Last mile logistics: an integrated view

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Abstract. Production and service companies try to increase their efficiencies through the application of different state-of-the-art solutions offered by the Industry 4.0 paradigm. The networking of manufacturing companies and logistics providers led to an increased complexity of supply chain solutions, especially in first mile and last mile logistics. This stream is remarkable in two different areas of the economy. The first one is represented by the cooperative supply of manufacturing companies, especially in the field of automotive industry, while the second field is the package delivery service. Within the frame of this paper, authors are focusing on the last mile solutions and give an overview of the mainstream of research. There are a lot of articles related to last mile logistics. The methodology of this structured literature review includes four main steps including the search for articles in databases and other sources, reduce the number of articles by reading them and identify the main topics, define a methodology to analyze the chosen articles and describe the main scientific results and identify the scientific gaps and bottlenecks.

1. Introduction
The last mile's typology is addressed as an innovative concept in logistics. The main question of this research is to specify the main characteristics of the last mile logistics. Companies work out these solutions to increase efficiency and decrease costs. Manufacturing and service participants try to increase their efficiency through the application of different state-of-the-art solutions offered by the Industry 4.0 paradigm.

The networking of manufacturing companies and logistics service providers led to an increased complexity of supply chain problems' solutions, especially in first mile and last mile logistics. The traditional supply chain can be optimized by innovative and modern methods and strategies. This stream is remarkable in two different areas of economy. The first is represented by the cooperative supply of manufacturing companies, especially in the field of automotive industry, while the second field is the package delivery service including effective managerial practices and technology to enhance the competitiveness. Competitiveness can be improved through better management of logistics networks and can lead to the development of new models for different sectors. The last mile challenge defines different aspects of the solutions to figure out logistics problems such as build the concepts, manage the requirements of a changing customers’ demands from supply chain, change industrial policies for efficient production and movement of goods and services (Neeraja et al., 2014).

This paper is organized as follows: Section 2 presents a literature review, which summarizes the research results related to last mile logistics and gives an overview about the mainstream of research.
Section 3 shows the impacts of last mile logistics concepts. Conclusions and future research directions are discussed in Section 4.

2. Literature review

There are a lot of papers related to determining the optimal decisions in manufacturing industrial processes. To build a link between literature and the research work, we are focusing on the previous research results to answer the following questions: Who is doing what? Who has done what? Who first did it or published it? What are the research gaps? Our used methodology of structured literature review includes four main steps (Lage & Filho, 2010):

- search for articles in Scopus,
- reduce the number of articles by reading the abstract and identify the main topic,
- define a methodology to analyze the chosen articles,
- describe the main scientific results and identify the scientific gaps and bottlenecks.

Firstly, the relevant terms were defined. It is a crucial phase of the review because there are excellent review articles in the field of manufacturing optimization and we didn’t want to produce an almost similar review, but we applied the presented methodology. We used the following keyword to search in the Scopus database: “Last mile”. Initially, 2147 articles were identified.

As Figure 2 demonstrates, the support of decision making in manufacturing processes has been researched in the last decades. The first publication in this field was published in 1999 for an integrative freight market simulation (Clark, E., 1999) and it was focusing on framework of pricing the last mile services. The number of published papers has been increased in the last 10 years; these show the importance of this research field.
We refined results by limited the following: Year: 2018; Document type: Article; Source type: Journals; and Language: English. After this, we got 39 articles. Our search was conducted in May 2018; therefore, new articles may have been published since then.

In the following step, the articles were reduced after reading the articles. We excluded articles, which topic did not find our interest and can’t be addressed the research of first mile and last mile supply solutions. After this reduction, we got 33 articles. We added one other paper selected through separated search (Lance L. Putong & Marlene M. De Leon, 2018), so the final list for classification and evaluation from the point of view scientific results includes 34 articles.

