

Article

A Visualization Study of Highway Investment Based on Network Analysis

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Abstract: The proportion of highways in infrastructure investment is growing and playing a significant role. It has many advantages in all aspects of social life and has become a timely subject of recent research. However, the existing literature lacks a systematic review of the current research status of highway investment. Thus, this study aims to conduct a scientometric analysis of the existing literature on highway investment to provide an overview of its current state of research. Using the Web of Science Core Collection database, this study conducted searches and screenings of 614 documents related to highway investment from 2013 to 2023. Subsequently, VOSviewer software was employed to perform a visual analysis of source journals, authors, countries/regions, article citations, and keywords. The results reveal that *Transportation Research Record* is identified as the most influential journal in the field of highway investment. Bullock, Darcy M. has published the greatest number of articles. In addition, the United States has published the largest number of studies and contributed significantly to the advancement of highway investment. Benjamin Faber has received the highest number of citations and normalized citations. Through co-occurring keywords analysis, keywords such as “risk”, “influence”, “investment decision”, and “infrastructure investment” receive more attention. The findings of this research can contribute to providing researchers and scholars with a more comprehensive understanding of the current research status of highway investment and its key issues.

Keywords: highway; infrastructure investment; scientometric analysis; visual analysis



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1. Introduction

Currently, due to rapid global economic growth and more than 50% of the world's population living in urban areas [1,2], the demand for infrastructure is increasing. Infrastructure constitutes a vital component of national economies and societal existence, exerting a profoundly significant role. Generally, infrastructure includes water supply, sewerage, housing, roads and bridges, ports, electricity, airports, railroads, urban services, communications, oil and gas production, and mining [3]. Over an extended duration, infrastructure has been regarded as a kind of principal instrument in fostering regional economic advancement and urbanization [4]. In many countries, especially in densely populated cities, the infrastructure system largely determines the distribution of essential public services that guarantee basic human needs for survival [5]. Effective function of societies and economies depends on infrastructure development, without which many societal attributes, such as globalized supply chains, transportation, global communications, and high-quality health care, would not exist [6].

Amongst diverse categories of infrastructure, transportation infrastructure stands as one of the utmost pivotal factors, given that transportation costs bear paramount importance in the economic development of a region [4]. Strong transportation infrastructure plays a tremendous role in improving the national economy and economic conditions of the population [7,8]. In recent years, there has been a significant increase in the demand for transportation infrastructure projects, as transportation plays an important role in different aspects of a country's economy, society, education, and health care [9]. Owing to the intricate interdependencies with numerous factors in the decision-making process regarding highway investments, it emerges as an exceedingly intricate undertaking [10]. Starting with Aschauer, a significant body of literature has investigated infrastructure investment [11]. Goh et al. [5], using the case of Western Australia, employed the fuzzy analytic hierarchy process (Fuzzy AHP) and life cycle cost analysis (LCCA) to assess highway infrastructure investment. Baum Snow [12] examined the impact of transportation infrastructure on urban population distribution. Sheard [13], using airports as a case study, estimated the influence of infrastructure on employment shares in metropolitan areas. Li [10] introduced a stochastic optimization model and solution algorithm to address budget uncertainty in highway investment decisions. Feng et al. [14] established a decision-making framework for highway investment planning, combining the analytic hierarchy process (AHP) and grey theory to construct a model for highway investment decision-making. Pereira and Andraz [15] examined the impact of highway investment on the regional concentration of economic activity in the United States by developing VAR models involving highway investment and output for each of the 48 contiguous U.S. states. Although existing studies have made significant progress in highway investment, no studies have been conducted to investigate its current research status and provide a comprehensive vision of the current literature. A quantitative study through scientometric analysis can reflect the current status of research, research hotspots and development trends more objectively. Against this background, this study aims to fill this research gap to determine the main research areas, define the existing research gaps, and conclude the impact of highway investment on investment management, economic development, and risk management by conducting a scientometric analysis of literature related to highway investment published between 2013 and 2023 in order to enhance comprehensive understanding.

The remaining sections of this article firstly introduce the required sources of data and the research methodology employed. Subsequently, an analysis of the collected literature encompassing aspects such as source journals, co-authors, countries/regions, article citations, and co-occurring keywords is conducted, leading to the generation of visualized network graphs. The obtained results are discussed based on the findings. Lastly, the conclusions are presented in Section 5 of this study.

2. Research Method

2.1. Data Collection

The data source for literature retrieval significantly determines the effectiveness and accuracy of bibliometric analysis [16]. The literature data utilized for analysis in this study were retrieved from the Web of Science Core Collection database using a thematic keyword search approach. The search was conducted using the search formula $TS = ("highway" AND "investment")$ as the thematic keywords, covering the time span from 2013 to 2023. This study exclusively focused on journal articles as the research subject, and excluded other types of literature such as book chapters, conference papers, books, reviews, and editorials [17].

After an exhaustive search, a total of 614 literature references related to research on highway infrastructure investment were retrieved, as depicted in Figure 1. As evident from Figure 1, since the year 2013 there has been a consistent upward trend in research pertaining to highway investment, culminating in its zenith by 2022. This signifies the gradual emergence of highway investment as a focal point within the realm of urban economics and regional development research.

