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Models and optimisation techniques on long distribution network: A review

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Abstract

The problems that are common in a distribution network can become more serious in long distribution networks due to the increased complexity of the system. In order to overcome such problems, network models should take into consideration the characteristics that are more representative of long distribution networks. This paper reviews existing studies related to the use of long distribution network models that include two-stage and three-stage distribution networks. In addition to highlighting some of the key elements associated with the development of models, this paper examines the techniques that can be used to optimise them. This paper stresses the need to consider important information in the process of developing a long distribution network model that takes into consideration the problems that are inherent in long distribution networks. The paper concludes by providing recommendations for future research in this field.

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Keywords: Long distribution network; Characteristics; Model; Optimisation technique.

1. Introduction

The effective implementation of supply chain management (SCM) processes is critical for companies to compete in the global market [1]. However, considering a company as part of the supply chain system is challenging, since the network system is complex. In order to reduce the complexity of supply chain systems while taking supply chain performance into consideration, analysis typically focuses on a significant part of the system. In a supply chain system, the distribution network makes a significant contribution to the overall performance of the supply chain.

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Optimizing the distribution network can allow companies to use a very different network to compete with others in the same industry. A proper distribution network design directly impacts the company's performance in terms of both service and cost [2]. The distribution network influences the customer's responsiveness and the agility of product delivery; for example, it can impact lead time and product availability [3, 4]. The distribution network also accounts for approximately 20% of manufacturing expenses and up to 30% of production and sales expenses for commodity products [4].

Distribution networks should be designed in a manner that satisfies the customer's demand at a minimum total cost [5, 6]. Adding intermediary participants, such as is the case in a long distribution network (LDN), allows companies to expand their market areas and consolidate distribution channels with other organisations in order to gain economies of scale [7]. Some products require special handling while miscellaneous products that are in small quantities need warehouse consolidation to reduce distribution costs. However, the design of a LDN that consists of at least two different tiers between manufactures and customers (the tiers could be a distribution center [DC], a transit or a consolidation point) introduces more challenges, since there are more storage points and product movements involved [7, 8]. The extended network size increases delivery time, and this eventually impacts product price, since each additional transit day can result in approximately a 0.8% increase in the final cost of goods [9]. Furthermore, common problems, such as variability, bottleneck, bullwhip effect, and critical cost of transportation, can become serious issues [8]. The combination of these problems entails that designing a LDN model that can simultaneously meet all requirements is complex and difficult.

A number of models have been proposed to solve LDN problems; however, current studies have overlooked a range of important aspects related to the characteristics of the LDN. Hence, this review paper aims to provide a comprehensive understanding of LDN model development together with some of the key methods that can be employed to optimise the model. For this purpose, the remainder of the paper is organised as follows: Section two discusses the characteristics, structure and basic features of a LDN; section three and four analyses some of the key decision variables and objective functions of the current models and optimisation methods; and section five provides a conclusion together with suggestions for further research.

2. The characteristics, structure and basic features of a long distribution network

The more facilities and capabilities that are integrated into a supply chain, the more variability it contains. The length of distribution channel becomes a key source of variability [10]. In this long distribution, products flow from manufacturers to final customers through multi-tier distribution models that consist of several warehouse levels or distribution centers (DCs) such as production warehouses, distribution centers, regional depots, and shop/stores that function as stock-holding warehouses or stockless depots [7]. In a LDN, the movement of product to other levels of DCs, particularly into the global market or geographically dispersed regions, often involves some seaports, which mainly consist of large docks. These large ports are usually connected to inland hubs [8, 11]. The physical characteristics of models such as these results in uncertainty, as the embedded character of LDNs include other related problems such as bottlenecks, bullwhip effects, and the critical cost of transportation and logistics [8].

Unfortunately, it is hard to locate current studies that provide solid recommendations or models as to how the problems that are inherent in LDNs can be solved. Currently, a LDN (three-stage or two-tiers between manufacturers and customers, see Table 1) is generally described as a network that consists of plants, incorporates at least two tiers in the distribution chain (mainly consisting of distribution centers and retailers) and involves end customers. In fact, distribution networks for global markets or geographically dispersed market areas commonly involve transit points such as seaports and inland terminals [5, 9, 11, 12]. Even though seaports play a significant role in supporting export supply chains [12] and are a fundamental requirement of a successful global supply chain strategy [13], they have received very little attention in the current long distribution models.

Melo et al. [14] identified four basic features that should be taken into consideration when developing a facility location model for the strategic planning of a supply chain. These are: multi-layer facilities, single commodity/multiple commodities, single/multiple period(s), and deterministic/stochastic parameters. Generally, the LDN models that are currently in existence incorporate basic features such as multi-layer facilities and multi products. Four out of eight models consider multiple periods of time. The features of deterministic/stochastic parameters will be discussed in the next section. A further important attribute is multiple transports. Jayamaran [15]

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