measured with two items.

Included attitudes focused in particular on perceived fairness and status, which seemed relevant to include based on the results of the qualitative interviews. *Attitude* (towards the crowdshipping company), was measured with three items that focused on the perceived value of participation and whether this value seemed fair compared to the understanding of what the crowdshipping company gained from the cooperation (*fairness*). To encompass both negative and positive effects of the economic compensation for participation, three items concerned the symbolic effects and potential feelings of embarrassment of receiving compensation (*status*).

PBC was measured with three items on the perceived ease/difficulty and time-consumption of participation. In addition, more specific barriers towards participation were measured with ten items created for the purpose. Of these, five items focused on liability issues in case of damage to the package caused by oneself or others, risk of theft/robbery and fear of transporting dangerous/illegal goods. Three items focused on the risks of forgetting the parcel and thus not handing it in, or not being able to hand it in due to the phone running out of battery. Two items measured the fear of a faulty system such as technical issues or not being able to find the package locker.

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Two *PMN* items measured the perceived mobility necessities required by the obligations and organization of the participants daily life (Haustein & Hunecke, 2007).

Two Satisfaction with Travel Scale (STS) sub-scales, *Time* and *Comfort,* were included with respectively three and four items. The *Time* items measured whether the participant in relation to their most frequent journey felt stressed, hurried and worried about arriving on time (Ettema *et al.*, 2011). *Comfort* was measured with three items on the ease, functioning and comfort of the trip (Ettema *et al.*, 2011), and one item created for the purpose of measuring the degree to which the participant feels safe on the trip.

4.1.2.1 Sociodemographics

In addition to psychological variables and information on public transport travel patterns, sociodemographic variables were collected regarding postal code of residence, age, gender, household composition (living with children/partner/parents/other adults), income, monthly public transport expenses, employment status (eight categories), work hour flexibility (fixed/flexible work hours) and education (seven categories).

4.2 Analysis

In order to reduce the number of psychological variables to their underlying dimensions, a principal component analysis (PCA) was performed using varimax rotation. The PCA resulted in six factors, which explained 61.8 % of the variance.

The items showed allocations to the factors as expected based on the pre-test results: Items related to SN, Relatedness (R) and Warm Glow (WG) formed a common factor, which measures positive feelings around participation, perceived social support and perceived value of participation, which we refer to as 'Social Value and Support' (SVS). The new factor "climate norm" includes PN as well as items on awareness for need (AN) in terms of climate action. PMN built a separate factor as expected. The five items related to exploitation as cheap labour and the symbolic values of the service built a common factor (Concept Attitude), but fell together with the three items for PBC. Although loading on the same factor, the items for PBC were treated as a separate factor, as there is a clear conceptual distinction between the control and competence oriented PBC-items and the attitudinal items evaluating the concept with a moral and symbolic focus. The more specific concept related barriers formed two separate factors. One consisted of seven items on risks resulting in the parcel not being handed in by the participant (Parcel Hand-in Concern). The other factor encompassed three items on dangers further beyond control of the participants; transporting something illegal or dangerous or being liable for a parcel damaged somewhere else in the delivery chain (System Risk Concern).

Principal Component Analysis Item	SVS	Concept Attitude and PBC	Climate-norm	PMN	Parcel Hand-in Concern	System Risk Concern
Many of my friends would participate in the concept. (SN)	**.596**	-124	-.004	.032	.060	-.211
I would feel a community spirit with the other users. (R)	**.742**	-.050	.117	-.032	-.041	-.027
I would feel part of a positive movement. (R)	**.793**	-.278	.178	.041	-.034	.005
I would feel good about having made a small difference for the environment and my city. (WG)	**.806**	-.197	.203	.109	-.013	.076
For me, it would give value to participate. (WG)	**.757**	-.309	.071	.055	-.062	-.043
I would feel proud to do my small part in making the city greener. (WG)	**.785**	-.219	.223	-.037	-.033	.021
It would be a bit embarrassing to meet someone I know, while I was picking up/delivering a parcel. (status)	.042	**.635**	-.144	.089	.210	.046
I do not want to be associated with parcel couriers. (status)	-.121	**.720**	-.085	.054	.097	.088
Participation is only for 'discount hunters'. (status)	-.196	**.604**	-.115	-.044	-.016	.002
It is mostly the involved companies that gain from the concept, not the participants. (fairness)	-.348	**.454**	.061	.102	.129	.272
The concept would unfairly take advantage of me as a form of cheap labour. (fairness)	-.316	**.508**	-.005	.017	.120	.411
It would be difficult for me to bring parcels on my journeys. (PBC)	-.268	**_.646_**	.034	-.051	.206	.061
The whole process of downloading an app and signing up would be too much hassle for me. (PBC)	-.257	**_.471_**	-.110	-.013	.262	.034
Bringing packages on my journeys would be too time consuming. (PBC)	-.349	**_.627_**	.051	.015	.123	.053
I feel personally obliged to take the environment into consideration in my transport behaviour. (PN)	.232	-.049	**.744**	.086	-.023	.115
Climate change is currently society's most important issue to address. (AN)	.200	-.010	**.817**	.091	.057	-.003
The fight against climate change has become too hysterical. (Recoded) (AN)	.118	-.207	**.782**	-.048	.035	-.106
The organisation of my everyday life requires a high level of mobility.	.028	.011	.040	**.900**	.144	.033
I have to be mobile all the time to meet my obligations.	.064	.058	.077	**.892**	.066	.045
I would be nervous about...						
... forgetting the parcel and not getting it handed in the locker.	-.081	.141	-.017	.029	**.774**	.010
... the package being robbed/stolen on the way.	-.013	.150	-.032	.054	**.623**	.348
... not being able to find where the package should be handed in.	.027	.206	.021	.011	**.751**	.187
... not being able to open the locker due to technical difficulties.	.032	.113	.061	.034	**.749**	.190
... not being able to open the locker because of my phone running out of battery.	.037	.193	-.023	.056	**.728**	.161
... accidentally damaging the parcel.	-.090	.007	-.04	.054	**.665**	.401
... forgetting to hand in the parcel and accidentally bringing it with me.	-.079	.105	.046	.094	**.809**	-.055
... that I might transport something dangerous.	-.035	.221	-.034	.052	.331	**.774**
... that I might transport something illegal.	-.029	.143	-.003	.025	.347	**.783**
... what I might be liable for, if the package is damaged somewhere else in the transport chain.	-.074	-.083	.077	.018	.522	**.567**
Cronbach's alpha	.883	.740 _.707_	.750	.796	.884	.815

Table 2: Principal Component Analysis
Note: For the second loading, the first Cronbach's alpha is for Concept Attitude, while the second is for PBC.

With Cronbach's alphas above .7, all resulting factors have acceptable internal consistencies. Based on the allocations presented in Table 2, six mean scales were calculated.

A separate PCA was calculated for the items related to the Travel Scale (STS) sub-scales *Time* and *Comfort* and the added item on safety. The PCA resulted in one common factor with all factor loadings above .76. As a differentiation between sub-scales was not relevant in the context of this study, we calculated a mean scale including all STS items, resulting in a high internal consistency (Cronbach's alpha =. 92).

Intention to participate in the service was operationalized by six items (see Section 4.1.2), which were likewise compiled to a mean scale. Cronbach's alpha for these were respectively .89 for interviewees presented with compensation formulated as percentage discount in their last two items and .88 for those presented with compensation formulated as monetary value.

In the data analysis, we will use the variables directly related to the concept (SVS, Concept attitude, PBC, Parcel Hand-in Concern, System Risk Concern, Intention) to describe participants' attitudes, barriers and intention around the new concept as well as related differences for demographic sub-groups. Group differences were tested for significance in ANOVAs including post hoc test with Bonferroni correction.

Subsequently, we examined how psychographic as well as sociodemographic factors are related to the intention to participate in the service when jointly included as independent variables in a linear regression modelling intention.

4.3   Results

The following section will first present descriptive results related to the adoption of the service by various sociodemographic groups. Subsequently, we examine how psychographic as well as sociodemographic factors are related to the intention to participate in a linear regression analysis.

4.3.1   Acceptance of the service by different demographic groups

Table 4 provides an overview of how people evaluated aspects of the service. In line with the responses of the qualitative interviews, the positive feelings associated with doing a small difference for the environment and one's city, as well as feeling part of a positive movement, stand out as the motivational aspects resonating the most with participants. The greatest concern among participants concerns liability, in case the parcel should be damaged somewhere else in the delivery chain, followed the concern of oneself accidentally damaging the parcel. Again, this was a common theme brought up by the qualitative interview participants.

Factors and Items	Agree %[a]	Mean	SD
SVS			
Many of my friends would participate in the concept.	19	2.81	0.88
I would feel a community spirit with the other users.	27	2.85	1.02
I would feel part of a positive movement.	45	3.32	1.06
I would feel good about having made a small difference for the environment and my city.	48	3.37	1.05
For me, it would give value to participate.	41	3.14	1.09
I would feel proud to do my small part in making the city greener.	40	3.25	0.97
SVS mean scale		3.12	0.80
Concept Attitude			
It would be a bit embarrassing to meet someone I know, while I was picking up/delivering a parcel.	11	2.13	1.02
I do not want to be associated with parcel couriers.	20	2.62	1.09
Participation is only for 'discount hunters'.	23	2.88	0.99
It is mostly the involved companies that gain from the concept, not the participants.	30	3.12	0.95
The concept would unfairly take advantage of me as a form of cheap labour.	30	2.97	0.95
Concept Attitude mean scale		2.75	0.72
PBC			
It would be difficult for me to bring parcels on my journeys.	35	3.07	1.13
The whole process of downloading an app and signing up would be too much hassle for me.	27	2.73	1.17
Bringing packages on my journeys would be too time consuming.	30	3.00	1.04
PBC mean scale		2.93	0.89
Parcel Hand-in Concern - *I would be nervous about...*			
… forgetting the parcel and not getting it handed in the locker.	37	3.02	1.12
... the package being robbed/stolen on the way.	34	2.97	1.11
... not being able to find where the package should be handed in.	42	3.18	1.07
... not being able to open the locker due to technical difficulties.	46	3.27	1.08
... not being able to open the locker because of my phone running out of battery.	34	3.01	1.12
... accidentally damaging the parcel.	43	3.28	1.06
… forgetting to hand in the parcel and accidentally bringing it with me.	34	2.93	1.15
Parcel Hand-in Concern mean scale		3.09	0.84
System Risk Concern - *I would be nervous about...*			
... that I might transport something dangerous.	37	3.13	1.10
... that I might transport something illegal.	43	3.26	1.12
... what I might be liable for, if the package is damaged somewhere else in the transport chain.	61	3.70	0.99
System Risk Concern mean scale		3.36	0.92
Intention			
How often would you make use of the opportunity to check in and out with packages if there were always packages to bring?			
… On your most used route in the Copenhagen area (outbound)	27	2.65	1.27
… On other journeys with public transport in the Copenhagen area	20	2.43	1.16
[picture and details] *If you had time and ability, how often would you be willing to bring...*			
… 1 package on your 2-zone journey, getting compensated with 50% discount on the journey costs?	30	2.70	1.29
… 3 packages on your 3-zone journey, getting compensated with the full journey costs?	25	2.56	1.33
[picture and details] *If you had time and ability, how often would you be willing to bring...*			
… 1 package on your 2-zone journey, getting compensated with 8 kr.?	28	2.60	1.31
… 3 packages on your 3-zone journey, getting compensated with 20.5 kr.?	28	2.54	1.28
Intention mean scale		2.57	1.09

Table 3: Acceptance of service
Notes: The answers to the underlying items were given on 5-point Likert scales (1-5). [a] Percentage of participants who answered "agree" or "totally agree".

In Figures 2, 3 and 4, mean scores on those psychological factors directly related to the service, are compared between various demographic groups to provide knowledge on the acceptance of the service in these groups.

When looking at gender difference, we find that women show slightly (but significantly) higher scores in SVS ($M = 3.25$, $SD = .75$) than men ($M = 3.01$, $SD = .84$), $F_{(1, 518)} = 12.03$, $p = .001$, $\eta^2 = .023$ but have higher concerns with regard to parcel hand-in ($M = 3.21$, $SD = .81$) than men ($M = 2.96$, $SD = .86$), F (1,

518)= 11.52, p = .001, as well as higher system risk concerns (M = 3.44, SD = .85) than men (M = 3.27, SD = .98), F (1, 518)= 4.60, p = .032, η^2 = .022.
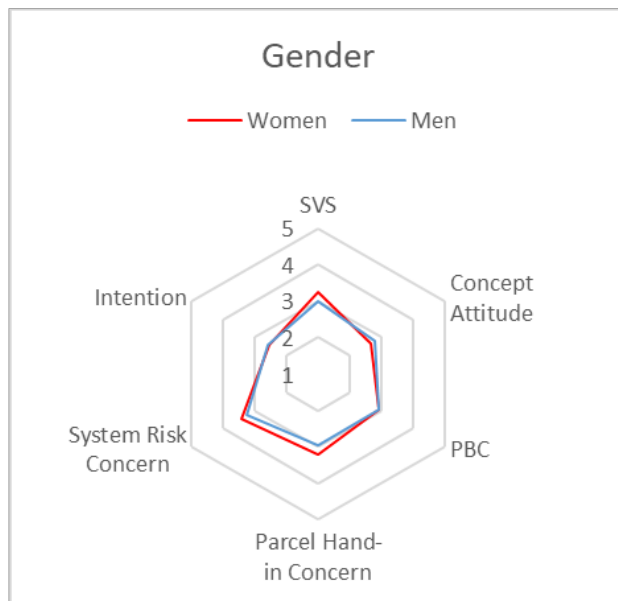
Figure 2: Psychological factor mean scores and gender

Significant differences were also found between age groups concerning SVS, F (3, 520) = 5.71, p = .001, η^2 = .032. Post hoc comparisons showed that the youngest age group (M = 3.40, SD = .67) differed significantly from the '40 - 64'-group (M = 3.08, SD = .82, p = .035) and the oldest age group (M = 2.96, SD = .77, p = .002). The '26 - 39'-group (M = 3.25, SD = .82) significantly differed from the oldest age group (p = .017).

While age is related inversely proportional to SVS (the youngest age groups have the highest mean scores), the opposite is the case for PBC where the oldest group perceived the highest difficulties (M = 3.29, SD = .87), followed by the '40 - 64'-group (M = 2.89, SD = .92), the '26 - 39'-group (M = 2.79, SD = .80) and lastly the youngest group (M = 2.61, SD = .73), F (3, 520) = 11.54, p < .001, η^2 = .062. The 65+ group stands out with high perceived difficulties represented in the PBC items and differs significantly from all other age groups in post hoc tests (p < .0001), while the other age groups did not differ significantly from each other.

The relation to age is less clear for parcel hand-in concerns in which only the '26 - 39'- (M = 3.25, SD = .77) and '40 - 64'-year-olds (M = 2.97, SD = .85) differ significantly from each other (p = .023).

There are also significant differences in Intention, F (3, 520)= 18.00, p < .000, η^2 = .094. Post hoc results show significant differences between the oldest age group and respectively the two youngest groups (p < .000) and the '40 - 64'-group (p = .014). The '40 - 64'-group also differed significantly from the youngest group (p < .000) and the '26 - 39'-group (p = .004).
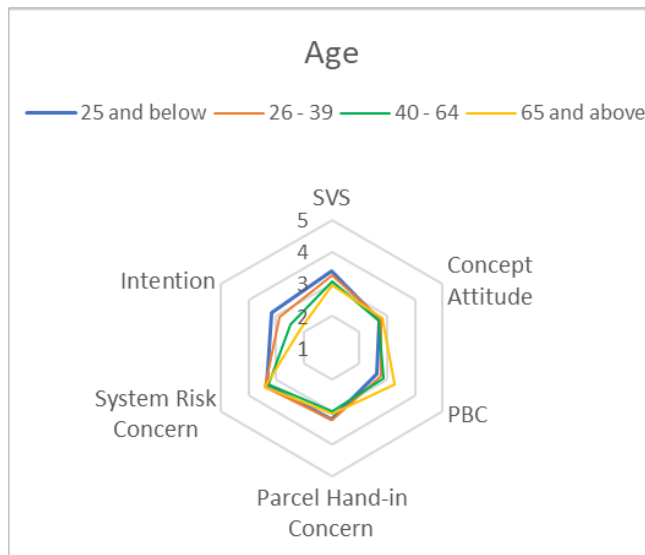
Figure 3: Psychological factor mean scores and age

Amongst the occupation categories, significant differences are found for SVS, $F_{(4, 519)}= 7.04$, $p < .000$, $\eta^2 = .051$. Post hoc results show that Retirees ($M = 2.92$, $SD = .81$) significantly differ from Non-working ($M = 3.25$, $SD = .73$, $p = .040$) and Students ($M = 3.54$, $SD = .70$, $p < .000$). Students also differ significantly from Working ($M = 3.09$, $SD = .81$, $p < .000$).

