



Article

# On-Demand Warehousing Platforms: Evolution and Trend Analysis of an Industrial Sharing Economy Model

Valerio Elia, Maria Grazia Gnoni  and Fabiana Tornese \* 

Department of Engineering for Innovation, University of Salento, Campus Ecotekne, Via per Monteroni, 73100 Lecce, Italy; valerio.elia@unisalento.it (V.E.); mariagrazia.gnoni@unisalento.it (M.G.G.)

\* Correspondence: fabiana.tornese@unisalento.it

**Abstract:** *Background:* The on-demand warehousing (ODW) model is emerging as a platform-enabled logistics solution based on resource sharing for businesses needing storage space. It is based on a business-to-business marketplace where companies can provide (or request) storage services with an elevated level of flexibility. The literature focusing on this topic is still scarce, and while the potential advantages of such a model seem quite clear, challenges and criticalities need to be further explored. *Methods:* Starting from a state-of-the-art analysis of ODW, a two-step methodology was adopted: first, a SWOT analysis was conducted to help summarize the challenges related to this emerging model. Then, an exploratory analysis of multiple case studies was employed to provide a first discussion on the advantages and criticalities of this model, highlighting its latest evolution. *Results:* The ODW model is still evolving, as several former pure ODW platforms have been changing their business model to become on-demand 4PLs (defined as “mixed ODW-4PLs”), adapting their core activities to manage the criticalities of on-demand services. *Conclusions:* This study represents the first attempt to investigate benefits and criticalities of ODW models, outlining the latest trend of ODW and identifying two distinct types of ODW model currently present on the market.

**Keywords:** on-demand warehousing; digital platforms; logistics services; sharing economy; industrial sharing economy; storage; exploratory analysis



**Citation:** Elia, V.; Gnoni, M.G.; Tornese, F. On-Demand Warehousing Platforms: Evolution and Trend Analysis of an Industrial Sharing Economy Model. *Logistics* **2024**, *8*, 93. <https://doi.org/10.3390/logistics8040093>

Academic Editor: Hao Yu

Received: 16 July 2024

Revised: 20 September 2024

Accepted: 23 September 2024

Published: 24 September 2024



**Copyright:** © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

The wide diffusion of e-commerce and increasing demand for customization is driving the logistics sector to seek for innovative solutions that can match the needs of customers in an efficient way. In addition, multi-channel and omni-channel strategies have contributed to an increase in demand variability in many sectors, giving the customer more choice in the process of order fulfilment, including delivery modes, times, and product returns [1]. Consequently, one critical challenge in logistics systems is to provide high service levels through an elevated level of flexibility and, simultaneously, containing costs.

In this context, new models based on the intensive use of digitalization as well as on resource sharing are arising. One reference model is the sharing economy (SE) paradigm, which is based on the shift from ownership-based to use-based models, allowing for better resource utilization providing access to a pool of users [2]. The interaction among users is enabled by a cloud platform, which allows peer-to-peer transactions. SE-based models are widespread in the service and transportation sectors: Airbnb and Uber are typical examples of SE business models [3]. However, examples of SE in industrial logistics are also becoming popular, with the diffusion of crowd logistics models, where logistics services are outsourced to a crowd of independent actors through the support of a platform [4,5].

Currently, academic research on SE models in logistics is mostly focused on crowd logistics and in particular on crowd-shipping (also known as crowdsourced delivery): a model where the demand for transportation of goods is satisfied by potential “informal” couriers through a platform system. Less attention has been given to shared storage

services, which could also be an effective solution for facing higher seasonal demands and for increasing company resource utilization [6]. One model is so-called on-demand warehousing (ODW): it is an emerging peer-to-peer model allowing owners of warehouses (i.e., lenders) to offer their empty storage space to external companies (i.e., customers) through a platform, thus enabling a quick matching of demand and offer and, at the same time, allowing a flexible commitment in terms of space and time [7]. This type of flexibility can allow businesses to increase their responsiveness towards an increasingly demanding market, characterized by higher levels of variability and tight schedules, responding to requirements that traditional warehousing models cannot satisfy. Typically, in ODW, customers can obtain storage space and services with more flexible unitary dimensions, e.g., per-pallet or per-week basis, unlike traditional models (e.g., leasing or owned storage space). Platforms usually limit their offer to a defined geographic area, such as EU, North America, or South-East Asia. Looking at the current market, different platforms enabling ODW models are operating: their business models vary significantly along with the value offered to participating companies. One example is the type of services that a lender can offer and a customer can request on each platform, thus influencing the overall performance of the ODW model. Even if the market for ODW services is increasing, a lack of systematic analysis of the business models and the organizational models can be outlined in the current literature, also leaving the main implications for businesses unexplored.

The aim of this work is to contribute to filling this gap, proposing a first conceptualization of the ODW models, by identifying the main trends and analyzing benefits and criticalities for both actors involved (lenders and customers) and the level of service provided through the digital platform. Firstly, an analysis of the literature was conducted to provide the state of the art of industrial SE model in logistics, and, focusing on ODW, the aim is to point out current main challenges and perspectives of this new platform-based model. The benefits and criticalities of this logistics solution are discussed through a SWOT analysis, with the aim of highlighting the main points of strengths and weakness of such a model and the external forces that might influence its diffusion. Finally, an exploratory analysis based on multiple case studies of ODW platforms was performed, focusing on their value proposal for lenders and customers and providing a picture of the current market with a focus on the latest evolution of the ODW model. This second step gives a more detailed perspective of the main characteristics of ODW and their impacts on the actors involved. This preliminary, exploratory analysis can represent a first systematization of ODW models to identify challenges and decisions that companies need to tackle when choosing these models.

The paper is organized as follows. Section 2 presents the background of SE models and the state of the art of ODW. The methodology is presented in Section 3. Sections 4 and 5 present the results of the SWOT analysis and the exploratory analysis, respectively, while the discussion and conclusions are shown in Sections 6 and 7.

