Available online at https://journal.rescollacomm.com/index.php/ijqrm/index

International Journal of Quantitative Research and Modeling

e-ISSN 2721-477X
p-ISSN 2722-5046

Vol. 2, No. 3, pp. 132-138 2021

Robust Optimization for Food Supply Chain Management Problems: A Critical Review and its Novelty

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Abstract

Optimization problems in real life often have problems with data that cannot be known precisely; constraints on the data are commonly referred as errors. This kind of data is called uncertainty. This uncertainty problem can be solved using Robust Optimization (RO). RO is growing rapidly with the participation of various kinds of research, especially the supply chain (distribution of food or goods between regions). It can be seen that RO is very active in providing support and contribution in various aspects of life by providing optimal results for an objective function and dealing with existing limitations and data uncertainty. This article discusses the background of the problem and the purpose of creating an article, provides an overview of bibliometric map analysis methods and discusses literature and studies. Critical review from OR database articles for supply chain problems are used as a reference, so at the end, it can be determined what novelty is an opportunity for further research.

Keywords: Robust Optimization, Supply Chain, Bibliometric Map, Literature Review

1. Introduction

optimization is a series of processes to obtain the necessary clusters of conditions to get the best results (Ben-Tal and Nemirovski, 2002; Bertsimas et al., 2011; Beyer and Sendhoff, 2007). In a normative approach, optimization identifies the optimal solution to a problem directed at the objective function of maximization or minimization, determining the objective function based on the problem to be studied. In optimization, companies, manufacturers, factories, or food hubs will get the best results by considering the constraints or limitations given (Gorissen et al., 2015; Mulvey et al., 1995; Bertsimas and Thiele, 2006).

Optimization problems in real life often have problems with data that cannot be known precisely; constraints on this data are commonly referred to as errors. This kind of data is termed uncertainty. The methodology for dealing with uncertainty data in optimization is the Robust Counterpart (RC) proposed by Ben-Tal and Nemirovski (2002). This uncertainty is caused by data measurements such as the dimensions and temperature of an object, errors in estimating data and rounding numbers. This is a drawback in using nominal data in optimization problems. This uncertainty problem can be solved using Robust Optimization (RO) (Li et al., 2011; Li and Floudas, 2014; Zhang and Jiang, 2014).

Since its first publication in 1970, RO has grown rapidly with its inclusion in various kinds of research such as in the field of health (determining the estimated duration of operations), supply chain management (distribution of food or goods between regions), natural and non-natural disaster management, technical problems (determination of maximum power flow), marketing, and so on. It can be seen that RO is very active in providing support and contribution in various aspects of life by providing optimal results for an objective function and dealing with existing limitations and data uncertainty.

The discussion of this article focuses on ORs that deal with supply chain management of food distribution. A supply chain is a network of companies that work together to create and distribute a product into the hands of end-users. These companies usually include suppliers, factories, distributors, shops, retailers, and supporting companies such as logistics service companies. The supply chain is a system in which organizations distribute their production goods and services to customers (Hosseini-Motlagh et al., 2019; Duan and Liao, 2013).

One of the keys to supply chain productivity and profitability is a distribution network that can achieve various objectives ranging from low costs to high customer response (Weaver, 2010; Anggraini and Tanjung, 2020). Designing a distribution network consists of three main problems: location-allocation, vehicle routing, and inventory control. Therefore, for the productivity and profitability of the supply chain to run well by the organization's main objectives, the distribution network must be designed effectively and efficiently (Qureshi et al., 2007; Gunasekaran et al., 2004).

The food supply chain is one of the most important (Marsden et al., 2004; Aung and Chang, 2014). Good distribution of producers and fulfillment of consumer demands is very beneficial to each other. However, there are always obstacles in the process, such as reduced raw materials, suppliers unable to supply materials, increased raw material prices, lost products, damaged machines, decreased demand, changes in orders, and failure to transport goods via transportation. Supply chain problems with these constraints are usually solved using the location-routing model. This model deals with distribution problems by considering time, cost, capacity, and transportation constraints (Wang, 2014), making it suitable for modeling supply chain problems. This article will analyze the content, keywords, and outputs of previous research and then conclude what novelties can be taken to be implemented in future research.

This article is divided into several sections: Part One, the introduction, discusses the background of the problem and the purpose of making the article. Part two, provides a general description of the method using bibliometric map analysis. Part three, discusses literature studies and critical reviews of RO articles for supply chain problems. part four, provides a conclusion to the whole discussion.

