

On-demand warehousing: main features and business models

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Abstract: Logistics and distribution need to be more responsive and flexible to satisfy changing and demanding customer requirements due to e-commerce and customization trends. This work focuses in particular on warehousing, with the aim of understanding how emerging business models provide companies with additional ways to acquire warehouse space or fulfillment services. To do so, this work classifies and describes traditional warehouse models. Next, on-demand warehousing is analyzed as an emerging business-to-business (B2B) model that embraces the sharing economy principle of accessing resources rather than owning them. On-demand warehousing companies operate through online platforms connecting companies who have underutilized warehouses or fulfillment capacity to other ones searching for warehousing services. On-demand warehousing enables more flexible resource acquisition, as fixed-cost investments are not necessary, and lengthy negotiations are eliminated through a standardized contract between the on-demand platform and the renter. This work contributes to the literature through an improved understanding and description of the main features of on-demand warehousing, representing a starting point for further research on this topic. Future developments are needed on the analysis of the main decisions a lender of space has to make when choosing an on-demand model.

Keywords: on-demand warehousing; shared logistics; capacity sharing; operations management; warehouse management

1. Introduction

Multi-channel strategies, and e-commerce, have expanded the options offered to customers in terms of product variety, quantity, delivery times and locations, and product returns. These trends, combined with today’s customer expectations, have resulted in demand being more variable and lead times for fulfillment operations being shorter (e.g., one hour and two-hour delivery windows) (Boysen et al., 2018; Kembro et al., 2018). Shorter delivery requirements have raised investments in distribution centers and warehouses closer to large population areas. However, the increasing capital requirements and limited supply of available distribution and warehouse spaces have created the need for innovative and more flexible warehousing models (Grant, 2017). In this context, new models based on the principles of the Sharing Economy (SE) are blooming in distribution and logistics services.

SE has been enabled in the last decade by the massive diffusion of information technology and social networks. Some well-known examples of successful SE business models are Airbnb, Uber, but also non-profit platforms like Couchsurfing. Business to business (B2B) SE models match resources owned by businesses to other businesses needing the resource. On-demand models based on resource sharing are different from the traditional outsourcing or supplier-customer relationships since outsourcing is not the lender’s core business model; instead, the companies typically are sharing non-core underutilized assets or services over an on-demand

business marketplace, like an extra office space (LiquidSpace, Sharedesk), an idle construction equipment (EquipmentShare), an empty location in their warehouse (Flexe, Ware2Go) or underutilized delivery trucks’ capacity for a certain route (Cargomatic, Convoy). The lender company’s main goal is to derive additional value from its underutilized resources, which can create a more constant workload (“Multichannel Merchant,” 2017). On the other hand, the renter fulfills its service/product requirements immediately (on-demand), which has the advantage of being able to adapt quickly to variable demand. For both parties, the decision-making process of acquiring and renting resources becomes more tactical compared to traditional ways to obtain resources, which were more strategic outsourcing decisions.

Lately, similar on-demand resource-sharing models have been conceived for the logistics sector (Carbone et al., 2017). The concept of crowdshipping or crowdsourced logistics is emerging as a trend in the delivery phase (Kafle et al., 2017; Le et al., 2019; Mofidi and Pazour, 2019; Zhang et al., 2019). Similarly, studies on shared logistics and peer-to-peer logistics can be found in recent literature, including not only distribution but also warehousing and infrastructures (Melo et al., 2019). Resource-capacity sharing in logistics is recognized as a possible strategy to improve operational efficiency (Ermagun and Stathopoulos, 2018; Melo et al., 2019), as well as sustainability (Cohen and Muñoz, 2016; Melo et al., 2019). However, the research community has primarily explored resource-sharing for transportation and delivery; it remains

still largely unexplored for warehouse and distribution handling services.

B2B on-demand warehousing platforms are spreading on the logistic market (Forger, 2018; Pazour and Unnu, 2018). The on-demand warehousing models involve three main actors: (i) a group of lenders, owning warehouses, that want to make accessible a portion of their resources to other customers; (ii) a group of customers, which have a need (or demand) for warehouse storing/handling capacity; (iii) an online platform, which manages the interactions and the matching between the lenders and customers (Pazour and Unnu, 2018). The on-demand platforms allow both lenders and renters access and visibility to each other. Each platform regulates these interactions through a set of principles and policies (e.g., booking mechanism, contractual terms).