## 2. Background

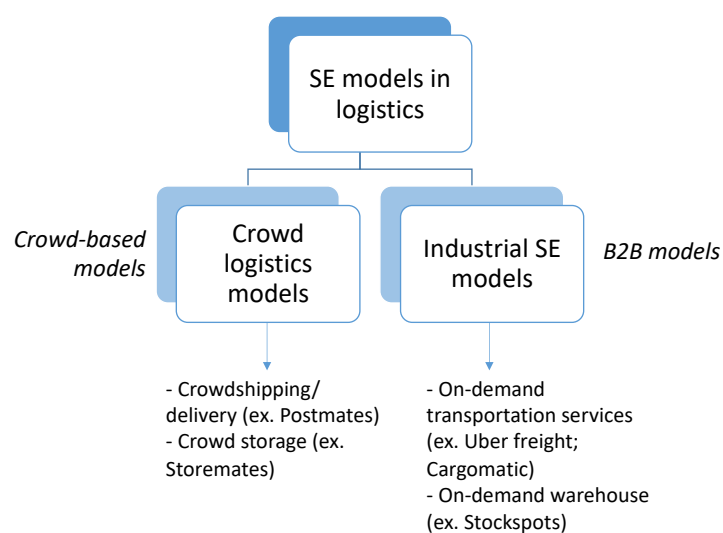
### 2.1. From Sharing Economy to Industrial Sharing Economy in Logistics

The SE paradigm has represented a revolution in the concept of consumption: traditional models based on product ownership and on a direct relationship between supplier and consumer have been replaced by one based on the sharing of underexploited goods, enabled by a network of actors (lenders and customers), usually through digital technologies. A unified definition of this concept does not exist, but several researchers have attempted to propose different points of view. An interesting contribution is given by Muñoz and Cohen [8], who define SE as “an economic system enabling an intermediated set of exchanges of goods and services between individuals and organizations which aim to increase efficiency and optimization of under-utilized resources in society”. Basic pillars of SE have been identified by Constantiou et al. [9]: the first is the access-based consumption pattern, that replaces the ownership-based one; the second is the peer-to-peer network, enabled by platforms and IT; the third is the possibility to allocate idle resources, increasing

their utilization through sharing. At first, the rise of SE models involved mostly the private sector, with many successful businesses providing platforms for customer-to-customer (C2C) transactions in different areas, while industrial actors were less involved in this revolution. Recently, Govindan et al. [2] defined the novel concept of the “industrial sharing economy” as a system “in which assets (man, machine, materials) and/or services are shared between industries (two or more), with the mutual consent with the means of technology”, pointing out how industrial SE must be characterized differently from traditional SE models. One critical point outlined is the different role of transaction cooperation, which, from one side, represents a key lever in C2C transaction cooperation, since individuals take advantage of mutual collaboration; on the other side, a competition factor might arise in business-to-business (B2B) models, thus potentially modifying relationships between the actors involved.

One industrial sector in which SE models are spreading lately is logistics, due to the increasing demand for flexible and high-level services pushed by the advent of e-commerce. SE in logistics allows for an elastic use of the resources of a network, providing logistics capacity where and when needed, enhancing resilience and sustainability [10].

A recent bibliometric analysis showed that research on SE in logistics is largely focused on crowd logistics [6]. As defined by Frehe et al. [11], the term crowd logistics refers to “the outsourcing of logistics services to a mass of (not necessarily business) actors, whereby the coordination is supported by a technical platform, which is hosted and managed by a crowd logistics provider”. Furthermore, some studies adopt the terms “crowd logistics” and “crowd shipping” interchangeably [12]. However, Carbone et al. [4] classified crowd logistics services highlighting the existence of crowd storage platforms: the analyzed model was based on a crowd of private citizens (not companies) supplying all kinds of free space (e.g., garages, cellars and spare rooms) for temporary storage. Despite the lack of a uniform and shared definition of crowd logistics, according to Frehe’s definition, one emerging characteristic of crowd logistics models is that they can be based on the participation of businesses or individuals. Based on this definition, crowd logistics models differ from industrial SE models, as the latter only refers to B2B transactions. Figure 1 proposes a schematization of SE models in logistics.

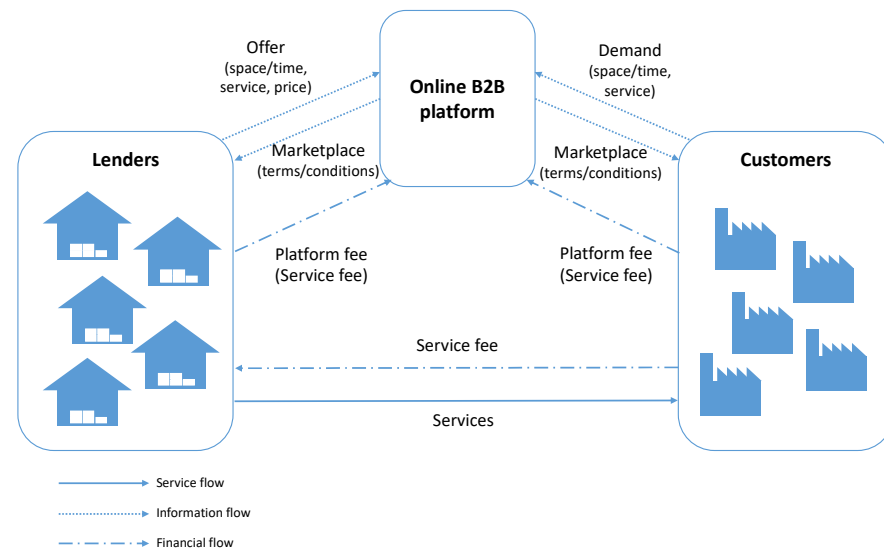


**Figure 1.** Classification of SE models currently applied in logistics activities.

## 2.2. On-Demand Warehousing: Basic Features

One emerging model in industrial SE is on-demand warehousing (ODW): it represents a B2B alternative to more traditional warehousing strategies, such as leasing or outsourcing proposed traditionally by third-party logistics providers (3PLs) [7,13]. Based on the sharing of storage space among industrial actors (B2B) through an intermediation developed by a software platform, this model involves three main players: a group of lenders, a group of

customers, and the owner of the platform, as several SE-based models (see Figure 2). In this case, the offer side is represented by the lenders: they are companies that internally manage their warehouse space, wishing to offer parts of their space and resources to provide services to other companies, aiming to increase their resource utilization levels. The demand side is represented by companies needing storage and handling capacity in a dynamic way, e.g., in terms of quantity to be stored and time for storage. The intermediation is conducted by the company that manages the cloud platform, which usually defines rules and conditions (e.g., services fees) for the interactions.



**Figure 2.** Actors involved in an ODW model and their interactions.

One main difference between ODW models and traditional services provided by 3PLs is their higher flexibility: Pazour and Unnu [7] propose an effective definition in terms of capacity granularity (provided by the lenders) and commitment granularity (required by customers). Leasing from 3PLs traditionally requires a minimum commitment period (expressed in years or months) and a minimum capacity (e.g., expressed in square meters); ODW models allow for renting on a per-pallet/per-month/per-day basis, thus providing a more dynamic demand for services. This capability also increases the final customer service level in terms of delivery speed, allowing warehouses closer to the customer base with low set-up costs to be chosen [14]. Similarly, from a lender's perspective, warehouse owners with an empty storage capacity for a limited period can rent this resource through the platform, therefore making profits from an underutilized resource. Two previous studies analyzed and discussed the main differences between ODW and traditional warehousing models in greater detail [7,13], underlining the related advantages in terms of flexibility and resource utilization. However, the criticalities of this model have not been investigated so far.

