UNIVERSIDAD DE LAS PALMAS
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Bibliometric Mapping: A Sino-Centric Synthesis of HSR Passenger Preferences, Resilience Gaps, and Air-Rail Intermodal Integration

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(Universidad de Las Palmas de Gran Canaria)

Thesis for the Degree of

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Contents

List of Figures

List of Tables

Abstract

This doctoral thesis integrates the main contributions from four papers studying high-speed rail (HSR), addressing critical gaps in understanding passengers' preferences, bibliometric trends, resilience of HSR systems, and Air-Rail Intermodal Transport (ARIT). Using systematic literature review and advanced bibliometric tools (such as Latent Dirichlet Allocation (LDA) modelling, CiteSpace, Python, and Visual Studio Code), we analysed these topic-related publications from Scopus, Web of Science, and CNKI. The key findings show that passengers prioritise travel time, travel cost, frequency, and in-vehicle time. There is a significant gap in coping with freight logistics and emerging competitors (such as maglev trains). Bibliometric analysis illustrates that China holds a dominant position in the HSR sector, with Beijing Jiaotong University leading in institutional contributions. Core journals include Transportation Research Part A and Transport Policy, and prolific authors like Pagliara Francesca and Albalate Daniel lead the field. The resilience study emphasises the increasing importance of HSR on spatial resilience and economic recovery, resilience through transportation mode integration, resilient transportation systems, and resilient environmental infrastructure. The ARIT research highlights that China places greater focus on infrastructure optimisation, while the global emphasis is on sustainability and passenger satisfaction. Emerging trends include cross-border transportation, e-commerce logistics, and climate adaptation strategies. This dissertation provides the first holistic overview of the current state of knowledge linking HSR preferences, resilience, and intermodality, offering actionable insights for researchers and stakeholders.

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To my tutor and thesis director, Prof. Juan Carlos Martín, I owe my deepest gratitude. You were more than a supervisor; you were the guardian of my academic survival. You have consistently demonstrated your profound expertise, unwavering patience, insightful critiques, and constant encouragement. My 5-year doctoral journey has not been easy, to be honest, I thought about giving up many times since I have been through the COVID-19 pandemic alone in Las Palmas de Gran Canaria and far away from my family (who are in China), twice-rejected my student residence permit by the Spanish government which hardly derailed my dreams, working two jobs with no weekends per week, etc. You understand all of my physical and mental challenges, and you never pressured me on my academic manuscripts. Despite unsuccessful attempts to find collaboration opportunities with professors or scholarships across China, you never gave up. When my manuscripts faced unjust rejections, you wrote directly to the editor with conviction to defend me. Whenever you find opportunities that could help my research journey, you always share them with me and support me, such as presenting our papers at international conferences. These chances did not just make me better at academic talks—they opened my eyes to new ways of thinking. You have always been there to help and guide me, regardless of whether it’s late at night, at a weekend, or even on a public holiday.

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consistently helped me: despite the 7-8 hour time difference, you always answered my questions; you downloaded research papers and materials for me that I couldn't access; you line-edited my academic drafts and taught me how to write more clearly; before the presentation of my first international conference, you stayed up late to conduct video rehearsals with me; during my final symposium presentation, you paused your meeting to attend mine and took notes on other presenters' key points for me to peruse. What I treasure most is the conference paper we co-authored and published in 2025, which is a tangible testament to our ten-year friendship.

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To my precious younger brother, I wholeheartedly thank you for your silent support and dedication. You are a remarkably sensible, kind, careful, and intelligent young man. Although we rarely communicate, we know our bond is eternal. Your presence with our parents lifted worries from my shoulders, turning my dreams into realities.

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1

1 Introduction

Since its first operation on Japan's Tokaido Shinkansen in 1964, high-speed rail (HSR) has revolutionised global transportation networks, combining unprecedented speed, safety, and sustainability (D. Wu & Martín, 2022a, 2025b). By 2023, the operating mileage of China's HSR network exceeded 45,000 km (Bai et al., 2025), covering 93% of cities with a population of more than 500,000, underscoring its role as the backbone of intercity transportation (P. Chen et al., 2024). The rapid expansion of HSR infrastructure has triggered intense modal competition, especially with air transport (Mizutani & Sakai, 2021). According to the "Long-Term Railway Network Plan", by 2025, China's HSR network will have 38,000 kilometres of passenger-only lines, and about 80% of China's domestic aviation market will overlap with HSR lines (Bai et al., 2025). HSR systems become increasingly integrated into the fabric of contemporary societies, and HSRs have been analyzed from different perspectives of various disciplines including engineering, transportation, social sciences, computer science, environmental science, economics, business, tourism, management & accounting, mathematics, decision sciences, energy, telecommunications, information systems, and automation & control systems.

Despite this growth and success, key knowledge gaps exist. Passenger preference (PP) research still focuses mainly on traditional attributes such as travel time, cost, and frequency. In contrast, emerging factors such as environmental attitudes, flexible ticketing systems, and multimodal integration have not been fully explored. Meanwhile, even though HSR can optimise rail utilisation and integrate with modern logistics, its potential in freight logistics, as a "green alternative" for express freight, has been largely overlooked. Furthermore, the ability of HSR systems to endure and recover from disruptions (such as natural disasters, technical glitches, or broader socioeconomic and environmental pressures) has emerged as a pressing issue. The intersection of HSR and resilience remains underexplored. In addition, the competition and integration of air and HSR have been explored for decades. However, "Air-rail intermodal transport (ARIT)" as a research topic has gained increasing attention in recent years worldwide, and it is still in the infant stage, especially for the understanding of China's leadership role in the HSR sector. The main contribution of this dissertation is to address these gaps, mainly by conducting systematic literature and bibliometric literature reviews based on the data from WoS, Scopus, and CNKI to determine the current state of research, reveal the emerging trends, and explore the research frontiers.

In the following chapters of this dissertation, four papers will be presented, two of which have already been published in top journals, one has been published in the conference proceedings, and the other one is under review in an indexed international journal. The first paper applied a Latent Dirichlet Allocation (LDA) method to extract the topics of the selected documents and found the key factors that affect passengers' preferences. The second article used the CiteSpace software to generate knowledge maps and visualize the analysis of co-authorship, co-citation, and the keywords' co-occurrence to understand preferences or choices made by passengers. The third study conducted a comprehensive overview of the existing literature that delves into the research topic of the resilience of HSR systems. The fourth work provided a holistic understanding of the current state of knowledge on "Air-rail intermodal transport (ARIT)" from the perspectives of Chinese and international scholars by adopting Python and Visual Studio Code for visualization. Finally, the last chapter will conclude the main results and future research directions.

2

2 PAPER 1: Research on Passengers' Preference for High-Speed Railways (HSRs) and High-Speed Trains (HSTs)

Di Wu and Juan Carlos Martín *

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Abstract

This paper aims to study passengers' preference for High-Speed Railways (HSRs) and High-Speed Trains (HSTs) through a systematic literature review. The existing relevant literature was examined by using the Scopus application, and the Latent Dirichlet Allocation (LDA) method is applied to extract the topics of the selected documents. By comparing the contents of the relevant literature, the general overview of research in this field can be further understood, and the key factors that have been studied so far that affect passengers' preference can be analyzed. As a green, safe, and sustainable transport mode, HSRs do not only play an essential role in serving passengers but could also be a novel option for freight transport as long as HSRs are able to adjust their technology to the requirements of the rapid growth of the modern logistics industry. The evaluation of passengers' preference for HSRs/HSTs presents some gaps that need to be addressed in future studies: (1) the speed of the HST line ought to be introduced clearly; (2) more competing alternatives, such as maglev, autonomous vehicles, and other access–egress transport modes to terminals, such as subways and aero taxis, need to be included; (3) the analysis of passengers' preferences needs to be extended to the new role that HSRs can play in the logistics industry as new cargo services have been developed with the participation of HSRs; and (4) some attributes related to environmental costs and carbon emissions for the transport modes, as well as segmentation variables that are proxies for different passengers' attitudes towards climate change concerns, need to be included in the design of the choice experiment.
Keywords: passengers' preference; high-speed rail; high-speed train; systematic literature review; LDA model; high-speed express train; logistics industry; sustainability

2.1 Introduction

The term "transportation" can be interpreted with two different meanings ac-cording to the Cambridge English Dictionary: vehicles and people vs. vehicles and goods. These two different meanings are the origin of passenger and goods transport. Governments, experts, policymakers, and researchers need to study both transport markets in order to: (1) provide efficient transportation services; (2) develop more effective transportation policies; and (3) estimate the demand of consumers accurately. However, most of the existing and relevant research on High-Speed Railways (HSRs) has been mainly focused on passenger transport, and the analysis of goods transport is practically negligible.

It is well known that after their introduction, HSRs have mainly substituted for traditional or conventional railway services on developed routes as passengers' preferences for reducing the travel time are aligned with the railway service's improvement (Givoni, 2006). It is the safest transport system that has been developed in the world (Evazzadeh et al., 2020). The transport mode is also seen as green, safe, and sustainable, and the network also has important economic and social effects at the regional level (Cascetta et al., 2020a). The fast development of HSRs has brought about a novel option for freight transport, but this has not gained researchers' attention. It is time to analyze whether HSRs can be used to move express freight transport goods. Thus, the HSR capacity could be used more intensively, and the rapid growth of the modern logistics industry will be better serviced (Shao & Zhao, 2016).

The HSR industry can be considered a remarkable exception to the obsolescence of transport technologies as railways have evolved during the last few decades from being a Victorian anachronism destined to a secondary role in interurban transport to one of the basic transport technologies of the twenty-first century (Banister & Hall, 1993). Since the first HST launched on the Tokaido line in Japan between the cities of Tokyo and Osaka, the HST network has been expanded worldwide (Givoni, 2006). The emphasis on building new HST systems is a consequence of dealing with the relationships between climate change, transport, and space, in which the logic of speeding up and increasing efficiency through new road construction and expansion is losing support (Schwanen, 2019). In addition, HSRs present a number of comparative advantages with respect to other interurban transport modes, such as being more environmentally friendly (Chen et al., 2017). HSRs can contribute to environmental protection, have a low price, and provide a speedy transportation service for the express transportation market, which has extensive benefits both in the economy and society (Yu et al., 2018). The environmental costs, traffic congestion, and carbon emissions have dramatically increased in most of the countries of the world (Armah et al., 2010).

The paper aims to: (1) analyze through a systematic literature review passengers' preference for HSRs and HSTs; (2) examine the existing literature using the Scopus application; (3) understand the main alternatives and attributes that have been used; (4) obtain the main segmentation variables that have been used to analyze the heterogeneity in passengers' preferences; and (5) summarize the main findings that could expand future research.