2. Materials and Methods

Many previous articles have discussed the Robust Optimization (RO) Model for supply chain problems under the uncertainty parameter. This article will discuss the relevance and novelty of previous research related to RO on the food distribution supply chain problem using the location-routing model. The Publish or Perish application can help carry out literature studies and critical reviews by displaying journal needs sourced from the Google Scholar database. This article takes the first step in searching for papers with three types of keyword groups: (1). The link between the food supply chain and the location-routing model with the keywords "supply chain", "food", and "location-routing" (2). The relationship between RO and the food supply chain with the keywords "robust optimization", "supply chain", and "food", and (3). The combination of RO for the supply chain problem and the location-routing model with the keywords "supply chain", "food", "robust optimization", and "location-routing". All articles obtained using the Publish or Perish application then filtered and matched with the inputted keywords, aiming to provide conclusions about the novelty that must be done in future research. The analysis will be discussed in the results and discussion section.

3. Results and Discussion

This section describes a descriptive analysis of studies related to the Robust Optimization model for food supply chain management. The database of articles related to topics sourced from the Publish or Perish application is stored in "*ris" format and then analyzed descriptively. The database used focuses on the publication of Google Scholar and is then extracted into the VOSviewer application to obtain a bibliometric map of research. One of them is based on Network Visualization.

The first topic regarding the relationship between the food supply chain and the location-routing model with the keywords "supply chain", "food", and "location-routing", produced 990 articles in the publication period of 1956-2021 with some citations of 82,383. It cited an average of 1268/year. For the second topic regarding the relationship between RO and the food supply chain with the keywords "robust optimization", "supply chain", and "food", it produced 750 articles in the publication period 1989-2021 with 113,499 citations and average citations as many as 3547/year. Furthermore, for the third topic regarding the combination of ROs for the supply chain problem and the location-routing model with the keywords "supply chain", "food", "robust optimization", and "location-routing", it resulted in as many as 80 articles over some time. Publications in 1975-2021 with 11,769 citations and an average citation of 226/year. Based on the database of articles obtained, we only use English-language research.

3.1. The Food Supply Chain Using a Location-Routing Model

On the first topic, not all articles are relevant to the topic. There is only part of the article which is relevant from some of the others. The articles with the most citations on this topic can be seen in Table 1. Based on Table 1, articles on vehicle schedule creation and their algorithms and supply chain management have the most citations. This means that many researchers have made it a source for other research.

After analyzing the database of articles sourced from Publish or Perish, the mapping is carried out on topics that often appear in abstracts and titles in this first discussion. One of the mappings is network visualization, as shown in Figure 1. Based on Figure 1, the topic of supply chain network design has no connection with problems or modeling using location-routing, so it is a novelty to carry out research that connects the two topics. Figure 1 also explains that there are 93 clusters with a total of 3056 items, which means that the types of circles are of different colors, where the larger the size of the circles, the more often the topic appears, and vice versa. It can be seen that chain network design ranks first in a topic that often appears, followed by objective models, centers, arc routing problems, and forward supply chains.

Table 1. Articles with the most 5 citations regarding the food supply chain using the location-routing model

Article	Author	Number of Citations	Publication Year	Publisher
Scheduling of vehicles form	Clarke and Wright, (1964)	5339	1964	Pubsonline.informs.org
Algorithms for vehicle routing	Solomon (1987)	4717	1987	Pubsonline.informs.org
The Lagrangian relaxation method for solving location-routing	Fisher (1981)	2700	1981	Pubsonline.informs.org
Facility location and supply chain management	Melo et al. (2009)	2136	2009	Elsevier
Multicommodity distribution system	Geoffrion and Graves (1974)	1743	1974	Pubsonline.informs.org

