

Insights into the application of the traveling salesman problem to logistics without considering financial risk: A bibliometric study

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ABSTRACT

Suppliers can use different strategies to distribute their products, Among the most common complex optimization problems related to the transportation of products is the traveling salesman problem. In the traveling-salesman problem, a route is chosen that visits each node exactly once, taking into account the shortest travel time, and finally returns to the original node. In this problem, all nodes must be visited. If we consider the application of this problem in logistics, we can study the necessity of this problem in transportation means such as trucks or drones. The upcoming paper is thoroughly studied and researched considering the related articles published in the last three decades, and bibliometric analysis is used for the details of this problem. This paper aims to statistically evaluate the influence and importance of the traveling salesman on logistics without considering financial risk by presenting an analysis of the works published between 1983 and 2023. As part of our comprehensive literature review table with analysis of export, we will conduct a comprehensive review of the most relevant articles in the field from 2020 to 2023 to better understand the trend in the subject in the last few years. Data were obtained from the Web of Science and focused on metrics such as the total number of publications, citations, average citations per publication, and trending countries. Graphical and statistical analysis was performed using Excel and R-Studio. China, the USA, and Germany are the countries with the most publications. Laporte is the most prolific author with 8 publications. Much research has been done on this topic, especially in the Journal of transportation research part E-logistic with 43 articles, and the main application areas are logistics, vehicles, and drones. These data may prove useful to researchers seeking an overview of the traveling salesman problem to determine future research directions.

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1. Introduction

The globalization of the economy and the shifts in the societal structure are intertwined and affect economic, social, and governance aspects in scenarios where sustainability is critical (Ghanbari et al., 2022; skoruchi & mohammadI, 2022). Due to the advancement of technology and industries, complex optimization problems are now needed to solve various problems, to avoid the risk of simple optimization (Karimi et al., 2022; Larni Fooeik et al., 2022). Production and distribution services include two processes: transportation and storage, which are important factors in the movement of goods from one place to another (Ruan et al., 2021). A popular problem used for explaining and solving logistics is the traveling salesman's problem (TSP) (Arigliano et al., 2019). Models for optimizing continuous variables are called complex optimization problems (COP). Optimization problems with continuous variables are typically more difficult than those with discrete variables (Veenstra et al., 2017). A significant feature of this category of optimization models is that continuous models play an important role in discrete optimization models (Gu and Liang, 2022). As a result, discrete optimization models are often used to solve discrete optimization problems, and continuous optimization models are used to solve these problems continuously (Roberti & Wen,

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2016). Methods for solving continuous optimization problems are thus essential components of discrete optimization models (Eskorouchi et al., 2022.). There is a famous COP known as the TSP(Pina-Pardo et al., 2021). This problem is raised in such a way that the traveling salesman has the shortest trip as determined by a set of nodes and the travel distance between pairs of nodes, and the route ensures that he visits each node exactly once, At the end of the journey, the journey returned to the initial node(Baniasadi et al., 2020). Each trip between two nodes in this problem costs money since all nodes must be visited. It is important to select the sequence of trips with the lowest cost among those that will be sequenced (Malaguti et al., 2018). A problem like this can be combined with other alternatives, such as a queue system, to create even more complexity(Felipe et al., 2009). As a result of the queuing system, the traveling salesman determines the priority of product deliveries, and the goods can be delivered in the same order according to the seller's warehouse, and this problem requires selecting which goods should be delivered at the highest priority (da Silva et al., 2019). In the old model, this problem can be generalized with a company truck delivering packages to all customers in the shortest possible time with the products that were delivered to them. However, drone delivery of products will be possible in a smaller range thanks to a new model(Rajabi et al., 2022.). In today's world, drones have more advantages than trucks. Therefore, after defining the itinerant salesman problem, it is important to emphasize its proximity and applicability to logistics (Schermer et al., 2020). As a general rule, logistics is the process of collecting, storing, and transporting resources or goods. Technology has advanced, and motorized vehicles, such as motorcycles and cars, have gained widespread use, along with drones, which have now become an integral part of companies' logistics (Ha et al., 2018). As a result, goods and raw materials delivery and supply have taken on a whole new dimension that is inseparable from large and small organizations alike (Anily & Bramel, 1999).