To this end, first, the data were extracted from Scopus with the following keyords: TITLE-ABS-KEY (hst AND preferenc*) OR TITLE-ABS-KEY (hsr AND preferenc*). Consequently, a database that contains 143 related articles was obtained. Second, the Latent Dirichlet Allocation (LDA) method was applied to elicit the topics of the selected documents. Then, by summarizing the alphabetic abbreviations "HSR" and "HST", 65 documents were filtered in which "HSR" and "HST" mean "high-speed railway" and "high-speed train", respectively. Third, after reading the abstracts of the selected documents, a further refinement was made to select 24 articles that applied a Stated Preference method.

2.2 Bibliometric Analysis

2.2.1 Scopus Database

The information database about passengers' preference for HSRs and HSTs was obtained from Scopus, a citation platform launched by Elsevier Science in 2004 (Vieira & Gomes, 2009). It is a navigation tool that provides the world's largest curated, peer-reviewed abstract and indexing database with over 24,000 active titles indexed in August 2020. Scopus offers new refining and sorting features for researchers with bibliometrics tools that can track, analyze, and visualize research, covering the fields of Sciences, Social Sciences, Medicine, Technology, and Arts and Humanities (Boyle & Sherman, 2005).

A total of 143 documents were obtained by using TITLE-ABS-KEY (hst AND preferenc*) OR TITLE-ABS-KEY (hsr AND preferenc*) as the search keywords on Scopus. This strategy guaranteed that all the 143 documents contained those terms, in either the title (TITLE), abstract (ABS), or keywords (KEY). In addition, the following information for each study was also extracted: author, author(s) ID, title, year of publication, source title, volume, issue, page start, page end, page count, abstract, keywords, and document type.

To further filter the 143 documents, each abstract was read carefully, and the meaning of the acronyms in each article was summarized. Thus, 65 documents that dealt with high-speed railways or high-speed trains were further filtered to make an additional selection. The selection was based on whether the study conducted or did not conduct a "Stated Preference" (SP) experiment. Thus, 24 papers were specified as the target references of this paper for further analysis.

Figure 2.1 shows the number of articles published annually from the extracted database. It illustrates that the publication of the documents began in 1966. Tracing back through history, the world's first high-speed railway was the Tokaido Shinkansen from Tokyo, Japan, which opened for regular service in 1964 (Kawakami, 1966). Thus, if the subject of the only article published in 1966 is about a high-speed railway, then it can be assumed that the study referred to the Japanese Shinkansen.

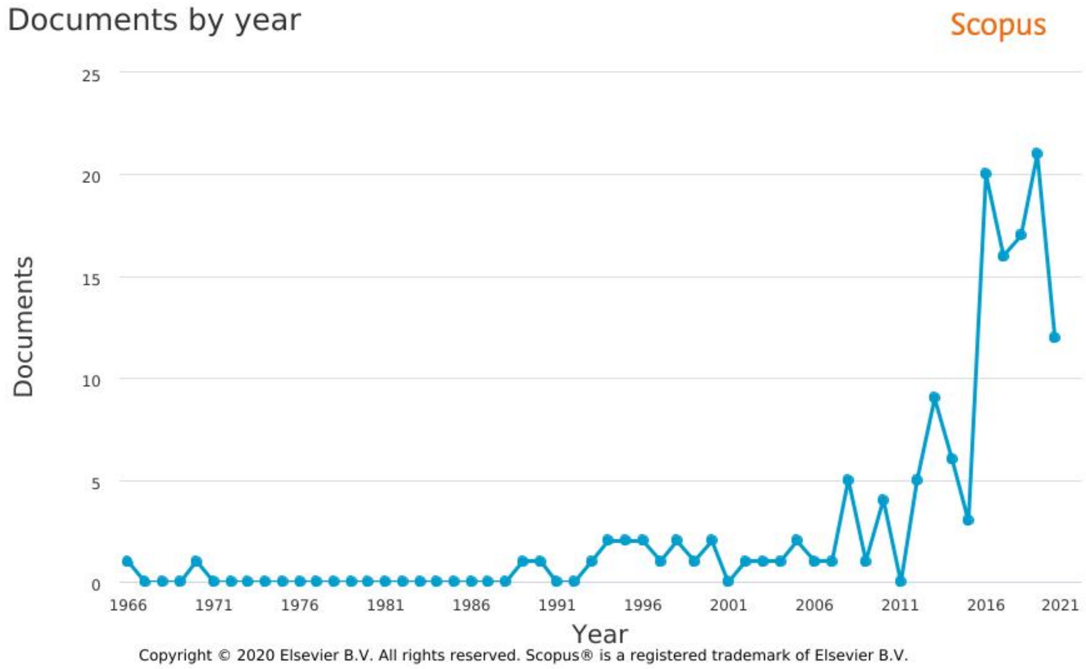

Figure 2. 1 The total number of published documents.

Figure 2.1 shows that from the year 1966 until the year 1991, there were only four published documents. From 1986 to 2001, there were some slight fluctuations in the curve with some ups and downs. In 2001, no papers were published. Then, an increasing trend of the curve occurs from 2008, in which the highest peak point for the period is observed in 2020.

2.2.2 Latent Dirichlet Allocation (LDA) Model

To determine the main topics studied by the selected papers, the Latent Dirichlet allocation (LDA) model was applied. The LDA model has been applied successfully within the computer sciences for information retrieval and text mining (Ponweiser, 2012). The LDA model was the first probabilistic topic model and was presented by Blei et al., 2003). More information can be obtained in other articles, e.g., (Blei & Lafferty, 2009; Griffiths & Steyvers, 2004). The fundaments of the model are based on the assumption that a document can be considered a collection of words, with no order or sequential relationship between words. A document can contain random mixtures of latent topics, and each word in the document is generated by one of the topics. For reducing each document in a given corpus, the LDA method can be used to extract a topic from the topic distribution of each document and a word from the word distribution corresponding to the extracted topic (Campbell et al., 2015).

Thus, the 143 abstracts were pre-processed by executing the Python programming language code on Google Colaboratory (Colab), which is a free-of-charge cloud service for disseminating data analysis, machine learning, and education (Carneiro et al., 2018).

Colab is an easy-to-use Chrome-browser-based collaboration tool that has two cell types (text cells and code cells), and the output appears below each cell directly (Tock, 2020).

Before training the LDA model, a Word Cloud image was made on Colab to provide an overview at first sight. Word Clouds depend on the frequency of words as follows: the more a specific word appears in a textual data source, the bigger and bolder it appears in the word cloud. A word cloud helps to determine whether a given text database is relevant in order to meet the specific information need (Heimerl et al., 2014). As shown in Figure 2.2, the biggest words are hsr, preference, high, speed, and hst. In principle, it seems that many of the 143 selected papers are related to high-speed railways. However, some smaller words are health, food, nutrient, and star. These words were unexpected and made the researchers cautious as other fields could have been part of the selected database; thus, the selected papers could have needed a further refinement.

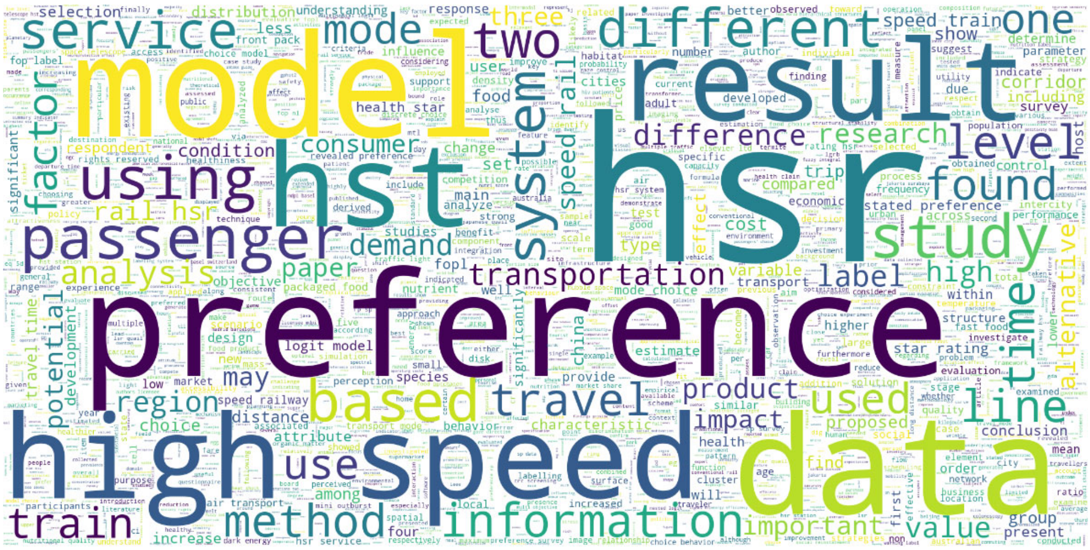

Figure 2. 2 Word Clouds image of the 143 abstracts.

2.3 Results

2.3.1 Results of the Database

The 143 articles were published in 106 publications. Figure 2.3 shows the five most prolific publications of these 106 sources. These five publications had published at least three articles during the period under analysis: Appetite (4); Nutrients (4); Transportation Research Part A Policy and Practice (5); The Astrophysical Journal (4); and The Astronomical Journal (3). Simultaneously, from Figure 2.3, we can see that the four documents published in Appetite were published from the year 2016 to the year 2018, the four documents published in Nutrients were published from the year 2017 to the year 2019, and the four documents published in Transportation Research Part A

Policy and Practice were published from the year 2014 to the year 2019. The names of some journals provide a piece of evidence that not all the domains of the 143 articles were related to transportation.

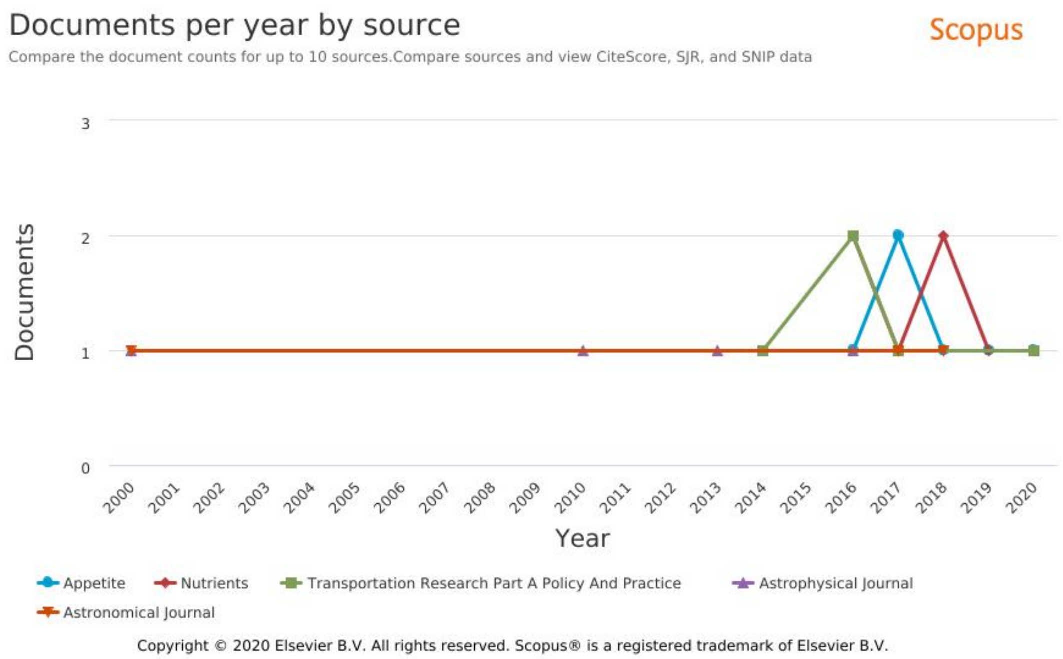

Figure 2. 3 The most productive sources.