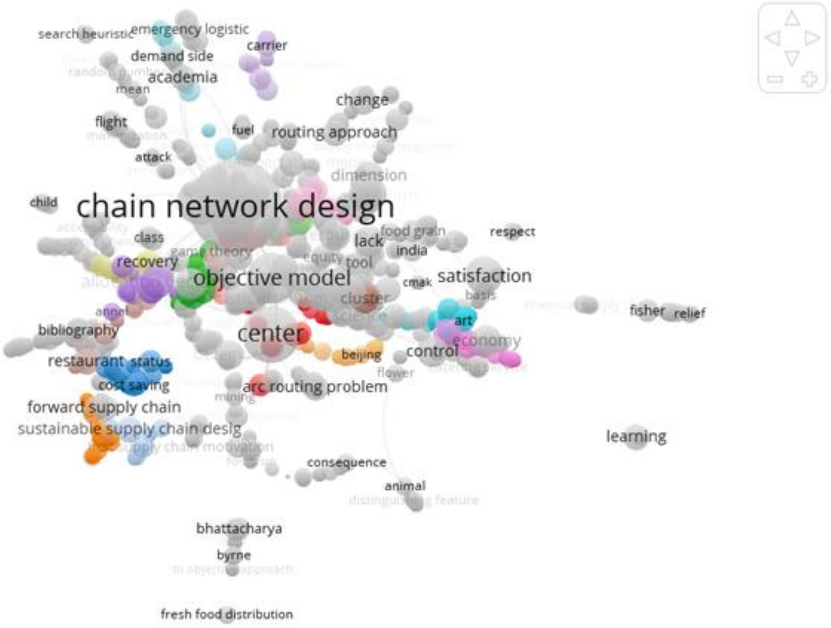

Figure 1. The most common topics in the food supply chain with the location-routing model

3.2. Robust Optimization for Food Supply Chain Problems

The second topic is the same as the first topic, where not all articles are relevant. There is only part of the article which is relevant from some of the others. The articles with the most citations on this topic can be seen in Table 2. Based on Table 2, articles on supply chain design, bullwhip effect, and robust convex optimization have the most citations. This means that many researchers have made it a source for other research.

After analyzing the database of articles sourced from Publish or Perish, the mapping is carried out regarding the topics that often appear in abstracts and titles in this second discussion. One of the mappings is network visualization, as in Figure 2. Based on Figure 2, if it is enlarged, the topic of the supply chain is already related to the optimization approach. Still, it is not specified in robust optimization, so it is a novelty to carry out related research between the two topics. Figure 2 also explains that there are 83 clusters with a total of 5096 items, which means that the types of circles are of different colors, where the larger the size of the circles, the more often the topics appear, and vice versa.

Table 2. Most 5 citation journals regarding ROs for supply chain problems

Article	Author	Number of Citations	Publication Year	Publisher
Designing supply chain concepts	Simchi-Levi et al. (2008)	7080	2008	Tata McGraw
Supply chain: the bullwhip effect	Lee et al. (1997)	6026	1997	Pubsonline.informs.org
Supply chain coordination with	Chacon (2003)	3924	2003	Elsevier
Robust convex optimization	Ben-Tal and Nemirovski, (1998)	2823	1998	Pubsonline.informs.org
Two-level supply chain	Lee et al. (2000)	2810	2000	Pubsonline.informs.org

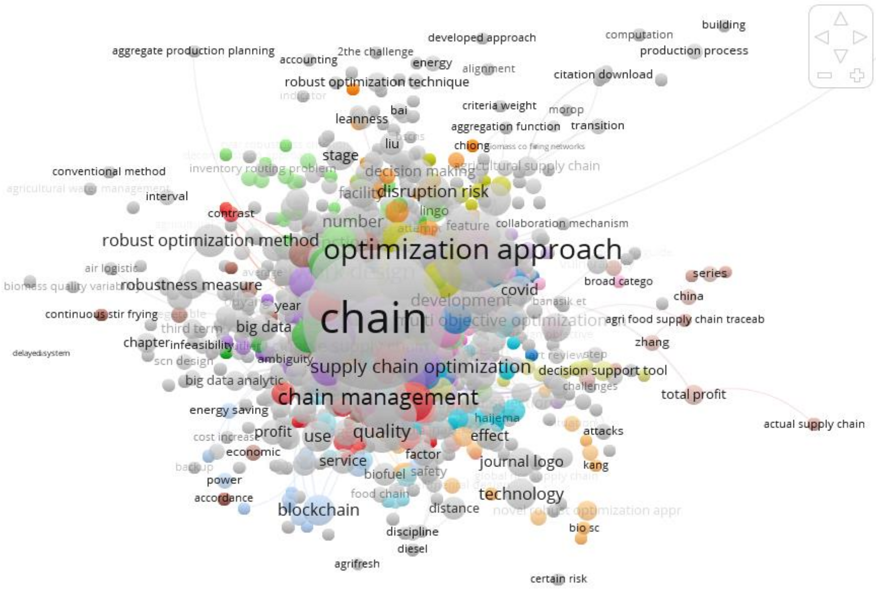

Figure 2. The most common topics in the food supply chain with a Robust Optimization approach

3.3. Robust Optimization for Supply Chain Problems Using the Location-Routing

The third topic is the same as the previous topic, where not all articles are relevant to the topic. There is only part of the article which is relevant from some of the others. The articles with the most citations on this topic can be seen in Table 3. Based on Table 3, articles on robust convex optimization, facility location, and supply chain have the most citations. This means that many researchers have made it a source for other research.