The main purpose of this paper is to review and analyze the literature on the TSP. The study categorizes this problem to answer the following questions: (i) What is the main concept of the TSP in logistics? (ii) What are the solution techniques that have been used in TSP's recent early years? In addition, a comprehensive bibliometric analysis and network analysis are conducted, which provides insights that have not been fully explored or analyzed in other studies.

In the remainder of this paper, we organize the information as follows. An explanation of the applied research methodology is provided in Section 2, while the results of the different bibliometric analyses are presented in Section 3 with corresponding knowledge maps and interpretations. A literature review and application of the TSP with a literature table are explained in Section 4, and a conclusion and future research directions are presented in Section 5.

2. Data and Methodology

With the advent of 'big science' in the scientific community, it can be difficult to stay on top of all contributions and review all scientific publications (Dalavi et al., 2022). The literature can be evaluated using Bibliometrics via statistical measures on a particular research topic to overcome this issue(Ghanbari et al., 2023). Analyzing the influence of publications in the field of science is possible with bibliometric analysis, which involves statistical evaluations of articles, books, or book chapters (Sabripor et al., 2023). A variety of scientific fields, from engineering to sports science, have been using bibliometric analysis in recent years(Zabavnik & Verbič, 2021). Nevertheless, its application in logistics is relatively new, especially when it comes to complex optimization problems, and only a few good research projects have been conducted on this topic in this area (Fig. 1). Bibliometric analysis primarily aims to determine emerging trends and identify outstanding publications, A scientific subject can be studied by identifying which articles, journals, authors, countries, and institutions have contributed significantly to its development.

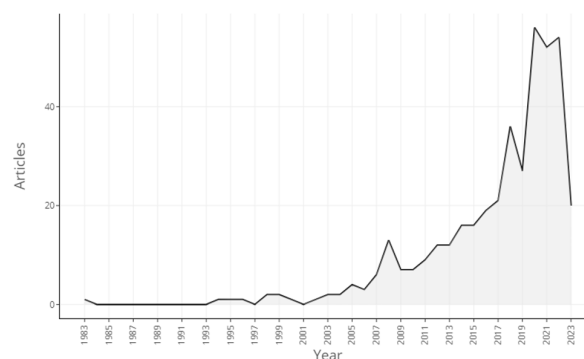


Fig. 1. Published Papers

Data must be collected to build a database of relevant documents in bibliometric analysis. To obtain a database of relevant papers, search terms should be defined appropriately in databases such as Web of Science and Scopus. In addition to providing relevant documents within the field of interest, the search terms must be large enough so that bibliometrics can be performed. Consequently, final keywords are found by following a two-step methodology. The first step was to review the literature for relevant search terms (Table 1), and the next step was to brainstorm with ourselves and subject matter experts about the final keywords. A list of keywords, including “traveling salesman problem”, and “logistics” are provided. Using conjunctions

“AND” and “OR” along with a list of keywords extracted from Table 1, 569 documents are obtained from 1983 to 2023 from the Web of Science, a bibliographic database that contains academic papers from a wide range of fields. As a result, document titles and abstracts were reviewed to exclude documents that were irrelevant. A total of 420 articles were reviewed using Scientometrics after 139 articles were removed. A detailed description of each type of document is provided in Fig. 2. Lastly, bibliometric data were collected, including titles, abstracts, keywords, full texts, and references. For a better understanding of readers, bibliometric analysis is illustrated in Fig. 3. Bibliometric analysis was performed after the collected data were sorted for duplicates and errors.

