
Road Transport Development: A Bibliometric Analysis of Scientific Discourse

Submitted 18/04/23, 1st revision 15/05/23, 2nd revision 11/06/23, accepted 30/06/23

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Abstract:

Purpose: The aim of the research resulting in this article is to identify the stages of evolution of the concept of transport, as well as to forecast further developments in this area of science. On this basis, a network of co-cited key words in the field of road transport was developed.

Design/Methodology/Approach: A bibliometric analysis of the literature on road transport was carried out. The data source was the international interdisciplinary database Scopus. The time span of the analysis was 2000-2022. A co-occurrence network analysis of road transport keywords was performed using VOSviewer version 1.6.19.

Findings: The results obtained are related to the extraction of cognitive knowledge about the preferred directions of development of the analysed category - road transport. Based on the analysis, the evolution of the number of published works on road transport between 2000 and 2022 and the countries with the highest number of publications in the area under study are presented. In addition, a co-occurrence network of road transport keywords was constructed using the VosViewer tool.

Practical Implications: The results developed will be used to identify effective pathways and research gaps for the road transport category. The identification of sources with the highest productivity and citations can be used by potential publication authors to adopt an appropriate publishing strategy.

Originality/value: There are now many publications that preface the bibliometric analysis of the road transport literature. This article provides an up-to-date, comprehensive analysis of this field and enriches the understanding of its existing patterns and trends.

Keywords: Road transport, bibliometric analysis, VOSviewer.

JEL classification: L91.

Paper Type: Research article.

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1. Introduction

The proper functioning of transport requires a well-functioning transport system, which is a set of integrated elements, processes and relationships, transforming a stream of material goods and passengers (demand for transport services) into a stream of outputs from such a perceived system. It is a functional relationship created in a given area by instruments of an organisational, economic and technical-technological nature that enable the construction of economic interactions. As one of the many definitions of the transport system assumes that it is an orderly interaction of different branches of transport - the authors of the monograph present the functioning of all branches of transport in its structure.

Globalisation processes, structural market changes in the area of production and consumption, as well as the geopolitical situation and scientific progress, mean that the conditions for the operation of transport are evolving over time. This necessitates the search for new solutions in the field of transport technology, taking into account environmental trends and ecodriving, transport systems, management of market entities of the TSL branch (Transport-Spedition-Logistics), as well as creation and implementation of the Community law with the national law in the field of organisational and economic conditions of conducting transport activities.

Transport as a production process, as a result of which society, in conditions of limited resources, carries out the movement of people, cargo and also energy in time and space in order to secure its various needs, plays an important role in the development of the state by ensuring the efficient functioning of individual branches of the national economy. The development of the economy and the development of the transport system are closely correlated.

The role of transport, understood in this way, is associated with the phenomenon of complementarity, which means there is no possibility of substituting it with another type of activity. When considering the role of transport in the economy, one should bear in mind the role of transport infrastructure, which is one of the most important factors stimulating the economic development of a country.

The availability of this infrastructure and its adequate capacity enable the diffusion of economic growth from strong regions to underdeveloped regions. It occupies an important place among the priorities that relate to the competitiveness and innovation of economies.

2. Road Transport – Literature Overview

Road transport is an important economic sector for the functioning of Poland and the European Union, with this sector handling 75.3% of the volume in freight traffic. Rail transport has a share of 18.7% in freight traffic and inland waterways 6.0%. Poland's accession to the European Community has given domestic hauliers access

to the EU transport market and created new development prospects for them under different conditions of international competition (Koźlak, 2018). There is a strong correlation between the efficiency of road transport and the efficiency of the economy which is confirmed by strategic transport infrastructure development programmes in the European Union countries (Gaca, 2017).

The essence of road transport boils down to the transportation (movement) of goods or passengers (persons) using means of transport (motor vehicles) based on the available transport infrastructure (Osinska *et al.*, 2020; Thalassinos *et al.*, 2022). A particular feature of road transport is that it is the most reliable and spatially accessible in relation to other modes of transport. It is important to be aware that, compared to rail and water transport, road transport costs are higher, but compared to air transport they are significantly lower.

