DISTRIBUTION NETWORKS IN NATIONAL
AND CROSSBORDER E-COMMERCE

Radovan Madlenak[1], Lucia Madlenakova[1], Peter Szatmari[2], Gyoergy Ivan Neszmelyi[2]
[1]University of Zilina, Slovakia; [2]Milton Friedman University, Hungary
radovan.madlenak@uniza.sk, lucia.madlenakova@uniza.sk, szatmari.peter@uni-milton.hu,
neszmelyi.gyorgy@uni-milton.hu

Abstract. This article deals with the classification and creation of logistic distribution models. The main objective of the article is to create the methodology for designing a global distribution network (GDN). The suitable GDN could play a significant role in the global supply chain and try to fulfil the needs of companies while entering foreign markets. Logistic operators with their optimized networks help facilitate international trade to deliver parcels, packages, partnering with express, courier services embracing mobile and online technologies, provide financial services etc. On the basis of these needs the methodology of designing the logistics network for cross-border or national logistics network will be formulated.

Keywords: e-commerce logistics, cross-border logistics, allocation models.

Introduction

E-commerce has emerged as one of the most significant forms of commercial exchange in the modern era, and it is anticipated to remain a vital retail methodology for both small- and large-scale businesses in the foreseeable future. There are numerous entities in the international commerce network that are engaged in the business environment, distributed across the globe. As a result, e-commerce has enabled companies to bridge the geographic gap and engage in global trade, providing businesses with new opportunities to reach customers and expand their market reach. In addition, e-commerce has enabled companies to reduce their overhead costs and become more efficient. Therefore, it is likely that e-commerce will continue to revolutionize the international business landscape in the years to come.

Consequently, the establishment of a global logistics network can be viewed as a driving force for the further growth of e-commerce in both a domestic and international arena. In order to create this network, it is essential to identify and understand the location of potential consumers, the best places to establish distribution centres and shops, the type of transport required for distribution, and the most effective way to connect producers and consumers. To address these queries and find solutions, we employed distribution logistics.

Theoretical background

Logistics can be understood as a comprehensive, market-oriented system of planning, development, implementation, and control of material, goods, and information flow from suppliers to businesses, within the enterprise, and from the business to customers at the most cost-effective rate. According to Straka [1], logistics constitutes a complex network in which the components are interconnected and function in such a way that there is a systematic flow of material, information, and finances which culminates in the satisfaction of customer needs and the attainment of economic benefits. Distribution logistics provides a physical, organizational, and informational connection between the origin of the enterprise and the consumer, including the input warehouse or the point of transportation of the goods [2].

Distribution logistics is a key element in the overall design of an enterprise's distribution system. It is responsible for determining the topology of the company's distribution system, creating a distribution network system, and allocating distribution locations [3]. These decisions taken together form the entire distribution system of an enterprise, which includes the selection of transportation modes, service personnel, and points of distribution that make up the network [4-6]. The result of this is an efficient and cost-effective system of distribution logistics that maximizes the delivery of goods to customers. The distribution network is the link between the distribution space elements and the transportation system, essential for the meeting of customer requirements. Three major aspects are taken into consideration when forming the network structure, these being the distribution elements, distribution factors and the distribution process. Distribution elements and factors are subdivided into three distinct categories, each with its own influence on the topology of the network. Firstly, the shape and size of the

distribution space is determined by the elements. Secondly, the elements affect the topology of the distribution network, while finally, the distribution process defines the characteristics of the network itself [7-9].

Models of e-commerce distribution networks

Logistics and distribution networks have a pivotal role to play in e-commerce. This encompasses not just the direct delivery of goods to customers, but also comprehensive logistics strategies. Currently, customers have high expectations regarding the speed and convenience of delivery, and in many cases, they are inclined to place as much emphasis on the delivery process as they do on product price and quality. Additionally, the volume of packages that require picking, packing, and shipping is increasing, albeit in smaller package sizes. Therefore, it is essential for e-commerce businesses to develop effective distribution plans and logistic strategies to ensure that customer demands are met and that the business remains profitable.
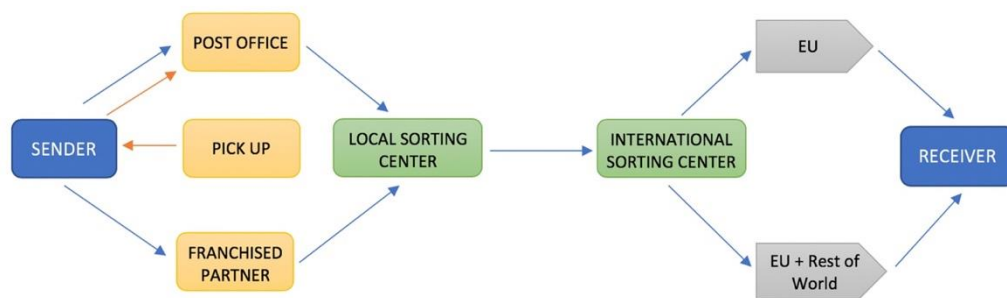

