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Micro-fulfilment Centres in E-Grocery Deliveries

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Abstract: This paper studies micro-fulfilment centres (MFCs) as a response to rising e-grocery sales and customer expectations from decreased delivery time and cost requests. MFC is a business solution that allows orders to be picked and packed in a hyper local facility. The study aim is to provide an overview on this subject from two research questions: i) how MFCs affect the last-mile delivery challenges? and ii) what design decisions are critical in building MFCs? While we evaluate the advantages and disadvantages of centralised versus decentralised warehousing strategies in the first question, we discuss the critical decisions in designing MFCs in the second question. In that, we discuss location and technology selection decisions as well as other warehousing design criteria. Further, this study provides future research directions at the end of this study.

Keywords: e-commerce • micro-fulfilment centre • sustainability• last-mile delivery • urban distribution centre

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Introduction: E-commerce and e-grocery increase

E-commerce has been growing rapidly in the past years. Online sales are accounted for 7% of the total retail sales worldwide in 2016 (Arslan et al., 2021), and it is declared to be reaching a penetration of 13.8% in 2019 (Statista, 2022). By the COVID-19 pandemic, although restrictions have reduced the economic activities in most countries and sectors, e-commerce sales have increased by a result of many businesses going online. Hence, the COVID-19 pandemic acted as a catalyst for the online market, accelerating the growth for 4 to 6 years, by causing consumers spend most of their time on the internet (Forbes, 2020). It is estimated that the global e-commerce market will reach more than $6,388 billion by 2024, with an annual growth of about 13.5% (Zennaro et al., 2022).

According to the NielsenIQ's Global New Shopper Normal Study, before the COVID-19 pandemic, 9% of global consumers were regularly purchasing online. As the precautions are taken to slow down the spread of the virus, the number of online consumers has massively increased by reaching 27% of global consumers (Nielsen, 2020). In a survey study, it is observed that 44% of global consumers stated that they were shopping online each week, with 23% declaring shopping online several times each week (Nielsen, 2020).

Increase in e-grocery purchasing also played a significant role in the increase of e-commerce. It is well known that due to the restrictions during COVID-19, many consumers purchased groceries online, resulting with a rise in the traffic of online purchasing (Contentsquare, 2020).

Although part of the shift in consumer spending towards online grocery may be thought to be temporary, a significant portion is expected to remain after the pandemic, with many previously sceptical customers that are now inclined to change their grocery shopping behaviour in favour of e-

commerce (Seghezzi et al., 2022). The McKinsey Consumer Pulse survey which is conducted worldwide shows that roughly three-quarters of people using digital platforms for shopping during the pandemic state that they would continue buying online, even when the situation would return to normality (McKinsey, 2021).

That growth in online purchasing paves the way of retailers reshaping their distribution strategies to cope with their omnichannel interacting with final customer to fulfil their orders (Arslan et al., 2021; Chopra, 2018).

Delivery-Time Requests are Decreasing

Increase in e-commerce has affected customer expectations towards more shorter delivery time and cost requests. The 2020 Flexe Omnichannel Consumer Survey (Flexe, 2020) found that 85% of consumers look elsewhere for better alternatives when the delivery time is longer than their expectations. One of the two main reasons for dropping the shopping cart is that the delivery speed was not sufficient. Moreover, these considerations are even more relevant for the groceries sector where speed of delivery is a crucial factor. Indeed, one of the fastest-growing segments in grocery is instant delivery, where consumers expect to receive the products within 15 to 30 minutes (McKinsey, 2022). Many major grocery retailers now offer some form of same-day delivery service. For instance, Amazon Prime Now, Waitrose Rapid Delivery, Ocado Zoom or Walmart Express Delivery are services that offer one- or two-hour delivery windows (Dethlefs et al., 2022). Customers increasingly accustomed to rapid deliveries, have created a demand for this type of fulfilment. Grocery customers often expect quick deliveries because they generally would like to consume products at short notice, while they are willing to wait longer for other type of products (Dethlefs et al., 2022).

According to the Fabric's Retail Report (2022), consumer expectations on short delivery requests is one the three biggest challenges that the retail industry faces today, together with a lack of fulfilment capacity and with last-mile delivery costs. Indeed, in the last two years retailers lost an average of 22% of sales due to insufficient fulfilment capacity and they are expected the issue to get worsen, with lost sales that can reach a figure near 30% during 2022.

Supply chains need to seek for new solutions to address those global trends and the associated challenges. One of the solutions to alter those

challenges might be to follow a MFC logistics model in distribution network which we discuss it in the following sections.

The concepts presented in this paper are taken from few scientific articles discussing the MFCs topic within the current literature. Since this topic is rarely discussed in literature and it is an emerging phenomenon in e-grocery area recently, we aim to provide an overview on this subject (Hübner et al., 2022; Seghezzi et al., 2022). Since it is expected that the growth of e-grocery will continue, new solution models for progressive penetration of omnichannel strategies are required (Kellermayr et al. 2021). We discuss centralized versus decentralized fulfilment centre models in the following section before discussing the details of MFCs.