### 2.3. State-of-the-Art Analysis of ODW Models

Only a few studies in the literature have focused on ODW models, as they are a recent market-driven innovation. A few research articles on ODW models focused on a strategic dimension defining the model organization and its key features. Pazour and Unnu [7] provided a first conceptualization of ODW, starting from the description of the main characteristics of on-demand business models and then comparing ODW models and traditional warehousing solutions. The comparison was conducted by analyzing different parameters, such as capacity granularity, commitment granularity, and access to scale. The authors highlighted the higher flexibility of ODW models compared to traditional ones, as they globally allow for better utilization of resources in a context of highly variable demand. The comparison with other warehousing options is further explored by Tornese et al. [13],

who proposed a critical analysis of specific features of ODW compared to traditional models (e.g., pooled warehouse and contracted warehouse), describing a framework of the general ODW business model.

Recent papers are focusing on more operational issues, by evaluating different perspectives typical of platform-based businesses. Unnu and Pazour [15] analyzed a dynamic facility location problem with different alternatives for customers (ODW, 3PLs, and self-distribution), showing the potentialities of ODW but also pointing out its inner risks related to the uncertain availability of services. The lender's perspective has been analyzed, exploring the resource allocation problem of evaluating how much space a company can allocate on the platform [16] through an approximate dynamic programming heuristic model. On the customer's side, one problem to address is defining the level of demand to be fulfilled by ODW services, and, consequently, how to distribute the inventory among different ODW lenders. Tian and Zhang [17] investigated this problem through a mixed integer programming model for an e-commerce supply chain. Similarly, Lee et al. [18] explored how to support decisions about inventory and commitment for an e-commerce company when choosing ODW. The study has been extended in [14] to include uncertainties related to supply and demand: authors, through an optimization model, have also pointed out the potential cost effectiveness of ODW compared to traditional solutions. Correia and Melo [19] proposed a distribution network redesign problem considering the integration of company-owned warehouses with temporary ODW ones. A comparison with the traditional 3PL leasing was also discussed. The study concluded that ODW could increase the responsiveness of the distribution network especially towards demand changes. Van der Heide et al. [20] analyzed the problem of dynamic shipments in shared warehouse and transportation networks, such as ODW models, proposing a modeling framework tested on different network structures.

Only one recent study considered the platform's perspective by proposing a model to allocate demands and offers to maximize interactions, introducing for the first time the On-Demand Warehousing Problem (ODWP) [21].

In conclusion, the state of the art outlines that few recent studies on ODW models have focused especially on the customer perspective; several research gaps have been identified by researchers, focusing on how this model can create value for both lenders and customers, and how it can impact their operations [13]. While the strategic benefits of the model for companies have been outlined by researchers and practitioners [7,14], the possible criticalities for both sides and the main challenges for platform owners have not yet been adequately explored.

### 3. Methodology

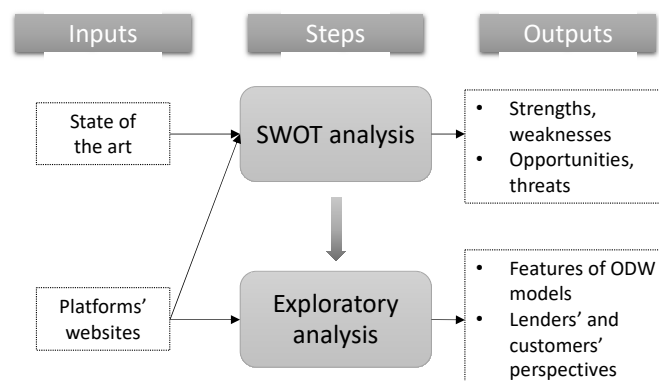
The aim of this study is to contribute to the conceptualization of the ODW model, exploring the possible challenges and limitations by analyzing the current solutions proposed in the marketplace, integrating the feedback deduced from the literature review proposed in the previous section, with the objective of highlighting benefits and criticalities for the actors involved. Studies on the adoption of methods and tools in scientific research suggest that in contexts where theory is not yet consolidated, due to the novelty of the topic, an exploratory approach should be preferred [22,23].

The methodology adopted for this study consists of two steps, depicted in Figure 3. In the first step, a SWOT (strengths, weaknesses, opportunities, threats) analysis of the ODW model was performed, starting from the findings of the state of the art previously presented, integrated with a search of the websites of currently active ODW platforms. The SWOT analysis helps the main challenges related to this emerging model to be summarized.

Since the literature on ODW is still scarce and the phenomenon is emergent, the second step of the methodology is an inductive and exploratory analysis. Specifically, this work is based on a case study approach, which aims at "investigating a contemporary phenomenon within its real-world context" [24]. A holistic multiple-case-studies approach has been



developed: the term “holistic” indicates that each case is analyzed as one unit, while multiple case studies are included to increase the robustness of the research outcomes [25].



**Figure 3.** The two-step methodology adopted.

An online search was performed to identify online platforms providing ODW services, active until September 2023. The research gave a final sample of 15 case studies from different countries in the world, which were explored through a content analysis: this method has proved suitable for the analysis of unstructured data, which is also the case for web-based research [26]. The following parameters were considered for the analysis of the platforms and their business propositions:

1. Geographic location and foundation year;
2. Core business of the company, aiming to identify whether ODW is the main activity proposed on the market or not;
3. Additional services proposed through the platform (besides basic storage and handling services);
4. Customer, lender, and intermediation platform cost, aiming to understand how the service pricing model is developed.

In addition, supplementary materials available on the platform, which could be useful for further understanding its value proposition and the business model, were analyzed (e.g., FAQ sections and blogs). Results are summarized in the next sections.

#### 4. The SWOT Analysis

##### 4.1. Strengths of ODW

Based on the state-of-the-art analysis, the main strengths of the ODW model can be outlined, focusing on the advantages for the two main actors involved.

From the customer’s point of view, the first and most widely underlined benefit is the possibility of accessing a storage service with high granularity level; this capability could enable flexibility along the supply chain, compared to traditional solutions. Therefore, customer-oriented companies can manage the variability of inventory levels without having to increase their base capacity [27], speeding up the time for implementation of the logistics solutions and drastically reducing the start-up costs [28]. This is beneficial especially when the variability of the demand increases, and businesses must deal with demand peaks not completely fulfilled by their baseline capacity. In addition, since the platform enables the connection to a network of lenders located in different areas, this influences their “access to scale”, defined as the percentage of demand that a seller can reach within a given distance, allowing companies to easily select warehouse locations close to their end point, thus reducing last-mile delivery cost and time [7]. Access to scale is usually limited in traditional scenarios, such as owned warehouse or 3PL warehouse networks. Moreover, the pay-per-use cost structure of ODW can be more convenient for short-term services compared to long-term agreements with 3PLs, switching from a fixed to a variable cost for

storage services [13]. Overall, ODW can respond to the increasing need for flexibility and speed of companies operating today.

On the other side, ODW allows lenders to optimize space utilization, responding to their demand fluctuations. This allows for better resource utilization, generating extra profits. Both customers and lenders are facilitated in the process of B2B connection [27]. Flexibility is guaranteed also for lenders as they can decide dynamically how much space to allocate to the platform, since they are not tied to strict contract terms. Moreover, a study shows that the use of the ODW model compared to 3PL warehouses can generate a lower total supply chain cost [14].