Table 1

The Proposed Keyword Combination Structure

Level	Search terms
1	traveling salesman problem AND
2	Logistics*

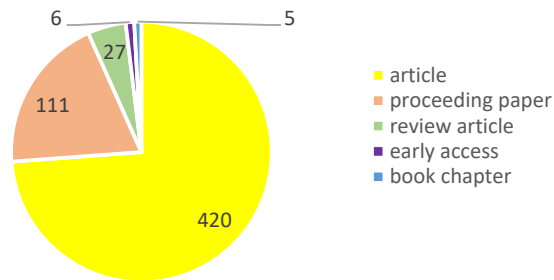


Fig. 2. Details of Search Results

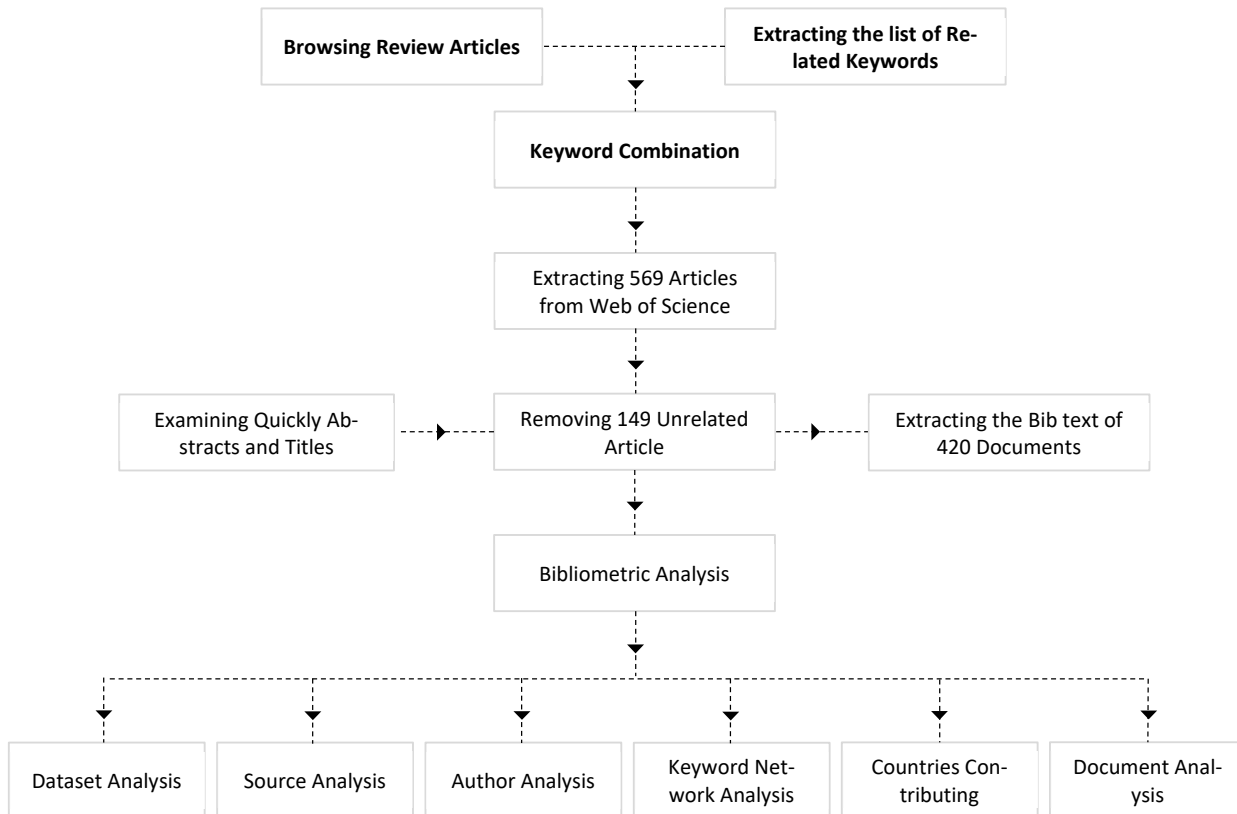


Fig. 3. An overview of the bibliometric analysis process

3. Detailed analysis of the sources

3.1 Information about general subjects

This study included 420 articles written by 1139 authors. The average number of citations received by academic papers is 25.46, which is highly regarded, and the number of papers cited has increased by 7.78% per year since 2000. The main document in this study is an article (378). A total of 543 keywords and 1139 keywords associated with authors were identified. Table 2 summarizes the general characteristics of the papers examined in this study.