The classification of the articles can be clearly seen in Figure 2.4. The three largest proportion distributions of the number of published documents are in Engineering (17.1%), Social Sciences (15.9%), and Earth and Planetary Sciences (7.4%) and Physics and Astronomy (7.4%). The percentage distributions of the Medicine, Nursing, Computer Science, Agricultural and Biological Sciences, Mathematics, Biochemistry, and other journal categories are 7.0%, 6.6%, 5.8%, 5.0%, 4.3%, 3.5%, and 20.2%, respectively.

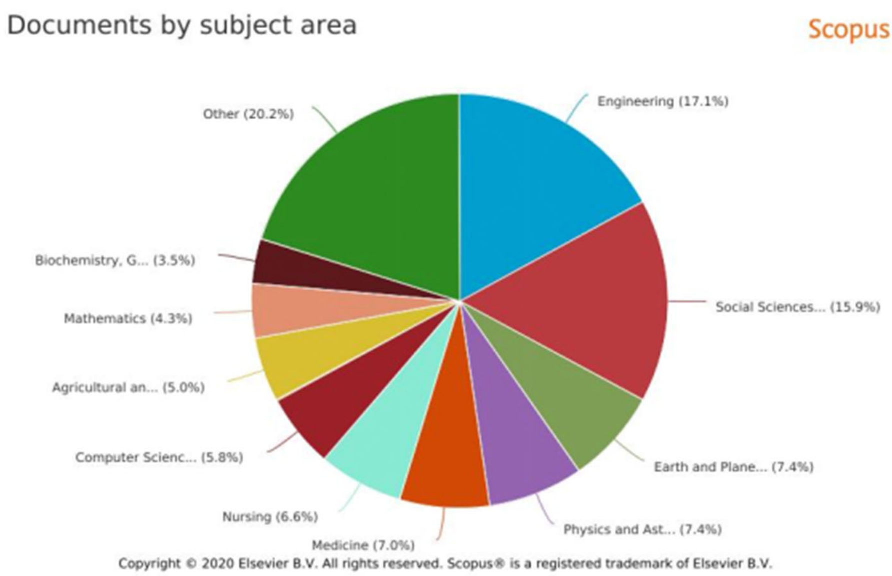

Figure 2. 4 The category analysis.

Figure 2.5 shows the most prolific authors in this field. We can see that (i) Pettigrew, S. is ranked in first place, with seven published articles; (ii) Pagliara, F., Román, C., and Talati, Z. were ranked in second place, with six published articles; (iii) and, finally, Martín, J.C. and Neal, B. were ranked in third place, with five published articles. Figures 2.1-2.5 have been obtained using Scopus through the analyze search results button.

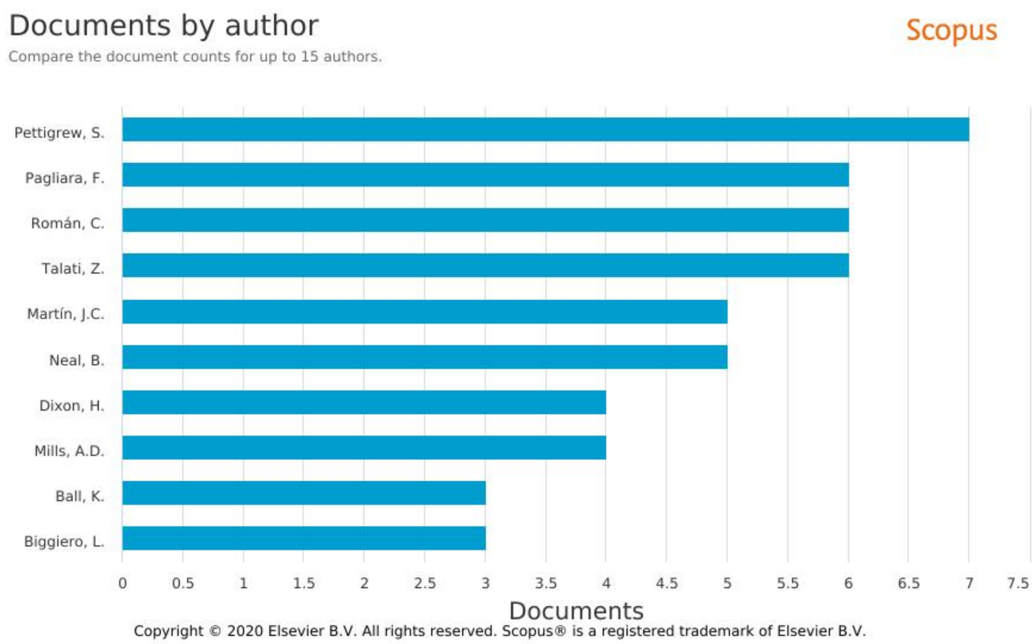

Figure 2. 5 The most prolific authors.

2.3.2 Results of the Latent Dirichlet Allocation (LDA) Model

So far, the results discussed above are all based on the Scopus database. The next step was to pre-process those abstracts to further extract the main topics of HSTs or HSRs. Tokenization and stop words removal are two basic procedures. The original text can be seen as a sequence of characters and, before doing any analysis of this corpus, sentences ought to be isolated. In order to isolate sentences, words have to be isolated from the original sequence of characters. This isolation of word-like units from a raw text is called tokenization. By performing tokenization, the character structure of units is recognizable, for instance, numbers, dates, and punctuation, and units will be subject to a morphological analysis (Grefenstette & Tapanainen, 1994). Stop words, such as "and", "but", "if", and "the", have a grammatical function and the same likelihood of occurring in textual materials, but are not relevant to the content of documents. It is a common practice to remove stop words for retrieval since they are not useful indicators of content (Wilbur & Sirotkin, 1992).

After pre-processing the 143 abstracts extracted from Scopus, a dictionary and a corpus are created as inputs to the Latent Dirichlet Allocation (LDA) model. The LDA model is an unsupervised method for capturing context-specific valences. The general and basic idea is that textual materials are represented as random latent topics, where each topic is composed of distributed words, and each word is a basic unit (Campbell et al., 2015). In this research, each abstract refers to a "document" in the literature, which is formed by a sequence of N words, w = (w1, w2, …, wN), where wN is the Nth word in the sequence. M documents form a corpus D = (d1, d2, …, dM), where dM is the Mth document of the collection. The LDA model is highly efficient because it can handle not only big data but also dis-aggregate periods with sparse data. It is more suitable because there is no need to make assumptions about the text structure, the language's grammatical properties, or the distribution of and relationships between words (Tirunillai & Tellis, 2014).

Python is a high-level programming language that supports modules and packages and has become very popular in recent bibliometric analyses. In the study, Colab, a code written following the standards and rules of Python, was used together with both NLTK and Gensim, two packages of Python.

The NLTK package of Python was adopted to remove the stop words at the pre-processing stage. NLTK is one of the commonly used Python packages for Natural Language Processing and one of the oldest packages. The default list of all the English stop words supported by NLTK was used with a list of added words that were specifically prepared for the study. Table 2.1 shows the 179 default English stop words of NLTK.

Table 2. 1 The 179 default English stop words supported by NLTK.

i, me, my, myself, we, our, ours, ourselves, you, you're, you've, you'll, you'd, your, yours, yourself, yourselves, he, him, his, himself, she, she's, her, hers, herself, it, it's, its, itself, they, them, their, theirs,

themselves, what, which, who, whom, this, that, that'll, these, those, am, is, are, was, were, be, been, being, have, has, had, having, do, does, did, doing, a, an, the, and, but, if, or, because, as, until, while, of, at, by, for, with, about, against, between, into, though, during, before, after, above, below, to, from, up, down, in, out, on, off, over, under, again, further, then, once, here, there, when, where, why, how, all, any, both, each, few, more, most, other, some, such, no, nor, not, only, own, same, so, than, too, very, s, t, can, will, just, don, don't, should, should've, now, d, ll, m, o, re, ve, y, ain, aren, aren't, couldn, couldn't, didn, didn't, doesn', doesn't, hadn, hadn't, hasn, hasn't, haven, haven't, isn, isn't, ma, mightn, mightn't, mustn, mustn't, needn, needn't, shan, shan't, shouldn, shouldn't, wasn, wasn't, weren, weren't, won, won't, wouldn', wouldn't.

Since there are no rules for identifying stop words, and any word can be chosen as a stop word for a specific purpose, more stop words can be added. On a sequence process, stop words could be added if researchers think that some words do not provide enough added value to the object of the study. As said, there are no magical recipes and the general trend is to move from the standard use of a large number of stop lists with 200–300 terms to small stop lists with 7–12 terms to no stop list (Schütze et al., 2008). To identify more stop words, we first performed the whole procedure of the LDA model by removing the 179 default English stop words and setting the output to obtain 50 topics with 30 frequent terms each. From the frequency of the 1500 terms, 300 of them were hand-filtered as stop words in order to obtain more accurate results in subsequent LDA runs (Table 2.2).

Table 2. 2 The 300 hand-filtered stop words for this study.

according, achieved, across, addition, additional, additionally, adopted, adopting, affect, affected, aim, al, allows, along, alongside, also, among, analyses, analysis, analyze, analyzed, answered, apparent, approach, appropriate, around, assessed, associated, assumed, atp, attempt, au, author, back, based, behalf, believed, best, calculated, ce, choosing, ci, cl, claim, claims, clearly, cm, cmb, col, collect, collected, combined, compete, conclusions, conducted, consider, considered, consistently, costs, cpcs, cr, criteria, current, currently, dce, demonstrate, demonstrated, depending, designed, detected, determine, determined, developed, dig, discussed, dls, dr, due, effect, eg, employing, eos, eq, er, error, estimate, estimates, et, eu, evaluated, even, ever, examined, example, exist, expected, explain, fact, far, fb, find, finding, findings, fine, following, fopls, found, front, gda, general, generally, generate, generated, given, good, gp, gphst, highly, however, hra, hree, hsp, identified, identify, ie, ii, implications, importance, important, improve, improved, improvement, imt, included, including, incorporate, increase, increased, indeed, indicated, indicators, influence, influenced, information, interpretive, introduced, investigate, investigated, investigation, ix, jeju, joint, kd, kj, labels, lccs, less, level, lgrbs, like, log, low, lower, lree, lsr, lt, main, make, mean, meaning, measure, method, methods, mini, modal, mode, model, models, mpacts, mrna, mtl, multi, near, new, nft, ngc, nice, nip, nl, non, novel, npsc, nutri, objective, objectives, obscured, observed, obtain, obtained, occur, occurring, od, one, optically, order, osa, overall, part, particularly, perceived, pgy, plp, point, potential, potentially, preferred, presence, present, presented, produced, product, promote, proposed, provide, psg, published, ras, ratings, rc, recently, reduce, ree, reflect, regardless, related, relatively, relevant, represent, research, reserved, respectively, result, resulted, results, review, scoring, second, selected, show, showed, shown, significantly, similar, slight, small, smaller, snia, snls, sobf, sr, ssb, stage, strategies, strategy, strong, studies, study, suggest, suggests, supporting, ta, terms, testing, therefore, thsr, thus, tll, together, total, towards, typically, understand, understanding, us, used, using, uv, versus, viewed, visuals, vs, warning, web, well, whether, widely, without, would, wr, york.