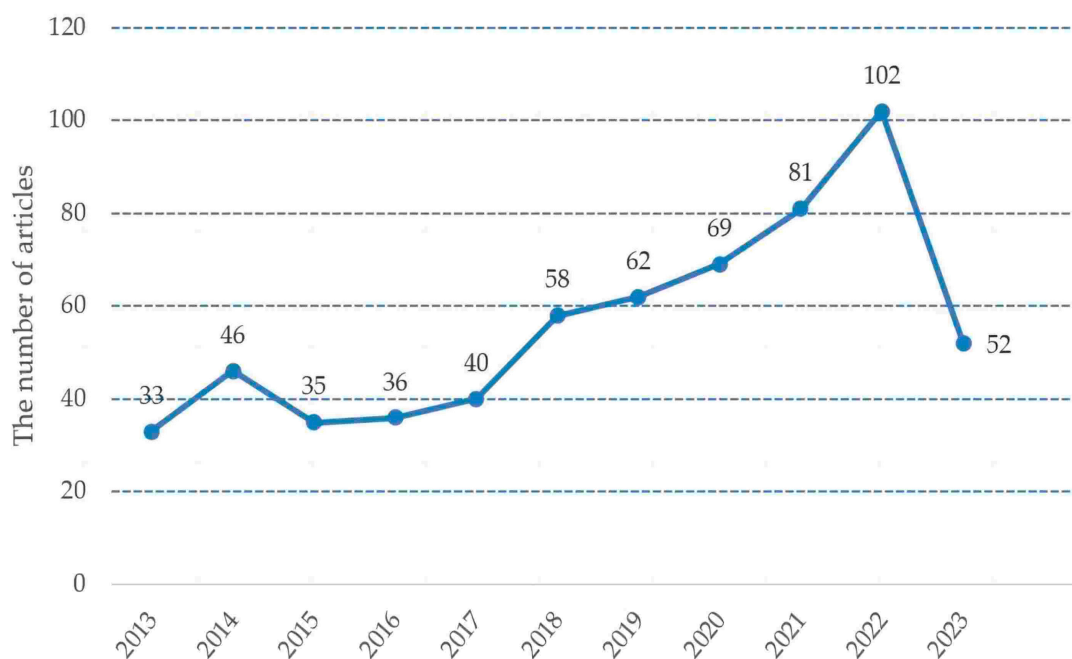


Figure 1. Articles on highway investment in WOS during 2013–2023.

2.2. Research Methodology

This study employs VOSviewer software version 1.6.19 to conduct a visual analysis of the retrieved literature. In VOSviewer, circles usually represent literature, authors, keywords, or other entities. Each circle represents a separate item or entity. The size of the circle usually reflects the importance or relevance of the entity in the network, and larger circles usually indicate more important entities. Lines usually represent relationships or connections between entities. In literature networks, these connections usually indicate citation relationships, collaborative relationships, subject matter relevance, etc. The thickness, color, or other attributes of the lines can often indicate the strength, type, or other characteristics of the relationship. In addition, different clusters are represented by different colors. The rationale for selecting VOSviewer lies in its capacity to offer a more objective assessment, thereby enhancing the scientific rigor of the research [18]. Developed collaboratively by Dutch scholars van Eck and Waltman, VOSviewer constitutes a visualization analysis tool [19] designed to construct maps based on network data and subsequently visualize and explore these maps. The first visualization approach is employed to present clustering outcomes within the cluster solutions, along with the citation relationships among these clusters. The second visualization method takes the form of a term map that shows the thematic coverage of the clusters. This term map distinctly illustrates the most significant terms within publications belonging to a specific cluster, revealing their co-occurrence relationships. Both of these visualization techniques are crucial for comprehensive analysis and understanding of the research domain [20]. Documents retrieved from the Web of Science database are exported in a tab-separated format and subsequently imported into VOSviewer to construct visual maps to facilitate visual analysis [21]. Following this, the visual results are utilized for analyzing and discussing research field trends, thereby gaining in-depth insights into the developmental dynamics of the research domain [19]. The methodology of the research is depicted in Figure 2.

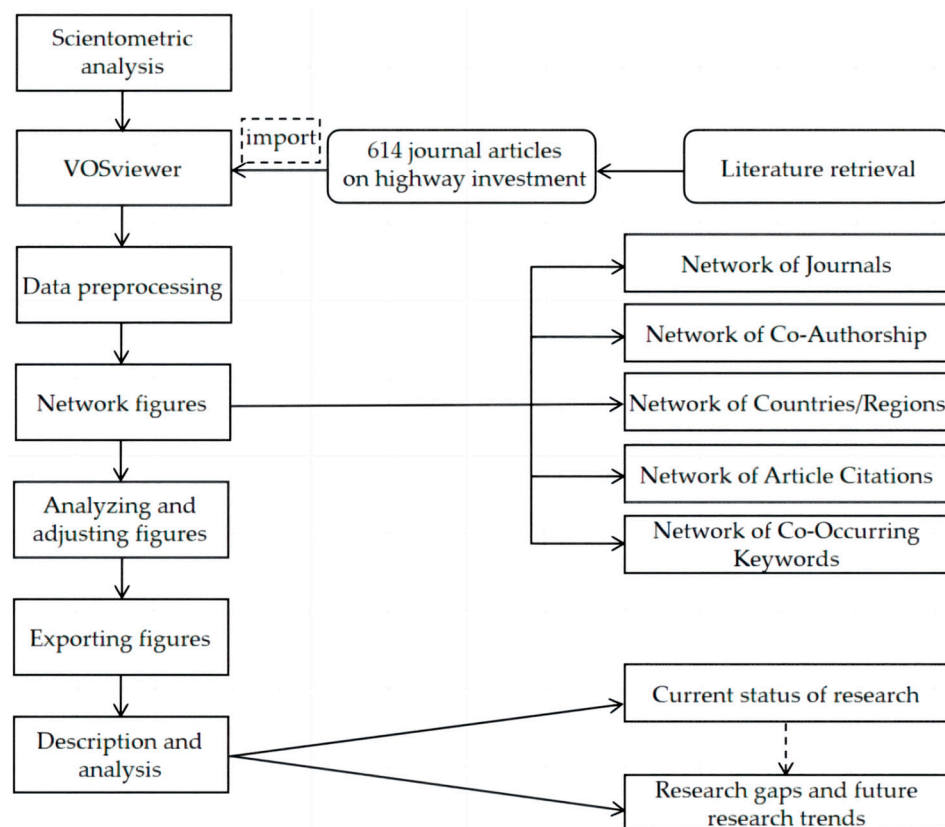


Figure 2. The methodology of the research.