Taking into account the criterion in terms of transport time and securing the goods, road transport is second only to air transport and, in terms of capacity, to rail transport. Road transport can be divided according to the criterion of economic activity into commercial transport and non-commercial transport, which is carried out by a transport undertaking for its own use.

Domestic road transport includes the performance of economic activity involving the carriage of persons or goods by means of transport registered in Poland (Zakrzewski *et al.*, 2021). It is essential that the movement of the vehicle, as well as the place of commencement or termination of the transport and the road on which it was performed are located on the territory of the Republic of Poland. In the case of international transport, the movement of the means of transport between the place of commencement and the place of termination takes place across the border of Poland.

Activities carried out in the area of road transport also include auxiliary journeys in relation to activities of a primary nature, as well as economic activity concerning intermediation in the movement of goods and persons (Mesjasz-Lech *et al.*, 2022). The importance of road transport in the carriage of goods and passengers is determined by factors stating that:

- road transport networks are characterised by cohesion and the highest degree of development in relation to other modes of transport,
- road transport networks are adapted to the needs of the spheres of supply, production, trade and consumption,
- the transport fleet is adapted to the movement of a variety of loads,
- there is a favourable relation of transport time in relation to the total cost of transport - in comparison with other modes of transport,
- there is a possibility of direct transport to the destination - other modes of transport do not offer such a possibility,
- there is a possibility to make the frequency of trips more flexible (Neider, 2008).

Road transport, despite the application of state-of-the-art solutions and technologies in the area of goods transport, remains the basic branch of transport without which it is not possible for goods to reach their destination (Papaioannou, 1998).

However, the use of air, rail, sea or river means of transport for freight requires that the final movement to the final storage destination is carried out using road transport (Rokicki, 2014). Its development, in qualitative and quantitative terms, affects the conditions for the realisation of the economic activity of transport-freight forwarding and logistics (TSL) companies, as well as influencing the quality of life of society.

Currently, we are witnessing attempts to reduce the role of road transport, and this mainly concerns freight transport and the use of other branches within multimodal transport. The development of road transport and its reorganisation will depend on fundamental changes in the regulatory area of the European Union, which are included in the *Mobility Package*.

It is assumed that the legal solutions introduced will contribute to an increase in the costs of transport networks with a decrease in their efficiency, as well as an increase in labour costs. Increasing requirements in the area of environmental protection will be not without significance for the shaping of the cost structure in transport companies. This will reduce the revenues of transport operators, especially in the area of crosstrade and cabotage services.

The development of road transport is closely correlated with the development of transport infrastructure (Larsson *et al.*, 2010). In this area, it is necessary to maintain a good level with regard to the technical condition of roads, which often entails the need for reconstruction or major reconstruction and then ensuring high standards in the maintenance of linear infrastructure elements. Road transport in Poland operates in the area and under the rules of (legal and economic) national and international regulations, which determine its condition.

The dominant position of Poland in the Community road transport is determined by the level of trade, liberalisation in the area of access to the EU transport services market, as well as price competitiveness of domestic carriers and other factors, which should be perceived as advantages of road transport. The efficient functioning of transport acts as an essential determinant of the free market.

National and international road transport of people and goods brings many benefits to the development of national economies and local communities. The main advantages of this activity include:

- the existence of a sustainable demand for transport services, which is the basis for the stable existence of transport operators,
- the numerous and modern fleet of transport vehicles,
- the possibility to move goods of different weights and sizes,

- possibility to choose various variants of routes to the place of cargo delivery due to a well-developed road network,
- possibility to deliver transported goods directly to the indicated unloading address,
- high degree of flexibility for the punctuality criterion,
- high availability of subcontractors and groupage carriers.

It should be noted that road transport complements other forms of passenger and freight transport.

