Transportation Research Part B 111 (2018) 227–243

Contents lists available at ScienceDirect

Transportation Research Part B

journal homepage: www.elsevier.com/locate/trb

# The integration of item-sharing and crowdshipping: Can collaborative consumption be pushed by delivering through the crowd?

Moritz Behrend*, Frank Meisel

*School of Economics and Business, Kiel University, Kiel, Germany*

ARTICLE INFO

*Article history:*
Received 28 September 2017
Revised 2 January 2018
Accepted 4 February 2018

*Keywords:*
Sharing economy
Item-sharing
Crowdshipping
Last-mile delivery
Home delivery
Neighborhood delivery

ABSTRACT

Item-sharing and crowdshipping are two concepts of the sharing economy. In item-sharing, members of a sharing community can temporarily rent items such as tools or leisure equipment from one another. In crowdshipping, private drivers offer to execute delivery jobs for other people on trips they would make anyway. Since the peer-to-peer exchange in item-sharing involves repeated, inefficient 'last-mile' transports of small shipments, we investigate here whether the integration of item-sharing and crowdshipping has the potential to facilitate collaborative consumption. To this end, the decision making for an integrated item-sharing and crowdshipping platform is modeled. This platform matches supplies, requests, and planned trips of the community members. We develop mathematical models and heuristics for maximizing the platform's profit and the number of fulfilled requests. Our results quantify and confirm the substantial benefit of integrating item-sharing and crowdshipping.



## 1. Introduction

The sharing economy includes but is not limited to well-known branches like car-, bike-, and ride-sharing (Shaheen and Cohen, 2013; Ricci, 2015; Furuhata et al., 2013). An emerging concept is the so-called *item-sharing* in which members of a sharing community can temporarily rent items from one another (peer-to-peer). This concept is particularly useful for items that are needed on rare or just temporal occasions like, for example, items for leisure activities (party equipment or camping gear) or tools (drills, chainsaws, lawn mowers, etc.). The benefit of item-sharing is that multiple members can sequentially use a same item instead of each buying one such item individually, which is referred to as access-based consumption (Bardhi and Eckhardt, 2012). According to Lamberton and Rose (2012), this offers a *consumer access* to a desired item at low rental fees, together with the opportunity of a more sustainable way of consumption. A shift from purchasing items to flexibly accessing them for the time needed does, however, come along with challenges from the perspective of operations management. For example, provided that multiple items of a same type are offered in an item-sharing platform it needs to be decided which particular item is used to meet a certain request. Another issue is to organize the transfer of items from their current location to the requesting consumers.

The prevalent practice in item-sharing is that online platforms such as Erento or Zilok coordinate the assignment of supplied items to requests. This is referred to as *supply-request matching*. The transportation of an item from its current location

* Corresponding author.
*E-mail addresses:* moritz.behrend@bwl.uni-kiel.de (M. Behrend), meisel@bwl.uni-kiel.de (F. Meisel).

https://doi.org/10.1016/j.trb.2018.02.017
0191-2615/

to the location where it is needed remains within the responsibility of the consumer (so-called 'consumer involvement', see Bardhi and Eckhardt (2012)). The consumers can assign courier companies like FedEx or DHL the task of transportation, but the prices charged by these companies might pose a threat to the acceptance of item-sharing. Consumers might also conduct the transportation themselves. This, however, requires that they are willing to spend time and effort which can again limit the acceptance of item-sharing.

An alternative way of dealing with the transportation tasks in an item-sharing system is to invoke a further sharing concept, the so-called *crowdshipping*. In this concept, registered private drivers with upcoming planned *trips* by car, execute deliveries on these trips (Archetti et al., 2016; Rai et al., 2017). To this end, these so-called *crowdshippers* are willing to detour from the direct route of their own trip within certain bounds to pickup an item at its current location and to deliver it to the location of the consumer. Crowdshippers receive a compensation for such a *delivery job* that (partially) covers the expenses of their own trip. Especially drivers traveling a lot like, for example, commuters may therefore have an interest in announcing their trips in order to get assigned suitable delivery jobs. This matching is referred to as *trip-delivery matching* and is done, for example, via online platforms such as Nimber or MyRobin. According to Arslan et al. (2016), well planned crowdshipping can enable faster and cheaper deliveries compared to commercial courier companies.