In summary, this study conducts a systematic investigation of 614 journal articles published from 2013 to 2023 on the research pertaining to highway investment, encompassing five aspects: source journals, authors, countries/regions, article citations, and keywords. Through this comprehensive retrieval and analysis, both domestic and international developmental statuses and research trends in the domain of highway investment are dissected. The purpose is to facilitate a more comprehensive and expedient understanding of the holistic progression within this field for relevant scholars. The network established from these five dimensions aids researchers in efficiently analyzing the present research landscape [22]. Moreover, this study employs measurements and evaluations based on the literature metrics, citations, average citations, average publication year, and average normalized citations. By importing the map file generated by VOSviewer into Excel, these five evaluative metrics can be effortlessly obtained.

3. Results and Discussion

This section presents the mapping outcomes of highway investment from five dimensions: source journals, co-authors, countries/regions, article citations, and co-occurring keywords.

3.1. Mapping of Journals

The literature on highway investment published in journals is abundant and widely distributed. By setting the minimum number of documents of a source to five and the minimum number of citations of a source to twenty in VOSviewer, a total of 15 out of 230 journals met the criteria, as illustrated in Figure 3.

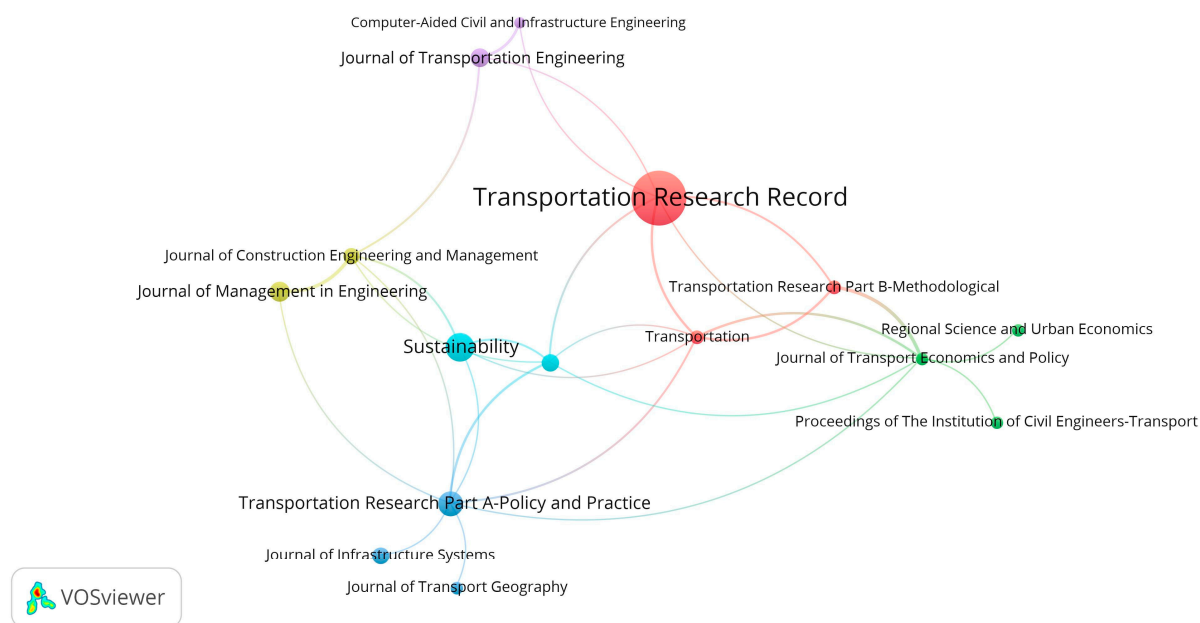


Figure 3. Map of dominant journals in the field of highway investment.

Table 1 presents an overview of the top ten journals by publication volume. We observe that the two journals with the highest number of publications in the field of highway investment research are *Transportation Research Record* and *Sustainability*. The former has published 46 studies, accounting for 9.58% of the total, whereas the latter has published 18 studies, constituting 3.75% of the total. This indicates that a significant portion of research on highway investment is situated within the domains of transportation, transit, and sustainability.

Table 1. Top 10 journals in terms of publications.

Journal Title	Number
Transportation Research Record	46
Sustainability	18
Transportation Research Part A-Policy and Practice	15
Journal of Management in Engineering	11
Journal of Transportation Engineering	10
Journal of Infrastructure Systems	9
Transport Policy	9
Journal of Construction Engineering and Management	8
Canadian Journal of Civil Engineering	7
Transportation	7

3.2. Co-Authorship Analysis

The authors of these articles can be identified through bibliographic records [23], and the co-authorship network can reflect the scholarly collaborations in the visualization domain of infrastructure highway investment [24]. By setting the minimum number of documents for authors to one and the minimum citation count to ten in VOSviewer, 655 out of 1820 authors met the criteria. As some authors did not collaborate with others, a total of 14 authors were ultimately selected, as depicted in Figure 4.