Table 2

Descriptive information overview, Using WoS databases and Bibliometrics research, compiled by authors

Description	Results	Description	Results
Main Information About Data			
Timespan	1983:2023	AUTHORS	
Sources (Journals, Books, etc)	159	Authors	1152
Documents	420	Authors of single-authored docs	18
Annual Growth Rate %	7.78	AUTHORS COLLABORATION	
Document Average Age	6.07	Co-Authors per Doc	3.25
Average citations per doc	25.46	International co-authorships %	32.86
References	11638	DOCUMENT TYPES	
DOCUMENT CONTENTS		article	378
Keywords Plus (ID)	543	article; book chapter	14
Author's Keywords (DE)	1139	article; early access	16
		article; proceedings paper	12

3.2 The publication output

According to Fig. 4a, publications have increased significantly over the previous year, which indicates that academics are becoming more interested. Compared to 1983, the number of documents produced every year in 2019 has increased to 55. This trend is expected to continue as 49 studies were published in 2021 about this topic. A distinction can be made between two categories of annual publication trends. Until 1995, the first one only allowed limited contributions to research. In the second period, Research contributions increased significantly from 2007 to 2015 due to advances in methodology. Based on Fig. 4b, the maximum number of sources was recorded in 1983 (8%) when the average number of citations per year was the highest.

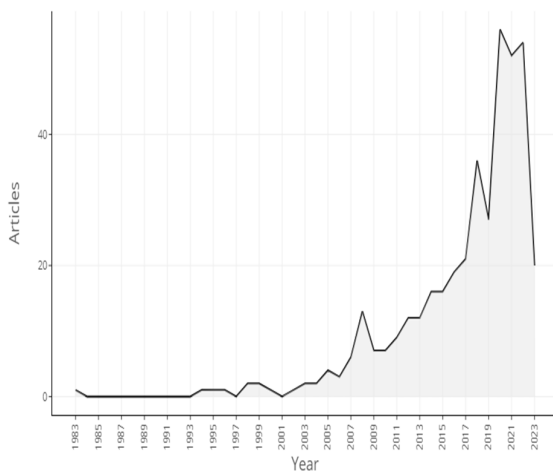


Fig. 4a. Research produced each year by scientific institutions

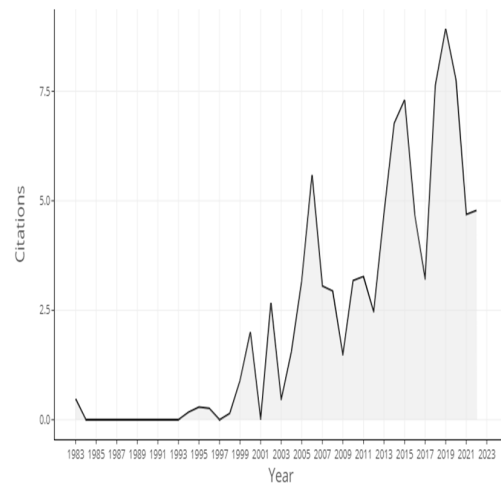


Fig. 4b. An average number of citations each year

3.3 An analysis based on disciplines

The articles of each source in Table 3 have been ranked in order of importance as they relate to researching dynamic co-movements between TSP and logistics. A considerable amount of research has been conducted on this topic, mainly in the Journal of transportation research part E-logistic (43). The European Journal of operational research was the second most popular journal in terms of occurrences (31). Among other relevant journals, transportation research part C-emerging technology (20) and computers and operations research (19) were ranked third and fourth respectively. As a result, these sources are of vital importance to the research related to the topic.

Table 3

The majority of trend journals on the relationship between traveling salesman problems and logistics

	Journals	No of. Document
1	Transportation research part e-logistics and transportation	43
2	European Journal of operational research	31
3	Transportation research part e-logistics and transportation	20
4	Computer& operations research	19
5	Naval research logistics	15
6	Computers and industrial engineering	13
7	Euro journal on transportation and logistics	13
8	networks	12
9	IEEE access	8
10	International Journal of production research	8