Gensim was used to create a LDA topic model for the 143 documents. Table 2.3 represents the outcome with 20 topics and 10 keywords form each topic, with a decreasing weight order. Table 2.3 indicates that the scope of some of the terms does not seem to be related to the object of the paper (passengers' preference for HSRs or HSTs). The suspicious words are highlighted in bold: (i) food, organic, eggs, sugar, health, and nutrition; (ii) stars, telescope, space, galaxy, cosmological, hubble, and cosmic; and (iii) salmon, animal, habitat, deer, wild, landscape, species, plant, savanna, termite, woody, soil, and forest.

Table 2. 3 The 20 topics (with 10 words each) of the 143 documents.

Topic	Keywords
1	hsr; fast; packaged; **food**; **organic**; hst; price; marine; sea; healthier
2	hsr; **eggs**; oviposition; foods; life; **sugar**; dose; fat; baby; age
3	railway; line; city; flows; transportation; net; speed; hst; gas; preference
4	hsr; utility; time; adult; trips; rail; travel; cost; line; commuting
5	hsr; fuzzy; humanoid; hst; genes; robots; navigation; cells; pyroptosis; functions
6	energy; hst; **stars**; **telescope**; luminosity; **space**; spectrum; **galaxy**; daylighting; hubble
7	temperature; **health**; hsr; heat; quails; **salmon**; arctic; tolerance; age; **animal**
8	hsr; social; line; choice; host; passengers; air; distribution; regions; discrimination
9	hsr; speed; high; travel; system; transportation; regions; workers; rail; distance
10	hsr; services; choice; rail; parents; transport; trip; demand; tourist; train
11	energy; neutrino; parameter; **cosmological**; number; **hubble**; **cosmic**; time; density; helium
12	elites; **habitat**; **deer**; passengers; ticket; crisis; Europeanness; **wild**; **landscape**; hsr
13	hsr; food; health; **nutrition**; consumers; products; star; quality; healthiness; daily
14	**species**; hsr; habitat; **plant**; **savanna**; **termite**; **woody**; sugar; **soil**; **forest**
15	hsr; high; rail; speed; travel; passengers; train; transport; conventional; intercity
16	stations; hst; train; hsr; surface; location; speed; urban; fast; transformer
17	hsr; hst; stability; structural; speed; intercity; rp; sp; corridor; train
18	travel; choice; train; hsr; passengers; distance; service; frequency; demand; pathway
19	travel; speed; choice; high; hsr; hst; transportation; time; passengers; train
20	hsr; transport; preference; speed; passengers; exclusion; rail; travel; air; access

2.3.3 A further Refinement of the Topics

All the 143 abstracts were meticulously read by one of the researchers to disentangle the strange words that appeared in bold in Table 2.3. Finally, it was possible to find that the well-known and profusely used acronyms HSR and HST in the literature on high-speed railways are also used in other fields. We found that, except for the 65 documents in which "HSR" and "HST" are related to high-speed railways, for the remaining 78 articles the acronyms referred to other different concepts. It was a surprise that the acronyms were used in 43 different contexts related to health, social, and science issues. Table 2.4 shows that the three main categories other than high-speed railways are: (1) Health Star Rating (18 documents); (2) Hubble Space Telescope (10 documents); and (3) High levels of Social Reinstatement behavior (5 documents). Furthermore, interestingly, three abstracts did not clearly state the meaning of HSR or HST, but they certainly were not related to passengers' preference for HSRs. The dubious words that appear in the list of 20 topics were found to be clearly related to different concepts that used the same acronym.

Table 2. 4 Meanings of the "HSR" and "HST" acronyms in the extracted Scopus abstracts.

Meanings of "HSR" or "HST"	Number of Documents
High-speed railway or high-speed train	65
Health Star Rating (HSR)	18
Hubble Space Telescope (HST)	10
High levels of Social Reinstatement behavior (HSR)	5

HanSaRam-IX (HSR-IX)	3
Hottest Spot Temperature (HST)	2
highstand systems tract (HST)	2
hydrostatic transmission	1
hump-shaped oviposition regulation (HSR)	1
human speech recognition (HSR)	1
human Serine racemase (hSR)	1
Hubble constant (HST)	1
HST/STIS	1
HST/GOODS	1
HST WFPC2 observations	1
HST solar cells	1
HST Guide Star Catalog	1
HSD and HST	1
host star	1
homogeneously staining region (HSR)	1
homogeneous shear turbulence (HST)	1
home stool test (HST)	1
home sleep testing (HST)	1
home safety toolkit (HST)	1
High-silica rhyolites (HSR)	1
highly specialized technology (HST)	1
Higher Specialist Training (HST)	1
high structural stability regions (HSRs)	1
high school class (HSR)	1
hierarchical structures for recommender systems	1
Herbaceous Species Richness (HSR)	1
Hemorrhagic shock and resuscitation (HSR)	1
heat storage tanks (HSTs)	1
heat shock response (HSR)	1
Health system responsiveness (HSR)	1
health services research (HSR)	1
Harvard Step Test (HST)	1
Handover Served Ratio (HSR)	1
Habitat Sharing Ratio (HSR)	1
H. syriacus (HSR)	1
local measurements (HST)	1
guinea pig adrenal hydroxysteroid sulfotransferase (gpHST2)	1
Others	3
Total number of documents	143

For this reason, a new LDA model was applied to only the 65 documents that really deal with high-speed railways. Table 2.5 presents the 20 topics with 10 words each for the new dataset. It shows that the suspicious words do not appear anymore, and that this list can now be used to provide interesting insights for the rest of the study.

The ultimate goal of transportation is sustainable development (Chang et al., 2018). The concept of sustainable transport was first proposed in 1996 by the World Bank and refers to accomplishing economic and financial sustainability, environmental and ecological sustainability, and social sustainability. Regarding the most frequent words shown in Table 2.5, though the data were collected from the perspective of passengers' preference for high-speed railways and high-speed trains, they indicate that some words (in bold) of some topics are related to the concept of HSRs as a sustainable transport mode. "Fuzzy" has been put in bold because the use of fuzzy models to evaluate sustainability is becoming very popular (Chang et al., 2018). For example, “environment”, “carbon”, and “emissions” appear in the second and fifth topics.

Table 2. 5 The 20 topics (with 10 words each) of the 65 documents related to high-speed railways.

Topic	Keywords
1	hsr; transportation; transport; tourism; business; service; futuroscope; speed; safety; leisure
2	train; hsr; passengers; air; transport; speed; infrastructure; services; **environment**; accessibility
3	hsr; trips; rail; services; travel; trip; business; distance; air; income
4	hsr; train; transfer; station; distance; railway; waiting; speed; travel; destination
5	hsr; speed; transportation; tourism; intercity; **carbon**; **emissions**; economic; capacity; security
6	revenue; hsr; train; railway; classes; fare; time; seats; transportation; speed
7	hsr; transport; economic; exclusion; rail; travellers; services; car; accessibility; speed
8	speed; trains; travel; railway; machine; software; class; seats; income; harmony
9	rail; passengers; integration; speed; air; economic; **energy**; **sustainable**; schedule
10	hsr; travel; speed; intercity; business; rail; future; security; tourism; economic
11	hsr; services; travel; tourist; trip; tourism; access; **emissions**; **dioxide**; **carbon**
12	corridor; competition; hsr; speed; welfare; cost; technology; business; bus; fare
13	hsr; speed; travel; intercity; service; **fuzzy**; economic; capacity; tourism; security
14	train; frequency; accessibility; cities; techniques; distribution; connectivity; speed; transportation; vehicles
15	exclusion; hsr; time; transport; speed; economic; rail; mobility; stations; passengers
16	high; travel; speed; trains; railway; software; machine; income; transportation; age
17	hsr; fare; speed; high; train; pricing; ticket; capacity; aircraft; seat
18	speed; hst; hsr; train; workers; **fuzzy**; **energy**; commuting; reliability; comfort
19	hsr; spatial; speed; rail; transport; equity; accessibility; economic; sp; rp
20	speed; intercity; travel; train; railway; trips; car; **fuzzy**; machine; software

The number of documents published annually for the new dataset was analyzed and is presented in Figure 2.6. The first paper about passengers’ preference for HSRs or HSTs was published in 2002. In comparison with Figure 2.1, Figure 2.6 demonstrates that the contents of documents published from 1966 to 2001 are not related to high-speed railways. In other words, the article published in 1966 was not about the Japanese Shinkansen. Furthermore, the number of articles dealing with passengers’ preference for HSRs published in 2016 and 2017 started to increase significantly compared with previous years. In addition, 2019 was the most productive year with 12 documents.

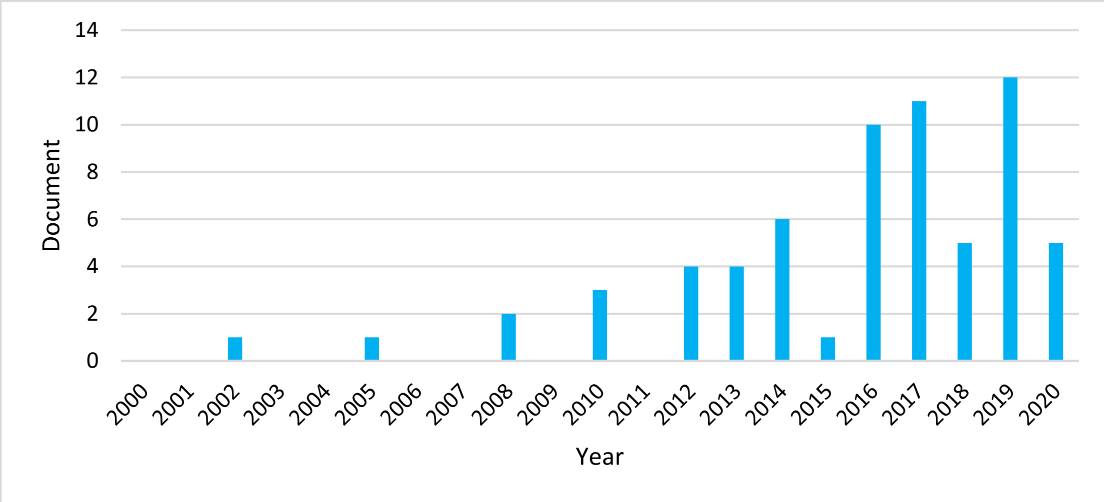

Figure 2. 6 The number of documents published annually.