The distributions of the most frequently used keywords are depicted in Figure 3. As the keywords show, the last mile solutions are complex systems; and their optimization can be solved through heuristic methods and AI algorithms. The objective function of design and operation of last mile solutions is the cost function.
Logistic is very important for companies because it is concentrated in several service support. The aim of logistic is serving the production area and the customer's demands. Logistics services must be performed in right time, from the right place, right products, in right condition, to the right user and with reasonable cost.

As we can find in the literature, logistic has undergone many changes based on science in the last few years. New aspects allow implementing modern and innovative strategies of supply chain. There are several impacts of supply chain such as resources, which indicate restructuring the whole logistics supply chain. Also, the Just-in-sequence (JIS) supply is mentioned as a reinterpretation of Just-in-Time (JIT) principles. The competition determines to make the manufacturing- and their processes more and more efficient through the quality and customer needs.

The industrial participants are focused to reduce operational costs, and stay competitive in the market. There are several advantages such as controlling costs, reducing risk of supply chain (Marujo et al., 2018) and minimizing energy utilization besides on travelling distance (Rabta et al., 2018).

Industry 4.0 touches the entire supply chain management, intelligent manufacturing, methods, and Logistic 4.0. The application of new technological approaches and elements become possible even with more complex systems. Smart solutions align processes to reduce resources, utilize capacities, and increase efficiencies. The logistic challenges and tendencies are representing changes in the supply chain. Supply Chain Management can improve the distribution processes by applying strategies such as Crowdsourced Logistics, CSL (Castillo et al., 2018). The supply chain management (SCM) development is a key challenge for logistics area, especially in production area, health care and in related logistics services. It means these systems need to serve society' demands and focus on network asset such as transportation. The network configuration can support the whole supply chain as synchromodal supply chain (Farahani et al., 2018). Also, the logistic service providers were analyzed in terms of parcel tasks, routing and transportation, and last-time delivery (Yi & You, 2018).

Other results show to advantage and application possibilities to analyze the customer's intention to use self-collection as last-mile delivery method (Yuen et al., 2018). Most of the studies considered to delivery tasks, and its additional issue as solving last-mile logistics problems. Delivery service providers should concentrate on their marketing force and customize their services for consumer groups, who have specific individual characteristics, such as optimism and innovation (Chen et al., 2018).

A number of books and articles have been published which addressed the available methods including analytic and heuristic development. These solutions can solve logistics issues for example profit maximization modelling, genetic algorithm, optimization, decision making, and simulation.
Algorithms are supporting the logistic enterprises to establish and resolve the fulfilment of e-commerce orders in distribution centres (Leung et al., 2018).

The Travelling Salesman Problem (TSP) solution obtained by the Concorde solver and the Randomized Variable Neighbourhood Descent (RVND) heuristic is implemented the solution of the problem (des Freitas & Penna, 2018). The computational experiments show the use of drones for last mile delivery can reduce the total delivery time. The TSP-LS algorithm (TSP-LS delivers the solution of lower quality, but very quickly.) and Greedy Randomized Adaptive Search Procedure (GRASP) algorithms can maximize the quality of service (Ha et al., 2018).

The Vehicle Routing Problem (VRP) arises in real-life applications such as in logistics. The efficiency and timeliness become important. Vehicle Routing Problem with Time Window is an NP-complete optimization problem, which can be solved by ant colony algorithm (Niroomand &Nsakanda, 2018). Other model is also able to solve this problem by modelling alternative distribution set-ups, which contains mathematical (Kin et al., 2018). There are available models provide a set of recommendations on how can minimize the routing costs as well as penalty costs for unsatisfied demands (Putong & Leon, 2018), and propose modelling approach to a new stochastic last mile relief network design problem (Elçi, 2018). The new city logistics problem involve to design of the routes for a vehicle fleet located at the depots to transport the customer demands to a subset of the satellites and the routing of a vehicle fleet from the satellites to serve all of the customers solving with hybrid multi-population genetic algorithm (Zhao et al., 2018).