Significant differences are also found for PBC, $F_{(4, 519)}= 8.54$, $P < .000$, $\eta^2 = .062$. Post hoc results for PBC show that only Retirees ($M = 3.29$, $SD = .91$) differ significantly from other groups; Non-working ($M = 2.82$, $SD = .97$, $p = .002$), Working ($M = 2.87$, $SD = .84$, $p < .000$) and Students ($M = 2.59$, $SD = .71$, $p < .000$).

Lastly, significant differences are found between the occupation categories in Intention, $F_{(4, 519)}= 13.49$, $P < .000$, $\eta^2 = .094$. Post hoc results show that only Retirees ($M = 2.09$, $SD = 1.04$) differ significantly from other groups; Non-working ($M = 2.72$, $SD = 1.07$, $p = .001$), Working ($M = 2.62$, $SD = 1.06$, $p < .000$) and Students ($M = 3.22$, $SD = .91$, $p < .000$).
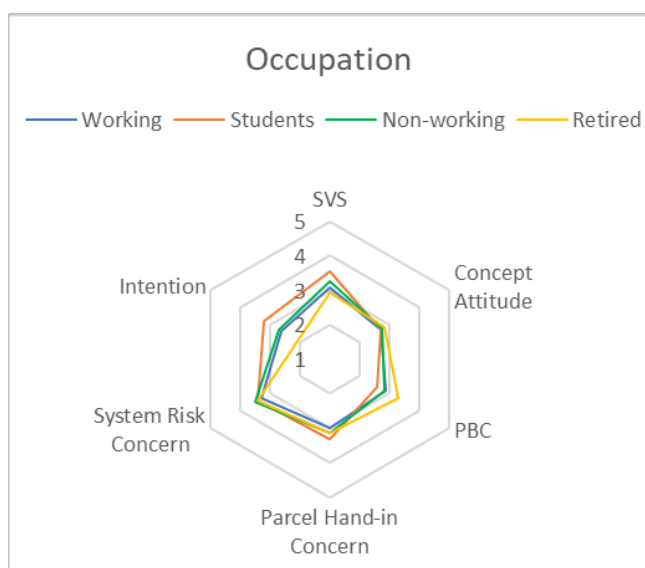
Figure 4: Psychological factor mean scores and occupation

4.3.2 Factors explaining the intention to participate in the service

A linear regression modelling the intention of participating in the crowdshipping service was calculated. The model included the psychological factors (see Section 4.1.2) and sociodemographic variables (see Section 4.1.3) with the constructed mean scale for Intention as dependent variable. The results are presented in Table 4.

The model explains 65.2% of the variance for the dependent variable. Six included variables were found to have a significant effect on the intention to participate in the crowdshipping service. SVS was by far the most important factor for intention to participate, indicating that feelings of being part of and doing your bit for a positive movement as well as social support are strong motivators for participation. PBC followed as the second most important psychological factor, with a negative impact on intention; as expected, perceived difficulties of signing up and bringing parcels is a demotivator. Also, a significant negative effect of the attitude related to status and fairness of the concept was found, indicating that symbolic values associated with the concept affect participation intention. Those who associate participation in the service with potential embarrassment and being exploited as a cheap source of labour were less inclined to participate.

Looking at the sociodemographics, the two youngest age groups are both found to be significant in their positive effect on the intention to participate compared to the reference age category '40 – 64'. When only including the demographic variables in a linear regression the occupation category Student shows significantly higher propensity to participate (model solely including demographic variables is not included in present paper). In the full model included in the present paper, the Student category is insignificant. This indicates that there is no significant effect in itself of being a student, but should rather be explained by a stronger propensity to connect participation in the service with the positive feelings represented in SVS, and lower expectations of difficulties participating among students. Male gender is found as a significant factor of intention. However, the gender effect seems related to the different assessment of SVS by men and women. While there is generally no gender difference in intention (see Figure 2), gender becomes significant when controlling for women's higher scores in SVS.

Finally, a significant positive relation is seen between the respondents' monthly expenses for public transport and the intention to participate; those with higher expenses for public transport have higher participation intentions.

Linear Regression

Variable	B	SE B	β	p
Constant	1.182	.440		.008
Age: 25 and below	.383	.173	.109	.028
Age: 26 - 39	.271	.104	.107	.010
Age: 65 or above	-.037	.133	-.015	.783
Male	.206	.079	.095	.010
Higher education or not: Higher education	-.059	.098	-.022	.550
Living with partner	-.061	.096	-.028	.523
Living in central city districts	.104	.080	.046	.190
Living with kids	.059	.100	.022	.557
Occupation: Non-working	.148	.160	.045	.355
Occupation: Student	.224	.205	.065	.276
Occupation: Working	.103	.132	.047	.436
Personal income: Below median	-.294	.156	-.073	.060
Household income: Below median	.069	.114	.026	.545
Flexible working hours	.007	.082	.003	.929
Monthly public transport expenses in Cph	.046	.019	.084	.018
SVS	.713	.060	.527	<.000
Climatenorm	-.048	.044	-.041	0.280
PMN	.031	.039	.028	.432
Concept Attitude	-.148	.071	-.098	.039
PBC	-.286	.059	-.233	<.000
STS	-.021	.044	.018	.637
Parcel Hand-in Concern	-.031	.061	-.024	.606
System Risk Concern	-.023	.053	-.019	.665

Table 4: Linear regression modelling intention to participate in the service.
Note: All VIF values were below 3.3

5   Discussion and Conclusions

The present study explored the motivational drivers and barriers for participation in a public transport based crowdshipping concept.

The results point to the importance of considering three attitudinal factors: (1) perceived ease of use and convenience (PBC), (2) the social value from participation and expected support from important others (SVS) and (3) the attitude towards participating in a commercially organized crowdshipping concept, including the potential negative associations tied to this (Concept attitude). This mirrors earlier work on motives related to participation in sharing economy concepts, where instrumental motives (economic as well as convenience), normative motives and social-hedonic motives were found most relevant (Andreotti *et al.*, 2018). In our study, the social value aspect was clearly the most relevant factor, followed by perceived constraints.

Age was found to be an influencing factor; younger people showed higher intention to participate. A slightly higher intention to participate amongst male respondents was found, but this was only significant when controlling for women's higher scores on 'SVS'. Monthly public transport expenses are also found to influence motivation to participate. No significant relation between the general satisfaction with travel by public transport and the intention to participate was found. As the qualitative interviews revealed, however, the travel context in which participation takes place - as well as passengers' (dis)satisfaction with this - should arguably still be taken into account when designing and applying a specific solution.

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These findings could advantageously be implemented in a range of realization aspects, including communication and product development, in order to increase success in establishing and maintaining use. For example, the findings of the study suggest that communication to potential users should highlight the service as a user-driven movement in which the wish to help each other – in addition to doing something good for the environment – is central. This message seems especially important to convey to the youngest group of users (those below the age of 26). Not only is this group more willing to participate than their elder co-passengers. The quantitative results showed that the social aspects of the service also resonate significantly better with young people, meaning that they to a higher extent expect participation to elicit positive feelings and support from their social surroundings. The same could – albeit less strongly – be said about communication to the second youngest age group (26-39 years). If on the other hand, wanting to attract more participants at age 65 and above, results indicate that communication efforts to this group should focus on demonstrating the ease of use and on reassuring them that they are capable of participating, thereby addressing this group's higher PBC concerns.

Survey results indicate that the wish to do something good for others and the environment, and to be part of a positive movement, was more important than the perceived need for climate action; the general personal obligation to behave in a climate-friendly way (climate norm). Interview results indicated that highlighting the environmental and not the economic aspects, also seemed relevant even for people who were motivated by the financial incentives, as they could use the green image to avoid any negative evaluations by others. This underlines the potential benefits of highlighting the green aspects tied to participation in communication efforts related to the service. Such messages could be made in combination with mentioning the economic incentive. However, the results could be interpreted to indicate not to mention the economic incentive independently from the environmental benefits in any outreach. It is worth noting, though, that the item on embarrassment related to participation noticeably stands out with the lowest mean score while none of the participants mentioned it as an issue for them personally; in general it does not seem like people would not be embarrassed to participate, financially incentivized or not.

The weight given by many interviewees to the environmental and social ideals of the service, which was reflected in the regression results, also indicate incentivization opportunities that could be pursued through the design of the crowdshipping platform and its user interface. On the environmental side, feedback has previously been proven to be an effective tool (e.g. Fischer, 2008; Stern, 2011). For example, calculated emissions savings could be presented to the participant upon hand in of the parcel. On the social side, privacy settings allowing community-building could entail visible in-app profiles, for example making possible gamification which has previously shown to provide effective motivational tools within the transport domain (e.g. Yen, Mulley and Burke, 2019). Such elements could be monthly "highscorers" or daily lotteries with each transported parcel representing a ticket.

However, results also indicate the risk of backlash stemming from potential perceptions of the commercial setup of the service that contrast its communal and altruistically oriented ideals. In other words, all reasons should be avoided, that give ground to perceptions of the service as a greenwashed precarization of delivery, capitalizing on peoples' good intentions. Such exploitative ventures have already been coined 'share-washing' (Kalamar, 2013); an exploitation of the Warm Glow connected to the sharing economy (Curtis and Lehner, 2019). As is indicated in the interviews, the antidote to this is transparency around the organization in general and the cost- and compensation structure in particular. If such unfavourable perceptions of the service gain traction, results indicate that many will not be as willing to participate for the relatively small compensation. For other users who are more

driven by instrumental motives, it may have less of a negative influence, as was found by Mikołajewska-Zając (2016) in the case of the sharing economic platform Couchsurfing that turned from a non-profit to a for-profit enterprise. Here it was found that community- and altruistically driven users were very sceptical after the for-profit switch, while those with more instrumental attitudes viewed it as unproblematic, even favourable.

Although the present study has taken a multifaceted approach, where the economic incentive has received relatively little attention, this aspect should not be neglected. The results of this paper should thus still be considered in connection with other studies that show larger importance of the economic incentive in forming actual intention to participate (and not just forming positive attitudes towards it) (Hamari, Sjoklint and Ukkonen, 2016), and large scale surveys such as a US-based (PWC, 2015) study on participation in the sharing economy where 86% of respondents highlight economic outcomes, 78% social outcomes, and 76% environmental outcomes. However, as Böcker and Meelen (2017) argue from their Amsterdam-based study that also highlighted the importance of economic incentive, it is important to not conceive the sharing economy as one coherent phenomenon, as the relative importance of economic, social and environmental motivations will vary across sectors of the sharing economy as well as across cultural contexts.

Future work could advantageously pursue an investigation of the concept's potential and its determinants in other cultural contexts, as well as of how motivation to participate might be furthered through the concrete app- and service-design.

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A public transport based crowdshipping concept: Results of a field test in Denmark

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A public transport based crowdshipping concept: Results of a field test in Denmark

Abstract

Increasing e-commerce and accompanying last mile delivery traffic challenges cities worldwide in terms of congestion, emissions, and road safety. This paper presents the main results of a full-scale field test of a public transport based crowdshipping concept aiming to address these challenges, by utilizing passenger flow to reduce the amount of delivery vehicles entering central city districts. The aim of this work was to assess adoption potential as well as the practical and conceptual aspects that may affect this.

The test took place in Denmark's capital region and northern Jutland over a two-month period, in which 28 automated parcel lockers (APLs) were placed at public transport stations/stops. Passengers were rewarded for bringing along empty test parcels on their trips, from APL to APL via an app developed for the purpose. Along with the app data, pre- and post-survey data was captured.

The practical viability of the concept was validated from a user perspective, with a high degree of post-measure Acceptance. Regression results show that ease of interacting with the service affected Acceptance of the tested concept, but not the Intention to participate in a future realized concept. Perceived Behavioural Control was the most important predictor of Intention, Acceptance and behaviour during the trial. Our results highlight the relevancy of contextualizing and supplementing Intention as a practice-based measure for adoption propensity.

Highlights

- A full-scale test of a public transport based crowdshipping concept was conducted
- 28 parcel lockers were placed at public transport stations/stops in Denmark
- An app was developed, allowing participants to bring parcels from locker to locker
- Viability was validated from a user perspective, with a high degree of Acceptance
- Perceived Behavioural Control was the most important predictor of Intention and Acceptance

Keywords

Crowdshipping, Last-mile package delivery, Field test, Theory of Planned Behaviour, Acceptance

1 Introduction

The growth of e-commerce represents an increasing challenge for logistics operators and the communities they cater to (Mangiaracina et al., 2019). Especially the last stretch of the transport chain, the last mile, is agreed by both practitioners and academics to be the most critical and inefficient element of the delivery process, both in environmental and economic terms (Macioszek, 2018; SOTI 2020). With customer expectations that set high service level targets, speed and flexibility must be prioritized to ensure competitiveness. The resulting lacking possibilities for consolidation means that costs of the last mile amount to half of total costs (Chen et al., 2018; Rodrigue et al., 2016), as well as necessitating fleets of delivery operators contributing to increasing congestion issues in cities (Allen et al., 2018; Taniguchi et al., 2016). Public transport based crowdshipping represents an opportunity to mitigate some of the abovementioned challenges. However, it has received very little attention academically or practically. In contrast to private vehicle based crowdshipping (e.g. Punel, Ermagun and Stathopoulos, 2018; Allahviranloo and Baghestani, 2019; Ermagun, Punel and Stathopoulos, 2020), utilization of public transport passengers' excess capacity would solely make use of non-dedicated trips and thus avoid the problem of detours that often cause crowdshipping with private vehicles to result in higher emissions than traditional delivery modes (Buldeo Rai et al., 2018). To enable this, a public transport system would make use of Automated Parcel Lockers (APLs), which in themselves have shown a range of advantages compared to traditional home delivery (e.g. Buldeo Rai et al., 2021; Oliveira et al., 2017).

Initial explorations of implementing such a system in the city of Rome found potential savings to be made (Simoni et al., 2019). Concurrently with the work of present paper, Cheng et al. (2022) used real-world data from a freight operator to simulate public transport based crowdshipping scenarios for last part of deliveries to Copenhagen. They found substantial savings potential in both economic and environmental terms compared to the status quo.

Although such a solution has shown potential for mitigating the issues the last part of delivery chains, its efficacy is dependent on user up-take. Recent work has shed some light on public transport passengers' willingness to act as crowdshippers (Gatta *et al.*, 2018; Fessler *et al.,* 2022a; Fessler *et al.,* 2022b), but has been based on Stated Preference experiments and surveys measuring Intention to participate. Though Intention – as proposed by the Theory of Planned Behaviour (Ajzen, 1991) – has proven useful in predicting behaviour, frequently low empirical Intention-behaviour relationships (e.g. Armitage and Conner, 2001) has also pointed to the value of contextualizing evaluations within the everyday practices in which the behaviour should actually take place (e.g. Lockton, 2012; Madsbjerg, 2017). In particular, in case of future mobility services, it has been found difficult to give a realistic indication of future adoption based on hypothetical scenarios, while hands-on experience can uncover practical limitations and lead to more accurate assessments of future use (Millonig & Haustein, 2020). As such, there is a need to ground research on crowdshipping solutions in contextualized practical interactions to evaluate theoretical and practical understanding of adoption potential.

In response to this need, this paper proposes and investigates a public transport based crowdshipping concept in which APLs are placed at public transport stations and stops, in spots that are convenient for passing passengers. Registered users then get the opportunity to bring along parcels on their matching public transport trips, from APL to APL. As such, this paper presents the main results of the (to our knowledge) first field test of a public transport based crowdshipping concept, and provides important practical and conceptual insights for the field.