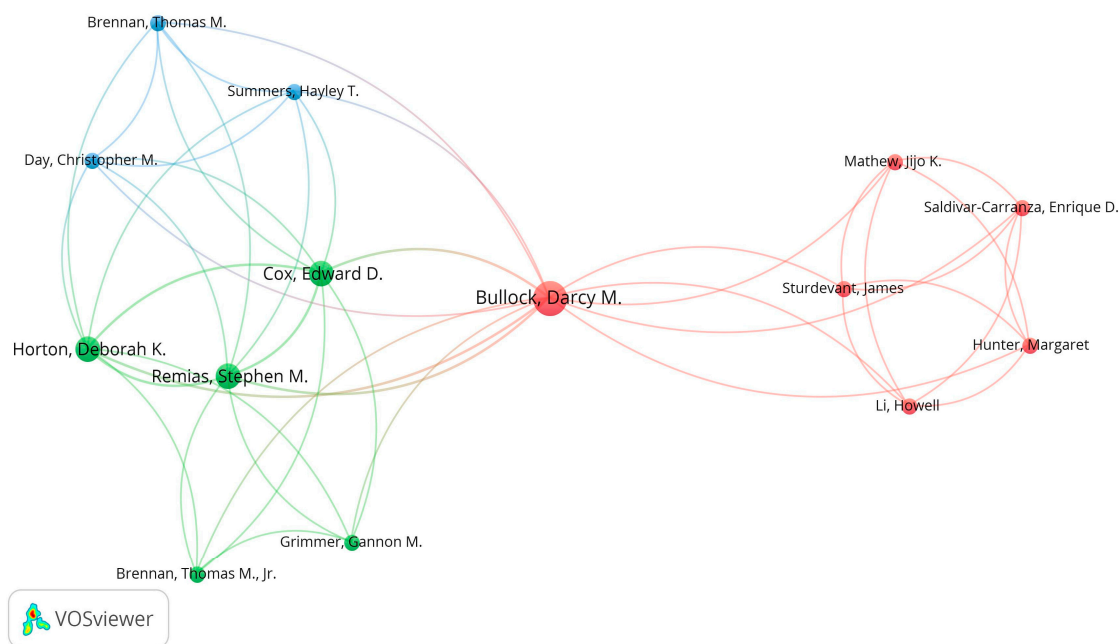


Figure 4. Map of co-authorships.

Different colors are indicative of the authors being categorized into distinct groups. The colors red, green, and blue signify the division of these authors into three separate clusters. The size of each circle corresponds to the volume of publications by the respective author, with larger circles denoting higher publication outputs. The network further enables the revelation of collaborative relationships among researchers within each network cluster, as noted in reference [25]. Analysis of the data presented in Figure 4 shows that Bullock, Darcy M. emerges as the most prolific author in terms of publication count, displaying close collaborative ties with authors from the other two groups. This suggests a pronounced focus by Bullock, Darcy M. on highway investment within the realm of high-speed transportation, accompanied by significant contributions to research in this domain. The specific collaborative network is detailed in Table 2.

Table 2. Details of productive scholars.

Scholar	Affiliation	Documents	Citations	Avg. Pub. Year	Avg. Citations	Avg. Norm. Citations
Bullock, Darcy M.	Purdue University	3	44	2016	14	1.20
Cox, Edward D.	Indiana Department of Transportation	2	32	2013	16	0.86
Horton, Deborah K.	Purdue University	2	32	2013	16	0.86
Remias, Stephen M.	INRIX	2	32	2013	16	0.86
Brennan, Thomas M.	Purdue University	1	15	2014	15	0.55
Brennan, Thomas M., Jr.	College of New Jersey	1	17	2013	17	1.18
Day, Christopher M.	Iowa State University	1	15	2014	15	0.55
Grimmer, Gannon M.	Purdue University	1	17	2013	17	1.18
Hunter, Margaret	United States Geological Survey	1	12	2021	12	1.88
Li, Howell	Purdue University	1	12	2021	12	1.88
Mathew, Jijo K.	Purdue University	1	12	2021	12	1.88
Saldivar-Carranza, Enrique D.	Purdue University	1	12	2021	12	1.88
Sturdevant, James	Indiana Department of Transportation	1	12	2021	12	1.88
Summers, Hayley T.	Purdue University	1	15	2014	15	0.55

Among indicators, Avg. Pub. Year. refers to the average of the years in which a given total number of articles have been published that can be used to assess the currency of a collection of literature. If it is relatively recent, the literature collection contains more recent research results. By contrast, a lower Avg. Pub. Year. may indicate that the literature collection contains some classic, early studies. Avg. Citations refers to the average of the citation counts associated with the analyzed subjects, which can be used to assess the impact of them. Avg. Norm. Citations refers to the ratio of the total number of citations to the average number of citations published in the same year, which can be used to assess the influence of the analyzed subjects in the academic community. For the latter two indicators, the higher their value, the higher the impact of the objects.