The road fleet reaches places where there is no infrastructure to enable the process of sea, air or rail transport. Road transport is involved in the development of the concept of intermodal transport, which integrates different modes of transport. Road traffic is also characterised by weaknesses. Its disadvantages include:

- creating congestion and being a participant in it,
- negative impact on the environment (it pollutes the environment more than rail and maritime transport),
- low efficiency of transport of heavy and bulky cargo,
- low efficiency of long distance freight transport,
- high proportion of loss-making businesses,
- accident rate (Rześny-Cieplińska, 2013).

Regardless of the advantages and disadvantages of road transport, its efficiency is determined by the choice of the means of transport for the load being moved (performance and technical characteristics). The specific nature of the routes on which transport is carried out is significant. The high profitability of road transport is attributed to the short distances over which the so-called general cargo is transported.

In the implementation of the road transport process, it is necessary to bear in mind the necessity to protect each batch of material from damage, and for goods that are significantly susceptible to damage, it is necessary to use full truckload transport that eliminates repeated repacking.

The importance of transport for the economic development of the country is determined by the occurrence of relations and dependencies taking place between various forms of economic, production, cultural, settlement activity and transport. The development of transport is positively correlated with the development of the national economy, but it should be borne in mind that the rapid rate of economic growth and development, as well as the rate of trade exchange have a positive effect on the development of transport.

Transport is a factor securing the implementation of socially useful objectives; its role in this area boils down to securing communication needs to ensure access to health care, education, culture and other areas of human social activity (Grzywacz *et al.*, 1989). In view of the above statements, it is extremely important for transport to develop at a faster rate than other sectors of the national economy.

It is important to be aware of the changes that will take place in the markets for transport services in the future. These transformations will involve a slow but steady reduction in the role of road transport due to the growing environmental awareness of society (Deng, 2013). This state of affairs will result in the European Union's transport policy aiming to promote and develop technologies in the area of intermodal transport with the well-known concept of trucks to tracks.

It is also assumed that there will be a return to steering transport systems, which will boil down to a central indication in the countries concerned of the role of individual transport modes and their impact on the economy (Slezak *et al.*, 2019).

3. Materials and Methods

This paper reviews the ever-growing literature on road transport. A three-step approach was used to collect data. First, we conducted a logical search for articles in the Scopus database, considered one of the most comprehensive databases of peer-reviewed journals (Ding, 2020; Donthu *et al.*, 2021). The international Scopus database covers almost all important scholarly articles, which also provide built-in analytical tools to produce representative data. What is more, search results from Scopus can be exported to a file by software for further analysis, such as VOSviewer (Yu *et al.*, 2020).

The Scopus database was searched using the following keywords: road transport, road infrastructure, road transport system. The search of the Scopus database was limited to the subject area, which includes article titles, their abstract and keywords. The results were then filtered by language (English), document type (articles), and areas resulting in 1297 articles.

The article title, authors' names and affiliation, journal name, number, volume, pages, publication date, abstract and cited references were extracted for bibliometric analysis. A search of the Scopus database was limited to the subject area, which includes article titles, their abstract and keywords. The prepared collection of publications in the field of road transport was then analysed in the specialised software VOSviewer.

Selecting publications based on search engines using specific ranking algorithms risks missing out on papers of interest (Bonilla *et al.*, 2015) with low citation counts but high potential for impact. As a result, it is increasingly difficult to get a reasonably comprehensive picture of research in a given field and to identify

a research gap of interest (Wisniewski *et al.*, 2022; Huchang *et al.*, 2019). Therefore, the authors applied a visualisation and clustering technique using a tool such as VOSviewer (Sanguankaew *et al.*, 2019; Eck *et al.*, 2014).