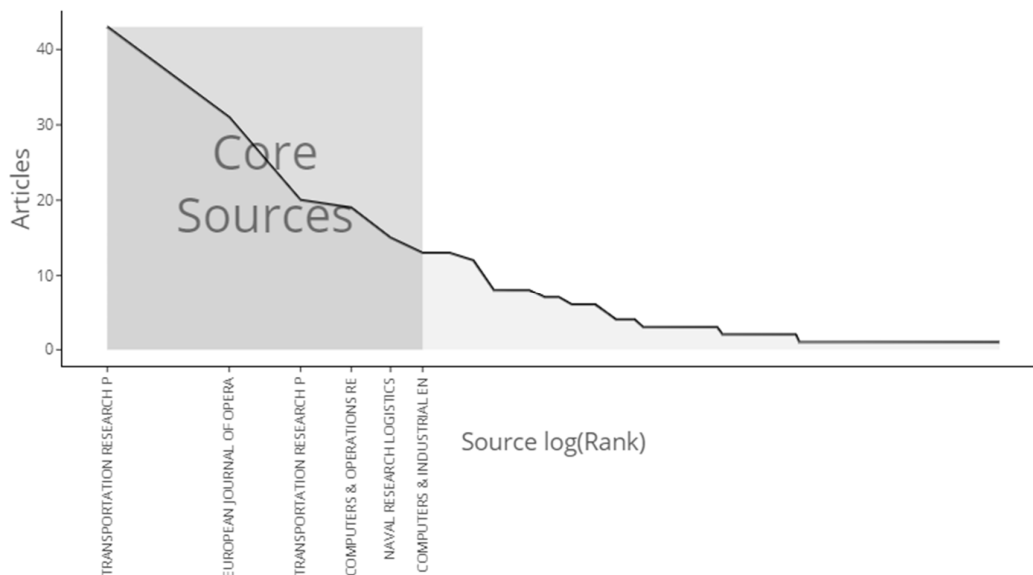
3.4 Sources most relevant based on citations

The following section discusses the most influential and significant sources of research on the TSP in logistics. As shown in Table 3, the most frequently cited sources are distributed. Based on the number of citations, The European Journal of operational research has 1509 citations, the Journal of computer operational research has 1002, and the Journal of transportation research part E-logistic has 838. Below is Fig. 5, which illustrates the importance of the Journal of transportation research part E-logistic in our research area. This part analyses the relationship between the TSP and logistics. Bradford's Law (Fig. 4) identifies only ten journals as being in Zone 1, the core area that has the most citations (Marín-Rodríguez et al., 2022). These three journals are considered to be the most important in the field of transportation research: the Journal of transportation research part E-logistic, European Journal of operational research, and the Journal of transportation research part C-emerging Technologies.

Table 4

Effect of the sources with Most cited sources

	Journals	No of. Local citation
1	European Journal of operational research	1509
2	Computer& operations research	1002
3	Transportation Science	838
4	Transportation research part e-logistics and transportation	712
5	Operation Research	599
6	Network	539
7	Transportation research part e-logistics and transportation	395
8	Computers and industrial engineering	326
9	Transportation research part e-logistics and transportation	322
10	Journal of operational research science	244

**Fig. 5.** Effect of the sources with Bradford's law based on source clustering

3.5 Most Relevant Authors and Authors' Impacts

As shown in Table 5, Laporte, Boysen, Cheong, Lee, and Li have published the most articles.

Table 5

The impact of the author's number of publications

	Authors	No of. Articles
1	Laporte	8
2	Boysen	5
3	Cheong	4
4	Lee	4
5	Li	4
6	Prins	4
7	Roodenberg	4
8	Rousseau	4
9	Winkenbach	4
10	Andrade-Pineda	3

3.6 An overview of the authors' production over time

A chart showing the top authors' documents on the dynamic co-movement between TSP logistics over time is shown in Fig. 6. Each bubble in a graph indicates how many publications the author produced each year based on its color and bubble dimension as example, Laporte published the first article on this topic in 2005. As of 2016, six papers had been published, up from four in 2008.