The aims of the study are to conceptualize on-demand warehousing models, positioning them in the landscape of warehouse solutions, and to provide the first classification of on-demand warehousing business models. The following section provides a classification of the common warehousing models currently available in order to understand the unique features of on-demand models. Then, an analysis of the on-demand warehousing platforms operating globally in February 2020 is presented, and a conceptualization of the on-demand warehousing business model is proposed. Finally, conclusions and further research opportunities are described in the last section.

2. Common warehousing models

Companies requiring stocking space and product handling to fulfill customer requests can choose among different logistic solutions according to their needs. We list the most commonly adopted warehousing models below, with their main differences summarized in Table 1.

- 1) Private warehouse,
- 2) Contracted dedicated warehouse,
- 3) Contracted shared warehouse,
- 4) Public warehouse,
- 5) Pooled warehouse,
- 6) On-demand warehouse.

Each of these solutions has different requirements, cost structures, and contract terms for customers, and offer various services (e.g., only pallet in and pallet out, versus more complicated order fulfillment) and service levels. Detailed descriptions are as follows.

A private warehouse is owned and managed by a company for its material storage, handling, and distribution operations. The company controls all processes, from the design phase to daily operations. However, a significant investment is required, and the long-term commitment results in less flexibility in adaptation to demand fluctuations. Due to long planning and building time, the time from approval to use can be lengthy. Additionally, the amount of capital needed for opening multiple facilities in

various locations makes this choice usually unsuitable for small players.

In a contracted warehouse model, the customer outsources the warehouse operations and management to a third-party logistics (3PL) company that owns the distribution resources and sells the stocking and handling services (van den Berg and Zijm, 1999). Contracted warehouse models generally offer two types of services. One is a dedicated facility, in which the 3PL operates the warehouse, but for the sole purposes of a single company. Therefore, the storage space and the handling operations are dedicated to a single, given company. This allows the company to have more control over the operations and capacity. For example, they can contract specialized services (e.g., order packaging, consolidation, cross-docking, and other value-added services); however, as the operations are specific to a single company, long contract periods are required (e.g., 3-5 years). The fee structure for customers is set for a predefined commitment, usually contracted ahead of time (Piasecki, n.d.). Therefore, contracted, dedicated warehouses are non-flexible solutions, storage costs are typically not entirely based on the actual usage, nor actual demand satisfied. Instead, they adopt a flat fee structure for storage, in which the fixed predefined cost is charged during the fixed contracted duration (Gesing, 2017; Piasecki, n.d.), and additional variable costs are charged for the actual usage (i.e., handling).

The other warehouse model is a contracted shared warehouse, which usually offers standardized services (for example, some provide only storage services for only pallet-in and pallet out operations), as opposed to the contracted dedicated warehouse that can offer a more personalized variety of services. In a shared warehouse model, the 3PL company can have several customers under the same roof, and the larger inventory mix can represent a challenge when dealing with the service level and efficiency improvements (Baruffaldi et al., 2019). Typically, there exists a reserved storage capacity for each customer, which is agreed upon in the contract. Contracting periods are typically shorter than the dedicated models (e.g., 1-2 years) (Piasecki, n.d.), but the cost structure is similar.

Public warehouses are similar to the contracted shared warehouses but without any commitment between customers and 3PLs. The services provided are also standardized, and in some public warehouses, customers can even manage the warehousing operations by themselves instead of outsourcing (Yuan et al., 2017). Usually, public warehouses apply a month to month per pallet-based fee depending on the customers' usage. The capacity is allocated in a first-come, first-serve policy (Ginepro, 2016). Public warehouses can have numerous customers requiring the management of a wide variety of stock-keeping units (SKUs) (Cao et al., 2018; Cao and Jiang, 2013). The uncertainty in the available supplied capacity and the effort required to find new 3PLs offering public warehouse space has been challenging.