Table 2 shows that the majority of authors originate from institutions of higher education in the United States. In terms of the quantity of published articles and citation counts, Bullock, Darcy M. consistently ranks first, with his publications typically appearing around the year 2016. This means that his articles are widely cited by other researchers and may be important references. Regarding the average citation counts, Grimmer, Gannon M. and Brennan, Thomas M., Jr. gain the highest number of citations (17), indicating that their articles have greater impact, importance and high quality in the field of highway investment. Moreover, considering the average publication year, it represents emerging scholars in the field of highway investment research. Intriguingly, as depicted by Table 2, seven authors hail from Purdue University, underscoring the substantial contributions made by this academic institution in the realm of highway investment research. Additionally, Hunter, Margaret, Li, Howell, Mathew, Jijo K., Saldivar-Carranza, Enrique D., and Sturdevant, James exhibit the highest average standardized citation counts, indicating their high visibility in the highway investment arena.

3.3. Countries/Regions Analysis

By means of countries/regions visualized analysis, an understanding can be obtained regarding the extent of contributions of various countries/regions to the research on highway investment. The minimum thresholds for the number of papers and citations per country/region were set at 6 and 1 respectively. Among the 67 countries/regions considered, a total of 16 met these criteria, as presented in Figure 5. The network connectivity model presented in Figure 5 illustrates the cross-references in research among different countries [25]. Figure 5 shows that the node representing the United States is the largest, followed by China, which exhibits strong connections with other countries. This underscores the remarkable contributions of scholars and researchers from the United States and China in the realm of highway investment research. Moreover, countries/regions such as the United Kingdom, Canada, and South Korea exhibit proactive engagement in this field.

Detailed information regarding countries/regions networks can be found in Table 3. Conclusions can be drawn from Table 3, indicating significant contributions to research on highway investment from the United States (209 articles), China (107 articles), the United Kingdom (36 articles), and Canada (27 articles). Scholars from the United States (4763), China (1340), and Canada (546) rank in the top three positions in terms of citation count, followed by South Korea (545) and the United Kingdom (406), indicating that research from these countries is of high quality and these countries have outstanding scientists and research teams in this field. It is noteworthy that among the top five countries in terms of published literature quantity, China is the sole developing country, underscoring the rapid advancement of highway investment research in China in recent years. Analyzing the average year of publication, emerging countries in the field of highway investment, such as Brazil and Iran, can be identified. In addition, Germany and South Korea demonstrate the top two average norm citation count, signifying their substantial influence and tight cooperation on the progression of research in highway investment.

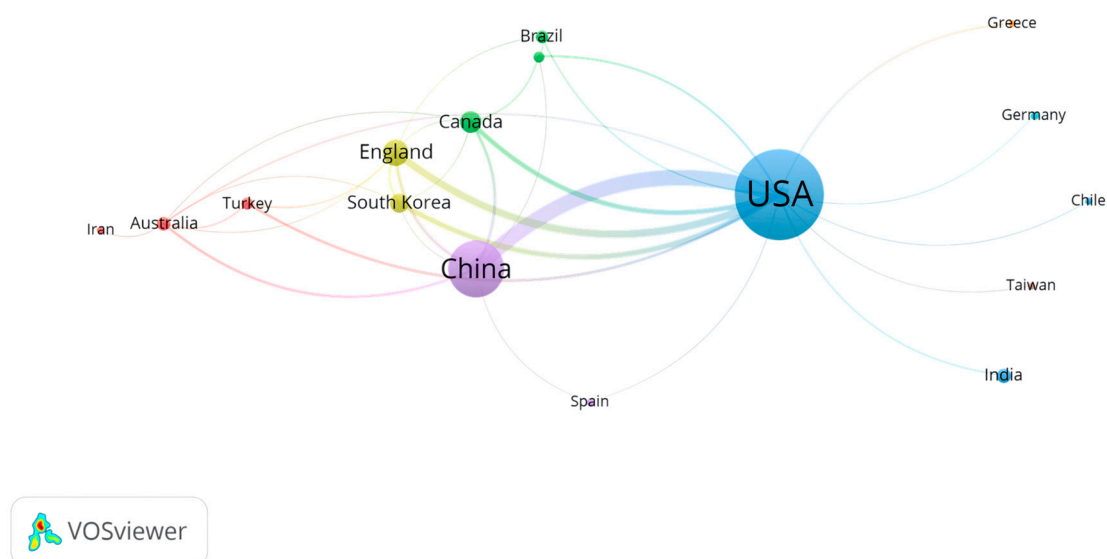


Figure 5. Map of active countries/regions.

Table 3. Details of active countries/regions.

Country/Region	Documents	Citations	Avg. Pub. Year	Avg. Citations	Avg. Norm. Citations
USA	209	4763	2013	22	1.00
China	107	1340	2018	12	1.07
England	36	406	2013	11	0.80
Canada	27	546	2013	20	1.12
South Korea	23	545	2013	23	1.37
India	16	172	2017	10	0.84
Australia	15	206	2017	13	1.09
Brazil	13	113	2019	8	1.13
Turkey	12	302	2017	25	1.08
Portugal	11	247	2015	22	1.12
Germany	7	127	2018	18	1.67
Spain	7	91	2013	13	0.79
Iran	6	31	2019	5	0.81
Greece	6	82	2018	13	0.87
Chile	6	45	2010	7	0.39
Taiwan	6	105	2010	17	0.78

3.4. Article Citations Analysis

The citation impact factor plays a significant role in scientific research, where the citation of articles facilitates the analysis of the fundamental structure within a knowledge domain [26]. Citation analysis is a method of bibliometric analysis that reveals quantitative characteristics and internal patterns of publications by analyzing their citation and the phenomenon of being cited [27]. It also serves as an indicator of the higher recognition accorded to articles in the field of highway investment. The minimum required citations for each article were set at 20, resulting in the selection of a total of 15 articles. The citation patterns for these 15 articles are presented in Figure 6.