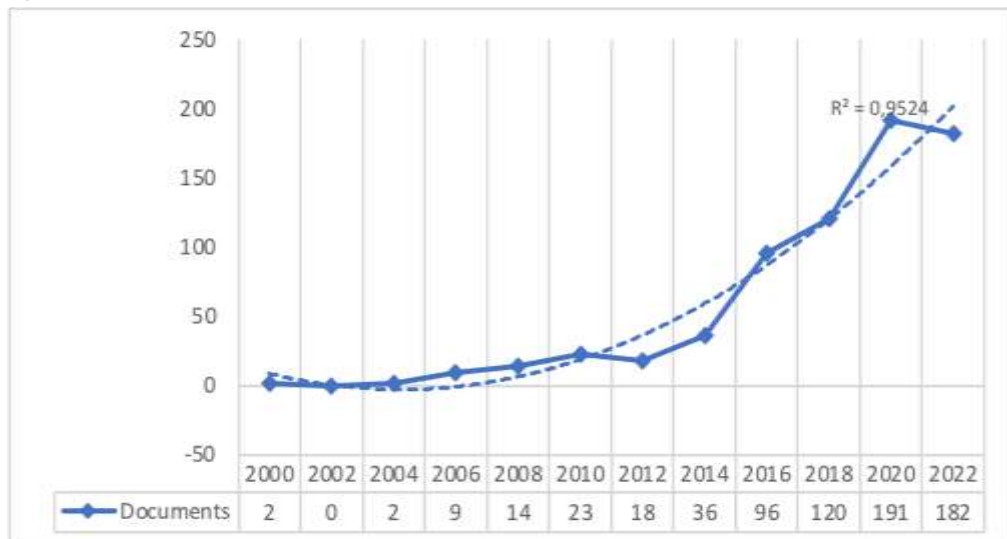
4. Results and Discussion

A systematic review of the road transport literature was chosen as the research method. A systematic review was chosen because it entails strict procedures for searching and selecting articles for review. Based on the listed keywords, a search query (Janik, *et al.*, 2020) was formulated across titles, keywords and abstracts, with no time limit. The query was entered into the Scopus database.

(TITLE-ABS-KEY (road AND transport) AND TITLE-ABS-KEY (road AND infrastructure) AND TITLE-ABS-KEY (road AND system AND transport)) AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))

The selected set of keywords enabled the analysis of individual topics and their trends using the methodology adopted. Only studies in English (including articles in the press) with available abstracts and literature were considered for analysis.

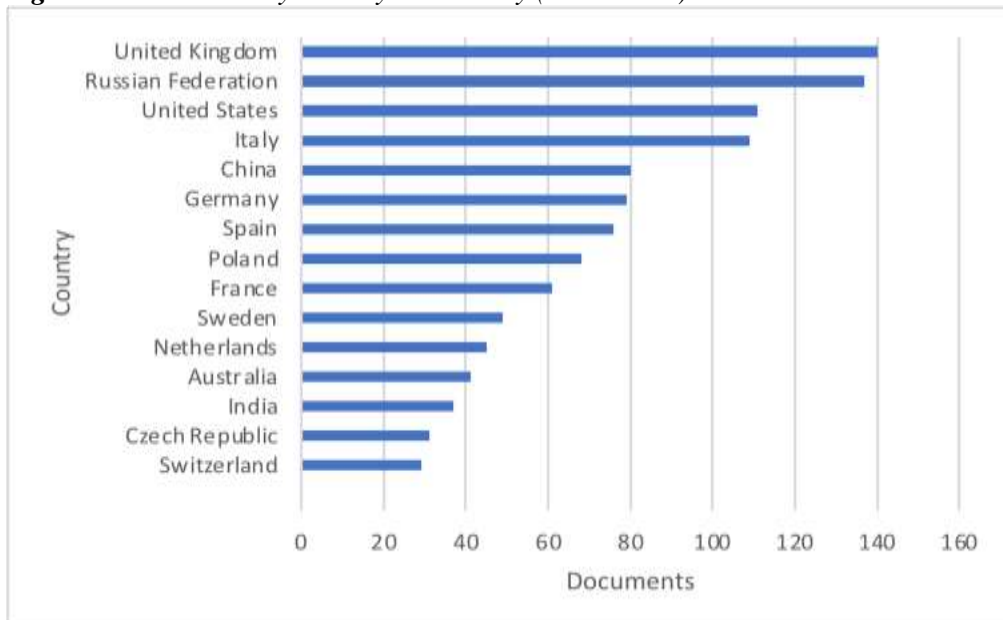
Figure 1. Number of road transport development publications between 2000 and 2022



Source: Own calculation based on Scopus.