Table 1: Types of warehouse models and their primary differences

Warehouse type	Business model	Owner of Facility	Space utilization	Fee service type	Commitment period
Private warehouse	Owned	Private company	Only items of the company	Internal cost	Long term (investment costs)
Contracted dedicated warehouse	Outsourced	3PL	Items of a single customer	Flat + variable fee	Long (e.g., 3-5 years)
Contracted shared warehouse	Outsourced	3PL	Items of different customers	Flat + variable fee	Long (e.g., 1-2 years)
Public warehouse	Outsourced	3PL	Items of different customers	Based on the actual service level	Short (e.g., one month)
Pooled warehouse	Consortium	Private companies	Only items of the participating partner companies	Shared internal cost	Long term (investment costs)
<i>On-demand warehouse</i>	<i>Mixed through a platform company</i>	<i>Private companies</i>	<i>Items of the lender company and of different on-demand customers</i>	<i>Based on the actual service level</i>	<i>Short (e.g., one month)</i>

A pooled warehouse is defined as “a warehouse shared logistically between several actors (manufacturers, logistics providers, and distribution companies) in order to share physical spaces, resources, and logistics information to improve the global performance of the overall distribution process” (Makaci et al., 2017). This is a partnership option, based on a pre-agreed collaboration between a group of members who decide to build and operate a joint facility (e.g., a consortium). Therefore, only customers affiliated with the consortium can use the facility. The building is owned and operated by the consortium of companies, and the commitment is long-term. Also, there exists less flexibility, since a consensus among partners is required to make any operational and structural changes.

On-demand models match the requests made by a set of individual customers to the collective offerings of a set of lenders that make part of their resources available for rent. The interaction is enabled through an online platform that works like a marketplace where demand and supply meet. On one side, on-demand models allow warehouse owners that have the extra storage capacity to rent their extra space to external customers. They join the system as lenders and can define the period, capacity, and services they want to make available for renters. On the other side, on-demand models provide an alternative solution to businesses that face demand variability and need extra stocking space or fulfillment capacities. Because on-demand models do not require long term contracts and have a variable costing structure (Unnu and Pazour, 2019), this model provides more flexibility than other models, in terms of where and when capacity can be acquired. Renters of on-demand warehouses switch from the fixed cost of a lease to the variable, pay-as-you-go cost of on-demand. This cost structure provides renters an advantage in that it allows for more stocking locations, which positions the renters' inventory closer to their customers – reducing last-mile delivery costs and time to delivery. Additionally, in hybrid models (e.g., private warehouse + on-demand), on-demand solutions increase capacity utilization and reduce unit distribution costs (Unnu and Pazour, 2020). On the other hand, risks to renters include potential unknown capacity

availabilities on the platform. Because lender's underutilized capacity is posted on the platforms, the availability and pricing of capacity changes over time, and seasonality has a significant impact on this available capacity. For example, in the US during the holiday season, many retailers have increased demand for warehouse space and fulfillment capacity; however, during these times, the available capacity listed on the platforms decreases (Flexe, 2019). There is also variability in the available locations and lenders. Since lender companies are free to remove their listings from the platform, this might require a new lender and/or location selection and the transfer of the existing inventory for the renter companies.

3. On-demand warehousing business model

As an innovative and recent addition to the warehousing sector offerings, on-demand models have not been deeply studied in the literature yet, and a conceptualization of this business model is still lacking. Currently, several companies worldwide operate a platform for on-demand warehousing, mostly located in the US and EU, and a few in Asia. In this section, we propose the first classification of on-demand warehousing business models, starting from the analysis of existing on-demand warehousing platforms.

Online market research identified 13 platforms that have been launched in the last few years globally. For each of these platforms, basic information regarding their cost structures, value offerings, and other features were collected by analyzing the platform's official websites, including the ‘frequently asked questions’ and ‘terms and conditions’ sections, when available. This analysis was completed in February 2020. The results of this research are summarized in Table 2, detailing for each platform the cost incurred by the renter and the lender, the type of physical services made available, extra services offered to renters, and any other unique feature.

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Table 2: On-demand warehousing platforms on the market in February 2020.

