Decades on the Robust Optimization Methods

-- A Bibliometric Analysis and Literature Review

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Abstract

In order to study the research situation of robust optimization methods in the field of emergency management. We searched the Web of science databases published by Science Citation Index (SCI) and Social Science Citation Index (SSCI) using the keywords "robust optimization and emergency". For the retrieved literature, we used the Citespace analysis tool. The analysis methods such as citation analysis, cluster analysis, and cooccurrence analysis were applied. Finally, we, present a graphical representation of the pioneers, highly cited papers, highly cited journals, and research hotspots of robust optimization methods in emergency management research.

Keywords

Robust Optimization; Emergency Management; Bibliometric Analysis; Literature Review.

1. Introduction

Robust optimization method is an approach to solve uncertainty problems. It uses uncertain budgets and data variability to control the range of uncertain parameters. This approach ensures that the worst-case objective optimization results are insensitive to uncertainties and that the performance metrics are optimal in unison [1, 2, 3]. Unlike stochastic programming, which requires assumptions about the distribution of uncertain parameters [4]. Robust optimization uses a strategy of prior analysis, which breaks the assumption of relying greatly on a priori knowledge and probability distribution. It is a replacement and supplement to stochastic programming and sensitivity analysis.

Bibliometrics is a sub-discipline of library intelligence. In a narrow sense, it mainly refers to data mining, quantitative analysis and citation analysis of the basic attributes of literature (such as authors, keywords, references, number of articles, citations, collaborations, etc.) using mathematical and statistical principles and computer analysis tools [5]. It can assist researchers in evaluating the current state of a field, identifying current research hotspots, and predicting future trends. At present, bibliometric methods have been widely used to study topical issues and trends in various fields [6]. The bibliometric approach has yielded excellent results in many fields [7, 8]. However, few scholars used bibliometrics to investigate the hot topics and trends of robust optimization methods in emergency management research.

In this paper, the data used were all sourced from the Web of science database [9]. In the web of science database, the search formula was "TI=robust optimization and emergency", the language was English, and 257 papers were retrieved. We analyzed these papers using citation analysis, cluster citation analysis, clustering analysis, co-occurrence analysis, and quantitative analysis. We used Citespace and analyzed the number of papers issued, frequency of citations, frequency of papers cited, journals, institutions, keywords, etc. Finally, we visualize the current situation of robust optimization methods in emergency management field and their research frontiers with figures.

2. Research on the Application of Robust Optimiza in Emergency Management Field

Usually, journals with high academic standards and influence have a strict review system, which guarantees the quality of the published papers to the greatest extent. Therefore, there is a positive correlation between the influence of journals and the influence of papers. In other words, the number of papers published by scholars in a discipline reflects the current state of theoretical development and the level of research in the field.

By constructing the search formula "TI=robust optimization and emergency", a preliminary screening of relevant literature in the Web of Science database was performed, and the statistical results are shown in Figure 1. From 2001, scholars began to apply robust optimization methods to research in the emergency management field. The few publications from 2002 to 2012 are the initial stage, indicating that the level of theoretical research in this field has still not been carried out in depth during this period. From 2013 to 2021 scholars studied the field in depth, which led to the rapid development of the field.



Figure 1. Web of science literature chronology

2.1. Analysis of High-impact Authors

2.1.1. Analysis of Author Collaboration

The author collaboration map visualizes the collaboration among scholars. Each node represents an author, and the size of the author's name represents the number of articles published [10]. Nodes with connecting lines indicate the collaboration between authors, the thickness of the line indicates the strength of the collaboration between authors, and the color of the line indicates the year of the first collaboration between authors. By mapping the co-occurrence of authors to reveal the status of research collaboration among scholars in the field of robust optimization methods in emergency management, researchers can easily find the leaders in the field.

From Figure 2, the authors with the most publications in the Web of science database are Reza Tvakkonlimoghaddam, Jianghua Zhang, Chungcheng L, Ali Bozorgianmiri, Akhtar Hussain. Their annual publication volume was 3. Next, scholars such as Huali Sun, Yang Wang. Chris Tine Santiago, Chel Sea Gessner, Alyssa Gianonne, Alexis Akeyson, Carsten Bantel, Analia T Mcdonald, Abigail B Waters have established collaborative relationships and are working more closely with each other. A network has been formed. They have formed a collaborative network. But on the whole, it seems that the connection between scholars is not strong, and only authors belonging to the same unit collaborate with each other, and the collaboration between scholars from different units is not strong.



Figure 2. Collaboration author network mapping

2.1.2. Analysis of Author Co-cited

Author co-citation mapping shows the distribution of author co-citations. Each node represents an author, and the larger the node, the more influential the author is in the field [11]. There is a line between the cited authors, and the thicker the line, the higher the intensity of their cocitation. The co-citation relationship between authors reflects the close relationship between authors in that research direction, and the more frequent co-citation of two authors indicates the stronger association of authors in that academic research direction.