The remainder of this paper is organized as follows. The next section introduces the relevant theoretical background before Section 3 describes the contributions we aim for with the paper. Section 4 introduces the method of the study, including a description of the practical test, the

procedure and participants, survey content and the analysis approach. Section 5 presents results. Lastly, Section 6 presents main conclusions and discussion points, including limitations and practical implications.

2   Theoretical background

The Theory of Planned Behaviour (TPB, Ajzen, 1991) is one of the most frequently applied frameworks for understanding user acceptance and is applied in a wide variety of domains including transport behaviour (Vlassenroot et al., 2010). Intention is the main determinant and immediate precursor of behaviour in TPB, and an indication of an individual's readiness to perform a given behaviour. Intention is shaped by 1) attitude toward behaviour 2) subjective norms and 3) perceived behavioural control (PBC). TPB is open for the inclusion of additional factors. Relevant extensions in the context of transport behaviour are, for example, the inclusion of habit (Klöckner & Blöbaum, 2010) and of symbolic motives and self-identity (e.g. Fallah Zavareh, Mehdizadeh and Nordfjærn, 2020). Specifically, applying an extended TPB to predict people's willingness to participate in a public transport-based crowdshipping concept, Authors (2022) identified a joint factor including the social value from participation and the expected support from important others (subjective norm) as the most important predictor of the Intention to serve as a crowdshipper. The study also highlighted the importance of Perceived Behaviour Control, operationalised as the perceived ease of use and convenience. Participation in the service would need to be a smooth experience that merges well with individuals' transport routines and habits, in order to be worth their while with the relatively small remunerations that would be possible within the current margins of deliveries. This brings attention to practical aspects of implementation, such as concept simplicity, app usability, and parcel locker placement, and followingly on the practical experience of participation.

Intention, acceptance, and acceptability are examples of terms that have been used interchangeably to describe (potential for) user uptake of new technology. Within the domain of transport psychology, one distinction between acceptability and acceptance has been defined by Schade and Schlag (2003, p. 47). *Acceptability* is here understood as "*the prospective judgement of measures to be introduced in the future*", and a construct that is measured prior to an individual's experience with the object of interest. *Acceptance* on the other hand is here referred to as individuals' attitudes, including behavioural reactions, after this object of interest has been introduced. Thus, for the purpose of this study, we are not only interested in evaluations of the concept (acceptability), but in the evaluation of participants' interaction with (a simulated version of) it – it's Acceptance (Nadal, Sas and Doherty, 2020). In other words, how will conceptual and practical aspects of the interaction with the concept serve to (de)incentivize future adoption. Intention, on the other hand, is applied in this paper as a measure, which is more related to the core concept rather than the practical experience with the service, although hands-on experience is still expected to enrich the post-measures for Intention and increase the reliability of the results.

3   Research aims

Based on insights from a practical test of a public transport based crowdshipping concept, we aim for three main contributions:

- to achieve a more realistic measure for Intention to participate in a realized public transport based crowdshipping concept, by providing practical experience as basis for evaluations;
- to examine what worked from a practical perspective and what should be iterated in a future concept;

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- to model how psychological constructs related to the TPB affect different evaluation criteria: post-intention, Acceptance, and engagement in the trial (behaviour).

Based on our results, we shed light on motivational and demotivational aspects relevant to the proposed crowdshipping concept.

4   Method

In order to answer the above research aims as well as provide a practical experience-based empirical foundation, a real world experiment was conducted in which public transport passengers were offered the opportunity to get economically rewarded for bringing (empty) test parcels from APL to APL along on their matching public transport trips between stations/stops included in the test.

The user experience of the crowdshipping concept was measured through a pre-survey, the field test and a post-survey that was split into two separate surveys; one for participants who took part in the practical test by bringing 2 or more parcels and one for those who did not take part in the practical test (to examine reasons for not participating). The survey responses were linked to data from the 'CrowdShip' app developed for the purpose. The app served as a tool for communication between participants and the system (opening of APL, feedback, reminders) and trip registration. Given this context, we first outline the practical aspects of the field test (Section 4.1), before providing details on the participants and procedure (4.2), survey approach (4.3) and data analysis (4.4).

4.1   Practical test

Participation in the practical test was possible from September 2nd 2020 and originally scheduled to last throughout September. However, as a national COVID19-lockdown[1] was announced on September 18th, the experiment period was extended to last throughout October, in order to compensate for the vastly diminished number of public transport trips taken due to being sent home from work etc.

In order to gain the required approvals, access to necessary locations and the facilities needed to maximize realism of the experience, the experiment was organized in collaboration with municipalities, DSB (the Danish national rail company), Metroselskabet (Metro company) and Nærboks (the APL-provider, partly owned by the Danish national postal service). This made it possible for participants to interact with an app, APLs and parcels as outlined in the following two sections.

4.1.1   App and participation process

A smartphone app, 'CrowdShip', dedicated to the experiment was developed for both IOS (iPhone) and Android, which through Bluetooth-connection facilitated the interaction with the placed APLs. Through the app, participants could 1) book a test parcel with a matching route, by entering their departure and destination station (Fig 1 screen 1), 2) use the app to open the APL at their departure station (one of the 28 included stations/stops) through Bluetooth (Fig 1 screen 2), and 3) open the APL to hand it in at their given destination (another of the 28) (Fig 1 screen 3).

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[1] During the lockdown, travel with public transport was still possible, but work from home was strongly encouraged.
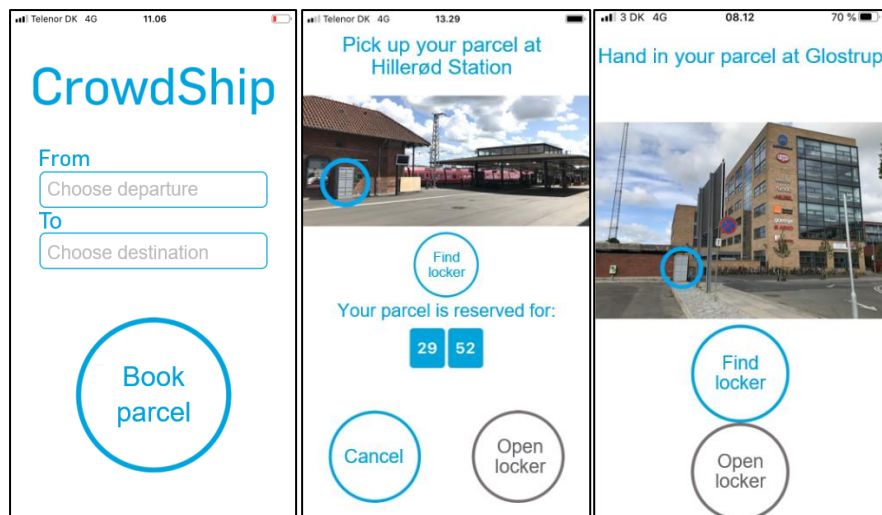
Figure 1: App screenshots: Screen 1,2,3

The whole process of booking a parcel for a matching trip, opening the locker through the app and closing it again after taking the parcel could be completed in less than 20 seconds, which comes close to the scope of the imagined realized solution. To imitate the imagined realized concept more closely, a booking of a parcel lasted 30 minutes. If the parcel was not collected within this time, a new booking had to be made. In a full implementation, it could be considered to extend the booking time frame.

The app gathered information about each participant's interaction with the service, registering each trip a parcel was brought, with date/time and departure/destination point.

To incentivize participation and reward participants for the time spent on surveys and installation of the app, they received a basic compensation of a 50 Danish kroner (6.7 €) gift certificate for completing a pre-survey, bringing a parcel on two trips, and completing a post-survey. In order to mimic the basic incentivization scheme of a realized concept in the most realistic way possible, participants moreover received 10 kr. (1.3 €), for each additional trip, which was added to their gift certificate. Maximum total amount per person was 100 kr. (=7 trips). In a realized concept, crowdshippers would receive their remuneration as credit for the transit system, and it would be possible to bring multiple parcels to earn more credit.

4.1.2 APLs and parcels

During a two-month period, 28 APLs were placed at public transport stations and stops; S-train, Metro, Bus and Train. In order to imitate the imagined operational area and direction of a last mile solution overseeing deliveries from city outskirts to central districts, 22 of these APLs were placed in the Greater Copenhagen area. The lockers were distributed within the operational area of S-trains, representing both satellite towns, suburban areas and central city areas. In addition to these 22, six APLs were placed throughout a larger geographical area of Northern Jutland, a less densely populated region of Denmark, of which four were placed in small towns and two in the larger town of Aalborg.
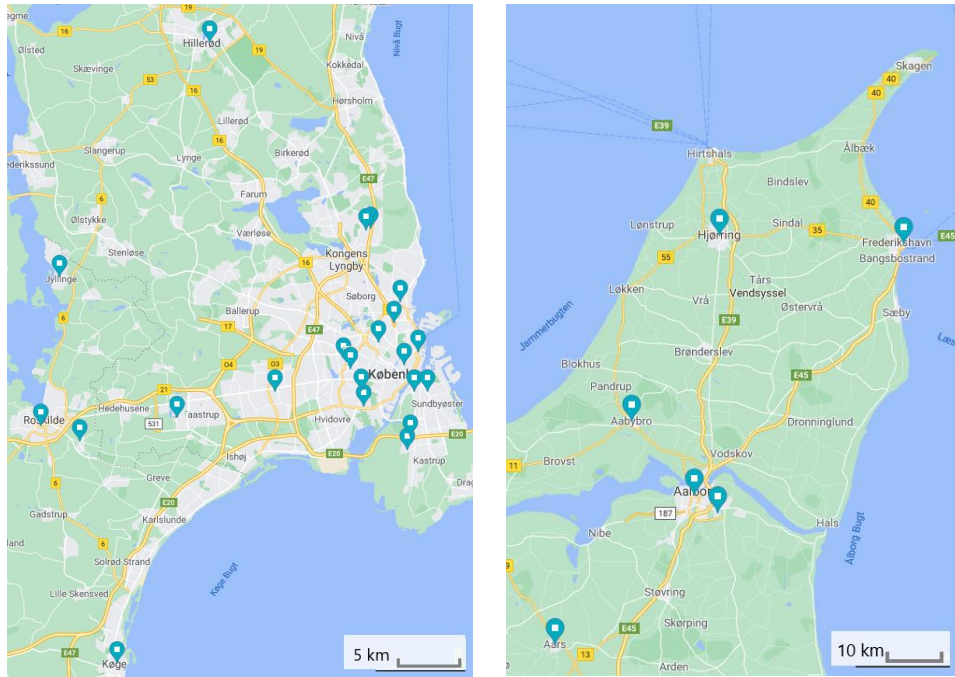
Figure 2: APL map for capital area and Northern Jutland

To ease localization as imagined in a realized solution, APL placements were depicted in the app when relevant; a picture of the departure APL with surroundings was displayed upon booking a parcel, and displayed for destination APL upon closing the locker door after pickup as seen in Figure 1. Further, in order to make participation as easy as possible, all APLs at S-train stops were placed on the station premises, as imagined for a realized concept. All metro station APLs were placed above ground, in the immediate vicinity (max 20 meters away) of the entrance. Some stations included both S-train, metro, bus and/or train connections. This provided the opportunity to test participation for multimodal trips, but was also a natural result of including some of the city's most central and frequented stations. APLs placed at bus stops varied more in terms of distance, with some placed immediately by the stop, and others placed up to 100 meters away. This was dictated by what was logistically possible, but was also seen as an opportunity to test for any influences of the varying distances.

Figure 3: APL placement example

Only one "locker" in each installed APL (that each contained 13 separate lockers) was used, and thus contained multiple test parcels, of which participants were instructed to bring just one. The empty test parcels where therefor of relatively small size, with dimensions of 19 x 12 x 4 cm, allowing 60 parcels to be placed in each at the beginning of the experiment. The parcels only weighed the few

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grams of their own cardboard material. This solution was chosen in order to limit complexity of the technical development of the app. In a realized concept, each individual locker would of course only contain the parcel(s) for the individual crowdshipper to bring, and the size and weight of parcels would vary. The test solution thus closely mimicked the experience of participating in the proposed realized concept, where a specific parcel with a matching itinerary would be booked, except for this aspect of the lockers containing multiple parcels and the weight/size of parcels. Possible implications of this are discussed in Section 6.

4.2   Procedure and participants

Recruitment took place through a sign-up link where participants registered with their email, after which they received a pre-survey link via email. This sampling was not chosen with the goal of being representative for a larger population, but rather to be illustrative of potential early adopters, which has previously been used as a purposeful sampling strategy in exploratory pilot studies, where the aim is general insights in uncharted territories (Storme et al., 2020). Sign-up links were distributed from September 1st 2020 via social media and was mentioned in various national and local tv-, radio- and online news outlets. Upon completion of the pre-survey, participants received an email with download links and installation-guides for respectively IOS and Android users, as well as a guide on how to participate by bringing parcels during the experiment. Immediately after the experiment period, post-survey links were distributed via email to all respondents completing the pre-survey (respectively to those who participated, which was automatically registered through the app, and those who did not).

Throughout most of the experiment period, emails reminding to participate were sent on a weekly basis to all pre-survey respondents who had not yet brought a parcel, with higher frequency in the last two weeks. The last four days, daily reminders were sent.

All Android-users (both those who had already participated and those who had not) also occasionally received push-notifications reminding to participate[2].

This resulted in 454 completed pre-surveys (64% women, 34% men) from respondents between 16 and 73 years of age (M = 29; SD 11.50) (see Table 1). 157 of these respondents (35%) also participated in the practical test, while 144 of those who did so (92 %) also completed the post survey (60% women, 38% men). Participants were likewise between 16 and 73 years of age (M = 29; SD 10.90). 145 respondents who completed the pre-survey but did not participate in the practical test completed the post survey for non-participants.

4.2.1   Participants

The main reasons for not participating in the practical test was being sent home due to COVID19 and thus not travelling as usual. 22% of non-participating respondents who installed the app, and 32% of those who did not, indicated this as the main reason. Additionally, 39% of app-downloaders and 29% of those who did not download, selected "Other" as main reason. A large proportion of these respondents elaborated in accompanying text entry, that their lacking participation was due to COVID19. Amongst non-participating respondents who installed the app, the main reason was forgetting to participate when travelling by public transport although they intended to (27%). There were found no attitudinal or demographic differences between those who downloaded the app, but forgot to participate and those who remembered to participate (in an independent samples t-test, the lowest p-value was .3).

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[2] Push-notifications are messages that can be sent to pop up on the users' phone screen without them having to be in the app and allow the user to go directly to the app by pressing it. Push-notifications for IOS were more complex to implement, and were therefor not prioritized given the available resources for the test setup.

Participants did not differ significantly from non-participants in any attitudinal variables, including Intention to participate in a realized concept (p > .10). Concerning demographics, one significant difference regarding participation was found. People from Northern Jutland (16.8 % of pre-survey participants) were significantly underrepresented as participants in the practical test (9.7 %) compared to Copenhagen-based respondents (84.4 % vs. 90,3 %), X^2 (2, N = 454) = 6.6, p = .038. The main reasons for not participating given by respondents from Northern Jutland were the same as for the rest of the sample.

Variables	Pre-survey only	Pre- & non-participant-survey	Pre- & post-survey test participants
N	152	145	144
Gender			
Female	63.5%	65.2 %	60.4 %
Male	31.7%	31.6 %	38.2 %
Other/Do not wish to answer	3.7%	1 %	1.4 %
Age			
25 and below	55.0%	51.3 %	52.1 %
26 – 39 years	27.5%	29.0 %	34.0 %
40-64 years	14.3%	16.8 %	13.2 %
65 years and above	1.1%	1.0 %	0.7 %
Employment status			
Working	36.0%	37.7 %	32.6 %
Student	57.1%	53.5 %	52.8 %
Non-working	4.2%	5.5 %	8.3 %
Retired	1.1%	1.6 %	4.2 %
Education level			
Low	50.3%	47.4 %	43.1 %
Medium	26,5%	27.4 %	31.3 %
High	19.6%	21.6 %	22.9 %
Income			
Below median	62.6 %	62.5 %	63.7 %
Median	21.6 %	20.7 %	16.1 %
Above median	15.8 %	16.8 %	20.2 %
Geography			
Copenhagen Outskirts	39.7 %	44.5 %	50.7 %
Copenhagen Central Districts	41.3 %	37.1 %	39.6 %
Northern Jutland	16.4 %	16.8 %	9.7 %

Table 1: Sample characteristics

In our sample 86% of participants are below 40 years old, compared to 57% of public transport users in the Copenhagen area, and 53% of participants being students compared to 29% of said population. 12,5% of participants are retired/not working, compared to 26% of the population. This is in line with previous results comparing sociodemographic characteristics related to participation propensity with the general population of public transport users in the Copenhagen area (For details, see Fessler et al., 2022a). In the sample of present study, women are overrepresented, with 60% compared to 46% of the population (Transport DTU, 2020).