Fig. 1. **Global logistic network [2]**

Consequently, when dealing with e-commerce logistics, businesses must be capable of quickly shipping large quantities of packages, and often within a limited delivery timeframe. Additionally, as e-commerce transactions become more frequent, organisations must efficiently handle the increased number of returned, exchanged and faulty goods [10; 11]. This highlights the importance of constructing and optimising the e-commerce logistics networks on a national or international scale.

Considering these factors, it is clear that the e-commerce industry must consider the development of sophisticated logistics solutions and strategies to ensure the highest level of customer satisfaction. Furthermore, businesses should also look into investing in new technologies, such as automation and artificial intelligence, to increase the speed and accuracy of their delivery systems. Additionally, companies need to be aware of the legislative and environmental regulations that are associated with e-commerce logistics and ensure that their operations remain compliant [12]. By doing so, businesses can ensure that their e-commerce logistics processes are efficient and cost-effective.

The model of distribution networks can be classified:
- the national distribution network,
- the cross-border distribution networks.

National distribution networks are defined as systems of delivery within a single country, with the aim of optimising the location of a central warehouse or setting up hubs and contact points across the nation. The design of such networks is based on the principles of strategic planning, in order to determine the most efficient and effective system of distributing goods. This involves considering factors such as demographic factors (state and structure of the population), economic factors of the region/country, psychological and socio-psychological factors (way of life, consumer habits, mentality), infrastructure, competitive conditions in the region/country, site selection factors for the location of the distribution centre or the intermediary (local evaluation of the site, location-dependent costs, disturbance factors, etc.). By understanding these elements, a national distribution network can be created that is tailored to the individual needs of a nation.

Cross-border distribution systems are designed to enable and accelerate international shipping for small to medium-sized freight forwarders [13, 14]. The primary purpose of this type of network is to transport parcels from the source nation (pick-up points) to the destination nation (delivery points).

These networks typically encompass a vast array of services, such as customs clearance, warehousing and logistics management, to ease the burden of international shipping for smaller companies. Moreover, these systems can help reduce the overall costs associated with international transportation by allowing freight forwarders to benefit from the economies of scale associated with collective shipping. In addition, these networks can help streamline the process of international shipping, thus helping to ensure that shipments are delivered in a timely and efficient manner [15; 16].

Various sub-models of this type of distribution network can be identified, each providing unique advantages and disadvantages in terms of efficiency, scalability, cost, and other factors. For instance, a traditional distribution network may have a centralized system, where a single entity is responsible for controlling the flow of goods, while a decentralized system may involve multiple entities collaborating to manage the distribution of goods. Additionally, an automated distribution network may utilize technology to automate the ordering, tracking, and delivery of goods [17]. By thoroughly assessing the needs of the organization, the most appropriate distribution network can be implemented to optimize the efficiency and cost of goods distribution. We can meet various sub-models of this type of distribution network:

Cross-border distribution is the delivery of goods across international borders, typically done through the use of **one national logistic distributor**.

Cross-border distribution with **multiple national distributors** (at least one in the sender's country and two or more in the receiver's country).

Cross-border distribution with a **consolidator**, logistics provider which involves having more than one distributor located in the sender's country and two or more distributors in the receiver's country.