The evolution of the number of articles published and the distribution of annual publications is shown in Figure 1. It should be emphasised that the earliest document found applying the selected criteria was published in 2000. In the following years, there was a systematic increase in the number of publications from the study area. It should be emphasised that since 2016, publications have achieved a significant increase, which is indicative of the particular interest of researchers in the phenomenon under study. The next stage of bibliometric data research was the analysis of citations in relation to countries, as shown in Figure 2.

Figure 2. Documents by country or territory (2000–2022)

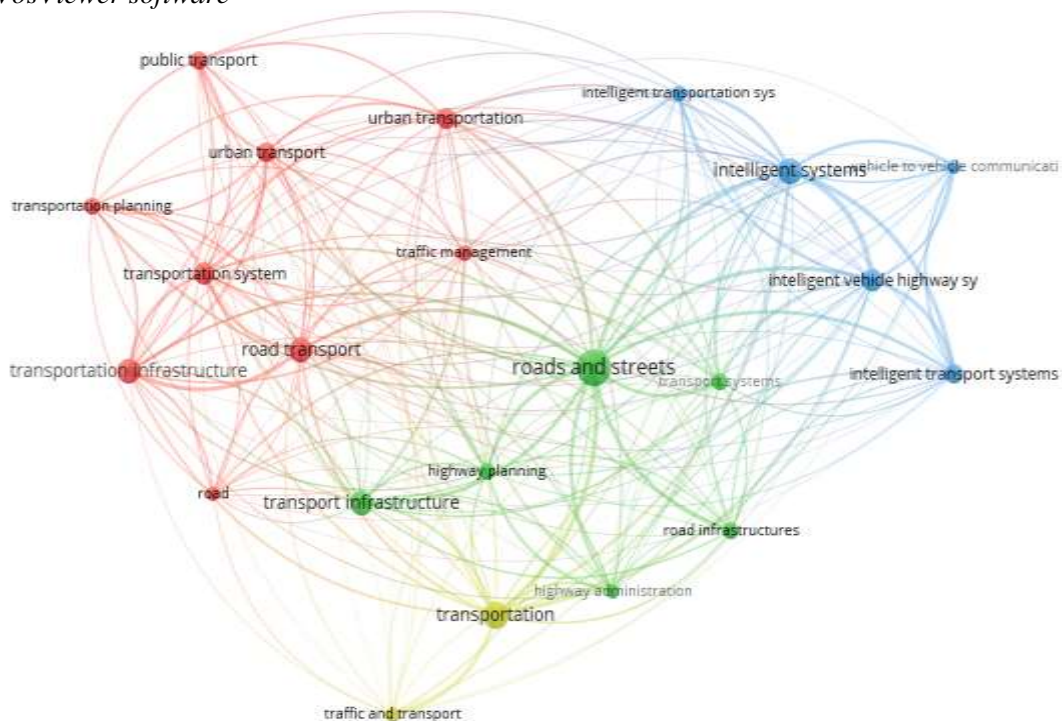


Source: Own calculation based on Scopus.

One type of citation document - articles - was selected for the study. Using the options of the VOSviewer programme, a visualisation was developed showing the Co-occurrence Network of road transport development keywords (Figure 4).

The VOSviewer programme is based on the visualisation of similarities (VOS) technique developed by the same authors. The VOS technique is used to visualise similarities between objects, in which similar objects are located close to each other and less similar objects are located away from each other (Eck *et al.*, 2014). The phenomenon of remoteness and object relatedness is shown in Figure 3.

Figure 3. Road transport development keyword co-occurrence network created in VosViewer software



Source: Own calculation based on VosViewer.