Platform	Location (launch)	Cost structure for renters	Cost structure for lenders	Physical service offerings available	Additional services and other features of note
DHL spaces	Germany (2017)	N/A	N/A	Storage	Can be combined with DHL services (transportation, WH operations)
Flexe	USA (2013)	<ul style="list-style-type: none"> • Basic packages based on # of orders / month • Per pallet handling fee • \$5,000 monthly minimum charge 	<ul style="list-style-type: none"> • Free listing • Information on platform fee N/A 	Storage, order fulfillment (also for e-commerce), palletization	<ul style="list-style-type: none"> • Inventory tracking • KPIs monitoring • Logistics consulting & benchmarking
FlowSpace	USA (2017)	Per pallet/per month	<ul style="list-style-type: none"> • Free listing • Platform fee upon agreement 	Storage, order fulfillment (also for e-commerce), transportation, kitting & special projects	<ul style="list-style-type: none"> • Platform can decide if to post a listing and set minimum fee • Lender must guarantee the offer posted. • Inventory Tracking
Log-hub	Switzerland (2017)	N/A	N/A	Storage	SC analytics and optimization (core business)
Mospaze	Malaysia, Indonesia (2017)	<ul style="list-style-type: none"> • Service fee • Platform fee 	Platform fee	Storage, other services not specified	Inventory tracking
OneVast Warehouse	UK (2019)	Weekly invoice based on services	<ul style="list-style-type: none"> • Free listing • Platform fee based on invoice • Lender decides price 	Storage, Pallet handling, Order fulfilment, Pick and pack, Transportation	
Stockspots	Netherlands (2017)	Weekly invoice based on services	N/A	Storage, Transportation	
Stord	USA (2015)	N/A	N/A	Storage, Order fulfillment, transportation, Palletization, Kitting	<ul style="list-style-type: none"> • Inventory tracking • «White glove installation»
Stowga	UK (2015)	Per pallet/per month	<ul style="list-style-type: none"> • Free listing • Monthly invoice-based platform fee • Lender decides price 	Storage, Order fulfillment picking, packing, transportation, Returns management	
Ware2go (by UPS)	USA (2018)	<ul style="list-style-type: none"> • Per pallet/per month (storage) • Per pallet fee (receiving, order processing & shipping) 	N/A	Storage, Order fulfillment, Transportation	<ul style="list-style-type: none"> • Inventory tracking • Max 2-days delivery to customer • No min. commitment for renter • Platform assigns lender to renter • Only certifies high quality lenders (warehouse audits)
Waredock	Scandinavian countries (2018)	N/A	N/A	Storage, order fulfillment picking, packing, transportation	
Warehouse Exchange	USA (2015)	<ul style="list-style-type: none"> • Per pallet/per month (or week) • 5% platform fee 	5% platform fee	Storage, palletization	No limit on time/space for lender
Warehouse Solutions.PH	Philippines (2018)	Per pallet/per week	N/A	Storage, palletization, transportation	

While some of the websites provide detailed information about the aspects analyzed, some others do not provide all information publically. Instead, these platforms require a request for further information through personal contact with the potential lender or registration as a company to the platform (e.g. DHL Spaces, Log-hub). Thus, some data appear as “not available” (N/A) in Table 2 as they are not declared directly on the websites.

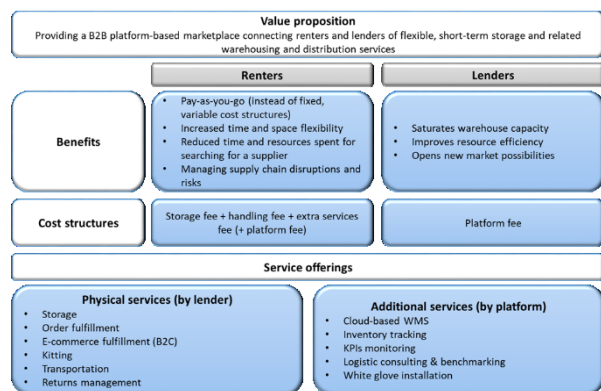
This data collection and categorization of the existing on-demand warehousing alternatives in terms of cost structures and service offerings allowed us to summarize and structure information collected about the individual companies, in order to infer the main features of a generic on-demand warehousing business model. This analysis and empirical inputs form the foundation of the theoretical framework proposed, which is summarized in Figure 1.