The concept of cross-border distribution with an **integrator** that allows for the entire distribution chain to be managed by one global logistics operator (see Fig. 2).
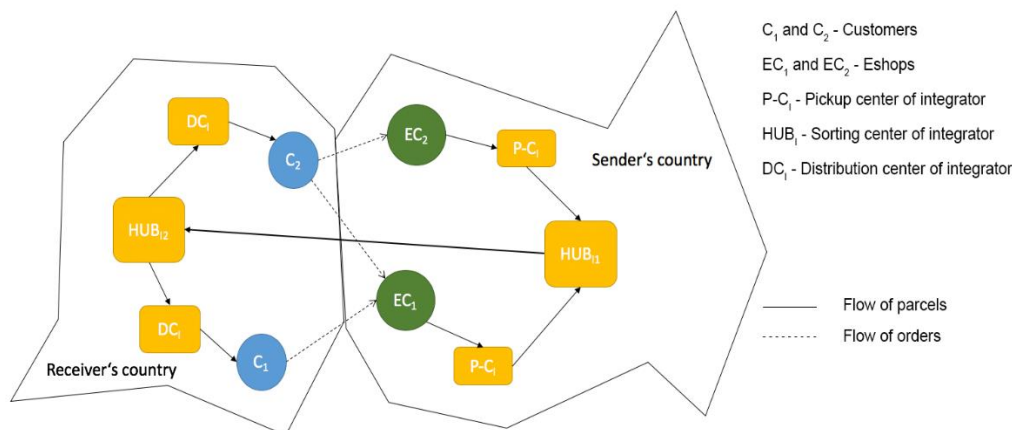

Fig. 2. **Cross-border distribution network – Integrator**

Each of these distribution models has the challenge of designing the distribution network in an optimal way. It is necessary to determine the most suitable combination of e-shop and distribution company cooperation to ensure the efficient development of the distribution network both domestically and internationally [18, 19]. Failure to properly design the distribution network could lead to a decrease in efficiency, increased costs, and a lack of competitiveness [20]. Therefore, it is important that companies carefully consider the structure of their distribution network before launching it.

The objective and methodology

The primary aim of this article is to outline an effective strategy for addressing the difficulties associated with constructing a distribution network for both domestic and international distribution. To this end, we can make use of both statistical methods, such as the median and arithmetic mean, as well as operational research techniques, such as allocation models. By employing a combination of both approaches, we may be able to identify the optimal solution to the problem at hand.

Results

It is possible to discern three primary associations between an e-shop provider and a distribution company. Firstly, the e-shop providers may offer the distribution service themselves. Secondly, a third-party logistics operator (3PL) may be employed to provide the distribution. Finally, a dropshipping company can be utilised to offer distribution. Each of these approaches has its own benefits and drawbacks, and it is necessary to evaluate them carefully to determine which arrangement is the most suitable for a particular business. So, we need to prepare the methodology for each of these three models. Recent studies [21-23] have identified some of the fundamental challenges associated with the design of distribution networks for these types of e-shop providers, as well as solutions to overcome these issues.

These problems and solutions are presented in Table 1.

Table 1

Problems and solutions of distribution network design

Type of distribution	Problems	Solutions
Distribution is provided by e-shop provider	Allocation of the central distribution warehouse in the selected territory Network design vending locations in the selected area	set-covering or p-median problem p-median problem
Distribution is provided by 3PL logistic operator	Design of the distribution network of the logistics service provider	p-median or cost-based facility location problem
Distribution is provided by dropshipping company	Design of the distribution network of the logistics service provider	p-median or cost-based facility location problem

Each of the solutions presented can be applied to solve a distinct problem. The p-median problem involves selecting p facilities from a set of potential sites to minimize the average distance between each location and its closest facility. The objective is to determine the optimal placement of p facilities to provide service to a set of demand points. The p-median problem is a type of distance-based facility location problem that can be used designing specified numbers of warehouses or vending location. The set covering problem involves selecting a subset of facilities from a larger set to cover a set of demands at minimum cost. The objective is to find the smallest subset of facilities that can cover all demand points. The set covering problem is a type of covering problem that is used to find minimum number of warehouses in specified territory. The cost-based facility location problem involves selecting the optimal location for new facilities based on a trade-off between fixed costs of opening a facility and variable costs of serving demand. The objective is to determine the optimal placement of facilities that minimize the total cost of serving demand. The cost-based facility location problem is a type of location-allocation problem and is perfectly suited for design distribution network in the case when we know all types of costs involved in construction and operation of e-commerce distribution network.

To take advantage of the methods of operation, it is necessary to construct a suitable structure that outlines the specified area. Thus, to begin, a graph must be created to illustrate the region and the major forms of transportation used for transporting goods. A graph is a data structure consisting of a collection of objects, wherein certain pairs of these objects possess some form of relationship. In mathematical terms, these objects are termed vertices, also commonly known as nodes or points, while the pairs of related vertices are referred to as edges, or arcs and lines. [26]