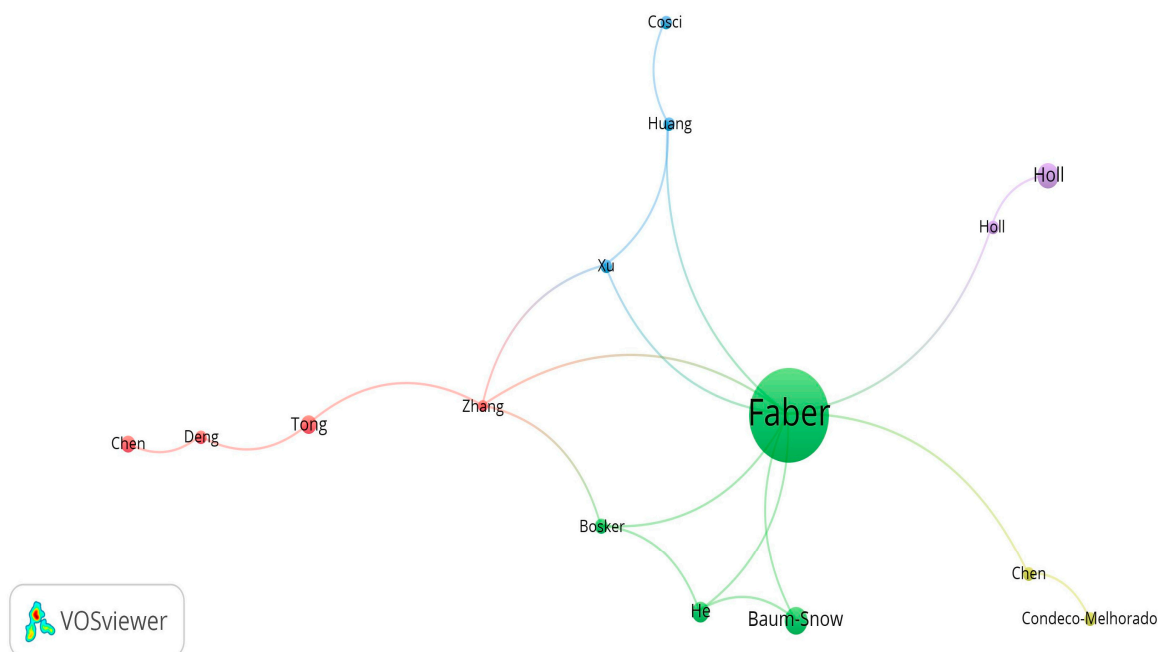


Figure 6. Map of article citations.

From Figure 6, we can find that the node representing Benjamin Faber [28] is the largest, indicating that Benjamin Faber has received the highest number of citations and maintains the closest connections with other cited articles. It contributes to emphasize the importance of potential unintended general equilibrium consequences in assessing and planning for mass transportation infrastructure policies. Following closely is Baum-Snow et al. [29]. Moreover, although the node of Zhang et al. [30] is the smallest, it has strong connections to other highly cited papers. They used county-level data from 1993–2013 in China’s Yangtze River Delta region in this paper and found that highway investment has contributed to local economic growth. Detailed information on the cited references can be found in Table 4.

Table 4. Details of articles citations.

Author	Citations	Norm. Citations
Benjamin Faber [28]	382	14.05
Baum-Snow et al. [29]	68	5.89
Holl et al. [31]	62	4.28
He et al. [32]	45	3.90
Tong et al. [33]	40	2.76
Chen et al. [34]	33	2.07
Bosker et al. [35]	28	1.93
Huang et al. [36]	26	2.25
Holl et al. [37]	26	1.80
Cosci et al. [38]	26	1.80
Condeço-Melhorado et al. [39]	26	0.96
Deng et al. [40]	25	0.92
Chen et al. [41]	25	2.17
Xu et al. [42]	24	1.56
Zhang et al. [30]	21	1.82

3.5. Co-Occurring Keywords Analysis

As a crucial instrument in the realm of text mining, word frequency analysis facilitates the statistical computation and examination of the occurrence frequencies of pivotal terms within a given document [43]. Key terms serve to encapsulate the fundamental essence

of previously published research endeavors [23]. Within the context of this study, the minimum occurrence threshold for each individual key term was set at 10. Out of a total of 13,102 identified key terms, 66 satisfied this established threshold. The graphical representation of the network of key terms is illustrated in Figure 7.