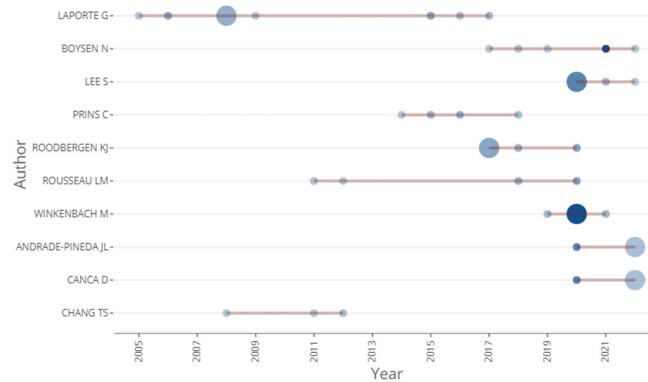


Fig. 6. A study of the dynamic co-movements between the traveling salesman problem and logistics from 2005 to 2022 by the top authors

3.7 Country and Institution Leaders

Among the leading countries and institutions in the world, a study was conducted. With 105 publications on this topic, CHINA is the most prolific country. The USA is in second place with 53 publications, and Germany is in third place with 35. The following is a list of other top nations presented in Table 6.

Table 6

The top 10 corresponding author countries.

	Country	No of. Articles
1	CHINA	105
2	USA	53
3	GERMANY	35
4	ITALY	32
5	TURKEY	28
6	FRANCE	24
7	INDIA	22
8	KOREA	22
9	BRAZIL	21
10	CANADA	20

3.8 Production of scientific research by the country

The proportions of numbers produced in different countries are shown in Fig. 7. Countries working in this area are shown in blue, while countries that haven't are shown in black. Those countries in dark blue have devoted more resources to this field of study

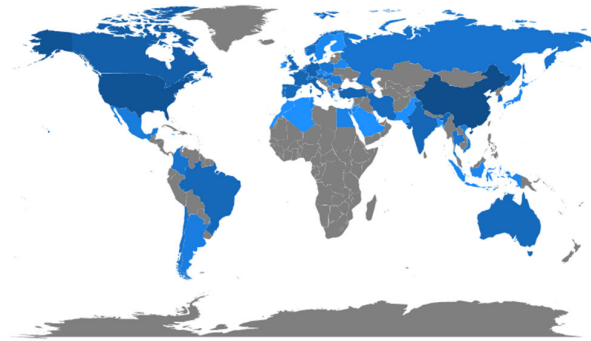


Fig. 7. Number of production distributions by country

3.9 Historical Trends in Topics

The trending topic analyses, which are essential for literature mapping, illustrate how the literature has evolved. Keyword analysis and a five-word frequency of each article are the criteria used to identify the topics depicted in Fig. 8.

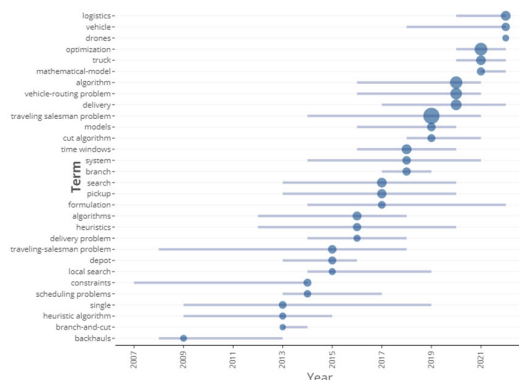


Fig. 8. Topics trending over time

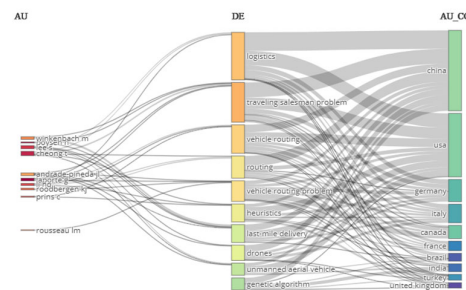


Fig. 9. Three-Field Plot

3.10 An analysis of three-field plots

Based on research conducted by the most relevant authors, figure 9 illustrates the most relevant topics Winkenbach's research focuses predominantly on TSP and logistics, and most of his papers have been published in China, the United States, and Germany. As shown in Fig. 8, there is an association between the top ten authors, trend keywords, and research.