4.3 Survey content

Some data-points where included in both pre- and post survey, while others we only necessary to include in one of the two. In addition to a common core part with psychological items, the pre-survey additionally included a sociodemographic background part, while the post-survey included specific questions on the experience with and evaluation of the tested crowdshipping solution.

4.3.1 Pre-survey

Following from our theoretical lens as well as the results of a prior study distributing a similar survey to a representative sample of the Greater Copenhagen area (for details see Authors, 2022), items included in the pre- and post-survey were intended to cover the following factors that were inspired by an extended version of the Theory of Planned Behaviour (Ajzen, 1991):

Intention was measured with three items that for various trip types asked how often the respondent imagined to make use of the opportunity to check in and out with packages if there were always packages to bring (e.g. "How often would you make use of the opportunity to check in and out with packages if there were always packages to bring - On your most used route in the Copenhagen area (outbound)"). Answers were provided on a five-point frequency scale (1= never; 5= always).

Concept attitude – towards the non-specified crowdshipping company – measured the perceived value of participation and the perceived fairness of this in comparison to the imagined gains of the crowdshipping company (four items, see Table 2) (e.g. Morton, Mattioli and Anable, 2021). In this, items related to symbolic motives (status) and potential feelings of embarrassment of receiving compensation were also included. Statements for concept attitude were assessed on a five-point agreement scale (1=totally disagree; 5=totally agree).

PBC measured the perceived difficulty and time-consumption of participation with three items. Additionally, more specific *Barriers* for participation were measured with separate items. Of these, five items focused on liability issues in case of damage to the package caused by oneself or others, risk of theft/robbery and fear of transporting dangerous/illegal goods. Three items focused on the risks of forgetting the parcel and thus not handing it in, or not being able to hand it in due to the phone running out of battery. Two items measured the fear of a faulty system such as technical issues or not being able to find the package locker.

Social value and support (SVS) consisted of five items covering 1) social aspects of participation that included Subjective Norm (Ajzen, 1991) and Relatedness (e.g. Schikofsky, Dannewald and Kowald, 2020), covering if participants imagined their friends to participate and potential positive feelings of being part of a movement or community as a result of participation. 2) The imagined potential of participation eliciting positive emotions as a result of contributing towards societal needs and environmental protection, which was covered by the construct of Warm Glow (e.g. Venhoeven, Bolderdijk and Steg, 2013).

We calculated a principal component analysis (PCA) using Varimax rotation based on the larger pre-survey sample to reduce the 22 items to their underlying factors. The PCA resulted in five factors (based on Eigenvalue criterion), as seen in Table 2. As in a previous study, PBC and Concept attitude loaded on the same factor. However, they were split up because of a clear conceptual distinction between the control and competence oriented PBC-items and the attitudinal items evaluating the concept from a moral and symbolic perspective (Authors, 2022). Total variance explained was 55.2 %. We conducted a PCA based on the post-survey data, which resulted in a slightly different solution explaining 64.2 % of the variance. The deviations of results could be due to the lower number of participants and/or the practical experience of the post-survey sample. As the solution based on the

pre-survey data is based on a larger sample and closer to the solution obtained from a representative survey, we used this solution as a basis to create mean scales. Table 2 shows the internal consistencies for the resulting mean scales as identified based on the pre-survey. Concept attitude and System flaw have a much lower internal consistency based on the second survey, while PBC has a low reliability in both the pre- and post-survey data, which needs to be taken into account when interpreting the results. Apart from that, all internal consistencies are above .7 and thus considered satisfactory.

Principal Component Analysis (Pre-survey)	SVS	Concept attitude and PBC	Losing/ damaging parcel	System flaw	Dangerous /Illegal goods
Item					
Many of my friends would participate in the concept.	**.559**	-.018	.187	-.057	-.057
I would feel a community spirit with the other users.	**.738**	-.256	-.174	.111	.015
I would feel part of a positive movement.	**.705**	-.182	-.040	.192	-.040
I would feel good about having made a small difference for the environment and my city.	**.695**	.030	-.068	-.169	.063
For me, it would give value to participate.	**.693**	-.192	-.035	-.119	.056
It would be a bit embarrassing to meet someone I know, while I was picking up/delivering a parcel.	-.095	**.700**	.191	.042	.068
I do not want to be associated with parcel couriers.	-.108	**.529**	-.034	.013	.309
Participation is only for 'discount hunters'.	-.253	**.654**	-.075	.117	.121
The concept would unfairly take advantage of me as a form of cheap labour.	-.301	**.487**	-.088	.224	.206
It would be difficult for me to bring parcels on my journeys.	-.030	**.602**	.190	.333	-.097
The whole process of downloading an app and signing up would be too much hassle for me.	.013	**.572**	.164	-.059	.096
Bringing packages on my journeys would be too time consuming.	-.138	**.581**	.149	.247	-.166
I would be nervous about...					
... forgetting the parcel and not getting it handed in the locker.	-.006	.173	**.827**	.217	.091
... accidentally damaging the parcel.	-.009	.077	**.603**	.329	.386
… forgetting to hand in the parcel and accidentally bringing it with me.	-.050	.123	**.753**	.275	.061
... not being able to find where the package should be handed in.	-.062	.185	.210	**.718**	.049
... not being able to open the locker due to technical difficulties.	-.027	.132	.100	**.683**	.241
... not being able to open the locker because of my phone running out of battery.	.003	.117	.228	**.613**	.093
... what I might be liable for, if the package is damaged somewhere else in the transport chain.	-.031	.007	.240	**.614**	.353
... that I might transport something dangerous.	.001	.149	.482	.199	**.498**
... that I might transport something illegal.	.003	.142	.132	.160	**.828**
... the package being robbed/stolen on the way.	.047	.070	.116	.236	**.825**
Cronbach's alpha (Pre-survey)	716	.665/.557	. 786	.727	.770
Cronbach's alpha (Post-survey)	.738	.482/.643	.767	.659	.768

Table 2: PCA Factors and items. Note: Results for PBC are underlined

Additionally, we used two sub-scales of the Satisfaction with Travel Scale (STS) : *Time* and *Comfort,* with respectively three and four items. *Time* measured whether the participant in relation to their most frequent journey felt stressed, hurried and worried about arriving on time (Ettema et al., 2011). *Comfort* was measured with three items on the ease, functioning and comfort of the trip (Ettema et al., 2011), and additionally one item created for the purpose of this paper which measured the degree to which the participant feels safe on the trip. For consistency with the rest of the survey, the STS items were measured on the same five-point likert scale as used in the other items. Cronbach alpha for the common STS scale was .907.

To compare sample characteristics, the pre-survey additionally included the following background variables: postal code, age, gender, household composition (living with children/partner/

parents/other adults), income, monthly public transport expenses, employment status (eight categories), work hour flexibility (fixed/flexible work hours) and education (seven categories).

4.3.2 Post-survey

Acceptance and post-measures of Intention

The post-survey initially gathered information about the extent of participants' public transport travel between included stations during the test period, in order to assess their participation in a relative sense. To identify any differences regarding technical issues, they were then asked whether they installed the app on IOS or Android. Subsequently, the survey included the same attitudinal items as the pre-survey. Additionally, the post-survey included a range of questions about test participation, in order to assess the experience and practicalities of interacting with the concept. These were also answered through five-point agreement scales. In addition to the theoretically based factors mentioned in Section 4.3.1, a range of mean scales were therefor created from selected post survey items evaluating the test experience.

Considering the technology adoption process as a temporal continuum, we employed *Acceptance* as a measure for user's first interaction with a service and followingly if this served to motivate future use, as it has been proposed for early stages of a design process (Arbelaez Garces et al., 2016). Like the majority of related studies, we do this by employing custom measures on Acceptance to adapt to the specific issues relevant for the test and its relation and comparability to a realized concept (Nadal et al., 2020). This was done through adapted Technology Acceptance Model items on Perceived usefulness, Perceived ease of use and motivation as result of test participation (e.g. Arbelaez Garces, Rakotondranaivo and Bonjour, 2016; Goudsmit and Vos, 2021).

Acceptance was measured with three items included in the post-survey; 'Participation in the test increased my motivation to participate in the concept if it should become realized', 'Participation was easy for me' and 'My overall experience of participating in the test was good'.

A Principal Component Analysis using Varimax rotation was conducted to empirically validate the distinction between the Acceptance items and post-survey measures for Intention as seen in Table 3. The distinction was confirmed with the items loading onto two separate factors (based on Eigenvalue criterion) following the theoretical divide.

Principal Component Analysis (post-survey dependent variables)

Item	Acceptance	Intention
How often would you make use of the opportunity to check in and out with packages if there were always packages to bring-		
… On your most used route in the Copenhagen area (outbound)	.149	**.797**
… On your most used route in the Copenhagen area (inbound)	.253	**.772**
… On other journeys with public transport in your city/area	.172	**.673**
Participation in the test increased my motivation to participate in the concept if it should become realized	**.688**	.391
Participation was easy for me	**.889**	.198
My overall experience of participating in the test was good	**.868**	.133
Cronbach's alpha	.804	.669

Table 3: PCA factors and items (post-survey dependent variables)

Practicalities and other experience measures

A mean scale for 'App difficulties' measured issues with connecting to the APLs with four items ('I experienced issues connecting to the lockers through the app', 'It was difficult to open the parcel

lockers with the app', 'It was difficult to open the parcel locker with the app (most used departure station)', 'It was difficult to open the parcel locker with the app (most used destination station)'), with a Cronbach alpha of .896.

A mean scale for APL Localization was created from four items; 'The placement of the parcel locker was good' and 'I had a hard time finding the parcel locker at the station/stop' respectively for the participant's selected Departure and Destination station. As satisfaction with APL placement at departure and destination are not necessarily related, Cronbach's alpha for this joint mean scale was not calculated.

Participants were also asked about the extent of their public transport travel during the experiment and which station they used most often as respectively pickup and drop off location.

For a range of the questions evaluating both the experienced concept, app and interactions with the service at the participant's indicated departure- and destination point, an elaboration through text entry was requested in the case of negative evaluations (values 1 and 2 on the five-point Likert scale). Further to get a deeper qualitative understanding than what could be expressed through quantitative measures, all participants were asked to elaborate via text entry on when and how they remembered to bring a parcel, what should have been done for them to have participated more often as well as the most positive and negative aspect of participation. Lastly, participants had the chance to give additional comments in a concluding open text field, in order to provide the possibility to elaborate or contextualize their answer as well providing an opportunity to catch any aspects that had not been covered by the standardized questionnaire.

4.4   Analysis

Data from pre-survey, Crowdship app and post surveys was merged into one dataset and analysed using SPSS software. After providing descriptive statistics (percentages and means), we performed paired samples t-tests to compare pre- and post-survey results, and Pearson's Correlations to examine linear relations between selected variables. Further, three multiple linear regressions were conducted to find potential effects of a range of post-survey measures (PBC, Concept Attitude, SVS, App difficulties, APL localization and barriers Losing/damaging parcel, System flaw, Dangerous Illegal goods, Public Transport travel during experiment and most used pickup direction) as well as pre-survey Intention and STS on respectively post-survey Intention, Acceptance and amount of Trips taken during the experiment with a parcel (= number of parcels brought during the experiment).

5   Results

5.1   Overall experience

In total, just under 900 trips were taken with a test parcel during the experiment period. On average, participants[3] brought 5.5 parcels (SD = 5.0).

A main purpose of the study was to assess adoption potential. As a backdrop to this, 82% of participants agreed or strongly agreed to the statement 'Participation in the test increased my motivation to participate in the concept if it should become realized'. 6.3 % disagreed or strongly disagreed with it. 11.8 % neither agreed nor disagreed. Figure 4 shows a range of Acceptance-related items, of which the three retrospective items were compiled in the mean scale, Acceptance.

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[3] Only including respondents of the post survey.
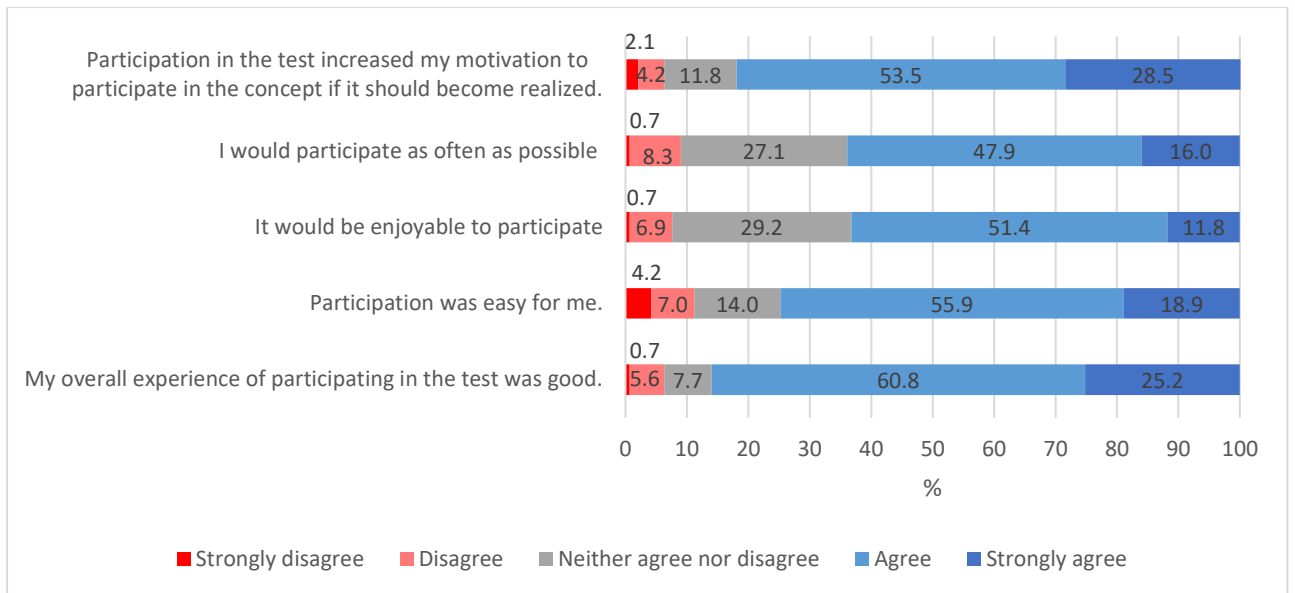
Figure 4: Agreement to Acceptance-related statements on participation (post-survey)

After participating in the test, 46.6% of participants would often or always bring a parcel on their most used outbound trip, while 39.6% would occasionally bring one. 68% of participants would often or always bring a parcel on their most used return trip, while 24.3% would occasionally bring one.
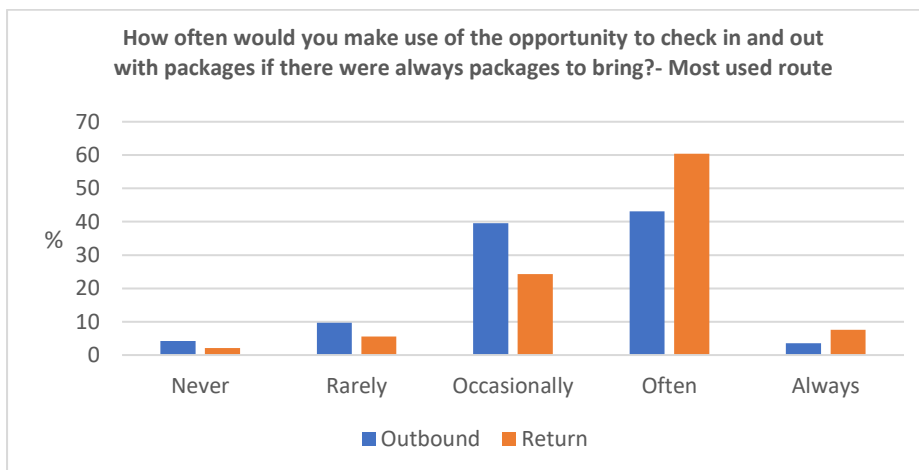
Figure 5: Expected participation in a realized concept (post-survey)

As such, the potential for user Acceptance of the proposed service was substantiated by the practical interactions with the service. In the next sections, we take a closer look at which practical and conceptual aspects of the service were related to positive experiences with – and subsequently Acceptance of – the service.