Centralized versus Decentralized Fulfilment Centres

In modern supply chains, retailers can usually opt for two types of strategies, namely centralized or decentralized warehousing (Schmitt et al., 2015). In the former, retailers manage their inventories in a single location, in a large central warehouse serving an entire region. Instead, the decentralized strategy utilises multiple strategic locations to store inventories closer to final customers. Each configuration has different strengths and weaknesses.

Centralized warehousing involves lower operating costs, higher product availability and a more efficient inventory management (Chopra, 2018). This last advantage is given by the risk pooling effect achieved in the central warehouse, allowing to reduce demand uncertainty and therefore the inventory costs (Schmitt et al., 2015). However, a centralized strategy leads to vulnerability to disruptions, longer lead time in last-mile delivery and high shipping costs due to longer outbound distances in the last-mile delivery (Chopra, 2018). Instead, decentralized warehousing may benefit from shorter lead times, lower shipping costs and a better customer service and order fulfilment, thanks to the proximity to final customers. Drawbacks mainly refer to high operating costs and less efficient inventory management than the centralized version. Following on, we discuss the role of MFCs in those two concepts.

Micro-Fulfilment Centres (MFCs) and Benefits

MFCs are defined to be highly automated logistics facilities located in large urban areas and cities, to become closer to the end customers (Kellermayr-Scheucher et al., 2021). Therefore, those centres, are also referred to be urban fulfilment centres (UFCs) which can perform a large range of activities from storage of products to order picking and last-mile distribution. The urban MFC can provide direct delivery of orders from online retail companies to the final customer. These logistics hubs require between 30-50 employees, a space between 1000 and 3000 square metres and serve in a radius of 5 km (Freichel et al., 2019). Due to its distributed location strategy, MFCs can be seen as decentralised fulfilment strategy for inventory management and last-mile delivery.

One of the main characteristics of these centres is that most of the activities are performed autonomously, by means of automated storage and retrieval systems according to a "goods-to-person" principle instead of the "person-to-goods" one, which is applied in many conventional logistics centres. This means that the goods are moved towards the operator to be picked up, instead of an operator moving the item to pick it up. The MFC concept tries to combine the advantages of efficiency of a big and automated warehouse with the advantages of small logistics facilities in terms of proximity to the customers to be served and the possibility for them to pick up products directly in the store. The high level of automation allows for achieving a better space utilisation. A conventional warehouse or distribution centre could take up to 300 thousand square feet, while a MFC takes up to 10 thousand square feet on average (Kellermayr-Scheucher et al., 2021). Many grocers such as Walmart, Tesco and Albertsons have already applied MFCs (Scriven, 2021).

According to Scriven (2021) in 2019 and 2020 while there were 16 and 29 MFCs, respectively, it is forecasted that over 2,100 MFCs would have been installed globally by 2025.

The main advantages of MFCs can be summarized as below (Kellermayr-Scheucher et al., 2021):

- picking activity costs and times are significantly reduced by the help of automated systems;
- increased accuracy in the order fulfilment by reducing the number of wrong deliveries, again through automated picking systems;
- last-mile delivery time and costs are low due to the proximity to the final customer;
- decreased leasing and operating costs due to low space requirements;

- increased efficiency in inventory management (e.g., more SKUs per square foot);
- better goods return flow management by also focusing on more return possibilities in e-purchasing;
- better sustainability performances from both decreased energy consumption and carbon emission based on lower last-mile delivery distances.

Research Questions

As already mentioned, one of the main features of MFCs is the high level of automation, which is the enabler for greater performance, the lower processing time and consequently saving on costs. The main technology solution adopted to in MFCs are automated storage and retrieval systems (AS/RS) where automated order picking robots collect the orders from their storage racks (Kocak et al, 2022). Once it is well designed in terms of technology, warehouse capacity, location, inventory optimization, etc., MFCs may provide great solutions for e-groceries from multi-objective perspectives: increased customer satisfaction, decreased energy consumptions, carbon emissions and costs.

In this work, we aim to provide an overview on MFCs by discussing the relevant studies in literature from their benefits and design perspectives. According to that, we explore the below research questions (RQs).

RQ1: How MFCs affect the last-mile delivery challenges?

RQ2: What design decisions are critical in building MFCs?

In RQ1, we research the potential benefits of MFCs on last-mile delivery challenges. In RQ2, we research the critical design decisions in building MFCs to realize the RQ1 benefits. In the following section, we summarize the regarding works according to RQ1 and RQ2.

Role of MFCs in Last-Mile Delivery

As mentioned above, MFCs are very small logistics hubs located next to urban areas, devoted to e-commerce orders, typically characterised by a high automation level (Seghezzi et al., 2022). They can provide benefits for last-mile delivery compared to other types of distribution centres. The advantages that they bring can be summarized in the following three categories.

- ***Delivery time benefits***

Last-mile delivery is the final step of the delivery process when a product is moved from a logistics hub to the destination. It is a critical process shaping the customer experience (Kim et al., 2021). Indeed, it is the interface between the retailer and the final customer. As mentioned, the customer expectations in terms of punctuality and delivery speed are the most challenging issues for retailers (Mangiaracina et al., 2019).