Decision making with agent-based simulation and dynamic routing procedures for sustainable provision in the field of food processing (Fikar, 2018). Simulation provides an ideal environment for modelled last mile logistics solutions. The optimization of large scale transportation problems can be optimized with simulation techniques, like hybrid framework simulation which makes it possible to support traffic movements (Simoni & Claudel, 2018). Travel distances and the inefficient movement can be reduced by applying optimization (Kin et al., 2018, Fikar, 2018). Multi-criteria optimization in humanitarian logistics supports the design and operation of last mile distribution in stochastic environment, so this model calculates an actual vehicle schedule while forcing vehicles to form convoys in humanitarian operations research (Ferrer et al., 2018). Crowdshipping platform was discussed to solve maximizing the platform's profit and fulfil requests (Behrend & Meisel, 2018). This solution serves to execute delivery demands and also support the item-sharing.

Communication network is related to design the last mile solutions. The Routing Protocol for Low Power and Lossy Network (RPL) are standardized solution in the smart grid, because this implementation reduces the complexity and controls interactions to distribute the network states and other related information in the network (Alishahi et al., 2018). The network can be controlled via federation of FiWi (Fiber-wireless) and Edge IoT software (Bellavista et al., 2018). Most of studies are focused on network performance such as two-way multiuser mixed radio frequency/free space optical (RF/FSO) relay networks (Al-Eryani et al., 2018), and wireless technology (Horibe, 2018) as millimetre wave communication. 5G mobile network project was reviewed and analyzed in the perspectives of radio engineering and implementation (Leinonen et al., 2018), which is one of the last mile network solution. There are several methods considering the function of distribution network and internal logistics network. Stochastic model was defined to solve network issues (Noyan & Kahvecioğlu, 2018). The internal logistics networks used to serve customers across channels; it means the exploratory study contains the retailers from different contexts (Wollenburg et al., 2018). Worldwide Interoperability for Microwave Access (WiMAX) networks contain several Quality of Services (QoS) structure for guaranteed multimedia services, so the efficient scheduling algorithm named Earliest Deadline First (EDF), Deficit Round Robin (DRR); Heuristic Earliest Deadline First (HEDF), and Modified Earliest Expiry First (MEEF) can reduce delay and packet loss ratio with number of Subscriber Station (SS) in increased (Sudha & Rengarajan, 2018).

One of the main streams of literature in the field of transportation addresses the development of last mile logistics and city logistics solutions. These are focusing on cost reduction in urban freight distribution (Morganti & Browne, 2018); design of parcel locker network maximizing the profit in city
transportation systems (Deutsch & Golany, 2018). The innovative contributions are classified into five main categories: innovative vehicles, proximity stations or points (Chen & Wang, 2018), collaborative and cooperative urban logistics, optimization of transport management and routing, innovations in public policies (Fillone & Mateo-Babiano, 2018) and infrastructures (Ranieri et al., 2018).

3. Impacts of last mile logistics concepts

As you can find in the literature, logistics has undergone many scientific changes in the last decades. Modern and innovative strategies are released, where solutions enable the implementation of smart supply chain management (SCM). New aspects of last mile solution can redesign the traditional supply chain, and can be serve and support the whole logistics services and processes.

There are several related issues in the logistics, namely factors and costs. It can be categorized as follows: internal, external, performance, system structure, technology integration, and other expenses as shown in Table 1.

The last mile of the supply chain is focused on the most expensive and problematic area of the supply chain. The main stream of the problems is the delivery process. Delivery processes have several issues, the main issues are the followings: One of them is a home delivery, which indicates extra costs, pollutions and transportation. The second is a DTD (door-to-door) delivery, where empty routes can be found. Also, the security is important, because several parcels are required signature to fulfil the delivery success.

| Internal | External | Performance | System structure | Technology integration | Other expenses |
|----------|----------|-------------|------------------|------------------------|---------------|
| Customer satisfaction | Technology | Productivity development | Better relationship | Information systems | Transportation cost |
| Quality | Globalization | Quality | Supply chain | Intelligent systems | Holding cost |
| Networks | Working force | Good service | Communications | Smart technology | Inventory cost |
| SCM | Environmental | Modify response needs | Organization care | Smart grid | Order processing cost |

The traditional supply chain represents the material flows, where goods are manufactured. These are shipped to distribution centres. There are two options; the first is (after buying) the direct shipping to customers, the second is through traditional supermarkets.