#### 4.2. Weaknesses of ODW

By focusing on the literature on ODW, the analysis of criticalities remains still largely unexplored by academics. However, ODW models entail some limitations for the actors involved, compared to other solutions, which can be seen as the flipside of the strengths previously described.

A first challenge is related to the lack of standardization of the services offered through a platform [29]. Lenders on ODW platforms are usually allowed to post their service offer deciding which type of activities are included. Not all lenders on one platform will necessarily provide the same services. This lack of standardization can represent a limitation for customers that need specific services and activities. Next to this, customers may complain about the lack of control and visibility in the fulfillment phase. Lenders that join the ODW platform usually have other flows of orders to manage (either their own products or orders from traditional customers); therefore, this could potentially lead to poor management in some of the activities performed, and the volatile nature of the collaboration in ODW between customer and lender does not allow for control and visibility in the fulfillment operations. Moreover, automation is typically not provided in this model. ODW usually enables basic logistics services, so it cannot be an option for customers needing advanced services based on highly automated warehouse operations. Another criticality is that ODW has been conceived as a short-term solution. Due to its intrinsic nature, it can be effective in the short term, but it may not work as effectively in the long-term. Being an open marketplace, the relationship with lenders is essentially fluid: it is unlikely for a customer to request the same services to the same lender more than once. Therefore, it can work if the customer does not need a long-term solution (for example, during seasonal peaks of demand). This also entails a certain performance variability: as the role of ODW platforms is usually limited to a marketplace where demand and offer meet, they do not have strict control of the services provided by lenders. Moreover, lenders can have diverse levels of expertise, and the risk of fulfillment errors varies significantly with the different providers. This can make ODW unappealing for customers that prioritize a high service level over flexibility and speed [29].

From the lenders' perspective, ODW can have a few weaknesses too compared to other models. A first challenge is related to resource prioritization since the warehouse owner typically manages both on-demand and traditional customers. Therefore, the lender needs to define priority rules to ensure the maximization of the profit, especially when the utilization rate of space and resources grows high. Another point to consider is demand uncertainty: listing space on a ODW platform does not guarantee that it will be filled. This uncertainty should be considered when the lender decides how much space and how many services to allocate to its customers. On the other hand, the high granularity guaranteed by ODW models increases the probability of having a large number of customers to serve at the same time. This can potentially increase the complexity of the processes and activities managed by the lender. Finally, being a short-term solution for the lender as well, the flexibility of the ODW model does not allow the lender to realize long-term activity planning.

A summary of the strengths and weaknesses discussed in these sections is provided in Table 1.

**Table 1.** Summary of strengths and weaknesses of ODW for customers and lenders.

	Strengths	Weaknesses
Customers	<ul style="list-style-type: none"> <li>• High granularity for commitment and capacity</li> <li>• High flexibility</li> <li>• No investment costs, low start-up time</li> <li>• High access to scale</li> <li>• Pay-per-use cost (no fixed costs)</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of service standardization</li> <li>• Lack of control and visibility in fulfillment</li> <li>• No automation</li> <li>• Short-term solution</li> <li>• Performance variability</li> </ul>
Lenders	<ul style="list-style-type: none"> <li>• Increased resource utilization</li> <li>• Possibility to increase profit</li> <li>• Easier B2B connection</li> <li>• High flexibility, no strict contract terms</li> </ul>	<ul style="list-style-type: none"> <li>• Resource prioritization</li> <li>• Demand uncertainty</li> <li>• Potentially high concentration of demand</li> <li>• Short-term solution</li> </ul>

#### 4.3. Opportunities of ODW

The current industrial and commercial context is characterized by some trends that have enhanced the diffusion of ODW platforms and could further boost this business model in the logistics sector, some of which have been discussed in the previous sections. Digitalization is pervading all industries, including logistics, pushing businesses to re-think their business model exploiting the advantages of digital technologies [30], in some cases enabling a sustainability perspective [31,32]. The adoption of digital technologies in logistics can enhance a higher degree of resilience and responsiveness, allowing even smaller companies to gain access to any kind of digital services, including ODW platforms. Furthermore, the growing diffusion of e-commerce worldwide surely represents a turning point in the logistics sector due to the radical changes it entails. The possibility of delivering goods directly to the customer has increased the complexity of last mile logistics: orders are mostly characterized by a low number of items, while customers often require shorter delivery times and the possibility of returning a product, often with no added costs [1,33]. Boysen et al. [33] report that online retailers are characterized by special needs, which are orders of small size, a large assortment, very tight delivery schedules, and varying workloads. These characteristics contribute to increasing the variability and uncertainty of the demand that businesses must manage, with inventory fluctuations remaining a significant challenge for companies [34], generating a need for scalable warehouse capacities and more flexible and responsive logistics models, to which the ODW platforms aim to respond. Next to this, the demand for storage services with high granularity and short commitment periods is increasing [33], posing a challenge to logistics companies that operate with long-term contracts and to customers that seek a fitting solution. The ODW model aims at filling this gap in the industrial logistics market.

Moreover, sharing economy models prioritizing access over ownership can provide environmental benefits, increasing resource sharing. With the rise of environmental awareness among industrial and private actors, sharing economy solutions can become more appealing in different sectors, including logistics [35].

#### 4.4. Threats of ODW

The advent of omnichannel retailing is increasing the complexity of logistics services and consequently the challenges related to the design of logistics systems [1,33]. In such a context, the ODW model might show its limits, previously described in Section 4.2. Pushed by increasingly highly competitive standards, many customer-oriented companies require high service quality and performance stability, which is something that the ODW model cannot always guarantee. Following this need, many 4PL (fourth-party logistics provider) competitors try to respond to this demand by providing services based on longer-term reliability and high-quality standards [36].

The main opportunities and threats to ODW are summarized in Table 2.



**Table 2.** Summary of opportunities and threats of ODW.

Opportunities	Threats
<ul style="list-style-type: none"> <li>• Digitalization</li> <li>• Diffusion of e-commerce</li> <li>• Increasing variability and uncertainty of the demand inventory fluctuation, need for responsive models</li> <li>• Need for storage with short commitment periods</li> <li>• Environmental awareness</li> </ul>	<ul style="list-style-type: none"> <li>• Increasingly competitive standards</li> <li>• Demand for high service quality and performance stability</li> <li>• 4PL market (competitors)</li> </ul>

## 5. Exploratory Analysis

The exploratory analysis involved 15 platforms identified, active as of September 2023. Table 3 summarizes the key features of the case studies. Data were collected from the official websites. It has to be noted that not all platforms freely provide all information: in some cases, information about the cost structure for customers and lenders using the platform was not public. In this case, no availability of data (N/A) is used in the table.