MFCs are positioned in urban areas closer to the final customer. In this way, it is possible to deliver the products faster respect to other types of distribution and thus enable short delivery times, like same-day delivery (Kellermayr-Scheucher et al., 2021).

The work of Arslan et al. (2021) shows that distribution from a tier of UFCs provides an increase in profitability compared to the shipment from a central warehouse. Indeed, the latter shows limitations in terms of potential demand satisfaction, mainly with the increase of the proportion of orders requiring a shorter response time, while UFCs make it possible to deliver to end customers when ordering online within a few hours (Kellermayr-Scheucher et al., 2021).

- ***Cost benefits***

  Last-mile fulfilment is the least efficient and most expensive part of the entire logistics process because of the challenging target service levels and due to the high level of dispersal of destinations and the small dimension of orders (Mangiaracina et al., 2019; Kim et al., 2021). For instance, the biggest challenge in designing a successful business model with omnichannel grocery retailing is the high cost and complexity of fulfilment for groceries bought online (Hübner et al., 2016). MFCs can provide high level of automation saving on labour costs and reducing operational costs such as heating and lighting (Azadeh et al., 2019). Moreover, the automation allows to increase the picking speed and so to reduce picking costs that represent a relevant portion of logistics costs (Hübner et al., 2016). It is estimated that order picking accounts for 50%–55% of the operating costs which is done for searching and retrieving items, travelling, which can account for 80% of the time needed to fulfil orders (Bozer et al., 2018).

  MFCs also reduce transportation costs since the products are stored in the urban areas near to the final customers. Indeed, in decentralized fulfilment centres, the transportation costs from

storage to customer are generally lower as the distance to a customer's home is shorter (Hübner et al., 2016).

- ***Sustainability benefits***
  The continuing boom in e-commerce gives rise to questions about the sustainability of home delivery services for online purchases (Janjevic et al., 2020). Last-mile delivery impacts on environmental and social spheres as it causes road congestion and air pollution (Kim et al., 2021). MFCs may bring an advantage here since they allow reductions of the total distance travelled to deliver the products and moreover, they can be coupled with usage of more sustainable modes of transport such as light electric vans and cargo bikes (Kellermayr-Scheucher et al., 2021; Arrieta-Prieto et al., 2022). The study of Kim et al. (2021) highlights that a tier of hyperconnected UFCs can reduce CO_2 emissions in comparison to a dedicated UFC.

Critical Decisions in MFCs

While designing MFCs, different perspectives can be considered: location selection and technology selection as well as some other perspectives referred to as warehouse design, here.

- ***Location selection***
  As already discussed, MFCs are positioned within large urban areas for more proximity to the end customers. Their exact positions can be selected by taking into consideration a facility location problem together with a vehicle routing problem (Arrieta-Prieto et al., 2022). Location selection would impact the type of vehicles utilized for last-mile distribution, and hence the sustainability (Janjevic et al., 2020). Also, deciding on the number of MFCs within a region is relevant as it would influence delivery times and product availability. Therefore, while selecting the location of MFCs, a well-developed optimization model taking into consideration multiple parameters is critical.

- ***Technology selection***
  Automation would be necessary in order to meet recent customer order profiles such as small order sizes with shortened delivery time requirements (Boysen et al., 2019). The decisions regarding the

level of automation and the type of it would be critical to take. The drivers for the automation level decisions are: investment cost, space requirement and flexibility needed (Boysen et al., 2019). One of the most common solutions might be automated storage and retrieval systems (AS/RSs) (Kocak et al, 2022). Shuttle systems are estimated to be the most utilized technology for MFCs followed by ultra-high density storage systems (Scriven, 2021).

- ***Warehouse design***
  The main decisions here are concerned with the product portfolio to match the demand in the area and the size of the warehouse (Kellermayr-Scheucher et al., 2021). Jin et al. (2019) study an integrated algorithm to select products in such warehouses. Regarding the capacity, usually many days of safety stock are kept in inventories regardless of the holding cost, since the main goal is to avoid stock-out and provide the customer with the best experience (Jin et al., 2019).

As a result, before implementing MFC strategies in businesses, applying algorithms finding optimal solutions for the above three decisions would be critical.

Conclusion

This paper presents MFC as a response to the rising challenges in e-commerce and specifically in e-grocery. Recently, the customer order expectations have changed towards more decreased delivery time requests with low costs. A distributed warehousing concept of MFCs may offer significant advantages for that purpose. We investigate the MFC strategy from two research questions, one of which seeks how MFCs affect the last-mile delivery challenges, and the other seeks what design decisions would be critical in building MFCs.

For the first research question, we evaluate the problem from centralized versus decentralized warehousing strategies. We also provide the advantages and disadvantages of those two strategies. In the second research question, we discuss the critical decisions in design of MFCs. In that, we discuss location and technology selection decisions as well as other warehousing design decisions.

As a future work, the effect of MFCs on total cost, transportation cost and sustainability subjects can be studied. Based-on different demand

distributions, a simulation study, providing those three outcomes under different demand points and distributions would be worthwhile exploring.

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