With this in mind the last mile can involve delivery processes, Boyler, Fohrlich & Hult (2005) used these typologies in several academic papers to describe sub-flows as Table 2 shows.

| Delivery | Order fulfilment |
|----------|-----------------|
| Indirect | semi-extended supply chain | decoupled supply chain |
| Direct | fully extended supply chain | centralized extended supply chain |

As Table 2 shows you can find four sub-types: semi-extended supply chain, fully extended supply chain, decoupled supply chain, and centralized extended supply chain.

The semi-extended supply chain is used in collection, where the delivery is indirect, and the order fulfilment is store-based.

The fully extended supply chain can also order picking process, where the order fulfilment is store-based. It is direct home delivery type. The decoupled supply chain is applied to the distribution
centres, where the delivery is indirect. Finally products are delivered through a centralized extended supply chain to customer by using distribution centres. Last mile solutions offer several benefits in the logistics, that relationship to the above mentioned typologies are shown in Table 3:

- Time savings: Supply Chain Management interprets and manages manufacturing and service processes. Routing time can be reduced in the last mile phase.
- Valuable data control systems: Last mile can use system data, and uses the necessary information which is required by each process.
- Security: Signature must accept to the successful delivery. Security becomes more complex, and smart with logistics and human resources.
- Energy and environmental effects: It means that the right delivery method can reduce emissions, and become economically competitive.
- Customer service level: The characterized service level is based on time windows.
- Mobility: It means the shipping time and delays are reduced by increasing mobility.
- Productivity: Last mile logistic solutions can allow productivity developments.
- Customer satisfaction: It measures the customer experiences in services/products, and assessing new markets for services and products that serve the customer's additional needs.
- Manufacturing: Logistic issues can be solved where the product is ready. The manufacturing and service companies are associated with business through the operation of last mile solutions.

These components provide important information and skills to the users, while improve the whole delivery processes, efficiency and cost reduction. However machining procedures are very important for the optimized manufacturing processes (Kundrak et al, 2014 & 2018), but in the case of networking manufacturing companies the logistics get more and more importance, especially from the supply chain solutions point of view. The networking of manufacturing companies and logistics providers led to an increased complexity of supply chain solutions, especially in first mile and last mile logistics.

Table 3. Component of last mile typology and their benefits(* less important, *** necessary)

| Impacts          | Semi-extended supply chain | Fully extended supply chain | Decoupled supply chain | Centralized extended supply chain |
|------------------|-----------------------------|----------------------------|------------------------|-----------------------------------|
| Security         | **                          | **                         | **                     | ***                               |
| Inventory        | ***                         | ***                        | ***                    | ***                               |
| Networks         | **                          | ***                        | **                     | **                                |
| SCM              | ***                         | ***                        | ***                    | ***                               |
| Energy           | **                          | ***                        | **                     | ***                               |
| Manufacturing    | *                           | *                          | *                      | *                                 |
| Delivery speed   | **                          | **                         | ***                    | ***                               |
| Customer satisfaction | **                   | **                         | **                     | ***                               |
| City logistics   | **                          | **                         | ***                    | ***                               |
| Mobility         | ***                         | ***                        | ***                    | ***                               |
4. Conclusions and further research directions

The solutions of last mile logistics make it possible to make decisions in supply chain networks aiming financial and environmental effects, and also reduce unnecessary movements of delivery. As the relevant state-of-art showed, significant financial savings are available for participants using the concepts of last mile. This result indicates the scientific potential of this research field including the problems of last mile logistic systems. The articles are addressed to the Manufacturing and service participants to identify the logistic aspects from design and operation point of view of supply chain. Therefore, the design aspects of supply chain processes still need more attention and research. In further studies the design of first mile and last logistics need more attention to support the modelling and optimization with heuristic based algorithms.

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