The SP method is a survey method that measures individuals' preferences and demand for non-market alternatives based on hypothetical choice situations (Aizaki et al., 2014). In other words, this approach is particularly suitable for estimating demand when one of the considered alternatives does not exist (Bergantino & Madio, 2020). Thus, experimental designs could include more information in the choice tasks. Each interviewer is asked for their choice when they are faced with different situations (Putri & Widyastuti, 2019). It might be a reasonable way to analyze what alternatives and attributes the previous authors who applied the SP method had adopted to measure passengers' preferences for HSRs or HSTs.

The selection of the 24 documents written in English that use the SP method to analyze passengers' preferences for HSR services provides very interesting information regarding the authors of the articles, the alternatives used in the choice sets, the attributes used to characterize the alternatives, the locations in which the authors conducted the surveys, and the main results.

Table 2.6 lists the authors of each article and assigns a number to each document that will be used as a label to create other tables more efficiently. It shows that four authors, Pagliara F., Román C., Martín J.C., and Biggiero L., also appear in Figure 2.5 as the most prolific authors in the field. In addition, the first paper was published in 2002 and this information coincides with Figure 2.6.

Table 2. 6 Authors of the 24 papers.

No.	Authors
(1)	Bergantino A. S. and Madio L. (Bergantino & Madio, 2020)
(2)	Cheng Q., Deng W., and Hu Q. Z. (Cheng et al., 2019)
(3)	Putri A. L. and Widyastuti H. (Putri & Widyastuti, 2019)
(4)	Raturi V. and Verma A. (Raturi & Verma, 2019)
(5)	Zuo Z. and Pan X. F. (Zuo & Pan, 2019)
(6)	Nurhidayat A. Y., Widyastuti H., and Utomo D. P. (Nurhidayat et al., 2018a)
(7)	Biggiero L., Pagliara F., Patrone A., and Peruggini F. (Biggiero et al., 2017a)

(8)	Brida J. G., Martín J. C., Román C., and Scuderi R. (Brida et al., 2017a)
(9)	Cartenì A., Pariota L., and Henke I. (Cartenì et al., 2017a)
(10)	Kusuma A., Tinumbia N., and Bakdirespati P. L. (Kusuma et al., 2017)
(11)	Muro-Rodríguez A. I., Perez-Jiménez I. R., and Gutiérrez-Broncano S. (Muro-Rodríguez et al., 2017)
(12)	(Raturi & Verma, 2017) V. and Verma A. (Raturi & Verma, 2019)
(13)	Sperry B. R., Burris M., and Woosnam K. M. (Sperry et al., 2017a)
(14)	Cascetta E. and Coppola P. (Cascetta & Coppola, 2016)
(15)	Lee J. K., Yoo K. E., and Song K. H. (Lee et al., 2016a)
(16)	Li Z. C. and Sheng D. (Li & Sheng, 2016)
(17)	Zhao W. Y., Zhu H. G., and Hu D. W. (Zhao et al., 2016)
(18)	Barreira Á., Reis V., and Macário R. (Barreira et al., 2013)
(19)	Kuo Y. W., Hsieh C. H., Feng C. M., and Yeh W. Y. (Kuo et al., 2013)
(20)	Yao E. J., Yang Q. R., Zhang Y. S., and Dai H. N. (Yao et al., 2013)
(21)	Yao E. J., Yang Q. R., Zhang Y. S., and Sun X. (Yao et al., 2013)
(22)	Pagliara F., Vassallo J. M., and Román C. (Pagliara et al., 2012)
(23)	Yang C. W. and Sung Y. C. (Yang & Sung, 2010)
(24)	Yao E. J., Morikawa T., Kurauchi S., and Tokida T. (Yao et al., 2002)

Table 2.7 indicates the publication year of the 24 studies. It can be seen that 2017 is the most prolific year, followed by 2013, 2016, and 2019. It is also worth noting that two gap periods exist: one between 2002 and 2010 and the other between 2013 and 2016.

Table 2. 7 Analysis of the publications by year.

Year	Counts	Papers
2020	1	(1)
2019	4	(2–5)
2018	1	(6)
2017	7	(7–13)
2016	4	(14–17)
2013	4	(18–21)
2012	1	(22)
2010	1	(23)
2002	1	(24)

Table 2.8 shows the counts of published papers according to the countries that were analyzed. China is the most prolific country (16 publications), followed by Italy (4 publications) and Spain and Indonesia (3 publications each). The remaining countries are India, Japan, South Korea, and the United States. It is interesting to note that there was only one research paper (No. 18) that studied passengers' preference for HSRs in two countries (Spain and Portugal).

Table 2. 8 Analysis of the publications by country.

Country	Counts	Papers
China	8	(2,5,16,17,19,20,21,23)
Italy	4	(1,7,9,14)
Spain	3	(8,11,22)
Indonesia	3	(3,6,10)
India	2	(4,12)

Japan	1	(24)
South Korea	1	(15)
United States	1	(13)
Spain and Portugal	1	(18)

Table 2.9 summarizes the alternatives used in the 24 publications. According to the data in Table 2.9, 23 studies are based on modal competition between HSRs and other existing transport modes, such as road transport (bus and private car) (15 publications), air transport (13 papers), and conventional rail (11 studies). Interestingly, there is only one paper (No. 8) that does not use HSRs as an alternative because the authors included the multimodal Air–HSR and Air–Air alternatives to analyze the competitiveness of the modal integration of HSR and air transport that is now being developed in some of the most important airports in the world.

Table 2. 9 Analysis of the publications by alternatives.

Alternative	**Counts**	**Papers**
HSRs	23	(1–7,9–24)
Road Transport	15	(1,4,7,10,11,12,14,17–24)
Air transport	13	(1,4,6,7,14,15,16,18,20–24)
Conventional rail	11	(1,4,5,7,9,10,17,20,21,23,24)
Multimodal Air–HSR	2	(8,16)
Air–Air	1	(8)

Table 2.10 shows the attributes included in the 24 papers by different transport modes: (a) HSR; (b) Bus; (c) Air Transport; (d) Conventional rail; and (e) Private Car. For the Time and Cost (Price) attributes, sub-categories were established according to the specific perspectives that authors took for their research purposes.

Regarding Table 2.10a (HSR), all 24 papers considered Time and Cost to be essential attributes. This is not a surprise in studies on transport economics, as these are the two main components in the definition of generalized price. In the Time group, the top three attributes were Travel time (16 articles), Access/egress time (5 papers), and In-vehicle time (4 papers). In the Cost group, 16 studies adopted Travel cost as an attribute. Furthermore, the Price of tickets can also be considered a cost, but as the original nomenclature was used in the table, this attribute ranks in third place (it was adopted in 10 papers). Herein, the Fare integration attribute in Paper 8 is a remarkable one, as is the Baggage integration attribute, since Paper 8 estimates the multimodal Air–HSR and Air–Air alternatives as mentioned above. In addition, the Frequency attribute appeared in the attribute lists of nine papers.

According to Table 2.10b (Bus), Time is a vital attribute and was included in 11 papers. Among those, eight articles analyzed the Travel time attribute, and two examined the In-vehicle time attribute. The Cost category ranks in second place with 10 studies, nine of which analyzed the Travel cost attribute. Moreover, Frequency and Price are crucial attributes and were included in four and three papers, respectively.

Similar to Table 2.10a (HSR), Table 2.10c (Air Transport) shows that the top four most important attributes are Time (13 papers), Cost (10 papers), and Price and Frequency (both with 6 studies). In the sub-categories of the Time group, Travel time (seven studies), Access/egress time (five studies), and In-vehicle time (three studies) were again important attributes. Nine papers included Travel cost as an attribute. As mentioned in Table 2.10a (HSR), Fare integration and Baggage integration were only included in Paper 8. Additionally, Duty-free shopping availability is a novel attribute that was analyzed in Paper 15.

Table 2.10d (Conventional rail) shows that: (i) 11 papers included the Time attribute, 6 and 2 of which included Travel time and In-vehicle time, respectively; (ii) eight papers considered the Cost attribute, especially Travel cost; (iii) four papers involved the Price attribute; and (iv) the Frequency attribute appeared in four papers.

Table 2.10e (Private Car) presents the following top three vital attributes: Time (nine papers); Cost (seven papers); and Price (three papers). Similarly to other transport modes, Travel time and Travel cost were the most considered attributes (five studies each). Differently from the above-mentioned modes, Frequency is not an attribute that could characterize this transport mode.

Table 2. 10 Analysis of the publications by attributes included by mode.

(a) HSR		
Attributes	**Counts**	**Papers**
Time	24	(1–24)
Travel time	16	(2,5,6,9–15,19–24)
Access/egress time	5	(7,8,14,16,23)
In-vehicle time	4	(1,4,8,16)
Total travel time	3	(3,11,18)
Departure time	2	(2,23)
Connecting time	2	(8,16)
Waiting time	2	(17,23)
Out-vehicle travel time	1	(4)
Ticket sold-out time	1	(5)
After-train time	1	(5)
Arrival time	1	(5)
Prob. of 2 h delay	1	(5)
Average headway	1	(14)
Cost	24	(1–24)
Travel cost	16	(3,4,7,8,10,11,13,15,16,17,19,20,21,22,23,24)
Access/egress cost	1	(7)
Operating cost	1	(12)
Cost reimbursed/not reimbursed	1	(14)
Early/late schedule penalty	1	(14)
Price (Cost)	10	(1,2,4,5,6,7,8,9,15,18)
Fare integration	1	(8)
Frequency	9	(1,3,4,9,15,18,22,23,24)
Service	4	(9,13,14,17)
Reliability	3	(1,19,22)
Comfort	3	(17,19,22)
Accessibility	2	(3,19)
Ticket type	2	(5,23)
Safety	2	(15,17)
Companion	1	(5)
Baggage integration	1	(8)