4. literature review

4.1 literature review with table

A variety of research in the field of regret biases has been investigated over the past few decades, which is presented as follows:

Schermer et al., (2020) presented a new formula for the TSP with drones to upgrade its quality. Anily and Bramel, (1999) devised algorithms for reloading traveling salesmen with limited capacity proved its worst-case bounding, and presented algorithms for it. Crişan et al. (2017) developed A TSP model that accounts for random adverse events occurring over large areas. Baniasadi et al. (2020) Use an efficient conversion method to demonstrate the application of clustered generalized TSP in practical situations. Felipe et al., (2009) discussed four new neighbor structures based on reinsertion and moving orders to modify routes and load schedules for drone TSP. Ha et al. (2018) examined the problem of a traveling salesman with a drone and a truck with the primary objective of minimizing operational costs. Da Silva et al. (2019) proposed a new mathematical model for a TSP with variable costs and priority prizes that incorporated customer preferences and product choices. Murray

a Raj, (2020) designed a strategy for delivering UAVs at the last mile based on a sequence of three subproblems. Felipe et al., (2012) have addressed the design of optimal routes for pickup and delivery operations, additionally considering some capacity and loading constraints for the vehicles to be used. de Freitas and Penna, (2020) discussed delivery by drone and a hybrid approach to flying sidekick trips. Pina-Pardo et al., (2021) introduced the TSP with drone delivery and replenishment appointments, which involves finding a minimum-time route for a truck to pick up newly available orders en route via a drone sent from a warehouse. Arigliano et al., (2019) addressed the time-dependent asymmetric TSP with a time window. formulated the TSP with drones and presented two algorithms that attempt to minimize operating costs and waste costs. Agatz et al., (2018) modeled the TSP with drones as an integer program and developed several fast route-first, clustered heuristics based on local search and dynamic programming. Kimms and Kozeletskyi, (2016) presented a cost allocation scheme for a horizontal cooperative of traveling salesmen using cooperative game theory. Ruan et al., (2021) considered a vehicle problem in which several bulky items are fetched from different warehouses and loaded onto the vehicle. They then attempted to optimize the retrieval and loading phase and the delivery of the product using an integer linear programming model. Sarhadi and Ghoseiri, (2010) have focused on the customer satisfaction aspect of the fuzzy TSP problem with the time window system by using the ant colony system approach and mathematical modeling. Veenstra et al., (2017) considered a TSP whose system is LIFO. In this problem, unloading cargo that blocks access is allowed, but this unloading is associated with a penalty. They tried to minimize the travel cost and the fines. Kota and Jarmai (2015) presented a single-phase algorithm for the multi-depot, multi-tour problem with fixed destination and multiple depots. Li et al. (2020) proved the correct operation of a model of the TSP, which involves a truck and several drones. Luo et al. (2021) investigated the multi-visit TSP with multi-drones, whose objective was to reduce truck and drone time needed to serve all customers simultaneously. Malaguti et al., (2018) developed a new generalization of the TSP with pickup and delivery, which arises from maritime logistics, where ports have known draft limits for each node. Saleu et al. (2018) devised a heuristic to solve the problem of parallel drone scheduling traveling salesmen. Montero et al. (2017) consider the Time-Dependent TSP with Time Windows, where time dependency is captured by considering variable average travel speeds. Murray and Chu, (2015) designed two mathematical programming models to optimize unmanned aircraft routing and scheduling, as well as delivery trucks in this new paradigm of parcel delivery. Table 7, present the categorization used in this review and the literature table and explain the literature review of the most relevant work from 2020 to 2023 in TSP in logistics.