5.2 Practicalities

5.2.1 App and APL interaction

In the following, results are presented on the main interaction with the service, which was the process of picking up and handing in the parcels in the APLs through the app. This is done to illustrate the influence of the most fundamental practical elements that served as contextualized basis for evaluations of Acceptance and Intention.

Figure 6: App-related items (post-survey)

A relatively large proportion of participants experienced difficulties with the app, as for example expressed in the item 'I experienced issues connecting to the lockers through the app', which 36 % agreed to and 18 % strongly agreed to.

The connection issues were also frequently mentioned as the most negative aspect of participation, where it became evident that pace of connecting had fluctuated heavily, with some participants spending ten minutes trying to connect and, in some cases, giving up. For a majority of the participants, however, the interaction with the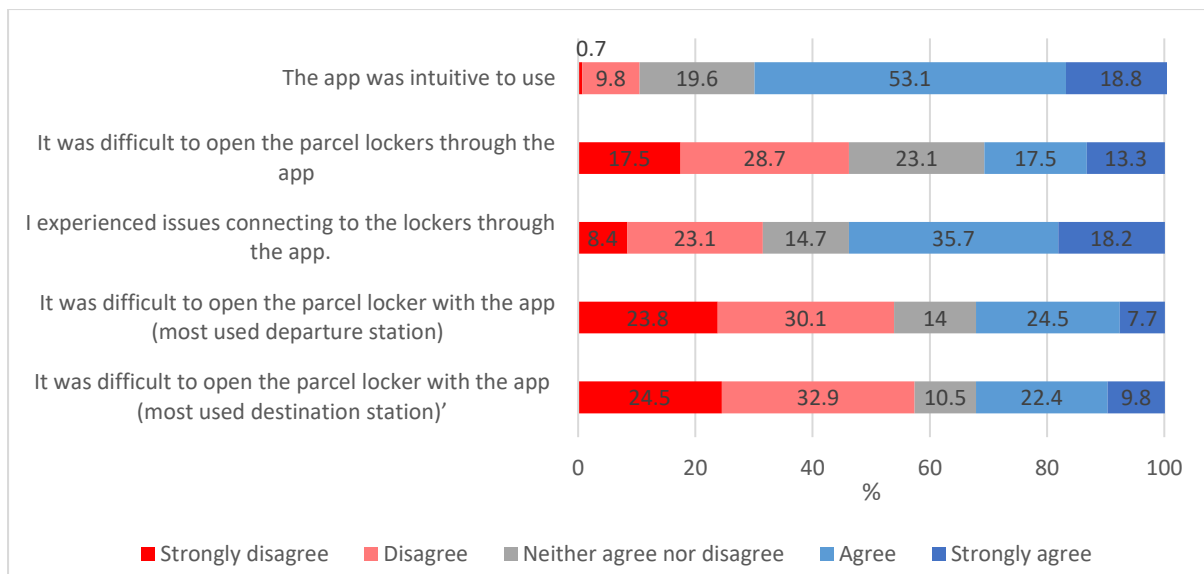 APLs seems to have run relatively smoothly most of the times, with 'only' 32% agreeing that they experienced difficulties connecting to the parcel locker at their given departure station's APL and equally 32% for their destination's APL. Further, as seen in the previous section, about 75 % agreed that 'Participation was easy for me' and 86% agreed with 'My overall experience in the test was good'. All participants answering 'Strongly disagree' or 'Disagree' to the item 'My overall experience in the test was good' were subsequently asked to elaborate by text entry. 8 of 9 answers to this was due to connection issues between the app and APL. The remaining one of the 9 was due to APL placement.

5.2.2 APL placement

Together with the app/APL interaction, the placements of the APLs were thought to be a central practical element in the determining how smoothly participation can integrate into existing public transport behaviour.

The APL placements were generally rated positively as seen in the item 'The placement of the parcel locker was good' (departure station M = 4.06, SD = .98; destination station M = 3.64, SD = 1.22). It is worth noting that even though the same APLs served as both Departure/Destination, participants seem to have experienced more difficulties with the placement of destination APL than departure APL, which was also seen in the item 'I had a hard time finding the parcel locker at the station/stop' (departure station M = 1.68, SD = .88; destination station M = 2.15, SD = 1.12´). For both items, the same APL placements were evaluated differently as respectively departure and destination APL. Satisfaction with Departure APL was positively correlated to Acceptance, r(141) = .212, p = .011, whereas no significant correlation was found for Destination APL r(141) = .148, p = .077. Potential explanations for these differences are discussed in Section 6.

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One station stood out, in terms of negative ratings. The APL at the station Østerport was placed at an alternative entry-point located at a bicycle-parking area, far (around 200 meters) from the main entrance to the station. Comments also elaborated that this parcel locker had been hard to find for many participants which had led to frustrations (with one participant even spending 40 minutes searching for it and others eventually giving up). The APL Localization mean scale had a mean score of 4.03 for all stations. Østerport scored just 1.65. For negative evaluations of APL placement, an elaboration was requested on where placement should have been instead. All placement suggestions for Østerport were for the main entrance.

The outlying example of Østerport illustrates a tendency found for throughout the list of stations; looking at the opposite end of the spectrum, the highest rated stations had APL placements that were in the immediate vicinity of the direct access point to the mode of transport or - in the cases of stations with entrance points as opposed to e.g. freestanding bus stops – in the immediate vicinity to where all passengers pass by on their way to the access point. For larger stations with multiple entry-points and/or modes of transport it was not possible to cater for all passengers, as only one APL was placed per station/stop.

In sum, APL-placements were generally well rated by participants, with main parameters of success being vicinity to boarding point and/or station entrance point. The placement's quality is related to Acceptance and in facilitating participation, but seems to be more critical for picking up parcels than handing them in.

5.3   Pre/post survey results

Although the great majority (82%) of participants agreed that participation in the test increased their motivation to participate in the realised concept, the post ratings of Intention, Concept attitude, SVS, PBC and two barriers are more negative than the ratings before participation, as paired t-test results show (see Table 4).

Paired samples t-test	Mean		SD		Diff.	t	df	p
	Pre	Post	Pre	Post	Mean			
PBC	2.00	2.16	0.64	0.58	-0.16	-2.78	143	.006
Concept Attitude	2.02	2.19	0.62	0.62	-0.18	-3.39	143	<.001
SVS	3.81	3.58	0.53	0.59	0.23	6.50	143	<.001
Losing/damaging parcel	2.66	2.99	0.92	0.85	-0.33	-4.65	143	<.001
System flaw	3.17	3.23	0.83	0.79	-0.06	-1.01	143	.313
Dangerous Illegal goods	2.82	3.14	1.01	1.11	-0.32	-4.30	143	<.001
Intention	3.72	3.35	0.63	0.64	0.37	6.12	143	<.001

Table 4: Paired samples t-tests

5.4   Predictors of post-survey Intention, Acceptance and behaviour

As the study was based on a practical test, we aimed to supplement Intention as a measure for future participation propensity, due to its questioned compatibility and adequacy as measure for the degree to which interaction with the concept serves to (de)incentivize future adoption. The purpose of this was to get a measure for the importance of various elements of the practical interaction with the concept, which was "closer to the action" and thus more isolated from influences not directly related to the concrete experience. In other words, a better measure for what concretely worked in the tested service and what did not, from both a conceptual and practical perspective. In this light, it is also relevant to look at pre-survey Intention as a predictor for the post-survey measure of Intention, and also for behaviour during the field test.

We conducted three multiple regressions: one with post-survey Intention, one with Acceptance and one with behaviour (the number of trips taken with a parcel) as dependent variables (see Table 5).

The pre-survey Intention and post-survey results for PBC and SVS were found to have a significant effect on post-survey Intention. PBC and SVS were also found to have a significant effect on Acceptance. By contrast, no significant effect of pre-survey Intention was seen on Acceptance. Instead, difficulties with the app had a significant effect on Acceptance. Pre-survey Intention also had a significant effect on behaviour during the experiment, measured as number of trips taken with a parcel during the experiment. Additional significant predictors of Trips with a parcel were ease of finding the lockers, pre-survey Satisfaction with Travel, the amount of trips taken with public transport during the experiment period, and whether participant's most used pickup point during the experiment was their outbound departure station (as indicated by the participant in the pre-survey).

	Intention (post)	Acceptance	Trips w. parcel.
Independent variables	β	β	β
PBC (post)	-.35***	-.37***	-.13
Concept Attitude (post)	.08	.11	-.07
SVS (post)	.22*	.19*	.02
Losing/damaging parcel (post)	.18	.05	.18
System flaw (post)	-.19	.12	-.15
Dangerous Illegal goods (post)	.02	.02	-.02
App difficulties	.09	-.28***	-.03
APL Localization	.03	.06	.14*
Intention (pre)	.29***	-.05	.19**
STS (pre)	-.17	.13	-.38***
PT during experiment	-.13	.03	.37***
Pickup on outbound station	.11	.08	.14*
R2	.313	.408	.441
Adjusted R2	.249	.353	.389

*p < .05, **p < .01, ***p < .001*
Table 5: Linear regression results

6 Discussion and Conclusions

Following our aim to provide insights from a practical test of a public transport based crowdshipping concept as an improved basis to evaluate adoption potential as well as practical and conceptual contingencies for crowdshipping solutions, the following section synthesizes and discusses three main findings before discussing the limitations of the study.

First, we confirm the practical viability of a public transport based crowdshipping concept from a user perspective, and thus substantiate the potential indicated by prior survey-based research on the concept (Gatta *et al.*, 2018; Authors, 2022). Specifically, we found that the vast majority, 82% of participants, stated that they, because of test participation, were more motivated to participate in the concept if it should be realized. As such, the results of the test substantiate the potential of realizing a crowdshipping concept from the user perspective, with respectively 47% and 68% of participants who after experiencing the concept would often or always bring a parcel on their most used outbound and return trips. This preference for return trips aligns with previous research, which has shown how

predictability affects stress levels of mass transit morning commuters (Evans et al., 2002). Implications of this preference are presented in Section 7. As such, this study provides an important proof of concept for a delivery system that has previously only been explored hypothetically.

Second, we add empirical support and elaborate assumptions regarding the practicalities of participation; ease of interacting with APLs has a significant positive effect on Acceptance as was seen in the regression analysis. Prior research had highlighted the importance of convenient APL placement (Gatta et al., 2018; Iannaccone et al., 2021). This was also confirmed; APLs should be placed in the immediate vicinity of where passengers naturally pass by. It should be noted though, that Danish stations are – in contrast to e.g. Gatta et al.'s Italian setting – not secluded by ticketing facilities. This blurs the inside/outside station distinction, which their results were based upon. Departure APL placement's higher and significant correlation with Acceptance compared to Destination APL, could be caused by a (perceived) higher importance of accessing the APL at the departure station swiftly, in order to catch the next train/bus, whereas this pressure might be less present when the trip has been completed, in line with both the prior mentioned research on the negative effects of unpredictability as well the negative effects of increased travel time (Wener et al., 2003). Thus, the found relations between APL placement and Acceptance as well as PBC illustrate the importance of providing a solution that interacts smoothly with participants' transport habits.

Third, our approach and results highlighted the relevancy of contextualizing and supplementing evaluations of Intention. For a range of constructs, Intention, PBC, SVS, Concept attitude, Forgetting/damaging parcel and Dangerous/Illegal goods the post survey showed less favourable results than the pre-survey. However, 82% of participants explicitly stated to have become more motivated to participate in a realized concept through their test participation. The differences may therefore simply reflect more reliable – yet still highly supportive – results that are less prone to behavioural equivalents to 'hypothetical bias' (e.g. Ajzen, Brown and Carvajal, 2004). In the context of this study, by trying out the service in practice, participants would to a higher degree bring the many situational constraints into consideration for their post-evaluations of Intention to participate in a realized concept. This resonates with numerous studies (e.g. Dunning, 2007), which show that individuals' prediction about their future behaviour is often too optimistic. Koehler and Poon (2006) argue that people in the assessment of likelihood of carrying out a behaviour in the future extrapolate and consequently overestimate from their current intentions, while at the same time underestimating external, situational, or contextual factors that may be of hindrance for these translating into action. Our results thus support the findings of Poon, Koehler and Buehler (2014), which show that situational constraints are underrated in self-predictions and how 'optimistic bias' increases with Intention strength. It is seen in the regression results that participants are able to abstract from the technical difficulties of the pilot setup when evaluating their propensity to take part of a realized concept, with App difficulties having a significant negative effect on Acceptance, but not on post-survey Intention.

Although the present study's results substantiate the argument of Intention's overestimation, they at the same time show support for Intention as a valid measure for predicting behaviour, with pre-survey measures having a significant effect on both post-survey results for Intention and behaviour during the trial.

6.1 Limitations

The contributions outlined in the discussion should be seen in light of the following limitations.

First, the fact that the experiment was undertaken during COVID-19 in general, and in particular after the national lockdown was announced halfway into the originally scheduled experiment period, is not without consequences for the results and their interpretation. Most notably, there were fewer people

able to participate, because of being sent home from work, as the non-participant post-survey results showed. Gathering public attention about the possibility to participate, was a gradual process that was only just starting to pick up at the time of lockdown. But for those still travelling by public transport, the unprecedented circumstances will have had more unpredictable effects on their participation and experience. In fact, research on changing circumstances indicates that participants might actually be more prone to (remember to) participate as a result of disrupted habitual behaviour, which leaves more room for intentionally induced action (Wood et al., 2005). On the other hand, having to cope with the circumstances – and perhaps nervousness (e.g. Przybylowski, Stelmak and Suchanek, 2021) – of travelling by public transport during the pandemic might have had an opposite effect. In the context of travel behaviour, it has been shown how divergence from habitual responses is difficult under conditions of cognitive load (Aarts & Dijksterhuis, 2000).

Additionally, the test setup itself is worth noting. The empty test parcels were of small size and weight. On the one hand, they were thus less of a burden to bring along. On the other hand, this might have left participants more prone to forget to hand in the parcel, and thus causing nuisance if for example needing to return to the station to do so (the trip would not be registered in the app if the destination APL was not opened and closed again using the app). Also, some participants expressed in text entry fields, that the fact that parcels were empty, served as a demotivator to participation, as bringing them could feel pointless. However, we argue that the inclusion of two motivational measures – Acceptance and Intention – allows us to meet many potentially related validity-issues, as participants were found to be able to distinguish between aspects related to their test-participation (captured by the former) and the propensity to participate in a realized concept (captured by the latter).

Further, the Concept attitude factor is also worth noting in relation to the test setup. The factor includes assessments of the perceived fairness of participant compensation in comparison to the imagined gains of the crowdshipping company and whether participants would feel taken advantage of as a cheap form of labour. It seems reasonable to assume that a realized concept operating on market terms would face scepticism in this regard, in comparison to a concept that was promoted as a research project in a joint effort between a university and a company.

Lastly, the rather elaborate test setup, an official information website, the relatively thoroughly developed app and user interface as well as the many placed parcel lockers on very commercially attractive public locations might also actually affect some evaluations negatively, as this might cause some participants to evaluate the concept on the premises of a solution closer to being realized than was actually the case for the setup, which rather mimicked the service. For example, some participants mentioned that the registration of users was not thorough enough to prevent theft, which would obviously be necessary in a realized concept. Likewise, it is difficult to estimate to which degree participants who experienced technical issues were able to abstract the test solution from the conceptual idea, in the questions in which such a distinction was relevant. Again, most seem to have been able to make this distinction, as 'App difficulties' was shown to significantly affect Acceptance, but not Intention (to participate in a realized concept).

6.2   Practical implications

The aim of present study was to provide insights from a practical test of a public transport based crowdshipping concept, in order to further academic and practical work on implementing new mobility- and sharing economic solutions, directly or indirectly related to the proposed concept.

Overall, the experience with the service was rated positively with a high degree of Acceptance. Although participation was easy for a majority of participants and the developed app was generally viewed as intuitive to use, a relatively large proportion experienced connection issues with the APLs,

which had a negative influence on Acceptance as a result of participating. Despite this, participants seem to have been able to abstract from the test experience in their Intention for future participation.