The size of the points in Figure 3, represents the occurrence of keywords. The larger the point, the higher the incidence was. The keywords 'roads and streets' and 'transportation' had the highest strength. The distance between two keywords showed relative strength and thematic similarity. Circles in the same colour group suggested a similar theme among these publications. The network of common keywords in Figure 3 clearly illustrates four distinct clusters, which are marked with colours respectively. Red colour indicates cluster 1, which is formed by 9 keywords. Cluster 2 (green) is also formed by 6 other keywords. Cluster 3 (blue colour) is formed by five keywords. The last focus (yellow colour) is formed by two keywords (Table 2).

Table 1. Clustering information for Figure

Lp.	Keyword	Occurrences	Total Link Strength
1.	roads and streets	264	581
2.	intelligent systems	135	396
3.	transportation	151	316
4.	intelligent vehicle highway systems	98	292
5.	transportation infrastructure	123	249
6.	road transport	124	235
7.	intelligent transport systems	81	220

8.	transportation system	102	209
9.	urban transportation	88	199
10.	urban transport	76	179
11.	transport infrastructure	127	177
12.	highway planning	57	167
13.	transportation planning	55	145
14.	road infrastructures	60	139
15.	transport systems	56	137
16.	intelligent transportation systems	48	136
17.	vehicle to vehicle communications	45	136
18.	highway administration	42	126
19.	traffic management	48	117
20.	public transport	68	110
21.	road	45	83
22.	traffic and transport	48	75

Source: Own calculation.

Table 2. Clusters based on the author's keywords discovered in VOSviewer

Cluster	Author's keywords
Cluster 1	public transport, transportation planning, transportation system, traffic management, transportation infrastructure, road transport, road, urban transportation, urban transport (9 items)
Cluster 2	transport infrastructure, highway planning, highway administration, road infrastructures, roads and streets, transport systems, (6 items)
Cluster 3	intelligent systems, intelligent transport systems, intelligent transportation systems, intelligent vehicle highway systems, vehicle to vehicle communications (5 items)
Cluster 4	traffic and transport, transportation (2 items)

Source: Own calculation.

In Table 1, Total Link Strength represents the co-occurrence of a link between two keywords. According to the VOSviewer manual, each link has a strength, represented by a positive numerical value. The higher this value, the stronger the Total Link Strength. The variety of keywords included in the analysis demonstrates the multifaceted and multidimensional nature of the issue under stud

5. Conclusions

The importance of transport for the development of the state is determined by the emergence of new transport needs, which result from the existence of globalisation processes, socio-economic integration and new international trade opportunities.

Transport fulfils the role of an instrument for the exchange of goods and services as it allows the realisation of trade processes by enabling the movement of goods traded between commercial, production and service enterprises. It also plays a role

in determining the location of production and settlement in a given geographical area. This means that the state of advancement of transport technology, as well as the quantitative and qualitative state of the transport infrastructure (point and linear) are determinants of the development of entrepreneurship on a regional basis, and this is linked to the development of settlement and construction.

Transport is seen as an important indicator of economic growth, which should be read as a positive impact of this sector on the development of other branches of the national economy (Banister, 2012). A non-harmonious development of transport will determine a slowdown in the pace of the country's development.

This implies the necessity to ensure the availability of factors that will create conditions for the development of transport, which include: access to a broadly understood infrastructure, a favourable tax system, access to means of transport, but also the qualifications of the personnel providing services to these means or the state of development of other branches of the national economy of the state.

The use of appropriate tools, such as cross-referencing computer programmes, makes it possible to carry out research covering various areas of bibliometric analysis. A bibliographic-abstract database obtained from the Scopus database was adopted as the data source for the research (research material).

The research performed revealed features of the road transport literature concerning, among other things, the productivity scale of individual countries. The results of the conducted research provided new and important knowledge about the features of contemporary road transport literature. The added value of the analyses performed is the information prepared in the form of relevant rankings using bibliometric indicators.

The map (Figure 3) showing the co-occurrence network of keywords was generated using the VOSviewer programme. The results of the bibliometric analysis presented here may have important practical implications. Determining the sources with the highest productivity and citations can be used by researchers to adopt an appropriate publishing strategy. Determining the countries with the highest publication activity represent the most influential authors in the area studied can provide a valuable basis for establishing future collaborations.

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