Distance	1	(9)
Capacity	1	(12)
High professional condition	1	(14)
Rapidness	1	(17)
Convenience	1	(17)
Seat pitch	1	(18)
Hand luggage space	1	(18)
Noise level	1	(18)
Efficiency	1	(19)
(b) Bus		
Attributes	**Counts**	**Papers**
Time	11	(1,4,7,10,11,12,18,20,21,22,23)
Travel time	8	(10,11,12,18,20,21,22,23)
In-vehicle time	2	(1,4)
Out-vehicle travel time	1	(4)
Access/egress time	1	(7)
Total travel time	1	(18)
Cost	10	(4,7,10,11,12,20,21,22,23,24)
Travel cost	9	(4,7,10,11,20,21,22,23,24)
Access/egress cost	1	(7)
Operating cost	1	(12)
Frequency	4	(1,18,23,24)
Price (Cost)	3	(1,7,18)
Reliability	1	(1)
Capacity	1	(12)
Seat pitch	1	(18)
Hand luggage space	1	(18)
Noise level	1	(18)
(c) Air Transport		
Attributes	**Counts**	**Papers**
Time	13	(1,6,7,8,14,15,16,18,20–24)
Travel time	7	(6,14,15,20–23)
Access/egress time	5	(1,7,8,14,16)
In-vehicle time	3	(1,8,16)
Connecting time	2	(8,16)
Average headway	1	(14)
Total traveling time	1	(18)
Line-haul time	1	(24)
Terminal time	1	(24)
Cost	10	(7,8,14,15,16,20–24)
Travel cost	9	(7,8,15,16,20–24)
Access/egress cost	1	(7)
Cost reimbursed/not reimbursed	1	(14)
Early/late schedule penalty	1	(14)
Price (Cost)	6	(1,6,7,8,15,18)
Fare integration	1	(8)
Frequency	6	(1,15,18,22,23,24)
Reliability	2	(1,22)
Baggage integration	1	(8)
High professional condition	1	(14)
Safety	1	(15)
Duty-free shopping availability	1	(15)
Seat pitch	1	(18)
Hand luggage space	1	(18)
Noise level	1	(18)
Comfort	1	(22)
(d) Conventional Rail		
Attributes	**Counts**	**Papers**
Time	11	(1,4,5,7,9,10,17,20,21,23,24)

Travel time	6	(5,9,10,20,21,23)
In-vehicle Time	2	(1,4)
Out-vehicle travel time	1	(4)
Ticket sold-out time	1	(5)
After-train time	1	(5)
Arrival time	1	(5)
Prob. of 2 h Delay	1	(5)
Access/egress time	1	(7)
Waiting time	1	(17)
Line-haul time	1	(24)
Terminal time	1	(24)
Cost	8	(4,7,10,17,20,21,23,24)
Travel cost	8	(4,7,10,17,20,21,23,24)
Access/egress cost	1	(7)
Price (Cost)	4	(1,5,7,9)
Frequency	4	(1,9,23,24)
Reliability	1	(1)
Ticket type	1	(5)
Companion	1	(5)
Distance	1	(9)
Comfort	1	(17)
Safety	1	(17)
Service	1	(17)
Rapidness	1	(17)
Convenience	1	(17)

(e) Private Car

Attributes	Counts	Papers
Time	9	(1,4,7,10,11,14,18,20,21)
Travel time	5	(10,11,14,20,21)
In-vehicle time	2	(1,4)
Access/egress time	2	(7,14)
Out-vehicle travel time	1	(4)
Average headway	1	(14)
Total travel time	1	(18)
Cost	7	(4,7,10,11,14,20,21)
Travel cost	5	(4,7,10,11,20,21)
Access/egress cost	1	(7)
Cost traveling alone/with party	1	(14)
Early/late schedule penalty	1	(14)
Price (Cost)	3	(1,7,18)
Reliability	1	(1)
High professional condition	1	(14)
Service	1	(14)
Frequency	1	(18)
Seat pitch	1	(18)
Hand luggage space	1	(18)
Noise level	1	(18)

The five sub-tables of Table 2.10 indicate that Travel time, Travel cost, and Price are the most important attributes of different passengers' transport modes that have been used by researchers when they analyzed the modal competition between HSRs and other transport modes. Other important attributes are Frequency, In-vehicle time, and Access/egress time. Finally, certain attributes, such as Departure time, Waiting time, Access/egress cost, Operating Cost, Reliability, Comfort, Ticket type, Capacity, Rapidness, Seat Pitch, Hand Luggage Space, and Noise Level, are attributes that have been less used in the literature. It seems obvious that passengers can make some tradeoffs with the secondary attributes as long as the travel time, travel cost, and ticket price, which determine the generalized cost, are within an acceptable range. It is interesting to note that researchers have not included any attributes related to sustainable transport, such as emissions, energy use, fuel consumption, and pollutants.

Table 2.11 summarizes the socio-demographic variables used to analyze heterogeneity in passengers' preferences. The top three variables are Age, Income, and Trip purpose, which are included in 12 papers, respectively. Career and Gender are two important variables, each of which is involved in eight papers. Education (five papers) and Trip frequency (four papers) are not considered to be as important as the previously mentioned variables. Number of Household vehicles, Number of children in the household, Pieces of checked bags, and Driving experience do not play an essential role in the studies. As stated above, it is remarkable that researchers have not used any type of variable that would act as a proxy for passengers' attitude towards climate change. For example, there are interesting social movements, such as 'Fridays for future' or 'flight shame' led by the young Swedish activist Greta Thunberg, that put emphasis on passengers' responsibility for reducing our personal footprint on the planet. It is time to make the necessary changes to minimize energy-intensive and environmentally problematic trips.

Table 2. 11 Analysis of the publications by segmentation variables.

Variables	Counts	Papers
Age	12	(1,2,3,8,13,16,17,19–23)
Income	12	(1,2,3,6,8,13,16,17,20–23)
Trip purpose	12	(1,3,6,8,15–18,20,21,22,24)
Career	8	(1,2,3,6,17,20,21,23)
Gender	8	(1,2,3,6,8,13,17,23)
Education	5	(2,6,8,13,19)
Trip frequency	4	(1,3,8,17)
Household vehicles	2	(13,19)
Number of children in household	2	(13,19)
Financial source	1	(2)
Consideration of ease of mode and mobility	1	(3)
Consideration of time and speed	1	(3)
Pieces of checked bags	1	(8)
Image package viewed	1	(13)
Number of adults in household	1	(13)
Driving experience	1	(19)

2.4 Existing Gaps

This paper aims to analyze the passengers' preference for HSRs and HSTs through a systematic literature review. In this section, several existing gaps are identified based on the obtained results.

2.4.1 Speed of HSRs

It is known that there is no uniform definition for the term “high-speed railways” across the world. For example, the Japanese government issued the “National Shinkansen Railway Development Act No. 71” in 1970. The definition of “Shinkansen railway” in this Act means that an artery railway is capable of operating at a maximum speed of more than 200 km/h in the predominant part of the railway. In mainland China, according to Article 107 of the Regulations on Railway Safety Management, the term “high-speed railway” refers to a passenger-train-dedicated railway that is designed to operate at a speed of more than 250 km/h and has an initial operation speed of no less than 200 km/h.

Comparing only the different definitions of HSRs in these two countries, HSRs in China are apparently faster than those in Japan. Therefore, as there are different speed standards for HSRs in each country, it is highly recommended that experts, scholars, and researchers clarify the speed of HSRs when studying HSR-related topics. Otherwise, readers from different countries may misunderstand the results as the speed of HSRs affects the transport mode’s competitiveness. In particular, none of the 24 articles clearly stated this important issue.

2.4.2 Competing Alternatives and Access to Terminals

Table 2.9 presents the commonly used transport alternatives. It can be seen that road transport (buses and private cars), air transport, and conventional rail have been, so far, the most used alternatives. However, in the future, there will be more competitive transportation modes, such as maglev, autonomous vehicles, and even ships or ferries; for example, China’s first cross-sea high-speed railway with a speed of 350 km/h will begin operation in 2022.

Another interesting area in which further research is required is associated with the access and egress transport modes to terminals. In this sense, currently, subways are booming in developing countries (Xiao et al., 2021). For instance, traffic congestion and emissions have increased because of the rapidly growing motorization, which has encouraged many Chinese metropolitan areas to invest in subway developments (De Jong et al., 2010). After the 2008 Olympic Games in China, many cities began developing and improving urban rail transit systems, including tram, light rail, metro, and monorail systems. At present, 31 cities in China have subways, with a total of 133 lines (Lu et al., 2016). In addition to avoiding serious traffic jams on the road, subways are more convenient, faster, cheaper, and, to a certain extent, the optimal option for the low-income and middle-income classes. However, this issue has been neglected in the current literature.

2.4.3 Attributes for the Development of HSRs in Logistics

HSRs do not only play an essential role in serving passengers among other transport modes, but also bring about a novel option for freight transport. HSRs are adjusting to the requirements of the rapid growth of the modern logistics industry. As shown in

Table 2.10a (HSR), Travel time, Travel cost, Ticket price, Frequency, and Access/egress time are the most-used attributes. Indeed, people prefer to use time rationally and efficiently, but this issue has not been deeply studied in logistics, and it may be relevant, especially in an era when more sustainable transport modes are a necessity to mitigate negative externalities.

High-speed freight trains have been launched in many countries, such as Germany, France, Denmark (Bi et al., 2019), and China. Since 2014, China Railway Corporation has launched the high-speed railway express delivery (HSReD) system, cooperated with express transport companies and e-commerce platforms, initially focusing on time-sensitive and valuable items, and launched services such as “Same-Day Delivery” and “Next-Day Delivery”. According to the Statistical Office of the People’s Republic of China (2017), in 2016, the volume of express delivery parcels reached 31.35 billion pieces, increasing by 51.67% over 2015. China’s example indicates that the HSReD system is feasible and has been operating for several years. Thus, questions need to be considered, for instance: What is the impact of HSReD on passengers’ demand and preferences? Will some attributes (e.g., number of carriages carrying parcels, delivery time, and delivery frequency) of HSReD affect passengers’ choices? In addition, Bi et al. (2019) claim that the HSReD parcel volume on China’s HSR network will reach the transportation capacity limit in 2021. Will this prediction be true? Will this affect the travel demand of passengers and the sustainable development of HSRs? These are worthy lines of future research.

2.4.4 Attributes Related to Environmental Costs and Passengers’ Attitudes towards Climate Change

This fourth gap probably represents the most promising line of future research. It was certainly a surprise to find that none of the 24 SP studies included any attributes related to environmental costs in order to characterize the transport modes. In this respect, the comparative advantages of HSRs over other transport modes could have not been properly analyzed in previous studies. Similarly, the more or less pro-environmentalist or green behavior associated with each passenger could also have an effect on mode choices, so it is highly possible that there is a latent heterogeneity in passengers’ preferences that has not been analyzed. Air travel can be affected by the interference of ‘flight shame’ supporters who obtain the media’s attention in order to change social norms, and, apparently, these changes have more or less been accepted by some nationalities. Gössling et al. (2020) assessed the effect of ‘flight shame’ on policy support for the decarbonization of the transport system for 16 different measures, and found that a majority of respondents considered the following three measures as the most effective: (1) an annual reduction in the aviation industry’s total CO2 emissions by 5%; (2) a reduction in specific emissions by 5% per year and a total of km flown; and (3) a decline in the cost of train travel to make this transport mode relatively more cost-competitive. Interestingly, the authors studied these issues from a conceptual point of view, and it is time to include these segmentation variables in the discrete choice approach.