The APL placements – the majority placed on the station grounds – were generally rated positively. Here, the main parameter of success was vicinity to boarding point and/or station entrance point. Participants had a harder time finding the APLs when handing in a parcel than when picking up. This may be due to the APLs being placed at street level, or in general being placed to face participants when entering stations, rather than leaving them. This would most likely be solved by more developed localization features, but must nonetheless be considered for future placements. The placement's quality is related to Acceptance and in facilitating participation, but seems to be more critical for picking up parcels than handing them in, which indicates that a smooth process for parcel pick-up is more critical to participants than for hand-in. This might be due to stress of making the next train, whereas an added few minutes for e.g. locating the APL is not as critical when having made the trip.

Participants were more willing to bring a parcel on their return trip than outbound, in post-survey results for Intention. This could potentially pose a challenge, as a solution would optimally make use of outskirt commuters on their way to work or school in central districts of the city.

Such issues of added unpredictability would be further pronounced for the relatively high number of participants who experienced such connection issues, which was also elaborated upon by many in the various text entry fields, as being the most negative aspect of participation and a reason for hesitation towards bringing a parcel in some instances. Text entry elaborations indicated that this is especially in cases with time constraints, such as going to work or transfers to other public transport. This highlights the need to ensure that a public transport based crowdshipping concept integrates smoothly to the travel routines of passengers, without fear of being delayed by e.g. connection issues to the lockers or not being able to find the APL. For a realized concept, more thorough app-development and troubleshooting should be completed to mitigate such issues, which was not possible with the relatively limited time and resources for app-development for the experiment. To facilitate APL localization, GPS-functionality should be included. However, regression results showed that participants who most often brought parcels on their outbound trips brought significantly more parcels during the experiment, which indicates that the outbound trips may be easier to build into existing routines.

Additionally, with a significant effect of Satisfaction with Travel Scale on behaviour during the trial, regression results highlighted the importance of a well-functioning public transport system as a pre-requisite for implementing a crowdshipping service. Again, this may be due to the need for predictability and a certain mental surplus in the relevant situational travel context in order for the user to actually undertake the behaviour which he/she had the Intention to perform.

Together these insights provide a basis for further work towards a realized concept, as the practical viability has now been confirmed from a user perspective. As this prerequisite has been established, future work is needed on determining the economic and environmental savings potential and on how is optimally pursued by logistics providers from an operational perspective.

Appendix A: Concept description

In the pre-survey, the crowdshipping concept was first mentioned and described to respondents after completion of more general questions regarding public transport use. Respondents will however have been aware of the main idea of the concept before, as a general description was necessary for recruitment. Included below, is the description of the concept provided to survey-respondents after the introductory questions. The recruitment material's description of the concept was also drawn from this.

This research project explores the possibilities for passengers with public transport to receive credit for their travel expenses by bringing small parcels from approved senders (e.g. web shops).

The idea is to reduce the number of vans going to the central city districts to deliver parcels, as the current method has a negative impact on congestion, urban life and the environment. With an increasing number of parcel deliveries, there is potential for large reductions in CO_2 emissions. Therefore, parcel lockers are set up at public transport stops. As a passenger, you can reserve parcels (with an app) that match your start and end stations. With the app you can then open the locker at your departure station, take the parcel and deliver it in a locker at your matching end- or transit station.

Thus, the process of collection and delivery is similar to checking in and out with the 'Rejsekort'. This takes a total of approx. 30 seconds. The locker automatically connects to the phone's Bluetooth. You simply press 'Open Door' in the app. After hand in, a credit amount is received as a 'Thank You'. From here, the customer who ordered delivery for this locker can pick up his/her parcel.

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A public transport based crowdshipping concept: Results of a field test in Denmark

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Formation of crowdshipping habits in public transport: Leveraging anticipated positive emotions through feedback framing

Abstract

To meet global goals for emission reductions, widespread behaviour change is needed. This includes adoption of novel travel habits. Public transport-based crowdshipping represents an opportunity for linking novel travel habit formation with the challenges posed by the environmentally burdensome state of last-mile parcel deliveries. This paper investigates potential links between anticipated as well as experienced positive emotions and behaviour formation in the highly habitualised context of public transport use. The empirical basis is a two-month real-world field experiment, in which public transport passengers could carry test parcels to and from Automated Parcel Lockers placed at public transport stations and stops. A pre- and post-survey was distributed in relation to the experiment. The results show that participants who to a higher degree anticipated having positive emotions evoked by participation reported a higher degree of habit formation. Second, recipients of an environmentally framed feedback showed more conducive attitudinal and behavioural results, including habit formation and post measures for anticipated positive emotions. Third, the environmentally framed feedback further supported the habit formation effect of anticipated positive emotions. Finally, a higher degree of habit formation was found amongst participants using a smartcard compared to monthly cardholders who do not need to perform any related physical tasks when travelling by public transport. Results indicate the possibilities of supporting motivated cueing, where the reward value of performing a behaviour is conditioned onto situational cues that, with repeated participation, become associated with the (emotional) reward.

Highlights

- A public transport crowdshipping concept was tested in a real-world experiment
- Anticipating positive emotions from participation leads to higher habit formation
- Environmentally framed feedback yields better attitudinal and behavioural results
- Environmentally framed feedback supports the effect of anticipated emotions
- Using a smartcard to check in/out has a positive effect on habit formation

Keywords

Crowdshipping, Habit, Cueing, Anticipated positive emotions, Goal framing

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1   Introduction

The increasingly dire prospects of global warming represent a challenge that, with equally growing clarity, dictates all hands on deck: a multitude of efforts is required to decrease carbon emissions sufficiently. This includes the promotion of pro-environmental behaviours, which, according to the United Nation's Intergovernmental Panel on Climate Change, is critical to keep hope alive of limiting warming to 1.5°C above pre-industrial levels (IPCC, 2018). In line with this, pro-environmental behaviour has received increasing academic attention. Two psychological mechanisms which have received recent attention in this domain are habits and emotions. The literature on how we can change our habits towards more environmentally friendly paths is well established and extensive (e.g. Mazar et al., 2020). Habits can be understood as learned automatic responses with specific features, such as speed and efficiency, but also rigidity, which thus calls for effort when behavioural changes are wanted (Wood & Rünger, 2016). Contextual cues related to the environment in which a behaviour is performed can take a central role in the formation of habits (Wood & Neal, 2007). In the psychological literature, attention has also been paid to the effect of positive emotions experienced when people feel good about themselves for acting pro-environmentally, resulting in intrinsic motivation to act accordingly (e.g. Taufik et al., 2016) How anticipated positive emotions may in this way serve as a guide towards sustainable behaviour such as choosing public transport has also been explored (Carrus et al., 2008). However, the potential to leverage emotions for sustainable action has been argued to be underexplored (Brosch & Steg, 2021). At the same time, the literature exploring the potential connections between contextual cues, anticipated emotions and habit formation is scarce.

The potential for emissions reductions in changing people's everyday routines has been illustrated for a wide range of consumption practices and daily activities, not least within transport (e.g. Grischkat et al., 2014). Most research in this field has focussed on achieving shifts from individual motorised transport to public transport or active modes (e.g. Cass & Faulconbridge, 2016). At the same time, research has been done on how the excess capacities of travellers may be utilised for freight transport, also known as crowdshipping (e.g. Le et al., 2019; Punel et al., 2018). The term refers to the distribution of delivery tasks to "the crowd", which is usually organized through an online platform. However, only a few papers have looked at the potential of public transport-based crowdshipping. By utilizing trips that would be taken anyway, this form of crowdshipping could avoid the dedicated trips or detours that can lead private vehicle-based crowdshipping concepts to emit more instead of less compared to traditional delivery. Public transport based crowdshipping could thus alleviate the issues of the last part of goods delivery (outskirt to city center). This last stretch is by far the most inefficient part of the goods delivery chain, taking up an unproportionate part of economic and environmental

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costs (e.g. Macioszek, 2018; Pourrahmani & Jaller, 2021; Vanelslander et al., 2013). A few papers have evaluated the feasibility related to operational impact and sustainability (e.g. Karakikes & Nathanail, 2022; Kizil & Yildiz, 2021). Using real-world data from a freight operator, Cheng et al. (2022) simulated crowdshipping scenarios for the last part of deliveries to Copenhagen and found substantial emissions savings potential.

Anyone travelling by public transport would be able to sign up and crowdship, which is important, as such a concept would be dependent on utilizing as many public transport trips as possible. Regarding the potential users, or 'crowdshippers', the focus of existing research has been on demographic characteristics and how intention to participate may be increased by relevant service features and communication efforts (e.g. Fessler et al., 2022a; Gatta et al., 2019; Punel et al., 2018). Only limited attention has been paid, however, to how new behaviour – and eventually new habits – can be promoted in the often highly habitual situational contexts, such as daily commuting, which may pose challenging conditions for transferring intention into action. As strong habits can undermine intentions, there is often a gap between intention and behaviour which may be difficult to overcome.

The purpose of the present paper is to investigate potential links between anticipated as well as experienced positive emotions and behaviour formation in the highly habitualised context of public transport use. More specifically, the paper seeks to shed light on how novel behaviour related to mobility or sustainability, such as participation in public transport-based crowdshipping, may be facilitated by leveraging intrinsic motivations to establish environmental cues that initiate action. Furthermore, this paper investigates whether existing travel habits facilitate or hinder such contextually induced cues. This study is based on data from a two-month real-world field experiment (to our knowledge the only one of its kind), in which public transport passengers could sign up to carry empty test parcels to and from automated parcel lockers (APLs) placed at public transport stations and stops. The hypotheses are examined based on a pre- and post-survey distributed in relation to the experiment, as well on data from a smartphone app developed for the purpose.

2   Research background

This section presents the central theoretical concepts before synthesising them in four hypotheses.

2.1   Habits as barriers towards behaviour change

Habit has been shown to be one of the most important concepts to include in explaining mobility behaviour (Hoffmann et al., 2017; Klöckner et al., 2003) Verplanken and Aarts' (1999) construct of habit refers to the stability of behaviour under defined conditions. They have been defined as "cognitive structures that automatically determine future behaviour by linking specific situational cues

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to (chains of) behavioural patterns" (Klöckner & Verplanken, 2018, p. 239). This happens through frequency of an action in stable contexts resulting in successful pairing of action and goal (Verplanken & Orbell, 2003). Frequency, context stability and success are thus central features of habits.

The proposed crowdshipping concept is set to operate in a domain – public transport travel – which can be highly habitualised, particularly in case of commuting (e.g. Kim et al., 2017; Légal et al., 2016). This represents a barrier to the concrete situational translation of intentions into action, as the accessibility of behavioural alternatives becomes limited when activation of certain responses in given contexts are repeated (Danner et al., 2007). Previous research has shown how – the sometimes intention-undermining – automaticity stems from developing associations between actions and performance circumstances (Neal et al., 2006). After repeated experiences linked to the same responses in the same contexts, coherent sequences of habitual responses can be activated by the environment, which provides cues that – as associative conditioning occurs – gain sufficient motivational power to launch and guide behaviour. This is due to our orientation towards prediction and control of rewards to which we are attracted, as well as punishments that we seek to avoid (Verplanken & Wood, 2006). This calls for attention to the nature of rewards and what role they can play in promoting new sustainability- and mobility-related behaviour in a highly habitualised context, where intentions are left little room.

2.2   Anticipated emotions and rewards

Previous research has shown the influence of anticipated emotions in environmentally relevant consumer choices for both high-involvement products such as cars (e.g. Rezvani et al., 2018; Schuitema et al., 2013) and low-involvement products such as groceries (Onwezen et al., 2013), as well as activities, such as the use of public transport (Carrus et al., 2008). A growing body of literature has explored the social aspect of taking sustainability-related action (e.g. Mackay et al., 2021; Masson & Fritsche, 2021; Wallis & Loy, 2021). A social component has also been applied to the positive emotions that are experienced in relation to sustainability-relevant behaviour. Identification with groups of likeminded people has been shown to yield more positive emotions as a result of conformity to the norms of the group (Christensen et al., 2004). The anticipation of positive emotions has also been shown to have relevance for the public transport-based crowdshipping concept addressed in the present paper: Examining the willingness to participate in a hypothetical crowdshipping concept, Fessler et al. (2022b) identified a joint factor including anticipated positive emotions, the social value from participation and the expected support from important others as the most important predictor of the intention to serve as a crowdshipper. In the present paper, this joint factor will be referred to as 'anticipated social value and positive emotions' (ASP), representing positive emotions with basis in both social and personal dimensions of sustainability-relevant self-identity.

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Baumeister et al. (2007) distinguish between consciously experienced emotions and automatic affective reactions. Conscious emotions often occur after a behaviour and seldom drive it directly. In contrast, the automatic affect can occur almost immediately, allowing it to guide behaviour even at a moment's notice, often just in the form of labelling good/bad or approach/avoid. After activation of the impulse to approach, a more precise evaluation of what to do depends on the situational affordances defined by its opportunities and constraints. These rapid evaluations may contain input from previous emotional outcomes. In this way, anticipated emotional outcomes – which guide action in accordance with the emotions people expect to be evoked – are shaped in a combination of previous emotional outcomes and current affect. Such positive emotional outcomes may entail psychological rewards for living up to ideals of 'doing the right thing', such as undertaking environmentally friendly behaviour (Venhoeven et al., 2013). These feelings have been shown to take the form of a 'warm glow', which may also encompass a social dimension of belonging or living up to social norms (Cabo et al., 2020; IJzerman et al., 2012; Taufik et al., 2015). The question then becomes if and how the motivational potential of anticipated emotional outcomes may be deployed to induce and guide environmentally friendly behaviour in situational contexts that leave little room for conscious deliberation.

Previous research suggests that contextual cues may facilitate such processes; people are more likely to act in accordance with environmentally supportive values when these are triggered and supported by cues present in the behaviour-relevant situational context. In this way normative goals are assumed to be more salient when such values are triggered in the relevant situation (Steg et al., 2014). It is possible to imagine how cues to value-congruent behaviour may also support habit formation, when considering the process of *motivated cueing* (Wood & Neal, 2007)*. In the development of habit associations, the reward value of response outcomes – such as positive automatic affect – is conditioned onto contextual cues. With repeated performance, the cues become associated with the reward. In this way, contexts that become associated with positive emotional outcomes may drive habitual behaviour. This happens due to the double role of past reward conditioning: establishing context-response associations as well as injection of a motivational pull to the given response in the context. Without necessarily being conscious about it, we anticipate feeling good from performing a behaviour, therefore (re)perform it and eventually develop a habit. This relation is explored as a partial purpose of this paper – that is, assessing the role of anticipated positive emotions on habit formation.

2.3   Goal frames and motivation

Goal framing theory (GFT (Lindenberg & Steg, 2007) has been applied to explain how behaviour is guided by our motivation and goal frames (e.g. Westin et al., 2020). These goal frames may vary from individual to individual and guide attention to and the relative importance of different available

information. This influences what information is considered important, as well as the perceived viability of different behavioural alternatives. GFT suggests three goal frames: hedonic goal frames focus on immediately feeling good about the action, such as maximising wellbeing and excitement; gain goal frames make the individual focus on personal pros and cons such as gains/losses in money or status; and normative goal frames guide the individual towards the behaviour which is perceived as "the right thing to do". Although varying in importance across sectors of the sharing economy, economic incentives have been shown to often be necessary prerequisites in the formation of intention to participate in sharing economic concepts (Böcker & Meelen, 2017; Hamari et al., 2016). Nonetheless, in the sphere of sustainable behaviour, it has been shown that appealing to economic self-interest (gain goal), in contrast to biospheric appeals (normative goal), is not necessarily the way to go in motivating change (Bolderdijk et al., 2013). A partial purpose of this paper is to assess how goal framings – gain vs. normative – may affect interaction, habit formation and attitudes related to the service. Furthermore, another purpose is to assess how these interact with anticipated positive emotions, which may be perceived as a hedonic goal in providing a positive feeling related to participation.