**Table 3.** ODW platforms analyzed and their key features.

Platform Cluster	Platform	Based (Founded)	Core Business	Cost for Customers	Cost for Lenders	Platform Intermediation Cost	Service Offering
Pure ODW	EVcargo	UK (1963)	On-demand services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>• +SC management services</li> </ul>
	OneVastWarehouse	UK (2019)	On-demand services	Pay-as-you-go (weekly payment to the lender)	<ul style="list-style-type: none"> <li>• Free listing</li> </ul>	Customers pay a weekly platform fee as a % on the services	<ul style="list-style-type: none"> <li>• Order fulfilment,</li> <li>• pick and pack,</li> <li>• transportation</li> </ul>
	Souco	Japan (2016)	On-demand services	Pay-as-you-go (payment to the platform, including a platform fee)	Free listing (receives payment from the platform)	Customers pay a platform fee	<ul style="list-style-type: none"> <li>• Shipping</li> </ul>
	Stockbooking	France (2016)	On-demand services	Pay-as-you-go (payment to the platform)	Free listing (receives payment from the platform)	Customers pay a monthly platform fee based on services	Not specified (service depends on lender)
	Stockspots	Netherlands (2017)	On-demand services	Pay-as-you-go (weekly payment to the platform)	N/A	N/A	<ul style="list-style-type: none"> <li>• Transportation</li> <li>• VAL—value-added logistics (order fulfillment, pick and pack, returns, labeling, kitting)</li> <li>• E-commerce fulfillment</li> </ul>
	Stowga	UK (2015)	On-demand services	Pay-as-you-go (monthly payment to the lender)	Monthly platform fee	Lenders pay a monthly platform fee as a % on the services	<ul style="list-style-type: none"> <li>• Order fulfillment</li> <li>• Picking and packing</li> <li>• Transportation</li> <li>• Managing returns</li> <li>• Accredited WH for heavily regulated industries (pharma, food, ...)</li> </ul>
	Warehouse Exchange	USA (2015)	On-demand services	Pay-as-you-go (monthly payment based on space and services)	Platform fee	Both customers and lenders pay a monthly platform fee as a % on the services	<ul style="list-style-type: none"> <li>• Palletization</li> </ul>
	Warehouz	USA (2019)	On-demand services	Pay-as-you-go (payment to the lender, including a % on transaction to the platform)	Free listing	Customers pay a platform fee based on services	<ul style="list-style-type: none"> <li>• E-commerce fulfillment</li> <li>• Retail distribution</li> </ul>
	Wareflex	Vietnam (2022)	On-demand services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>• Fulfillment services</li> </ul>

Table 3. Cont.

Platform Cluster	Platform	Based (Founded)	Core Business	Cost for Customers	Cost for Lenders	Platform Intermediation Cost	Service Offering
Mixed ODW-4PL	Flexe	USA (2013)	Warehousing and fulfillment services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>E-commerce fulfillment</li> <li>Omnichannel fulfillment</li> <li>Inventory management</li> <li>Order management</li> <li>Storage and distribution</li> <li>Integrated software</li> </ul>
	Flowspace	USA (2017)	Warehousing and fulfillment services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>E-commerce fulfillment</li> <li>Omnichannel fulfillment</li> <li>Inventory management</li> <li>Order management</li> <li>Network optimization</li> <li>Supply chain analytics</li> <li>Integrated software</li> </ul>
	Stord	USA (2015)	Warehousing and fulfillment services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>Distribution</li> <li>Omnichannel fulfillment</li> <li>Custom packaging</li> <li>Cross docking</li> <li>Network optimization</li> <li>Integrated software</li> </ul>
	Ware2go (by UPS)	USA (2018)	Warehousing and fulfillment services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>Distribution</li> <li>Fulfillment optimization</li> <li>Omnichannel fulfillment</li> <li>Integrated software</li> </ul>
	Waredock	Scandinavian countries (2019)	Warehousing and fulfillment services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>Distribution</li> <li>E-commerce fulfillment</li> <li>Omnichannel fulfillment</li> <li>Integrated software</li> </ul>
	WarehouseQuote	US (2019)	Warehousing and fulfillment services	N/A	N/A	N/A	<ul style="list-style-type: none"> <li>Retail distribution and fulfillment</li> <li>Omnichannel fulfillment</li> <li>B2B fulfillment</li> <li>Supply chain consulting</li> <li>Integrated software</li> </ul>

A first relevant finding regards the core business of the platforms: two main clusters were identified. The first, defined as the “pure ODW” platform, includes ODW platforms currently providing on-demand services through a peer-to-peer model, as described in Figure 2: they can operate at different service levels, starting from basic services, or extending their offer to include advanced logistics services. The second one, defined as “mixed ODW-4PLs”, includes actors that started their business as ODW platforms and recently changed their business model to focus on warehousing and fulfillment services like 4PLs. In this case, the ODW service is provided through a different model, which is not based on peer-to-peer transactions but involves the platform owner as intermediary between lenders and customers, providing also a variety of logistics services. These two categories are better described and explored in the next sections, as they represent the current state of the market for ODW services.

### 5.1. Pure ODW Platforms

More than half of the case studies analyzed provide the typical ODW service as depicted in Figure 2. Specifically, eight of them are companies born with ODW as the

core business, while one is an SCM company with decades of experience in the sector that recently decided to extend its business to the ODW market (i.e., EV Cargo).

By analyzing the information acquired, a first relevant difference can be outlined in the cost structure proposed to lenders and customers (which in three cases was not accessible on the website). In 50% of the cases (four platforms), lenders can post with no fee their offers on the platform, which receives a payment only from the customers. In two cases, the lender must pay a platform fee, and the amount depends on the type of service provided. On the customer's side, the cost of the ODW service is usually based on a pay-as-you-go mode (weekly or monthly payments on a per-pallet base), and it can include an extra fee for the platform (calculated as a percentage of the transaction). Overall, platforms receive a fee either from the customer or from the lender; in one case, both actors pay a transaction fee (Warehouse Exchange). Moreover, the financial flows can vary: the payment can be either direct from the customer to the lender, or it can be intermediated by the platform, which is currently the most common solution.

Another issue to be outlined is related to the types of service, which vary among a wide spectrum of different services. In detail, two pure ODW platforms provide only basic storage and handling operations, while three of them also include order fulfilment and distribution. The rest offer larger service packages. Stockspots provides "Value Added Logistics activities" like return management, order processing, kitting and quality inspections. Stowga includes the possibility to reach accredited warehouses for heavily regulated industries. Only one platform (i.e., Stockbooking) does not specify the service type, therefore leaving this possibility to the lender. EV Cargo provides access to a wide range of services, ensuring the control of shipments and inventory for their ODW customers "from source to shelf" or final user.

Finally, considering the geographic distribution of the pure ODW platforms, half of the platforms analyzed in this work are based in central-north Europe (two in the UK, one in France and one in The Netherlands), while only two of them operate in the US, and the remaining two are based in South-East Asia. Thus, while the pure ODW model was born in 2013 in the US (with Flexe, the first ODW platform), and only a couple of years later it started spreading in the EU as well, nowadays it seems to be more successful in the European market than in the American one.