2.5 Conclusions

This paper provided a critical overview of the evolution of passengers' preference for HSRs in the last 20 years. An initial database containing 143 related articles, obtained from Scopus by using the keywords TITLE-ABS-KEY (hst AND preferenc*) OR TITLE-ABS-KEY (hsr AND preferenc*), was filtered because it was found that the use of abbreviations was not appropriate for selecting a particular field of study. The bibliometric analysis with the refinements showed that the first paper about passengers' preference for HSRs was published in 2002.

The Latent Dirichlet Allocation (LDA) method was applied to elicit the topics of the 65 selected documents that deal with high-speed railways. The meanings of the abbreviations "HSR" and "HST" other than "high-speed railway" and "high-speed train", respectively, are shown in Table 2.4. The other three main categories are: (1) "HSR", which stands for "Health Star Rating"; (2) "HST", which means "Hubble Space Telescope"; and (3) "HSR", which means "High levels of Social Reinstatement behavior".

The 24 studies that conducted a SP experiment were selected to provide more insights into passengers' preferences for HSRs. The in-depth analysis of the selected papers demonstrates that: (1) the SP surveys were implemented for measuring the passengers' preference for HSRs in different countries: China, Italy, Spain, Indonesia, India, Japan, South Korea, the United States, and Portugal (Table 2.8); (2) the most frequently used transport alternatives are Road Transport, Air transport, and Conventional rail (Table 2.9); (3) the top five most used attributes are Travel time, Travel cost, Price, Frequency, and In-vehicle time (Table 2.10); and (4) the top five segmentation variables are Age, Income, Trip purpose, Career, and Gender (Table 2.11).

We found four important gaps that need to be addressed as future lines of research: (1) the definition of HSRs according to the speed needs to be mentioned; (2) more competing alternatives need to be included as well as other transport modes for accessing and egressing to/from terminals; (3) the role of HSRs as an alternative in logistics needs to be studied to analyze what effects HSRs could have on passengers' demand; and (4) environmental and sustainability issues need to be included in the choice experiment to determine whether HSRs could be more competitive, as well as other variables that could act as proxies for passengers' attitudes toward mitigating transport externalities.

This study is also subject to some shortcomings. First, the information was extracted from only a single platform (Scopus), and the results may be biased by this issue. Second, using the abbreviations HSR and HST as search keywords is inappropriate when researchers want to study a specific field. Third, only the SP method was considered when filtering out the 24 papers written in English in order to analyze the passengers' preferences. Other methods or topics need to be used in the future and, for that, the list of the topics presented in this study will be valuable.

3

3 PAPER 2: Exploring Passengers' Preferences for High-Speed Rails: A CiteSpace Bibliometric Analysis

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Abstract

Since passengers' preferences (PP) for high-speed rails (HSRs) play a fundamental role in optimizing service quality, enhancing user experience, and fostering the sustainable growth of HSR systems, understanding PP for HSRs becomes increasingly crucial. To determine the research status quo and reveal the emerging trends in PP for HSRs, this study for the first time conducted a bibliometric analysis underpinning PP within the HSR domain by adopting the CiteSpace software for visualization. The data was retrieved from the two world-leading citation databases, Web of Science (WoS) and Scopus, by following the search strategies: Topic = TITLE-ABS-KEY ("high speed rail*" or "high speed train*") AND (a combination of terms that focuses on understanding preferences or choices made by passengers, travelers, commuters, tourists, or users of a transportation system)**,** from 1998 to 2023. A total of 135 qualified articles written in English and Chinese were used for generating knowledge maps and visualization analysis of co-authorship, co-citation, and the keywords co-occurrence. The results showed (1) Francesca Pagliara is the prolific author; (2) Daniel Albalate is the highly cited author; (3) Beijing Jiaotong University (China) is the core research institution; (4) China stands as a leading place in this research field; (5) Transportation Research Part A ranked first among other high-quality journals; (6) The top keywords are air transport, China, and competition, except railroad transportation, high-speed rail/train; and (7) The "integration of air and HSR systems", "consumer behavior and demand modeling", and "transportation infrastructure and capacity" have recently attracted researchers' attention and will continue to be a focus of future research. This study contributes to helping scholars, policymakers, and stakeholders interpret and comprehend the HSRs PP state-of-the-art, providing researchers with potential academic opportunities and international collaborators, and inspiring them for future studies.

Keywords: Passengers' preferences; High-speed rail; Bibliometric analysis; CiteSpace; Visualization

3.1 Introduction

High-speed railways (HSRs) are designed with significant advantages of speed, safety, environmental-friendliness, comfort, and energy-saving compared with other interurban transport modes. Thus, since its introduction in Japan in 1964, HSR has attracted considerable attention of researchers from different countries of the world, such as China (Wu & Nash, 2000), Spain (Brida et al., 2017b), Italy (Cascetta et al., 2020b), South Korea (Lee et al., 2016b), and United States (Sperry et al., 2017b), Japan (Komikado et al., 2021), Australia (Hensher et al., 2014), India (Sahu & Verma, 2022), Indonesia (Nurhidayat et al., 2018b), Germany (Heuermann et al., 2018), Belgium (Schillemans, 2003), Netherlands (Willigers & Van Wee, 2011), Canada (Wong & Habib, 2015), Czech Republic (Paril & Viturka, 2020), United Kingdom (Tomaney & Marques, 2013), Slovakia (Michniak, 2018), and South Africa (Deel-Smith & Jooste, 2023). Cartenì et al. (2017) provided a classification of the possible HSR service impacts dividing them into transportation (internal) impacts, socio-economic and land-use (external) impacts, and environmental (external) impacts. In terms of transportation (internal) impacts, due to the reduction in travel time after a new HSR was introduced (Román et al., 2014) and access time at terminals (Martín et al., 2014), the use of HSR between 2.0 and 2.5 h travel time affects air services by reducing the number of flights in Europe (Dobruszkes et al., 2014). Some readings focused on the socio-economic impacts of HSR, such as in the tourism market and social inclusion.

The relationship between HSR and tourism is unclear. Only a few tourists have chosen HSR to visit Futuroscope Park in France and other places near it as their destinations, while numerous tourists come to Disneyland Paris by HSR and they would not have come without HSR (Delaplace et al., 2016). In the Spanish cultural tourism markets, HSR has significantly increased the number of tourists visiting museums and monuments in Madrid and Andalucía, while these outcomes are not significant in Cataluña and Castilla (Campa et al., 2019). Joint Revealed/Stated Preference (RP/SP) surveys carried out among Italian travelers showed that economic and geographical exclusions do exist, i.e., a high sensitivity for the access/egress travel costs and HSR ticket costs is registered, and the low accessibility to the arrival/departure HSR stations affects users’ choice of this service (Biggiero et al., 2017b; Pagliara et al., 2016; Pagliara & Biggiero, 2017).

Plenty of research has investigated the effects of HSR on land use patterns and environment. For example, in China, the HSR operation has increased urban land use intensity by about 4.4% (Niu et al., 2021), having negative impacts on agricultural land in the West (Zhang et al., 2019), and could lead to significant changes in the sources of growth in tourism land use (Jiao et al., 2023). Concerning the environmental benefits, HSR has relatively limited impacts on the reduction of carbon dioxide (CO_2) emissions in the UK (Miyoshi & Givoni, 2014), while the transition from automobile trips to HSR would provide positive effects on the atmosphere in California (Chester & Horvath, 2012). Similarly, the shifting from truck to rail freight and from air and road travel to HSR travel would significantly reduce the life cycle emissions in Sweden (Åkerman, 2011).

HSRs have been analyzed from different perspectives of various disciplines including engineering (Levinson et al., 1997), transportation (Román et al., 2007), social sciences (Dobruszkes et al., 2022), computer science (Yin et al., 2020), environmental science (X. Yang et al., 2019), economics (Chen & Haynes, 2017), business (Liang et al., 2022), tourism (Masson & Petiot, 2009), management & accounting (Li et al., 2023), mathematics (Mota et al., 2017), decision sciences (Costa et al., 2016), energy (Bruno et al., 2017), telecommunications (Ai et al., 2014), information systems (Yildirim & Bediroglu, 2019), and automation & control systems (Liu et al., 2013). Meanwhile, HSRs have emerged as a pivotal mode of transportation, revolutionizing travel dynamics across various regions globally. As these advanced rail systems continue to expand and integrate into modern transportation networks, understanding passengers' preferences (PP) for HSRs becomes increasingly crucial. The proliferation of HSR networks has not only reshaped the traditional notions of commuting but has also offered a competitive alternative to other modes of transport, promising efficiency, speed, and sustainability. Amidst this transformative landscape, comprehending the nuanced elements that shape PP becomes fundamental for optimizing service quality, enhancing user experience, and fostering the sustainable growth of HSR systems. This study delves into the bibliometric analysis of PP for HSRs by employing a visualization analysis tool.

Software for visualization analysis has been employed in many fields, such as environmental research and emissions, computing, medical research, information science, natural disasters, sustainable development, and social commerce, to facilitate the analysis of bibliometric studies (Cantillo et al., 2021). CiteSpace is a Java-based scientific visualization software developed by Prof. Chaomei Chen at Drexel University (USA) in 2004 (Chen, 2004), which has been used in this paper.

To the best of the authors' knowledge, this is the first study to embark on a journey of a comprehensive literature review underpinning PP within the HSR domain. By employing the valuable CiteSpace as the visualization tool, this study aims to (1) understand the state-of-the-art PP for HSRs research; (2) uncover hidden relationships and connections between authors, institutions, countries, journals, and keywords; (3) identify patterns, clusters, and trends within this study field; (4) reveal emerging themes and future research directions; and (5) help researchers, policymakers, and stakeholders to interpret and comprehend the literature easier, deeper, and more efficiently.

The remainder of the paper is organized as follows: Section 2 provides the Literature Review of the existing articles. Section 3 introduces the data collection process and research method. Section 4 discusses the results by displaying the knowledge maps and tables. The last section presents the concluding remarks and limitations.

3.2 Literature Review

The footprints of published literature pave the way for scientific development (Wang & Peng, 2023). Following the purposes of this study, we focus on existing research examining PP for HSRs and studies leveraging CiteSpace.