2.4   Habit chaining

Due to the nature and context of public transport travel, the best basis for inducing new behaviour might be given by disrupting the environmental cues that facilitate existing habitual performances, thus creating opportunities for change (Wood et al., 2005). Such cues inducing routine behaviour might, for example, be seeing that it is the usual point in time for leaving home, getting the usual on-the-go coffee or checking out the departures timetable upon arrival at the station. As such, the task of a crowdshipping solution is both to intervene in existing cues and accompanying habits as well as to establish new ones by linking the two. As described, existing habits may pose a barrier to such new habits. However, within the sphere of technology use, it has also been shown that existing habits can be leveraged to stack on new habits (Labrecque et al., 2017). Also referred to as *chaining,* existing behavioural responses may here act as cues to trigger the novel required action and eventually habit formation (Judah et al., 2013; Pinder et al., 2018). This relates to the situated cognition perspective, in which the likelihood of a novel behaviour piggybacking on pre-existing situational cue associations increases with the extent of elements shared with existing situated conceptualisations such as time of day, actions or visual cues (Best & Papies, 2017).

A partial purpose of this present paper is therefore to assess how existing public transport travel routines affect novel habit formation. In the Danish context, this makes it relevant to consider the payment practices for travelling by public transport of season ticket holders versus users of 'Rejsekort', an electronic ticketing system. Danish public transport stations/stops are not closed off by ticketing

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facilities. The main practical difference between the two payment groups is therefore, that the former can in most cases enter the train/bus directly without having to perform any additional task, while the later must remember to place a smartcard at card readers installed on stations or onboard busses at the start and end of a trip. The use of a Rejsekort could be a potential habit with which the new habit of bringing a parcel could be chained, as the pick-up and hand-in of the parcels occur around Rejsekort check-in and check-out, respectively.

2.5   Field test

The practical field test of the crowdshipping solution was conducted in the autumn of 2020. An app, 'CrowdShip', was developed for the purpose, while 28 APLs were placed at public transport stations/stops (S-train, Metro, Bus and Train[1]) in two areas of Denmark, Copenhagen and Northern Jutland. This allowed for public transport passengers to book and carry (empty) test parcels from APL to APL on their matching trips between included stations. Upon handing in the parcel, participants either received an environmentally or an economically framed feedback in the app, thanking them for participating. Participants were equally financially rewarded for each time they carried a parcel. Further details on the field test are described in the Methods Section.

2.6   Hypotheses

On basis of the presented literature and field test, we formulated four hypotheses. Considering the potential for motivational pulls from anticipated positive emotions, we expected participants scoring higher on such emotions to report a higher degree of habit formation:

- H1: Participants who reported a higher degree of anticipated positive emotions in the pre-survey will report a higher degree of habit formation in the post-survey.

We expected the environmental feedback framing condition to yield better attitudinal and behavioural results than the economic feedback condition:

- H2: Compared to recipients of the economic feedback condition, participants who received the environmentally framed feedback will show more favourable results in post-measures for attitudinal variables, habit formation and the quantity of parcels carried during the experiment.

In the crowdshipping experiment, the feedback condition in the app may be considered part of the situational context that becomes associated with a reward. Following the described mechanisms for

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[1] To gain the required approvals, access to necessary locations and the facilities needed to maximise realism of the experience, the experiment was organised in collaboration with municipalities, DSB (the Danish national rail company), Metroselskabet (Metro company) and Nærboks (the APL provider, partly owned by the Danish national postal service).

anticipated emotions and rewards, we anticipated that the feedback condition would influence the degree to which habit formation was supported by anticipated positive emotions measured as pre-survey ASP. In other words, any positive relation between ASP and habit formation found in H1 would be more pronounced for recipients of the environmental feedback framing condition, as their anticipated positive emotions were to a higher degree "redeemed" in each instance of successful participation. This means that the higher values in habit formation indicators for participants with higher ASP scores compared to those with lower ASP scores will be more pronounced for recipients of the environmental feedback condition compared to the economic feedback condition. We therefore hypothesised that:

- H3: The interaction between high ASP and the environmental feedback condition will have a more positive effect on habit formation than the other ASP/feedback interactions.

Finally, in considering the behavioural context in which H1 and H2 are embedded, we looked at existing routines' supportive/obstructive potential for participation cues. In line with the concept of habit chaining, this led to the following hypothesis:

- H4: Participants who actively must 'check in' and 'check out' when travelling by public transport will report a higher degree of habit formation compared to monthly travel card holders.

3   Method

The experience of the concept was measured through (a) a pre-survey, (b) the practical test data and (c) a post-survey. The latter was split into two separate surveys: one for those who took part in the practical test by carrying the minimum of two parcels and another for pre-survey respondents who did not engage in the crowdshipping activity.

3.1   Practical test

The practical test was launched in early September 2020 and originally scheduled to last throughout the month. However, a national COVID19-lockdown[2] hit on September 18th. The test period was therefore extended to last through October to compensate for the vastly diminished number of public transport trips taken due to being sent home from work, among other causes. Through the app, participants could 1) book a test parcel with a matching route, by entering departure and destination

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[2] During the lockdown, travel via public transport was still possible, but work from home was strongly encouraged.

station/stop[3], 2) open the APL at their departure point through Bluetooth and 3) likewise hand in the parcel at their destination's APL (depicted in, respectively, screen 1, 2 and 3 of Figure 1).
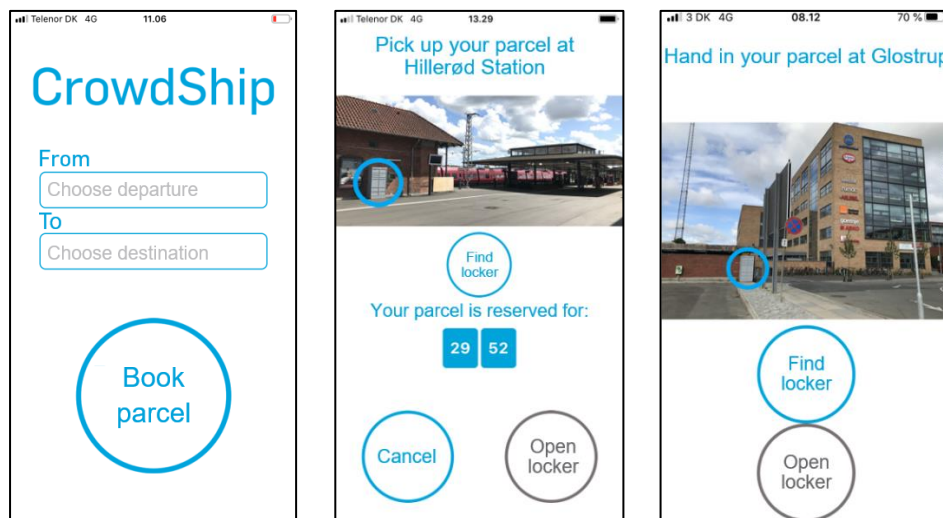

Figure 1: App Screenshots: Screen 1,2 and 3

When the APL was closed at parcel hand-in, a "Thank you"-animation screen was shown in the app (see Figure 2). Two such feedback screens were deployed to assess potential differences in goal framing: appealing to the social/environmental vs. monetary value of participation. Participants were randomly selected to receive either one for the entire duration of their participation. Half received the environmentally framed feedback: 'Hand-in completed! Thank you for helping in making the city greener', along with a green-coloured animation. The other half received the economically framed feedback: 'Hand-in completed! 10 kr. transferred to your gift certificate;, along with an animation of a spinning coin. Only this framing varied: the two groups were equally compensated. The process of booking a parcel and opening/closing the locker to pick it up could be completed in less than 20 seconds.

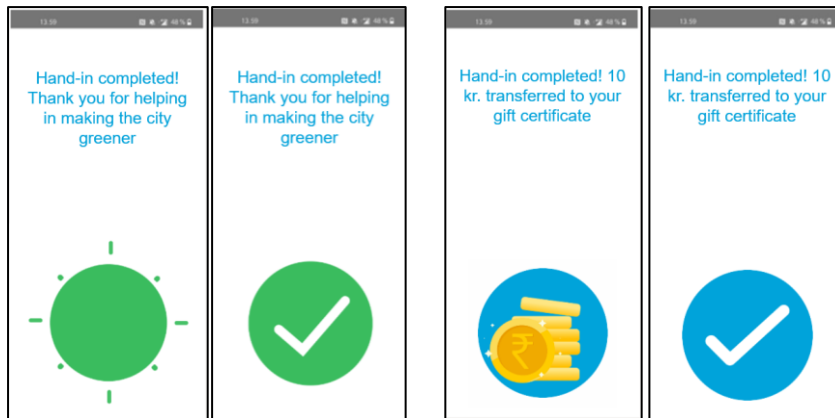[3] Both being amongst the 28 included stations/stops

Figure 2: The Two Feedback Framings

Participants received a basic compensation of 50 Danish kroner (€6.7) in the form of a gift certificate for completing a pre-survey, carrying a parcel on two trips and completing a post-survey. This rewarded participants for their time spent on the two surveys and installing the CrowdShip app. To imitate the basic financial incentives of a realised concept, participants then received 10 kr. (€1.3) added to their gift certificate for each additional trip. The participants could maximally be compensated with 100 kr. (=7 trips).[4] Parcels were of relatively small size (19 × 12 × 4 cm) and only weighed a few grams (the weight of their own cardboard material).

The smartphone app for the experiment was developed for both iOS (iPhone) and Android. It gathered information about each participant's interaction with the service: each time a parcel was carried (including timestamp and departure/destination point) as well as to which feedback framing group (environmental or economic) the given participant had been assigned.

3.2   Procedure and participants

Participants were recruited through sign-up links distributed on social media from September 1st 2020. The experiment was also mentioned in various national and local tv, radio and online news outlets, which helped to promote it more broadly. After completing the pre-survey, participants received an email with download links and installation guides for the app, as well as a guide for participation. During most of the experiment period, a weekly reminder email was sent to all pre-survey respondents who had not yet carried a parcel. Frequency of reminders increased over the last two weeks, with daily reminders during the last four days. Links to the post-survey were sent to all respondents who

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[4] In a realised solution, crowdshippers should receive the remuneration as credit for the transit system. Also, it should be possible to earn more credit by carrying multiple parcels.

had completed the pre-survey immediately after the experiment period. Separate surveys were sent to those who participated and those who did not.[5]

The pre-survey was completed by 454 respondents (64% women, 34% men) aged 16–73 years (*M* = 29.07; *SD* = 11.45). Of these, 157 (35%) also took part in the practical test, while 144 (92%) of those who did so also completed the post-survey (60% women, 38% men). The vast majority either paid most of their public transport trips through a monthly pre-paid card (47%) or by Rejsekort (47%). Participants in the practical test covered the same age span of 16–73 years (*M* = 29.66; *SD* = 10.88). Of the pre-survey respondents who did not participate in the practical test, 145 completed the post survey for non-participants. During the experiment, just below 900 trips with a test parcel were made. The average number of parcels carried per participant was 5.5 (*SD* = 5.04).[6] Upon request, the regional scientific ethics committee in the Capital Region of Denmark informed us that ethical approval was not necessary for the study.

3.3 Survey respondents not taking part in the practical test

The overall most frequently indicated reason for not taking part in the practical test was being sent home due to COVID-19 and consequently not travelling as usual. In the survey for non-participants, this was given as the main reason by 22% of respondents who installed the app, and 32% of those who did not install it. Further, 39% and 29% of installers/non-installers, respectively, selected "Other" as the main reason, for which many elaborated that their non-participation was due to COVID-19 in an accompanying text entry. Amongst app-installers, the main reason for not participating was forgetting it when they travelled by public transport, although they had intended to do so (27%). No attitudinal or demographic differences were found when comparing respondents who downloaded the app, but forgot to participate and those who did remember (independent t-tests, *p* > .10). Participants and non-participants did not differ significantly in any attitudinal variables, including intention to participate in a realised concept (*p* > .10).

3.4 Survey content

To assess the effect of interacting with the crowdshipping concept in practice, the pre- and post-surveys included a joint set of psychological items intended to cover factors inspired by an extended version of the theory of planned behaviour (Ajzen, 1991). The pre-survey additionally covered information on the respondents' public transit use, such as most used routes, frequency, mode of payment and travel satisfaction, as well as the following sociodemographic variables: postal code of

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[5] Participation was automatically registered through the app. The only content of the survey for non-participants was their reasons for not participating.

[6] Only including respondents of the post-survey.

residence, age, gender, household composition, income, employment status, work hour flexibility and education. All relevant pre-survey items were included in a principal component analysis (PCA; see Table 1). In addition to the joint item set, the post-survey included specific questions on the experience with the crowdshipping concept. The following section describes the items relevant for the purposes of this paper. All items were answered on five-point agreement scales, except for the items in the Satisfaction with Travel Scale. For more details on the content of the two surveys, see Fessler et al. (2022c).

Habit of public transport use was measured through a *context stability* and a *habit automation* construct with three items each. The items on context stability measured perceived stability of purpose, time and route to/through station in the context of the journey specified by the participant as their most frequent (adapted from Friedrichsmeier et al., 2013). Habit automation was measured with two items on journey automaticity adapted from the Self Report Habit Index (SRHI; (Verplanken & Orbell, 2003). In addition, one item was created to measure the degree to which the participant leaves for the station/stop to take the first coming departure without checking timetables in advance. This new item loaded on the same factor as the two aforementioned in the PCA. The Cronbach's alpha of mean scales created from the two groups of items was .710 and .615, respectively.

Satisfaction with travel (STS) was measured with seven items. This was done through two STS sub-scales, time and comfort. These entailed three items measuring, respectively, whether the participant in relation to their most frequent journey felt stressed, hurried and worried about arriving on time, and three items on the ease, functioning and comfort of the trip (Ettema et al., 2011). Additionally, one item was created to measure the degree to which the participant feels safe on the trip. Cronbach's alpha was .907.

Concept attitude measured the perceived value of participation and the perceived fairness of this in comparison to the imagined gains of a non-specified crowdshipping company imitated in the test (e.g. Morton et al., 2021). It also included items related to symbolic motives (status) and potential feelings of embarrassment in receiving compensation. The construct was measured with four items. Cronbach's alpha was .665.

Anticipated social value and positive emotions (ASP) consisted of five items that formed a common factor measuring positive feelings around participation. The items first covered social aspects of participation that included subjective norms (Ajzen, 1991) and relatedness (e.g. Schikofsky, Dannewald & Kowald, 2020). This measured the degree to which participants imagined their social circle participating, as well as potential positive feelings of being part of a movement or community as a result of participation. Second, they covered the construct of warm glow (e.g. Venhoeven,

Bolderdijk & Steg, 2013), which assessed the imagined potential of participation to elicit positive emotions as a result of contributing towards societal needs and environmental protection. Cronbach's alpha was .716.

Table 1: Principal Component Analysis (Pre-survey Items)

Principal Component Analysis (Pre-survey)	Context stability	Habit automaticity	STS	ASP	Concept attitude
Item					
I always make this journey more or less at the same time of the day.	**.785**	.043	.100	-.007	.037
The purpose of this journey is always the same.	**.774**	.090	-.029	-.012	.001
The journey is a (daily, weekly, monthly) routine for me.	**.766**	.199	.062	.136	-.046
I just go out the door and take the first departure, without checking the timetable in advance.	-.081	**.764**	.015	-.030	.099
I make the journey without having to think what to do.	.283	**.729**	.059	-.076	-.027
I make the journey automatically.	.403	**.675**	.120	.015	-.032
Travel is uncomfortable – Travel is comfortable	.045	-.057	**.801**	.148	.036
Travel is laborious – Travel is uncomplicated	-.021	.098	**.759**	.047	-.057
Travel works poorly – Travel works well	.042	.038	**.841**	.064	-.028
I feel safe – I feel unsafe	.046	.030	**.777**	.005	-.021
I feel stressed – I feel calm	.041	-.035	**.843**	.017	-.019
I feel hurried – I feel relaxed	.034	.015	**.826**	.035	.016
I feel worried about arriving late – I feel confident about arriving on time	.035	.102	**.732**	.063	-.021
Many of my friends would participate in the concept.	.053	-.180	.079	**.521**	-.050
I would feel community spirit with the other users.	.082	-.099	.017	**.702**	.012
I would feel part of a positive movement.	-.029	.101	-.021	**.715**	-.176
I would feel proud to do my small part in making the city greener	.014	.082	.081	**.747**	-.241
For me, it would give value to participate.	-.027	.027	.140	**.697**	-.191
It would be a bit embarrassing to meet someone I know, while I was picking up/delivering a parcel.	.011	-.055	.029	-.091	**.731**
I do not want to be associated with parcel couriers.	.068	.000	.035	-.030	**.711**
Participation is only for 'discount hunters'.	-.020	.074	-.096	-.218	**.709**
The concept would unfairly take advantage of me as a form of cheap labour.	-.087	.061	-.049	-.251	**.602**
Cronbach's alpha (Pre-survey)	710	.615	.907	. 716	.665

In addition to the theoretically based factors, a mean scale for *habit formation* was created from four items loading on the same factor in a separate PCA for post-survey items. The construct measured the perceived extent of habit formation during the test and expected habit of participation in a realised concept (See Figure 3). Cronbach's alpha was .725.