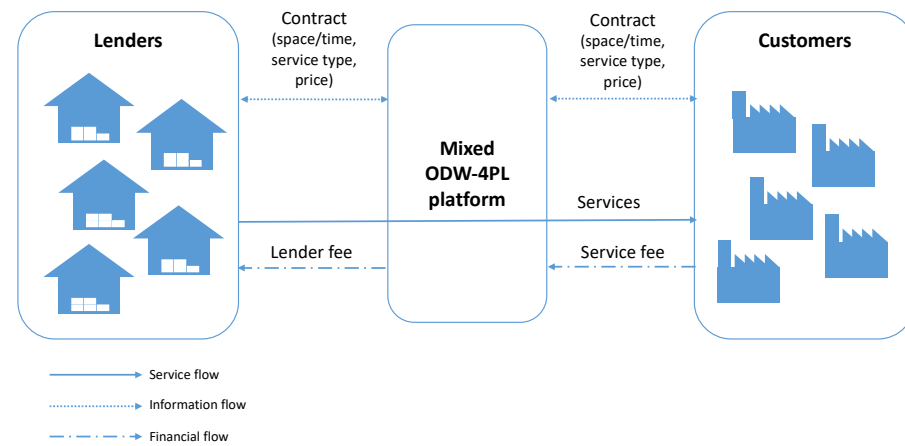
### 5.2. Mixed ODW-4PL Platforms

As shown in Table 3, the exploratory analysis identified six actors that started their activities as pure ODW platforms but lately changed their business model, becoming de facto a 4PL company that provides also ODW services. An interesting point is that some of the companies included in this category (i.e., Flexe, FlowSpace, and Stord) were pioneers of ODW, and most of them operate in the US market, with only one case from Europe. All these companies have changed their core business, switching from being pure ODW providers to logistics providers specialized in pay-per-use warehousing and fulfilment services.

Thus, by comparing pure and mixed ODW-4PL models, one relevant difference can be found in the dynamics among the three actors involved, as depicted in Figure 4. In the pure ODW model, there is a peer-to-peer relationship between customer and lender, which is only facilitated and enabled by the platform that acts like a marketplace (as reported in Figure 2), similarly to other SE models (e.g., Airbnb and Uber).

In this new, mixed ODW-4PL approach, the customer has direct contact only with the platform company (e.g., Flexe), which is the direct service provider, not an intermediary for both the client and the lender. In fact, similarly to some pure ODW companies, the company provides a range of services through a wide network of lenders, guaranteeing the same access-to-scale and flexibility as in pure ODW, but, differently from pure ODW, these lenders have a strategic partnership with the company with a specific consolidated agreement of collaboration. In brief, their contract is with the logistics company, not with the single customer. In this case, companies are acting as on-demand 4PLs [37], as they

act like traditional 4PLs but provide services on a pay-per-use base. The literature defines traditional 4PLs as providers of logistics services that can help their customers design, build, manage, and operate supply chains based on their own and other companies' resources [38]. In other words, 4PLs can manage the activities of many 3PLs, working as a supply chain integrator to provide high quality services to its customers [36].



**Figure 4.** The mixed ODW-4PL model.

However, these mixed ODW-4PL companies keep some peculiarities of ODW, since they continue to provide the flexibility and the access-to-scale of on-demand services, unlike other 4PLs [28].

Consequently, the communication between companies is also different from the pure ODW model as it is focused on a specific target: potential customers needing fast and reliable logistics services for all their fulfilment operations, including e-commerce and omnichannel or multi-channel strategies. This feature outlines the largest service portfolio of these companies, compared to the pure ODW model: together with storage and handling services, these logistics providers guarantee a wide range of activities, including distribution, inventory management, and fulfillment services but also more strategic services like supply chain analytics and network optimization. While pure ODW models put emphasis on the flexibility of their services, mixed ODW-4PLs also focus on reliability and the high service level guaranteed by their control of the supplier of services [28,29]. This is often stressed by these companies, underlining the advantage for the customer of having a single point of contact in the 4PL, who can provide its services through the many partner companies belonging to the network, and guarantee control over the whole process as well as homogeneity in the service level. This is possible because, differently from the pure ODW model, in this case, the service providers are verified partners that commit to guaranteeing a specific service level to the 4PL and its customers. Another core difference lies in the commitment period for the customer: while this is typically short for ODW platforms, these logistics companies aim at reaching a medium-to-long-term relationship with their customers, although they can still provide flexibility and scalability due to the network of partners operating with them.

## 6. Discussion

### 6.1. Pure ODW vs. Mixed ODW-4PL: Customers' and Lenders' Perspectives

The analysis performed has shed light on the key features the ODW model compared to other outsourcing strategies. On one side, ODW emerges as a more flexible solution than traditional 3PLs, entailing several advantages for both customers and lenders. On the other side, the SWOT analysis also highlighted the criticalities and challenges of the ODW model, while the exploratory analysis revealed that several former pure ODW platforms have recently abandoned this model to become what we have defined as mixed ODW-4PLs. Our hypothesis, based on the platforms' websites analysis, is that these companies are trying

to overcome the main weaknesses of ODW while keeping its distinctive trait of flexibility. As an example, customization and reliability are cited by Stord as specific advantages of their business model compared to the pure ODW [29]. They also underline that pure ODW models allow limited innovation and automation as well as network planning and optimization compared to their current business model [39]. For the customer, this means that the mixed ODW-4PL model could solve some limitations of pure ODW, granting access to a wider range of logistics services, and overcoming the lack of standardization and performance variability, since the 4PL company usually requires that its partners respect some predefined quality standards. However, ODW-4PL entails a longer-term engagement of the customer with the provider, erasing one of the peculiarities of pure ODW models, therefore it could be inconvenient for companies that only need short-term integration of their storage capacity. Considering the lenders' perspective, joining an ODW-4PL network would require them to guarantee a predefined level of service, as opposed to the ODW in which usually the lender itself defines types and quality of the services offered on the platform. However, granting some level of control to the 4PL can pay off in terms of stability of the demand, increasing the chances of being matched to a customer.

It is evident that the mixed ODW-4PL model aims at a different target customers than ODW: while the pure ODW model has been conceived to respond to unexpected storage needs with minimum commitment requirements, in a fluid relationship with customers mainly based on flexibility, the mixed ODW-4PL model tries to respond to the needs of customers that look for logistics solutions with high service levels and reliability, aiming at establishing medium/long-term relationships with their clients while still guaranteeing a good level of flexibility. Overall, a deeper exploration of the implications of the two models for different target customers would be an interesting point to investigate through future research. Next to this, the future evolution of the ODW and ODW-4PL models should also be monitored, as the phenomenon is still in development and further changes and innovations might characterize this sector.

Clarifying the main differences between pure ODW and mixed ODW-4PL compared to the traditional 3PL and 4PL models can potentially help both customers and lenders to choose the logistics model that fits better to their needs. Table 4 summarizes these characteristics, based on the literature and exploratory analysis presented in the previous sections.