In some cases, it is necessary to decrease the number of vertices in a graph in order to make it simpler. To achieve this, the use of statistical methods such as the arithmetic mean, median, and quartiles are often employed. The simplest solution to the problem of reassessing the validity of the existence of a particular vertex in the graph seems to be the use of statistical indicators – quantiles, especially the lower quartile. We applied the lower quartile to the characteristics of regions and eliminated the vertices, which characteristic values were under the lower quartile. Additionally, multi-criteria analysis is used to identify the weight of the vertices; this weight is a combination of various parameters, such as demographic, geographic, and financial, among others. We used two methods of multicriterial evaluation: Standardized variable method and distance to dummy object method. Using both independent methods, we obtained the same results as the lower quartile method. We created a

simplified model of the distribution network (reducing from 41 vertices to 33 and from 101 edges to 84) (See Fig. 3).
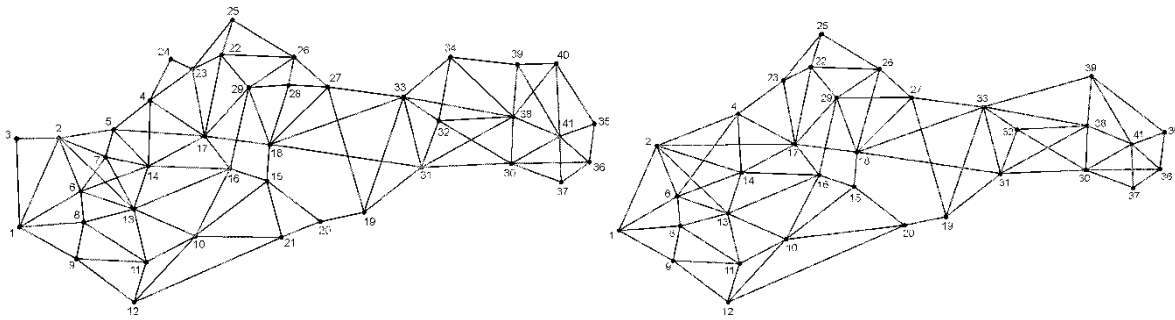

Fig. 3. **Model of distribution network in the graph before and after simplification**

By synthesizing all individual findings, we can formulate a comprehensive strategy for addressing issues associated with the design, construction, and optimization of logistics networks. This methodology can then be used to identify solutions that help maximize the efficiency of these systems. Furthermore, it can be used to assess the performance of existing logistics networks, as well as to improve their operational efficiency. Ultimately, this research will contribute to enhancing the sustainability of logistics networks.

The methodology employed consists of three distinct phases: phase I - the collection and normalization of entry data, phase II- the creation of a distribution network model, and phase III - the identification of a problem and selection of the optimal solution (See Fig. 4). Through the completion of each of these steps, the methodology is designed to provide a comprehensive guide for successful implementation of a distribution network.
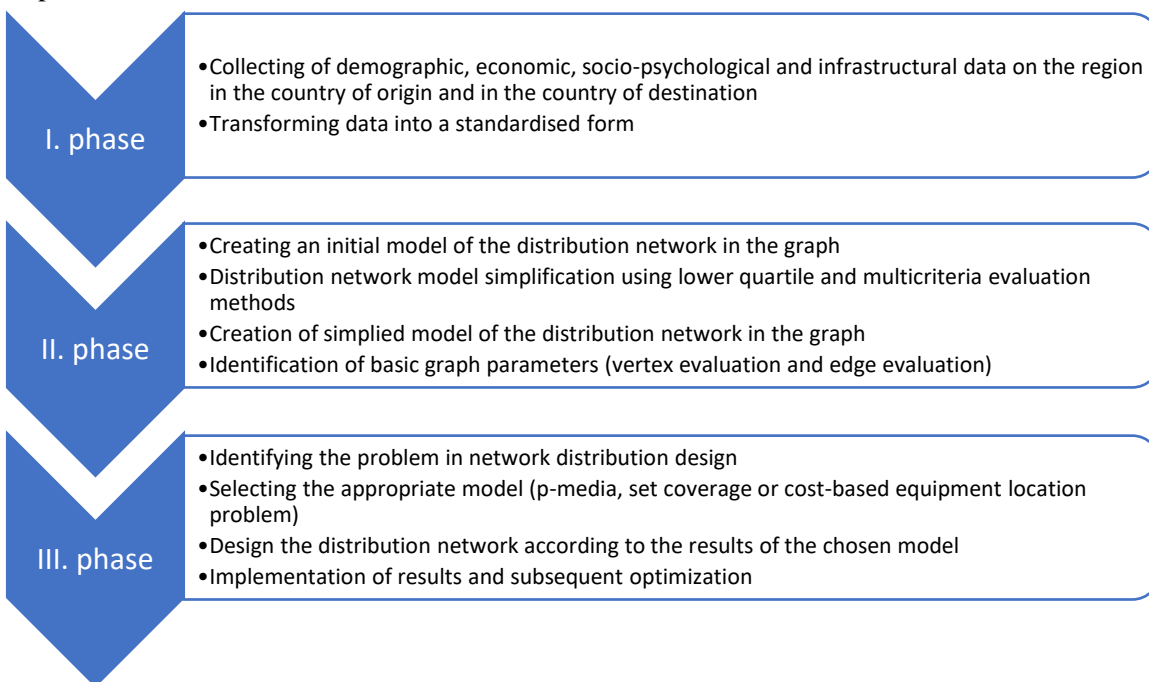