Table 7
Review of the Most Relevant Documents from 2020 to 2023

Article number	Authors	Year	Solution Technique			Example Type				Data type			
			Exact solution	Heuristic algorithm	Metaheuristic algorithm	Simulation	Numerical	Case Study	Hypothetical	Certainly	Robust	Fuzzy	Stochastic
1	Zhang and Yu	2023			✓								✓
2	Zhao et al.	2022		✓			✓						✓
3	Tong et al.	2022			✓					✓			
4	Meng et al.	2022			✓					✓			
5	Kundu et al.	2022		✓						✓			
6	Dienstknecht et al.	2022			✓					✓			
7	Cha et al.	2022			✓		✓						✓
8	Yu et al.	2021	✓							✓			
9	Y. D. Wang et al.	2021			✓								✓
10	Singh et al.	2021			✓		✓						✓
11	Seda, 2022	2021		✓									✓
12	Ruan et al.	2021		✓			✓			✓			
13	Ochelska-Mierzejewska et al	2021			✓		✓						✓
14	Nejma and M'Hallah	2021		✓			✓			✓			
15	Hansknecht et al.	2021		✓						✓			
16	Gomes et al.	2021			✓					✓			
17	Du et al.	2021				✓				✓			✓
18	Bravo et al.	2021	✓							✓			
19	Baniasadi et al.	2021		✓						✓			
20	Yang et al.	2020	✓							✓			
21	M. Wang et al.	2020			✓					✓			✓
22	Schermer et al.	2020		✓			✓			✓			

4.2 Document Analysis

As shown in Figure 10, 14 percent of articles use exact algorithms when solving models, while 5 percent use just simulation, 45 percent use metaheuristic algorithms, and 36 percent use heuristic algorithms. Fig. 11 illustrates how 32 percent of articles

use numerical data, 59 percent use case studies, and 9 percent use hypothetical data. In Fig. 12, 59 percent of articles use sure dates, whilst 41 percent use uncertain dates, and most are robust.

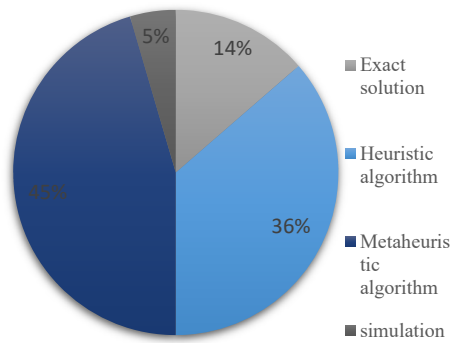


Fig. 10. Category of Solution Technique

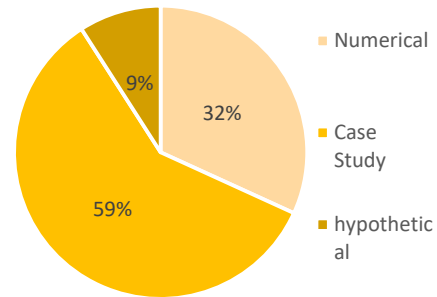


Fig. 11. Category of example type

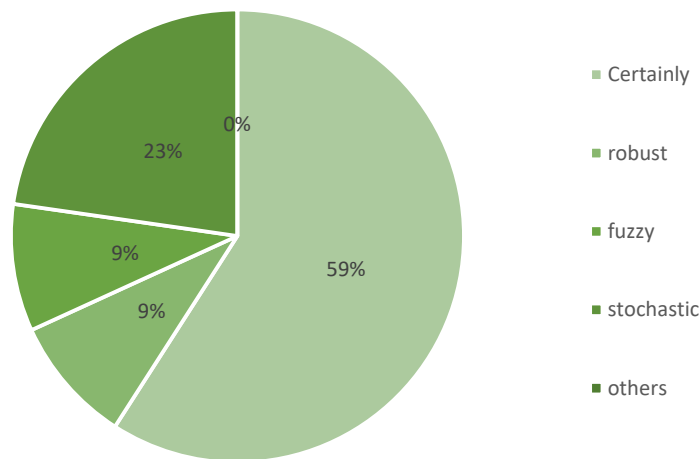


Fig. 12. Category data type

5. Conclusion and discussion

Throughout the years, the traveling salesman problem has gained a great deal of popularity in logistics research. Consequently, analyzing research and publications in this area is critical for understanding complex optimization problems. As science and technology have developed rapidly, data analysis is becoming an increasingly important decision criterion. Based on the data analysis tools and bibliometric methods available, this paper analyzes the application of this topic from 1983 to 2023. The observed trends indicate the different future research directions for TSP. For future research, it could be examined how the transportation salesman problem might be applied to other areas of research, such as computers, transportation, and many others.

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