**Table 4.** Summary of the key features of the pure ODW model and mixed ODW-4PLs compared to 3PLs and traditional 4PLs.

Features	Pure ODW Platforms	Mixed ODW-4PLs	3PLs	4PLs
Time to First Service	Days	Days/Weeks	Weeks/Months	Weeks/Months
Relationship with lenders	Short-term, flexible. Involves many lenders	Medium/long-term. Involves many lenders	3PL is the only lender	Medium/long-term. Involves many lenders
Lenders' reliability	Variable	High (verified lenders)	High	High (verified lenders)
Number of facilities involved	High. Network-based	High. Network-based	Low	High. Network-based
Service portfolio	Medium variety of logistics services (depending on the lender)	Wide variety of logistics services offered	Wide variety of logistics services offered	Wide variety of logistics services offered
Automation	Not provided	Usually non provided	Can be provided	Can be provided
Inventory tracking	Optional	Guaranteed	Guaranteed	Guaranteed
Time commitment granularity	Weeks	Weeks/Months	Months	Months
Capacity granularity	Per pallet	Per pallet	Minimum space required	Minimum space required
Access to scale	High	High	Low	High
Cost structure	Pay-as-you-go	Pay-as-you-go	Flat + variable fee	Flat + variable fee



### 6.2. Contribution and Limitations of the Study and Further Research

The analysis performed clarified the main benefits and criticalities of the ODW model for the actors involved (customers and lenders), contributing to build knowledge on this topic that is still largely unexplored in the literature. The analysis also revealed that a few companies born as ODW platforms have recently transitioned to a mixed ODW-4PL model, shedding a light on a phenomenon that has invested primarily the US market so far but also has one example in Europe.

The limitations of this study are mainly related to the methodology adopted: although the exploratory analysis represents a valid method to study new and underexplored topics, the multiple case study based on websites content gave only a broad picture of the pure and mixed ODW models described, since not all data and information are available for access on their public websites. As an example, it was not possible to retrieve data on the cost structure of both models. Further research could be oriented towards integrating this preliminary analysis with other methods, such as surveys involving ODW platforms, as well as their users (both customers and lenders).

## 7. Conclusions

The literature and current market trends suggest that the ODW model could be particularly useful for companies needing storage space that wish to keep up with the increasingly complex nature of logistics in the era of e-commerce and omnichannel, where flexibility and speed have become essential to survive on the market. Benefits for the actors involved, namely customers and lenders, have been briefly explored in the literature, as well as some operational issues related to ODW. However, this model also entails some criticalities that must be considered, which have not been discussed in the literature so far, although they represent key issues that can influence the decision of a customer to choose ODW platforms instead of traditional logistics players.

Starting from a SWOT analysis of the ODW model, complemented by an exploratory analysis performed through a multiple case study involving the main ODW platforms operating around the world, this study highlights some of the criticalities emerged about ODW that can eventually affect the decision of both customers and lenders to choose this option over a more traditional one. Next to this, the analysis revealed that several former ODW platforms changed their business model to become mixed ODW-4PLs, probably aiming at overcoming the main limitations of ODW. A first qualitative comparison was proposed considering how the pure ODW model differs from the emerging trend of mixed ODW-4PLs, and from traditional 3PLs and 4PLs. The discussion highlights that the two logistics models identified aim at different target customers, as ODW tries to respond to unexpected or short-term storage needs, while the ODW-4PL model focuses more on long-term customer retention based on high-level services, both aiming at guaranteeing flexibility.

This work represents an attempt to contribute to the theoretical framework on ODW, exploring benefits and challenges for ODW users, both customers and lenders, and describing the evolution of mixed ODW-4PLs. The main limitation of this study is related to the research method applied for the case study analysis, which was conducted relying solely on publicly available data obtained through the platforms' websites: this might have limited the amount and depth of information collected. However, being an exploratory analysis focused on an emergent topic, this can be intended as a preliminary step for a deeper analysis, which could be conducted as further research through more structured approaches, such as surveys and interviews. Further research on this topic is needed to investigate the details of both solutions, and it should be oriented towards understanding the conditions in which ODW and the ODW-4PL model can be more convenient, both for customers and lenders; the impact that they can have on different target customers; as well as the future evolution of both logistics models.

**Author Contributions:** Conceptualization, V.E., M.G.G. and F.T.; methodology, V.E., M.G.G. and F.T.; formal analysis, V.E., M.G.G. and F.T.; data curation, V.E., M.G.G. and F.T.; writing—original draft preparation, V.E., M.G.G. and F.T.; writing—review and editing, V.E., M.G.G. and F.T. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Data Availability Statement:** The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