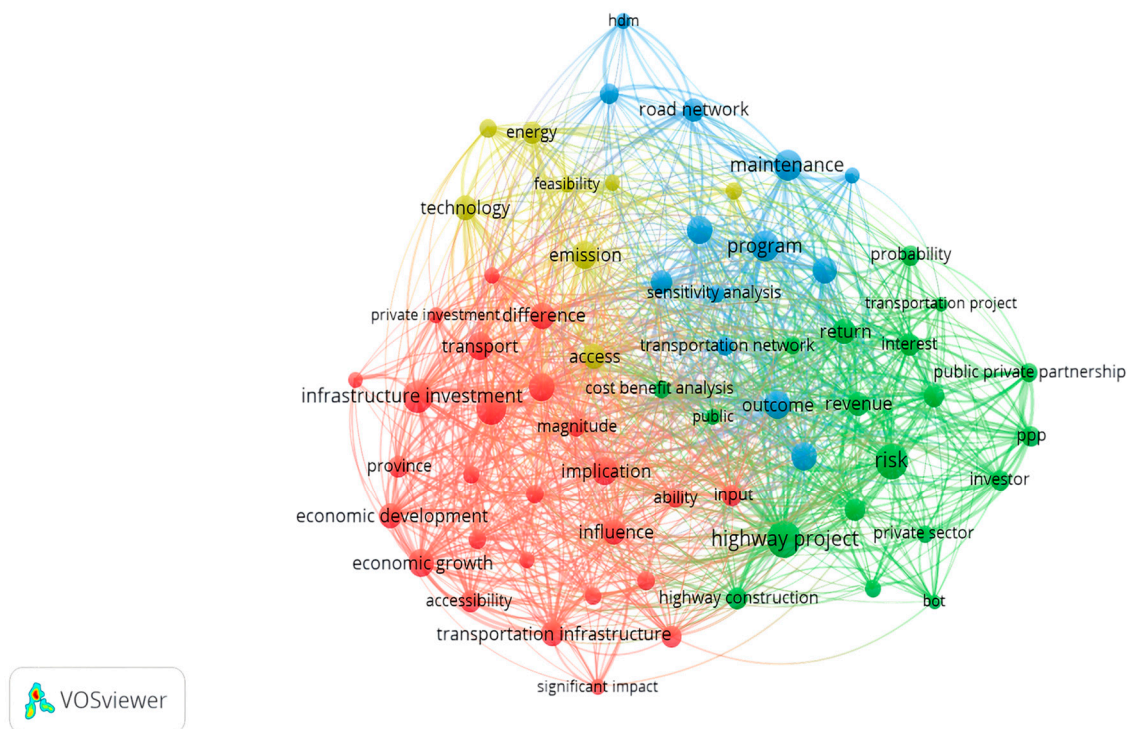


Figure 7. Map of co-occurring keywords.

Figure 7 shows that the various clusters are closely interconnected, exhibiting strong correlation. Among them, the node labeled as “highway project” stands out as the largest. Other crucial terms such as “infrastructure investment”, “transportation infrastructure”, and “transport” belong to the same cluster. The remaining key terms indicate that highway investment is closely associated with numerous factors, such as “economic development”, “risk”, “maintenance”, and “technology”. These high-frequency and well-connected keywords indicate that they are hot topics in current research and that there is intersectionality between different fields, which can be used by researchers to understand current research trends.

Detailed information about the keywords is presented in Table 5. In terms of average citations, keywords such as “risk”, “influence”, “investment decision”, and “infrastructure investment” have garnered greater attention, meaning that these keywords represent research trends in highway investment. The average year of publication delineates the latest keywords within research concerning highway investment. It is evident that articles related to “emission”, “economic growth”, and “highway investment” were published in recent years, suggesting that researchers are already interested in these research areas and have begun to focus on the economic development impacts and emissions of highway investment. The average norm citations value signifies substantial attention directed toward these terms, with “risk” attaining the highest value of 1.42, indicating that researchers have placed more emphasis on risk management in this field.

Table 5. Details of co-occurring keywords.

Keywords	Occurrences	Avg. Pub. Year	Avg. Citations	Avg. Norm. Citations
highway project	55	2013	18	1.08
risk	51	2015	30	1.42
infrastructure investment	44	2014	23	0.94
economy	43	2015	19	1.06
program	40	2013	16	0.84
maintenance	38	2014	22	0.97
investment decision	33	2013	23	1.13
outcome	33	2015	9	0.63
transport	33	2017	16	1.04
alternative	32	2013	14	0.79
efficiency	32	2017	9	1.24
emission	32	2019	14	1.34
implication	32	2014	17	0.92
economic growth	31	2019	13	0.80
difference	29	2014	21	1.02
safety	29	2016	12	0.77
economic development	27	2016	10	0.69
transportation infrastructure	27	2016	8	0.61
access	26	2015	17	0.69
return	26	2015	11	0.82
technology	26	2016	13	1.08
influence	25	2015	23	1.23
effectiveness	23	2013	19	0.93
revenue	23	2016	12	0.69
road network	23	2015	13	0.69
financing	21	2014	12	0.71
highway investment	21	2018	19	0.87
interest	21	2015	10	0.80
stakeholder	21	2017	8	1.02
accessibility	20	2015	19	1.22

4. Discussion

Transportation infrastructure represented by highways can be utilized for investment management. The global trend increasingly involves the adoption of public–private partnership (PPP) models for the provision of public infrastructure and services, particularly in the realm of transportation infrastructure [44,45]. The PPP model unites the strengths of both the public and private sectors to address infrastructure supply shortfalls [46]. The application of PPP models in transportation infrastructure development has made significant progress worldwide [47]. Zhang et al. [48] employed a dynamic infrastructure PPP project strategic management financing model to investigate the dynamic relationship between financing strategies and project performance. Feng et al. [49] posit that investors in PPP highway projects primarily recoup their investments through toll revenues during the operational phase. Mac’ario et al. [44], using the example of Portugal, analyzed the factors contributing to the success and failure of applying PPP models to provide transportation infrastructure. Zhang et al. [48] developed a strategic management financing model for infrastructure PPP projects, which utilizes system dynamics (SD) to explore the dynamic relationship between project performance and financing strategies. Goh et al. [5], using Western Australia as a case study, evaluated highway infrastructure investment through the utilization of the fuzzy analytical hierarchy process (Fuzzy AHP) and life cycle cost analysis (LCCA).