After analyzing the database of articles sourced from Publish or Perish, the mapping is carried out on topics that often appear in abstracts and titles in this last discussion. One of the mappings is network visualization, as shown in Figure 3. Based on Figure 3, if it is enlarged, the topic of the supply chain is already related to the topic of optimization approach and robust optimization. Still, it has nothing to do with location-routing problems. This means that research on the determination of supply chain using a RO approach already exists. Still, no research relates these two things to the location-routing problem, so it is a novelty to connect the three things. Figure 3 also explains that there are 31 clusters with a total of 784 items, which means that the types of circles are of different colors, where the larger the size of the circles, the more often the topic appears, and vice versa.

If analyzed, from the first to the third discussion, the number of clusters and items has decreased. This happens because the topics entered are increasingly diverse and specific, so that the research articles produced will be more conical and lead to a certain topic.

Table 3. Most 5 citation journals regarding OR for food supply chain problems using the location-routing model

Article	Author	Number of Citations	Publication Year	Publisher
Robust convex optimization	Ben-Tal and Nemirovski, (1998)	2823	1998	Pubsonline.informs.org
Facility location and supply chain management	Melo et al. (2009)	2136	2009	Elsevier
Linear integer programming for supply chain	Glover (1975)	790	1975	Pubsonline.informs.org
Lagrangian relaxation method	Fisher (2004)	625	2004	Pubsonline.informs.org
Location-routing problem surveys	Prodhon and Prins, (2014)	572	2014	Elsevier

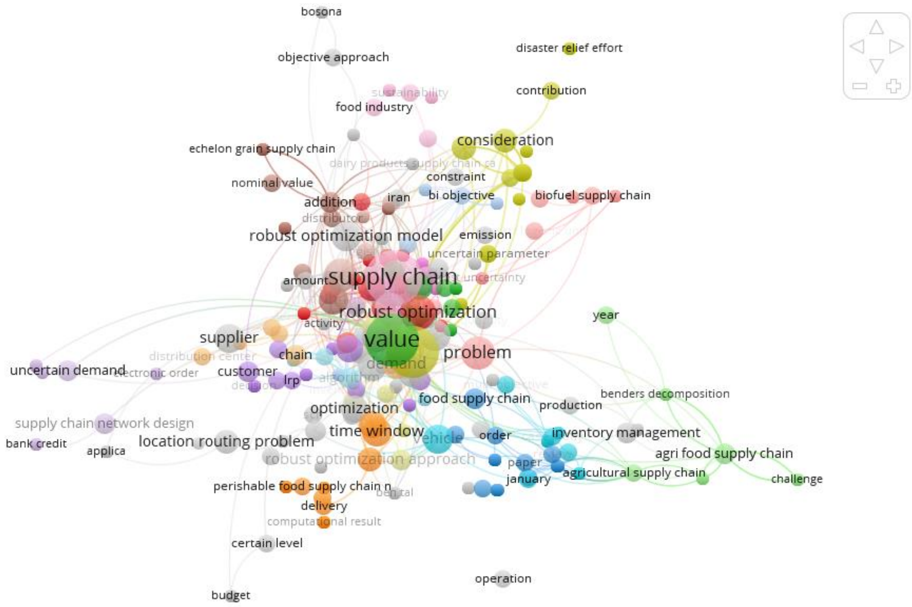

Figure 3. Topics most appear in the food supply chain with the location-routing model and Robust Optimization approach

4. Conclussion

In this article, a critical review of the database sourced from the Publish or Perish application has been carried out. Then it determined the novelty of what research should be done. This article discusses the relationship between supply chain, location-routing, and robust optimization issues. Based on the analysis, it can be concluded that the topic of supply chain and location-routing is not yet related. In contrast, the topic of supply chain with a robust optimization approach has been widely used. Based on this, research that links the three is a novelty.

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