So far, item-sharing and crowdshipping are dealt with independently on separate online platforms. Also research considered these concepts in isolation up to now. Since crowdshipping represents a promising solution to the transportation issues in item-sharing, a combination of both concepts appears as a relevant research area. To this end, we investigate here how to match supplies and requests from item-sharing in such a way that the resulting transportation tasks fit to the trips announced by crowdshippers. The benefits of such an integrated platform are manifold. For example, service-sensitive consumers can get shared items delivered to their homes instead of having to pick up the items themselves. Although they have to compensate crowdshippers for this convenience, this option might be less costly and maybe even faster compared with using courier companies. For crowdshipping trips that include only small detours, the environmental impact will be comparably low, too. Furthermore, crowdshippers receive more suitable delivery jobs, which makes participating in the system more attractive for them. Finally, items might be shared among more distant members because the actual transportation distance is of minor importance if a delivery job fits to an announced trip of a crowdshipper. This expands the pool of items to choose from and makes it more likely that item requests can be satisfied. Eventually, we investigate three different modes of transferring items among consumers. First, consumers themselves pick up the items at the supply locations and take them to their homes. We refer to this as *self-sourcing*. Second, items are picked up by crowdshippers and are brought directly to consumers' doorsteps. This mode is referred to as *home delivery*. In the third mode, the associated crowdshipper just takes the item to his/her place. The consumer then self-sources the item from this location. We refer to this collaborative transportation, where a crowdshipper and a consumer share the burden of transferring an item, as *neighborhood delivery*.

Our contribution is to show and quantify the potentials of a joined decision making of supply-request and trip-delivery matching. We present optimization models and heuristics based on assignment problems that match supplies with requests and that also recommend in which transfer mode (self-sourcing, home delivery, or neighborhood delivery) items are made accessible to consumers. A comprehensive computational study is conducted to estimate the potentials in terms of profit maximization and service level maximization.

The remainder of the paper is organized as follows. In Section 2, we point out the research gap in the related literature. In Section 3, we formally describe the problem setting and present mathematical optimization models for the integrated supply-request and trip-delivery matching. Heuristic solution methods based on a hierarchical decomposition scheme and a graph-theoretical approach are described in Section 4. The computational experiments are subject of Section 5. Section 6 concludes the paper.

## 2. Related literature

The sharing economy gives rise to an emerging field of research in various disciplines. This includes the two concepts investigated here, namely item-sharing and crowdshipping, which are increasingly recognized by research. Item-sharing receives attention mostly in marketing research, especially consumer research. For example, Lamberton and Rose (2012) provide a theoretical framework on market-mediated commercial sharing systems, Baumeister et al. (2015) deal with the branding of 'access-offers', and Schaefers et al. (2015) analyze the effect of consumer misbehavior in access-based services. Item-sharing can also be seen as part of 'use-oriented Product-Service Systems' in which business models are not geared to selling products but to renting products to different consumers sequentially, enabling a need-based access (Tukker, 2015; Reim et al., 2015). In both cases, transporting individual items between (distant) locations lacks economies of scale, necessitates substantial dead-heading, and results in high transportation costs, which are typical issues in *last-mile deliveries* (Wang et al., 2016). Although such systems call for efficient mechanisms to match the supplied items with item requests, the operational decision making of such item-sharing systems is not addressed in the literature so far. This paper aims to fill this gap by developing quantitative models to recommend allocations of items to consumer requests with the goal to improve the profitability and service level achieved by item-sharing platforms.

Research on crowdshipping has begun just recently. One stream of research involves empirical studies. For example, Punel and Stathopoulos (2017) and Devari et al. (2017) investigate peoples' motivation to participate in crowdshipping and Rai et al. (2017) conduct interviews with logistics service providers to figure out what role these companies can take when