I. phase
- Collecting of demographic, economic, socio-psychological and infrastructural data on the region in the country of origin and in the country of destination
- Transforming data into a standardised form

II. phase
- Creating an initial model of the distribution network in the graph
- Distribution network model simplification using lower quartile and multicriteria evaluation methods
- Creation of simplied model of the distribution network in the graph
- Identification of basic graph parameters (vertex evaluation and edge evaluation)

III. phase
- Identifying the problem in network distribution design
- Selecting the appropriate model (p-media, set coverage or cost-based equipment location problem)
- Design the distribution network according to the results of the chosen model
- Implementation of results and subsequent optimization

Fig. 4. **Methodology for designing a distribution network**

This methodology was trialled in the context of a Slovakian e-commerce platform to identify the optimal location for the central warehouse and contact point network. Moreover, it was applied for the construction and optimization of distribution networks, logistics service providers in Slovakia, as well as other EU countries. Remarkably, these implementations of the developed methodology have been successful in streamlining logistics processes, thus providing greater customer satisfaction.

Conclusions

The European Commission's Green Paper on "Integrated market for parcels for e-commerce growth in the EU" has identified three key factors that will influence the development of both national and cross-border e-commerce: the appropriate pricing of the product and delivery costs; the assurance of quality product delivery; and the availability of order status information (e.g. regarding delivery). These factors are integral to the establishment of an effective and integrated e-commerce market within EU. The importance of the design and construction of distribution networks in facilitating the effective delivery of e-commerce services cannot be overstated. This is evidenced by the three key factors highlighted in this study. The created methodology and methods demonstrated herein are suitable for the design of distribution logistics networks for e-commerce transactions in both national and cross-border trade. Therefore, this research promises to be a valuable resource for scholars and practitioners in the field of e-commerce and related disciplines. Furthermore, the findings of this research can inform the development of strategies to improve the design and construction of distribution networks in order to ensure the smooth delivery of e-commerce services. The proposed methodology and methods can be applied in designing robust logistics networks that can support the expansion of electronic transactions both domestically and globally. This methodology has been tested in the context of Slovakia to develop a distribution network within the worldwide distribution network. The implementation of this methodology provides a unique opportunity to enhance the efficiency and effectiveness of e-commerce services and elevate the success of businesses across various industries.

The utilization of the proposed methodology and methods in the design of logistics networks can enable businesses to enhance their competitiveness in the electronic commerce market by establishing reliable and responsive supply chains that can meet the demands of their customers in a timely and cost-effective manner. The integration of these methods can assist in identifying the optimal location of distribution centres and the most suitable modes of transportation, as well as the selection of appropriate suppliers and partners.

The application of this methodology in the context of Slovakia can contribute to the development of a more efficient and effective logistics network that can support the growth of the country's electronic commerce industry. This can provide a significant advantage for Slovakian businesses seeking to expand their operations both domestically and internationally. Furthermore, the implementation of this methodology can offer valuable insights for other countries seeking to establish robust logistics networks that can support the growth of their respective electronic commerce markets.

Our future research should focus on developing a methodology for designing a global distribution network (GDN) that takes into account the needs of companies entering foreign markets. This research should include the optimization of logistic operators' networks to facilitate international trade, as well as the delivery of parcels, packages, and other services such as express and courier services, mobile and online technologies, and financial services. Additionally, the research should aim to develop a methodology for designing a logistics network for both cross-border and national logistics networks.

Acknowledgements

Author contributions:

Conceptualization, L.M.; methodology, R.M. and L.M.; formal analysis, R.M and G.N.; investigation, R.M., L.M., P.S. and G.N.; writing original draft preparation, R.M.; writing review and editing, P.S. and G.N.; visualization, R.M. and G.N.; funding acquisition, R.M.

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