Figure 3. Co-cited author mapping

Figure 3 shows the results of the analysis of the data in the Web of science database. We can find authors with significant influence in the field through the graph. The order of node size is Bertsimas D, Ben-Tal A, Rawl CG, Bozorgi-Aniri, etc. Both Bertsimas D, Ben-Tal A cited more than 50 times. This shows that they played a leading role in the field of robust optimization. They provide guidance for subsequent research in this area.

2.2. Analysis of Highly Cited Papers

Highly cited papers are papers with high citation frequency, in other words, they are classic papers in the field. The literature co-citation knowledge graph analyzes the citation frequency of papers, each node represents a literature, and the node size indicates the citation frequency. The larger the node, the more frequently it is cited, and the more fundamental literature and turning literature in the field are obtained accordingly.

Figure 4 shows the web of science database for co-citation knowledge mapping of literature. As can be seen from the figure, the node with the largest is Najafi et al., (2013) [12]. They published an article in the journal of "Transportation Research Part E" titled "multi-objective robust optimization model for logistics planning in the earthquake response phase". They propose a robust model to manage the logistics of emergency commodities and casualties after an earthquake. In second place is Özdamar and Ertem (2015) [13] published a paper in the journal of "European Journal of Operational Research" titled "Models, solutions and enabling technologies in humanitarian logistics". The review provides details on the structure of the objectives, constraints and existing mathematical models and solutions in humanitarian logistics. In third place is Ben-Tal et al (2011) [2] published a paper in the journal of "Transportation Research Part B" titled "Robust optimization for emergency logistics planning: Risk mitigation in humanitarian relief supply chains". They apply robust optimization to dynamically allocate emergency response and evacuate traffic flow problems with demand uncertainty. In fourth place is Jabbarzadeh et al (2014) [14] published a paper in the journal of "Transportation Research Part E" titled "Dynamic supply chain network design for the supply of blood in disasters: A robust model with real world". They propose a robust model for postdisaster blood supply. The main decisions include facility location and material distribution. It can be concluded that the research that should be used in the field of emergency management focuses on the integration of theory and practical applications.



Figure 4. Co-cited papers mapping

2.3. Analysis of High-impact Journals

High impact journals are judged by several indicators: volume of articles, total citation frequency, etc. The more articles a journal contains, the more informative and important the

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journal is [15]. The total citation frequency of a journal can indicate how much the journal is used and valued in general, as well as its role and status in scholarly communication. Each node represents a journal, and the size of the node indicates the size of the citation frequency of the journal.

Figure 5 shows the results of the analysis of the literature in the Web of science database. Sorted by co-citation frequency, they are "European Journal of Operational Research", "Operations Research", "Computers & Operations Research", "Transportation Research Part E", "Annals of Operations Research". These journals provide seminal theoretical material for scholarly research.



Figure 5. Co-cited journals mapping

Analysis of High-impact Organizations and Countries 2.4.

Most High-impact papers are done in collaboration between institutions, with many opportunities for information sharing and research collaboration [16]. The analysis of Highimpact institutions can start with the frequency of the institutions' appearances and the amount of literature appearing together between them to find research institutions that have made outstanding contributions to the subject area and the collaboration between them.



Figure 6. Cooperation organization mapping

An institutional analysis of the literature in the Web of science database, the results shown in Figure 6 and Figure 7. The institutions that appear in Figure.6 are internationally renowned universities, which shows that universities account for a large share within the use of robust optimization methods in the field of emergency management. Figure.6 can school in China and the United States almost dominate the development of the use of robust optimization methods in international emergency management, indicating that schools in China and the United States cooperate most closely with other institutions and have closer academic exchanges.



Figure 7. Cooperation country mapping

2.5. Analysis of Research Hotspots

Research hotspots can be indicated by the recurrence of keywords related to the topic [17]. A hot topic can be thought of as one or more topics of common interest to scholars in a given field. The frequency of keywords can reflect the attention of scholars to one or more topics.

The data in the Web of science database were analyzed, and the results are shown in Figure 8. The research hot words are "robust", "optimization", " facility location", "uncertainty", "model" and so on. The research hotspots are roughly divided into two areas. (1) Research on theoretical methods. Including optimization methods, uncertainty handling methods, robust optimization methods and stochastic programming methods. (2) Research on Emergency Response Network. Including facility location, material distribution, casualty evacuation, etc.



3. Conclusion

This study approached the authors, papers, journals, institutions, and research hotspots from the following perspectives and came to several conclusions.

(1) A study of the authors shows that the connections between scholars are scattered, especially with little collaboration between different institutions. As for author co-citations, Bertsimas D, Ben-Tal A play a pivotal role for subsequent research in this field.

(2) A study of the literature, scholars focus on combining theory and practice. Models and simulations are used to solve practical problems.

(3) Research on journals, scholars' research on the field continues to evolve, and Chinese and American journals provide theoretical support for the field.

(4) Research on institutions has been conducted, and universities have always been the main site of research in this field. In China, institutions in the United States, dominate the field of research. As a whole, cooperation between institutions is fragmented and should focus on mutual cooperation among schools.

(5) By analyzing the keywords, the research hotspots mainly focus on theoretical applications, emergency rescue networks, etc.

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