The value proposition of on-demand warehousing models consists in providing a B2B marketplace connecting renters and lenders of short-term storage and related services, which can be traded easily and with benefits for both sides. This promotes a transition from centralized to decentralized warehousing models, through a network where the value of the offer increases with the number of participants. One of the main benefits of on-demand warehousing models is their granularity, both in terms of commitment time and capacity. Granularity is defined as the minimum renting time or capacity that the lender requests (Pazour and Unnu, 2018). While leasing from 3PLs and pooling have a typical commitment granularity of 1-3 years, and a capacity granularity measured in square feet, on-demand models are conceived to satisfy demands with lower granularities (commitment in months, capacity in pallet positions). This answers to the need for flexibility and agility of companies that deal with variable or seasonal demands, or that need to face unforeseen events leading to a peak in their demand. In particular, the main benefits for renters can be found in the increased time and space flexibility, since on-demand warehousing enables short-term storage on a per-pallet basis, while traditional warehousing models usually require longer commitment periods and higher space granularity. Next to this, the renter can save time and resources spent searching for a lender, which traditionally required contacting individual warehouses and inquiring about their services. On-demand warehousing reduces this effort via their open marketplace, available through the platform, which creates visibility and transparency. This solution also represents a possibility to mitigate supply chain disruptions and risks for renters, because it provides easy and quick access to warehousing when needed. On the other side, on-demand warehousing models also have benefits for the lenders: joining the platform as a provider can help warehouses find a demand for their underused capacity, which traditionally was thought of as a sunk cost. Therefore, on-demand platforms can enable lenders to make additional profit from unused space or fulfillment capacity, which also improves their resource efficiency. At the same time, this solution opens new market possibilities simplifying the connection with potential renters. Some sustainability benefits related to this model can also be highlighted: enabling renters to choose

warehouse locations closer to their products’ destinations, on-demand warehousing can utilize more sustainable modes of transportation (e.g., truck versus air) when tight customer delivery requirements exist. These models also help increase resource efficiency by promoting resource sharing rather than a new storage facility building. This is especially valuable for city planning and increased livability in urban settings.

Looking at the cost structures for participants and the revenue stream of the platform, these can change according to the platform chosen. In general, the cost for renters is a variable cost with a ‘pay-as-you-go’ structure. The fee structure is usually made up of three components: a storage fee, a handling fee (both paid to the lender), and an extra services fee (paid to whoever provides the extra services). Sometimes (e.g. Warehouse Exchange, Mospaze) the renter also pays a fee to the platform. The storage fee is usually calculated per pallet/per month, with a minimum time allowed of one month, but some platforms also allow contracts and payments on a per-week basis. The handling fee is calculated per pallet, based on the services required (receiving, order processing, shipping), while the extra services fee, when present, is calculated based on the additional services requested by the renter. This fee structure is in contrast to traditional models, in which commitments are typically decided ahead of time (e.g., either in the form of investing in a building or signing a long term lease). Traditional models, therefore, typically have much higher fixed costs, but lower variable costs (if used for the capacity requested ahead of time). The cost for lenders is less standardized. Usually, registering in the marketplace and listing a post is free, while a platform fee is charged according to different platform policies: it can be calculated monthly or per invoice, through a fixed share or agreed with the lender after a negotiation. This information is not always made available by platforms until the lender decides to register and asks for more information. Therefore, information retrieved shows that the platform revenue stream mostly comes from the fees paid by lenders, since only a few platforms seem to charge also the renter. However, a share of the fee paid by the renters to the platform and later transferred to the lender could be withheld by the platform itself in a “masked” transaction.