3.5   Analysis

A combined dataset encompassing pre-survey, Crowdship app and post-survey data was analysed. We first provide descriptive statistics (percentages and means) as well as Pearson's correlations to examine linear relations between selected variables; to test Hypothesis 1, we examine the correlation between ASP and habit formation. Subsequently, to test Hypothesis 2, an independent samples t-test is conducted to assess post-measure differences in attitudinal and behavioural variables between the two feedback groups. Finally, to test Hypotheses 3 and 4, multiple linear regression is performed with habit formation as dependent variable. Included independent variables are habit automaticity, habit stability, STS, existing transport habits (payment mode) and interactions between ASP and feedback conditions.

4   Results

Figure 3 presents the level of agreement for the four items included in the habit formation variable. The first two items referring to experiences during the field test received lower levels of agreement than the last two items referring to expectations about future habit formation.
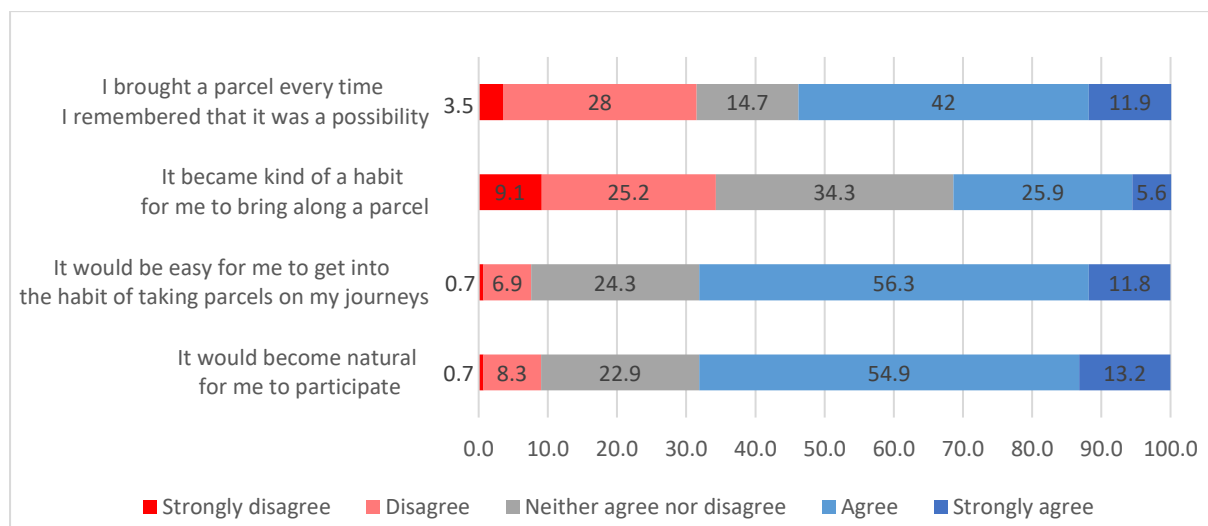

Figure 3: Habit Formation Items (Percentage of Agreement)

The aggregated habit formation variable consisting of the four items depicted in Figure 3 had a mean score of 3.42 and standard deviation of .71.

A small correlation was found between habit formation and the number of parcels carried during the experiment, $r(141) = .260$, $p = .002$.

A moderate positive correlation was found between ASP and habit formation, $r(141) = .327$, $p < .001$, which confirmed H1.

To assess potential differences between the environmentally focused feedback group and the economically focused feedback group, independent samples t-tests were performed. The two groups did not differ significantly in the pre-survey results, so differences between groups in the post-survey results can most likely be attributed to the different feedback conditions.

Table 2: Independent Samples T-test: Differences Between Feedback Framing Groups

T-test results	Pre survey scores				Post survey scores				Independent samples *t*-tests						
	Environment (*N*=66)		Economy (*N*=78)		Environment (*N*=66)		Economy (*N*=78)				95% CI of diff.				
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*p* (pre)	*p* (post)	Lower	Upper	*df* (post)	*t* (post)	Cohen's d
ASP	3.89	0.46	3.74	0.57	3.71	0.54	3.47	0.61	0.102	0.016	0.04	0.43	141	2.43	0.40
Concept attitude	1.97	0.58	2.07	0.65	2.08	0.56	2.3	0.66	0.363	0.034	-0.42	-0.02	141	-2.14	-0.36
Habit formation	—	—	—	—	3.58	0.63	3.29	0.74	—	0.015	0.06	0.52	141	2.47	0.41
% of trips with parcel	—	—	—	—	42.54	27.80	33.8	24.61	—	0.048	0.08	17.41	141	1.99	0.36

In the independent samples *t*-test, we found that recipients of the environmentally framed response brought along parcels on significantly more of their public transport trips between stations/stops included in the test compared to the recipients of the economically framed response. Where the economic feedback group on average brought along parcels on 34% of such trips, the environmental response group carried parcels on 43%. They also scored higher on habit formation. Additionally, in post-survey measures, the environmental response group scored significantly higher in ASP and reported a significantly lower degree of concept attitude reservations. We thereby see significantly better results for a range of both attitudinal and behavioural variables for those receiving the social/environmental feedback condition, confirming H2. Scores for ASP and concept attitude are generally seen to go 'the wrong way' from pre- to post survey. See Fessler et. al (2022c) for an elaboration and discussion of this.

We performed multiple linear regression with habit formation as the dependent variable to test the assumed interaction between ASP and the feedback-condition (H3) and the influence of the payment

mode (H4). We additionally included the number of trips on which a parcel was carried, the two public transport habit constructs and satisfaction with travel as control variables. As expected, a higher degree of pre-survey ASP in combination with the environmental response had a statistically significant effect, while the other three combinations of ASP and feedback conditions were not significant. H3 was thus confirmed (see Table 3). We also found a significant positive effect of the Rejsekort payment mode, thereby confirming H4.

Table *3*: Multiple Linear Regression Explaining Habit Formation

Predictors	B	SE	Std. β	95% CI β	t	p	VIF
Constant	2.256	0.416		1.434–3.078	5.429	<.001	
Trips with parcel	0.039	0.011	0.279	0.017–0.062	3.431	<.001	1.165
Habit automaticity	-0.145	0.068	-0.176	-0.28– -0.009	-2.116	.036	1.228
Habit stability	0.165	0.071	0.207	0.024– 0.306	2.318	.022	1.406
Satisfaction with travel	0.13	0.068	0.157	-0.004–0.264	1.914	.058	1.192
Payment mode Rejsekort	0.314	0.117	0.215	0.083–0.545	2.692	.008	1.131
High ASP – Environmental feedback	0.438	0.145	0.28	0.152–0.724	3.027	.003	1.512
High ASP – Economic feedback	0.183	0.15	0.111	-0.115–0.48	1.215	.227	1.474
Low ASP – Environmental feedback	0.137	0.161	0.074	-0.182–0.456	0.849	.397	1.325

Model statistics

F	5.204
Degrees of freedom	8, 135
p	<.001
Adjusted *R*-squared	0.19
Durbin-Watson	2.06

We found a significant positive effect of trips with parcel[7] and habit stability and a negative effect of habit automaticity. Satisfaction with travel had no statistically significant effect.

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[7] An equivalent regression was performed substituting a variable that took the amount of travel with public transport during the experiment period into account for the trips variable, as included in Table 2. It thus

5   Discussion and conclusions

This paper investigated the links between anticipated as well as experienced positive emotions and habit formation in the already highly habitualised context of public transport use. Following this, it investigated the potential to leverage intrinsic motivations to establish contextual cues to initiate action through goal framings. Further, whether different existing travel routines (actively checking in/out or not) facilitate or hinder such habit formation was also investigated. This was done based on data from a two-month real-world field experiment in which public transport passengers could bring along test parcels to and from APLs placed at public transport stations and stops.

We found that the construct 'anticipated social value and positive emotions', ASP, is significantly positively related to habit formation; those who to a higher degree anticipated having positive feelings evoked in relation to participation reported a higher degree of habit formation. These results illustrate the facilitating potential of anticipated positive emotions in habit formation. A higher degree of ASP may influence the automatic affect that can occur almost immediately in the participant's evaluation of the behaviour, guiding him/her to pursue it. In this interpretation the (emotional) reward value of participating becomes conditioned onto contextual cues, establishing motivated cueing (Wood & Neal, 2007). An alternative explanation could be that anticipated positive emotions led directly to participating more often and thus developing stronger habits. To test this, another linear regression was performed with habit formation as the dependent variable, and independent variables that included the number of trips taken with a parcel and pre-survey ASP as a separate continuous variable (see Appendix). Here, ASP was also highly significant, which supports our first interpretation.

As hypothesised, recipients of the environmentally framed feedback showed more conducive results for ASP, concept attitude, habit formation and number of trips taken with a parcel during the experiment in comparison to the economically framed feedback. This suggests that the motivational potential of environmentally focused goal framings may also be applied to increase crowdshipping participation. The more positive results amongst recipients of the environmental framing mirror the results of prior research on emotional versus monetary motives influencing environmental behaviour: People are more likely to engage in pro-environmental action if they anticipate feeling good when performing it, thus they do not take only instrumental costs and benefits into consideration (e.g. Carrus et al., 2008; Taufik et al., 2016).

Also as hypothesised, we found that giving an environmentally framed feedback further supported the habit formation effect of ASP; participants with high ASP who received the environmental

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showed the percentage of trips in which a parcel was carried rather than the raw number of times a parcel was carried. The model yielded similar results, with the same variables showing (in)significant effects.

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feedback were the only ASP/feedback group for which a significant effect was seen on habit formation. These results indicate that the emotional reward value may become conditioned onto situational contexts to establish behavioural cues. Results are in line with Bamberg's (2013) stage model of self-regulated behavioural change, consisting of a predecision, preaction, action, and postaction stage. In the model's predecision stage, positive emotions anticipated with goal progress support the creation of 'goal intention' as an element in the formation of a new behaviour. The anticipated positive emotions included in the ASP factor could be interpreted in this light as being to a higher degree redeemed for environmental feedback recipients, which is further underlined by the regression results: the positive relation between ASP and habit formation was further pronounced for those with higher ASP who received the environmental feedback. In this interpretation, the norms and values which they have successfully lived up to (normative goals) are made salient through the in-app feedback. The experienced positive emotions related to this support the new behaviour – and eventually habit formation (Carver & Scheier, 1990). In contrast, the activation of financial symbols, has previously been shown to activate egoistic values (e.g. Lindenberg, 2018). Such appeal to economic self-interest has been shown to undermine intrinsic moral motives, and thus in some instances is less suited to support behaviour change within the environmental domain (Bolderdijk et al., 2013). The results show potential implications for the crowdshipping concept and related mobility- or sustainability-related solutions, as well as for research on habits. They indicate that a crowdshipping solution might increase chances of success by catering to altruistically and socially oriented values, by framing participation environmentally towards users rather than focusing on economic incentives in its design and communication.

Finally, as hypothesised, we found that public transport passengers using the Rejsekort – paying their trips by physically checking in and out by placed cards readers – reported a significantly higher degree of habit formation. The result indicates that users of Rejsekort have been able to benefit from existing routines, related to the cognitive and practical task of physically checking in with the smartcard. This suggests that promotion of novel transport- or sustainability-related behaviour may benefit from chaining effects: new habits may be supported by chaining to related established habits. At the same time, the results point to the relevance of an intervention – such as push notifications – to disrupt existing automaticity-imprinted travel behaviour in general and the routines of pre-paid monthly cardholders in particular.

In the confirmation of the four hypotheses, three central features of habit were illustrated. Frequency, context stability and success were all found to significantly influence habit formation. Frequency, in the form of trips taken with a parcel during the experiment, and stability of public transport travel habits were both found to have significant effects on habit formation. The understanding of success

is here expanded upon to include the experience of positive emotions evoked from living up to one's own and others' ideals of 'doing good' as well as from being part of a social group sharing these values. The effect of anticipating these emotions was seen to be significantly correlated to habit formation, and it was seen that if the anticipations were to a higher degree redeemed by the feedback at parcel hand-in, the success of this completed participation to a significantly higher degree contributed to habit formation. The three features of habit are seen to support motivated cueing, where the reward value of the response outcome (the redemption of ASP resulting in positive affect) is conditioned onto the situational participation cues that, with repeated participation, become associated with the emotional reward. The potential barrier of habit automaticity was also illustrated in the results by the significant negative effect on habit formation.

5.1   Limitations and future research directions

There are limitations to consider when interpreting the results. First, the relatively brief period in which the experiment took place was shorter than what is often considered necessary to form a new habit (Lally et al., 2010), especially when considering the COVID-19 lockdown, which was announced shortly after the launch of the experiment. The lockdown meant that many did not travel as frequently as usual and probably also less habitually. To compensate for this, the habit formation construct was composed of both retrospective and prospective items. Although the construct was empirically formed and had acceptable internal consistency, this should be kept in mind when interpreting the results. Future research under normal conditions and over a longer test period should be conducted to confirm the findings. The relatively small sample size resulting from the lockdown also entails limited generalizability and that the work should be regarded as exploratory.

Other potential limitations related to the constructs include the scope of 'anticipated social value and positive emotions' (ASP). The construct was intended to measure the anticipated positive emotions stemming from both social value, feelings of community and living up to own ideals. Although the construct has acceptable internal consistency, the range of sources for these anticipated positive emotions is broad. This could be argued to complicate interpretation of related results. The constructs of context stability and habit automation measuring habit-strength for public transport and the concept attitude construct have Cronbach's alphas ranging between .62 and .71. For those with reliability scores in lower end, this should be considered as a limitation.

For findings related to the two feedback framing conditions, the lack of a control group is a limitation entailing that results should only be interpreted as a comparison between normative- and gain-focused framings.

Another limitation is related to the sample of participants, who were all volunteers and probably had more positive environmental norms than average public transport users. Thus, results cannot be generalised to all public transport users. However, as high ASP has previously been identified a relevant factor of the intention to participate in the service (Fessler et al., 2022b; Fessler et al., 2022c), we can assume that the sample to some degree reflects attitudes of people who would participate in a realised crowdshipping system. To pursue this, work is needed that assesses the relations between anticipated emotions and habit formation for realised concepts (either directly or indirectly related to the concept proposed in present paper) operating on market terms.

To get a more detailed understanding of when and how the opportunity to bring a parcel was cued and acted upon, participants could have been prompted to reflect on their participation immediately after their parcel hand-in. This was possible within the experiment's technical setup. However, we did not choose this option to avoid that the 'burden' of evaluation could become associated and/or confused with the actual participation. This might 1) demotivate participation and 2) affect post-survey evaluations. Yet, future studies could advantageously apply research designs that allow for more detailed descriptions of how cues may be conditioned onto the situational contexts of public transport travel.

Appendix A. Supplementary data

Table A1: Multiple Linear Regression Explaining Habit Formation

Predictors	B	SE	Std. β	95% CI β	t	p	VIF
Constant	1.205	.527		0.163–2.248	2.286	0.024	
Trips with parcel	.039	.011	.275	0.016–0.061	3.399	<.001	1.170
ASP	.320	.108	.238	0.107–0.533	2.972	.003	1.142
Habit automaticity	-.114	.069	-.139	-0.251–0.023	-1.652	.101	1.266
Habit stability	.162	.070	.203	0.024–0.300	2.320	.022	1.361
Satisfaction with travel	.111	.069	.134	- 0.025–0.247	1.619	.108	1.229
Payment mode Rejsekort	.313	.116	.215	0.084–0.542	2.706	.008	1.121

Model statistics

F	6.892
Degrees of freedom	8, 137
p	<.001
Adjusted *R*-squared	0.20
Durbin-Watson	2.07

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