1. Kembro, J.; Eriksson, E.; Norrman, A. Sorting out the sorting in omnichannel retailing. *J. Bus. Logist.* **2022**, *43*, 593–622. [CrossRef]
2. Govindan, K.; Shankar, K.M.; Kannan, D. Achieving sustainable development goals through identifying and analyzing barriers to industrial sharing economy: A framework development. *Int. J. Prod. Econ.* **2020**, *227*, 107575. [CrossRef]
3. Kauffman, R.J.; Naldi, M. Research directions for sharing economy issues. *Electron. Commer. Res. Appl.* **2020**, *43*, 100973. [CrossRef]
4. Carbone, V.; Rouquet, A.; Roussat, C. The Rise of Crowd Logistics: A New Way to Co-Create Logistics Value. *J. Bus. Logist.* **2017**, *38*, 238–252. [CrossRef]
5. Li, S.; Wu, W.; Xia, Y.; Zhang, M.; Wang, S.; Douglas, M.A. How do crowd logistics platforms create value? An exploratory case study from China. *Int. J. Logist. Res. Appl.* **2019**, *22*, 501–518. [CrossRef]
6. Saglietto, L. Bibliometric analysis of sharing economy logistics and crowd logistics. *Int. J. Crowd Sci.* **2021**, *5*, 31–54. [CrossRef]
7. Pazour, J.A.; Unnu, K. On the Unique Features and Benefits of On-Demand Distribution Models. In Proceedings of the 15th International Material Handling Research Colloquium, IMHRC, Savannah, GA, USA, 23–27 July 2018; Available online: [https://digitalcommons.georgiasouthern.edu/pmhr\\_2018/13](https://digitalcommons.georgiasouthern.edu/pmhr_2018/13) (accessed on 10 March 2024).
8. Muñoz, P.; Cohen, B. Mapping out the sharing economy: A configurational approach to sharing business modeling. *Technol. Forecast. Soc. Chang.* **2017**, *125*, 21–37. [CrossRef]
9. Constantiou, I.; Marton, A.; Tuunainen, V.K. Four Models of Sharing Economy Platforms. *MIS Q. Exec.* **2017**, *16*, 231–251.
10. Carissimi, M.C.; Creazza, A. The role of the enabler in sharing economy service triads: A logistics perspective. *Clean. Logist. Supply Chain* **2022**, *5*, 100077. [CrossRef]
11. Frehe, V.; Mehmman, J.; Teuteberg, F. Understanding and assessing crowd logistics business models—Using everyday people for last mile delivery. *J. Bus. Ind. Mark.* **2017**, *32*, 75–97. [CrossRef]
12. Le, T.V.; Stathopoulos, A.; Van Woensel, T.; Ukkusuri, S.V. Supply, demand, operations, and management of crowd-shipping services: A review and empirical evidence. *Transp. Res. Part C Emerg. Technol.* **2019**, *103*, 83–103. [CrossRef]
13. Tornese, F.; Unnu, K.; Gnoni, M.G.; Pazour, J.A. On-demand warehousing: Main features and operational models. In Proceedings of the XXV Summer School Francesco Turco, Virtual Online, 9–11 September 2020.
14. Lee, J.; Ko, C.; Moon, I. E-commerce supply chain network design using on-demand warehousing system under uncertainty. *Int. J. Prod. Res.* **2022**, *62*, 1901–1927. [CrossRef]
15. Unnu, K.; Pazour, J.A. Analysing Varying Cost Structures of Alternative Warehouse Strategies. In Proceedings of the 2019 IISE Annual Conference, Orlando, FL, USA, 18–21 May 2019; Romeijn, H.E., Schaefer, A., Thomas, R., Eds.; Institute of Industrial and Systems Engineers (IISE): Peachtree Corners, GA, USA, 2019.
16. Shi, Y.; Yu, Y.; Dong, Y. Warehousing platform’s revenue management: A dynamic model of coordinating space allocation for self-use and rent. *Eur. J. Oper. Res.* **2021**, *293*, 167–176. [CrossRef]
17. Tian, Z.; Zhang, G. Multi-echelon fulfillment warehouse rent and production allocation for online direct selling. *Ann. Oper. Res.* **2021**, *304*, 427–451. [CrossRef] [PubMed]
18. Lee, J.; Park, J.; Moon, I. Inventory and Commitment Decisions for On-Demand Warehousing System. In *Advances in Production Management Systems. Artificial Intelligence for Sustainable and Resilient Production Systems*; Dolgui, A., Bernard, A., Lemoine, D., Von Cieminski, G., Romero, D., Eds.; IFIP Advances in Information and Communication Technology, Volume 630; Springer International Publishing: Cham, Switzerland, 2021; pp. 455–463. [CrossRef]
19. Correia, I.; Melo, T. Distribution network redesign under flexible conditions for short-term location planning. *Comput. Ind. Eng.* **2022**, *174*, 108747. [CrossRef]
20. Van der Heide, G.; Buijs, P.; Roodbergen, K.J.; Vis, I.F.A. Dynamic shipments of inventories in shared warehouse and transportation networks. *Transp. Res. Part E Logist. Transp. Rev.* **2018**, *118*, 240–257. [CrossRef]
21. Ceschia, S.; Gansterer, M.; Mancini, S.; Meneghetti, A. The on-demand warehousing problem. *Int. J. Prod. Res.* **2022**, *61*, 3152–3170. [CrossRef]
22. Ketokivi, M.; Choi, T. Renaissance of case research as a scientific method. *J. Oper. Manag.* **2014**, *32*, 232–240. [CrossRef]
23. Swedberg, R. Exploratory Research. In *The Production of Knowledge*, 1st ed.; Elman, C., Gerring, J., Mahoney, J., Eds.; Cambridge University Press: Cambridge, UK, 2020; pp. 17–41. [CrossRef]
24. Yin, R. *Case Study Research: Design and Methods*, 5th ed.; Sage Publications: Thousand Oaks, CA, USA, 2014.
25. Rowley, J. Using case studies in research. *Manag. Res. News* **2002**, *25*, 16–27. [CrossRef]

26. Seuring, S.; Gold, S. Conducting content-analysis based literature reviews in supply chain management. *Supply Chain Manag. Int. J.* **2012**, *17*, 544–555. [[CrossRef](#)]
27. Shin, N. Creating Shared Value from Collaborative Logistics Systems: The Cases of ES3 and Flexe. *Asia Pac. J. Inf. Syst.* **2020**, *30*, 214–228. [[CrossRef](#)]
28. Flexe. The Guide to Fixed and Flexible Logistics—Understand Applications, Evaluate Partners, and Build Internal Consensus. 2021. Available online: <https://www.flexe.com/whitepaper/whitepaper-guide-to-fixed-and-flexible-logistics> (accessed on 25 October 2023).
29. Stord-Omnichannel. Available online: <https://www.stord.com/industries/omnichannel> (accessed on 25 October 2023).
30. Stradner, S.; Brunner, U. Impact of Digitalization on Logistics Provider Business Models. In *Data Science and Innovation in Supply Chain Management: How Data Transforms the Value Chain. Proceedings of the Hamburg International Conference of Logistics (HICL)*; epubli GmbH: Berlin, Germany, 2020; Volume 29. [[CrossRef](#)]
31. Kayikci, Y. Sustainability impact of digitization in logistics. *Procedia Manuf.* **2018**, *21*, 782–789. [[CrossRef](#)]
32. Parhi, S.; Joshi, K.; Gunasekaran, A.; Sethuraman, K. Reflecting on an empirical study of the digitalization initiatives for sustainability on logistics: The concept of sustainable logistics 4.0. *Clean. Logist. Supply Chain* **2022**, *4*, 100058. [[CrossRef](#)]
33. Boysen, N.; de Koster, R.; Weidinger, F. Warehousing in the e-commerce era: A survey. *Eur. J. Oper. Res.* **2018**, *277*, 396–411. [[CrossRef](#)]
34. Flexe. The State of On-Demand Warehousing. 2019. Available online: <https://www.flexe.com/thank-you/2019-state-on-demand-warehousing> (accessed on 25 October 2023).
35. Gesing, B. *Sharing Economy Logistics—Rethinking Logistics with Access over Ownership*; DHL Customer Solutions & Innovation: Troisdorf, Germany, 2017.
36. Büyüközkan, G.; Feyzioğlu, O.; Şakir Ersoy, M. Evaluation of 4PL operating models: A decision making approach based on 2-additive Choquet integral. *Int. J. Prod. Econ.* **2009**, *121*, 112–120. [[CrossRef](#)]
37. Rosebrough, J. 3PL vs. 4PL: Choosing the Right Solution for Your Business, WarehouseQuote. Available online: <https://www.warehousequote.com/resources/3pl-vs-4pl/> (accessed on 13 October 2023).
38. Wang, H.; Huang, M.; Ip, W.H.; Wang, X. Network design for maximizing service satisfaction of suppliers and customers under limited budget for industry innovator fourth-party logistics. *Comput. Ind. Eng.* **2021**, *158*, 107404. [[CrossRef](#)]
39. Stord-Fulfillment. Available online: <https://www.stord.com/fulfillment> (accessed on 25 October 2023).

**Disclaimer/Publisher’s Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.