Figure 1: Proposed framework of the on-demand warehousing model



The standard process for joining the platform is usually quite easy for renters, and slightly more articulated for

lenders. A renter only has to register on the website as a company (anonymous customers are usually not allowed to join the B2B marketplace), accept the terms of the contract and start the process of specifying their company’s space and capacity needs, time frame, location, and service type. A lender is required to register, accept terms of the contract, and start posting listings for its space. To post a listing requires the lender to specify the details of the offer in terms of space available, timeframe, requested service fee, and types of services being offered. Only one platform (Ware2go by UPS) declares to have an audit for lenders, so their registration can only happen after a thorough examination of the company that has to satisfy some constraints. However, discussions with platform businesses indicate that many of the platforms do require further vetting of lenders.

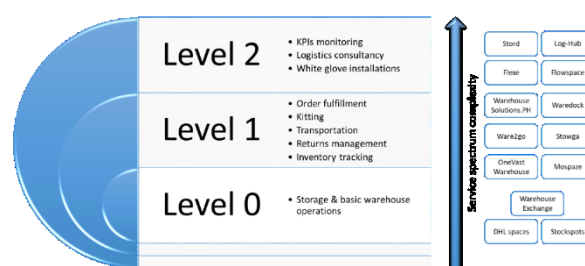
We distinguish between two main types of service the platform offers: physical service offerings and additional services. In the first category, we include different warehouse operations: all platforms guarantee basic storage (intended as pallet-in/pallet-out operations). Most of them also allow for more complicated operations to be posted on their platforms. For example, it is common for platforms to facilitate order fulfillment, which includes picking and packing activities and palletization. Some players also provide e-commerce fulfillment (B2C). A few platforms include kitting activities and transportation services. Only one (Stowga) also allows postings for managing returns. On the same platform, the type of service available can change according to the lender selected, and the renter can specify the services needed when looking for a warehouse. All physical services are provided and managed by the lender, with the exception of transportation, which can also be outsourced to an external provider when requested by the renter. In additional services, we include the cloud-based warehouse management system (WMS) provided by all platforms. Most platforms also allow inventory tracking for renters, enabled by the WMS. Some offer extra services like logistic key performance indicators (KPIs) monitoring, consulting, and benchmarking services (Flexe, Log-hub) or white glove installation (Stord). These extra services are usually provided by the platform itself, not by the lender of space, and represent an enrichment of the basic warehouse offer.

Based on these results, platforms currently operating on the market can be classified into three main groups, according to the spectrum of services they offer (Figure 2). The first cluster (indicated as Level 0) includes the platforms that only offer basic storage services to their renters (DHL spaces, Stockspots, Warehouse Exchange). Level 1 includes the platforms that also provide additional warehouse operations, if requested by the renter, such as order fulfillment, palletization, transportation, and inventory tracking (Stowga, OneVastWarehouse, Ware2go, Waredock, WarehouseSolutions.PH, Mospaze). The highest level (2) includes those platforms that guarantee the broadest set of services to their renters, providing some extra services beyond the ones managed by the lenders, such as consultancy and KPIs monitoring (Flexe, FlowSpace, Stord). One of the platforms considered, Log-hub, represents an atypical case, as the lender has only to

guarantee basic storage service to renters, but the company also provides supply chain optimization services, which are its main core business. Given the added value of their extra services, we include it in Level 2.

While our classification of platforms is accurate as of 2020, an evolutionary path is likely to be adoptable by companies that may start as a level 0 platform and transform to a higher level by offering more complex services.

Figure 2: Clusterization of platforms according to the service spectrum.



4. Conclusions

On-demand warehouse models match companies with underutilized warehouse and distribution center capacities with customers who need these services. They create flexibility and risk minimization to one party and additional revenue and steadier demand flow, which has advantages for resource utilization of operations, to the other party. This work first presents a critical comparison of existing traditional warehousing alternatives with on-demand models, then provides the first conceptualization of on-demand warehousing business models.

This qualitative analysis represents a starting point for further research on on-demand warehousing models, in particular their operational and managerial implications for lenders and borrowers. Possible developments include the analysis of the impact of on-demand models on the actors involved, considering the benefits and challenges entailed. Some interesting open research questions include what kind of decisions a lender has to make when joining on-demand platforms, such as to their receiving, put-away, order picking, packaging, and shipping operations? What is the role of information technology in enabling the implementation of on-demand warehousing?

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