Transportation infrastructure, represented by highways as a prominent example, can facilitate economic development. Infrastructure is one of the most important aspects of increasing the country’s gross domestic product (GDP) through the development of various businesses [50]. Firstly, transportation infrastructure stimulates demand for goods

and services [51]. Secondly, it efficiently reduces travel time, thereby saving both time and costs [52]. Thirdly, transportation infrastructure can attract foreign investors into the domestic market [53]. Duranton and Turner [54], focusing on the impact of transportation infrastructure, developed a dynamic model to examine the relationship between transportation infrastructure and urban growth, investigating the effects of road investments on economic development. Fan and Chan-Kang [55] discovered that infrastructure investment promotes economic growth and poverty alleviation in China. Lall [56] identified transportation infrastructure as a crucial determinant of economic growth in the Indian region. Cain [57] explored the connection between infrastructure investment and U.S. economic development, and Herranz-Loncan [58] found positive promoting effects of infrastructure investment on economic growth during the late 19th and early 20th centuries in Spain. Zhang and Cheng [59], utilizing a vector error correction model (VECM), uncovered diverse roles played by transportation infrastructure in the economic growth of the UK. Hong et al. [51], using panel data from 1998 to 2007 encompassing 31 provinces in China, researched the impact of transportation infrastructure on Chinese economic growth, affirming its significant role. Wang et al. [60] studied the impact of transportation infrastructure on economic growth at the national and regional levels in the countries along the Belt and Road by constructing a spatial weight matrix (SWM). It was found that transportation infrastructure plays an active role in facilitating the economic growth of the countries along the Belt and Road.

Transportation infrastructure represented by highways can also be employed for risk management purposes. Osman [61] utilized a probabilistic life cycle cost analysis (LCCA) decision framework for infrastructure projects. Through Monte Carlo simulation, two distinct highway investment opportunities with differing risk and return profiles were analyzed. Han et al. [62] proposed a methodological framework to assess investment risks in PPP toll highway projects, employing Monte Carlo simulation to evaluate the overall project risk. Pantelias et al. [63], using a quantile-based approach, formulated a methodological framework for evaluating the financial feasibility of transportation infrastructure projects, subsequently employing this framework to examine the impact of various financing scenarios on investment risks in highway PPP projects. Kumar et al. [64] utilized a Monte Carlo simulation-supported net present value (NPV) risk model to analyze the financial risks involved in 30 PPP-based highway projects. Ashuri et al. [65] identified traffic demand risk as one of the most important risk factors in the operational phase of highway PPP projects. Zheng et al. [66] explored critical risk factors influencing the risk value ratio (RVR) measurement in highway PPP projects using a conceptual model comprising two risk dimensions (four risk categories) and 29 indicators. Liu et al. [67] studied 15 highway infrastructure investment projects over the past decade and established an investment risk index system.

5. Conclusions

The highway constitutes a pivotal component of infrastructure development, thus understanding its investment paradigms is of paramount significance to further fortify pertinent research endeavors. To comprehensively comprehend the extant research landscape, this study employed VOSviewer to conduct a retrieval of 614 journal articles published between 2013 and 2023 on the Web of Science database, assessing them in terms of five dimensions: source journals, co-authors, countries/regions, article citations, and co-occurring keywords, and subsequently constructing pertinent network visualizations. Findings elucidated *Transportation Research Record* as the most influential journal in the realm of infrastructure highway investment. Additionally, Bullock, Darcy M. from Purdue University emerged as the most prolific contributor in terms of article count. In the context of countries/regions, the United States spearheaded research output, wielding substantial contributions to the advancement of infrastructure highway investment. Simultaneously, China, the United Kingdom, and Canada also exerted noteworthy roles. Among the outcomes, it is evident that Benjamin Faber garnered the highest citation and normal-

ized citation counts. Analysis of keyword co-occurrences delineated primary clusters within infrastructure highway investment research, encompassing terms such as “highway project”, “risk”, “infrastructure investment”, “economy”, and “program”. Keywords like “risk”, “influence”, “investment decision”, and “infrastructure investment” commanded heightened attention.

Overall, the research findings presented in this study contributed to a more comprehensive understanding of the current state of highway investment and key issues concerning it for researchers and scholars. These provide data to support future research.

Firstly, this study conducted a scientometric analysis of the existing literature on highway investment, so researchers can gain a deeper understanding of the status of research on articles related to highway investment from this study.

Secondly, this study presented results by analyzing source journals, co-authors, countries/regions, article citations and co-occurring keywords. By analyzing dimensions such as co-authors, collaborating countries/regions, etc., researchers can identify potential partners with whom to collaborate. By analyzing citation relationships between articles, researchers can know whose studies are important for highway investment. By analyzing co-occurring keywords, researchers can identify key concerns within the field of highway investment. Therefore, future researchers can gain more comprehensive data insights and understand trends in articles related to highway investment from multiple dimensions simultaneously.

Thirdly, this study utilized an analytical approach that collected data through the Web of Science database and generated visual networks using VOSviewer which can provide more value to other researchers. Bibliometric analysis and visual exploration using VOSviewer can help researchers better understand the current state and future trends in their field, leading to more targeted future research plans and collaborations and increased research efficiency and impact.

Lastly, researchers and academics could gain the maximum benefit from the article. This study can help them understand the latest research trends on highway investment, key authors in the field, and important journals and relevant keywords, which could help them to better target their research interests, find suitable partners and publish their research results.

However, this study is not without its limitations. First, this study only searched for articles from 2013 to 2023, which may limit the study’s external validity. In addition, it solely conducted searches on journal articles within the Web of Science database, neglecting other databases, such as Scopus and CNKI, which could lead to incomplete data and overlook valuable research from other databases. Consequently, future investigations could expand the scope of data sources to address this constraint.

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