3.2.1 Research on PP for HSRs

Due to the discrepancy in gender, age, income, social status, travel purpose, and travel distance of different passengers, they will incline toward dissimilar travel time, departure time, price, and transport mode. Many studies have discussed the factors that affect PP on HSRs. Influencing factors mainly come from two aspects: travel attributes and personal attributes (e.g., Martín & Nombela, 2007; Román & Martín, 2014; Wang et al., 2017; Zhang & Jiang, 2021). Wu and Martín (2022) conducted a systematic literature review on PP for HSRs based on the Scopus database by applying the Latent Dirichlet Allocation (LDA) model. They summarized that the commonly used variables of passengers are age, income, trip purpose, career, gender, and education, and the primary determinant attributes of HSR are travel time, travel cost, and frequency. In addition to these, travel distance, population, GDP, and access time are also examined as important attributes in the research of Nurhidayat et al. (2023). Many other attributes can affect passengers' choices, such as reliability, comfort, accessibility, safety, ticket type, capacity, convenience, luggage space, and noise level. Recently, environmental concerns have been influencing the evolving nature of preferences. After plenty of robustness tests, Wang et al. (2020) concluded that the opening of HSR significantly increases access to the cities on the same day and improves the air quality. For example, Zanin et al. (2012) reported that HSR reduces close to 5 kg of CO_2 per passenger, which attracted more people choosing HSR. Furthermore, the emergence of digital technologies impacts the passengers' travel experience. For example, wireless communications technologies used in smart rail transportation systems can significantly improve not only the operation, efficiency, and reliability but also passengers' experiences (Briso-Rodríguez et al., 2017). Zhao et al. (2018) estimated channel and evaluated throughput for the fifth generation (5G) wireless communication systems in various scenarios on HSRs. As channel estimation has a crucial impact on the quality of wireless communication, Chen et al. (2023) provided a comprehensive review of existing pilot-aided channel estimation schemes, identified the unique challenges, and discussed innovative techniques aided HSR systems in the future sixth generation (6G) wireless communication.

On the one hand, according to the characteristics and attributes of different transport modes, passengers' decisions differ from the basis of the demand to the greatest extent. On the other hand, passengers' demand is the reason and purpose for product design and organization for passenger transport modes. A great number of studies have carried out the comparison between HSR and other transport modes, such as ordinary railway, expressway, aviation, coach, and private car (e.g., Abouelela et al., 2022; Feng et al., 2022; Li et al., 2021; Mahardika et al., 2022; Zhang et al., 2019) from diverse perspectives in various countries. Among the transport modes, the relationship between HSR and air transport has attracted more attention from researchers, scholars, and practitioners. Román et al. (2007) analyzed the potential competition between HSR and air transport along the Madrid-Barcelona corridor using disaggregate demand models based on a mixed revealed and stated preferences database. Their findings indicated a substantial willingness-to-pay estimate for reductions in delay time, particularly notable in the context of HSR compared to air transport. Additionally, many other earlier studies have also considered HSR as a competitor to air transport (Adler et al., 2010; Behrens & Pels, 2009; Dobruszkes, 2011; Milan, 1993; Yang & Zhang, 2012). With the increase of empirical experience, it has become a consensus that HSR has fierce competition in the short- and medium-haul market, mostly likely between 400 and 800 km (D’Alfonso et al., 2015; Fu et al., 2012; Li & Sheng, 2016; Park & Ha, 2006; Wan et al., 2016; Zhang et al., 2017). However, as both modes have been developing, HSR has far from a purely competitive relationship with air transport, it may also play an intermodal complementary and substitution role with air transport (Givoni & Banister, 2006). By taking a supply-oriented empirical analysis, Albalate et al. (2015) discovered some evidence that HSR can support long-haul air services, whereas Kroes & Savelberg (2019) established the potential for HSR as a substitute for short-distance air transport at Amsterdam Airport. Yet Zhang et al. (2018) found that HSR significantly substituted short- and medium-haul (below 1000 km) air routes while the introduced HSR services have encouraged long-distance (over 1000 km) air travel in Mainland China. Furthermore, several other forms of relationships between HSR and air transport have been studied. For example, in the analysis of Xia & Zhang (2016), they found that improvement in rail speed or HSR-air connecting time decreases airfare on the routes where HSR and air transport compete, and HSR-air cooperation would be socially beneficial. Taking the Madrid-Malaga route (Spain) as a case, Socorro & Viecens (2013) adopted a theoretical model to evaluate the social and environmental effects of HSR and airline integration and showed that integration is always profitable for the airline and HSR. Takebayashi (2014) highlights a one-sided influence on connectivity benefits. While good connections between air and HSR improve the well-being of international passengers, the impact is not reciprocal. From the profitability point of view, only airlines would be motivated to collaborate with HSR as a second-best solution, but there was no beneficial incentive for HSRs. Rattanakijsuntorn et al. (2022) conducted a content-based analysis to classify the relationships between air and rail passenger transport and categorized the relationships as modal comparison, competition, cooperation, integration, and influence. As the relationship between HSR and air travel becomes increasingly complex, understanding passenger adoption and behavioral preferences for emerging services becomes even more crucial.

3.2.2 Research used CiteSpace

Bibliometric mapping or science mapping is becoming a popular information visualization tool that provides the spatial representation of how fields, disciplines, specialties, and authors or individual documents are related to one and another (Small, 1999). Different software tools and techniques have been proposed to conduct science mapping analysis. Cobo et al. (2011) compared nine representative science mapping software tools (Bibexcel, CiteSpace II, Leydesdorff’s Software, IN-SPIRE, CoPalRed, Network Workbench Tool, Science of Science (Sci2) Tool, VantagePoint, and VOSviewer) by showing their advantages, disadvantages, and most important differences. Among them, CiteSpace, developed by Dr. Chaomei Chen at Drexel University (USA) (Chen, 2014a), could perform a social and intellectual analysis and be adopted for a document co-citation analysis as well. Besides, Cui et al. (2023) claimed that the analytical perspectives of CiteSpace and VOSviewer are similar, but CiteSpace can further extend the analysis of attributes of each node and make it more convenient to gain in-depth understanding. In addition, CiteSpace helps to eliminate duplications in the data pre-processing (Ye et al., 2023). Moreover, because of its advanced and powerful functions, CiteSpace has gained extensive attention and has been applied in various academic research domains worldwide, such as medicine and healthcare (Cheng et al., 2022; Du & Wang, 2023; Jiang et al., 2022; Tang et al., 2023; Wang et al., 2023), environmental science and sustainability (Huang et al., 2022; Li et al., 2023; Shuyan Xiang et al., 2023; Zeb et al., 2022), oceanography and marine biology (Cantillo et al., 2021; Chen & Xing, 2023; Wu et al., 2020), tourism (Chen et al., 2022; Chen et al., 2023; Guan et al., 2023; Guo & Zhang, 2022), computer science (Wang et al., 2020; Wei et al., 2015; Zhang et al., 2021), information science and bibliometrics (Jia et al., 2020; Liu et al., 2022), transportation (Bao et al., 2023; Cheng et al., 2023; Jia et al., 2019; Li et al., 2023), and other social sciences (Liu et al., 2022; Wang et al., 2021). Thus, this study adopted CiteSpace Basic Version 6.2.R6 (available downloaded freely at https://citespace.podia.com/) as the visualization tool.

In terms of academic research area of transportation, many previous authors leveraged CiteSpace to serve their specific study aims from different perspectives, such as the evolution of transportation system resilience (Li et al., 2023), development of socially sustainable transport (Bao et al., 2023), emission reduction potential of electric vehicles (EVs) (Cui et al., 2023), and pandemic crisis on the aviation industry (Ye et al., 2023). Most of these studies used Web of Science (WoS) as the database to collect valuable data, a slightly smaller number chose Scopus, and very few extracted data from the China National Knowledge Infrastructure (CNKI) database (Chen et al., 2023) or other repositories. Chen and Liu (2020) are the only authors with a focus on HSRs. They retrieved published papers from 1900 to 2019 from the WoS core collection and conducted the visualization analysis using CiteSpace to clarify the status and development trends of HSR research. Our study is highly inspired by (Chen & Liu, 2020) with some important differences to keep in mind, such as the use of WoS and Scopus as the databases and special emphasis on the research area of PP of HSRs.

3.3 Methods and Data

3.3.1 Bibliometric Analysis

A literature review is an essential step of any research project to map and assess the start-of-the-art intellectual territory and develop the corresponding knowledge of studies (Tranfield et al., 2003). In 1969, Alan Pritchard defined the term ‘bibliometrics’ for the first time as the mathematical and statistical analysis of patterns in the publication and use of literature (Lawani, 1981; Ramos-Rodrígue & Ruíz-Navarro, 2004). Bibliometric analysis is a popular and rigorous method for exploring, analyzing, and summarizing large quantities of scientific data to present the state of the intellectual structure and the emerging trends of a specific research topic or area (Donthu et al., 2021). Bibliometric methods are quantitative by nature, but are used to make claims about qualitative characteristics and can easily scale levels from micro (institution) to macro (world) (Wallin, 2005).

Scientific databases such as the Web of Science (WOS) and Scopus contain large volumes of bibliometric data and have made acquiring the data convenient and easy. Science mapping is one of the techniques for bibliometric analysis focusing on the relationship between research constituents (Cobo et al., 2011; Noyons et al., 1999), which includes citation analysis, co-citation analysis, co-authorship analysis, and co-word occurrence analysis. Bibliometric analysis is often implemented or complemented by network visualization software. As mentioned in the Literature

Review, some bibliometric tools (e.g., CiteSpace, Bibexcel, Sci2, and VOSviewer) enable the analysis of such data appropriately and pragmatically, raising academic interest in bibliometric analysis.

3.3.2 Data Collection and Cleaning Process

Web of Science (WOS), based on the products from the "Thomson Reuters Institute of Scientific Information" (ISI) in the 1960s, covers a wide range of disciplines, including sciences, social sciences, arts, and humanities, contains all article types, and indexes all authors, institutions, countries, publishers, and bibliographic references for each article. WoS was the main tool for citation analysis until the launch of Scopus by Elsevier Science in 2004 (Mongeon & Paul-Hus, 2016). Like WoS, Scopus covers cross-the-board disciplines, including natural sciences, social sciences, and the arts. It is recognized for its extensive coverage of international content and offers sophisticated tools for citation analysis, author profiling, and assessing journal impact. WOS is known as the most in-depth and highest quality, while Scopus claims to have the largest database and the widest range of records (Chadegani et al., 2013). More and more researchers and scholars from various countries or regions and knowledge domains are involved in the use of these two databases (Zhu & Liu, 2020), and plenty of them combined WoS and Scopus to carry out their academic studies. Hence, this study adopted the two databases.

The data was retrieved from the WoS core collection and Scopus on December 15, 2023. The dataset is obtained according to (Wu & Martín, 2022), avoiding the use of the abbreviations HSR and HST as search keywords to collect data in a specific research field. The authors found that acronyms are inappropriate search terms since they could represent different meanings, and the results will include articles in different fields. Besides, to obtain more comprehensive and precise data, we considered broader terms that could better reflect other types of "passengers" (such as travelers, commuters, tourists, or users) and "preference" (or "choice"). Thus, different expressions of "passengers' preference" (or "preference of passengers") that had been used by previous authors were included as the search keywords.

Figure 3.1 illustrates the five stages of the data collection and cleaning process.

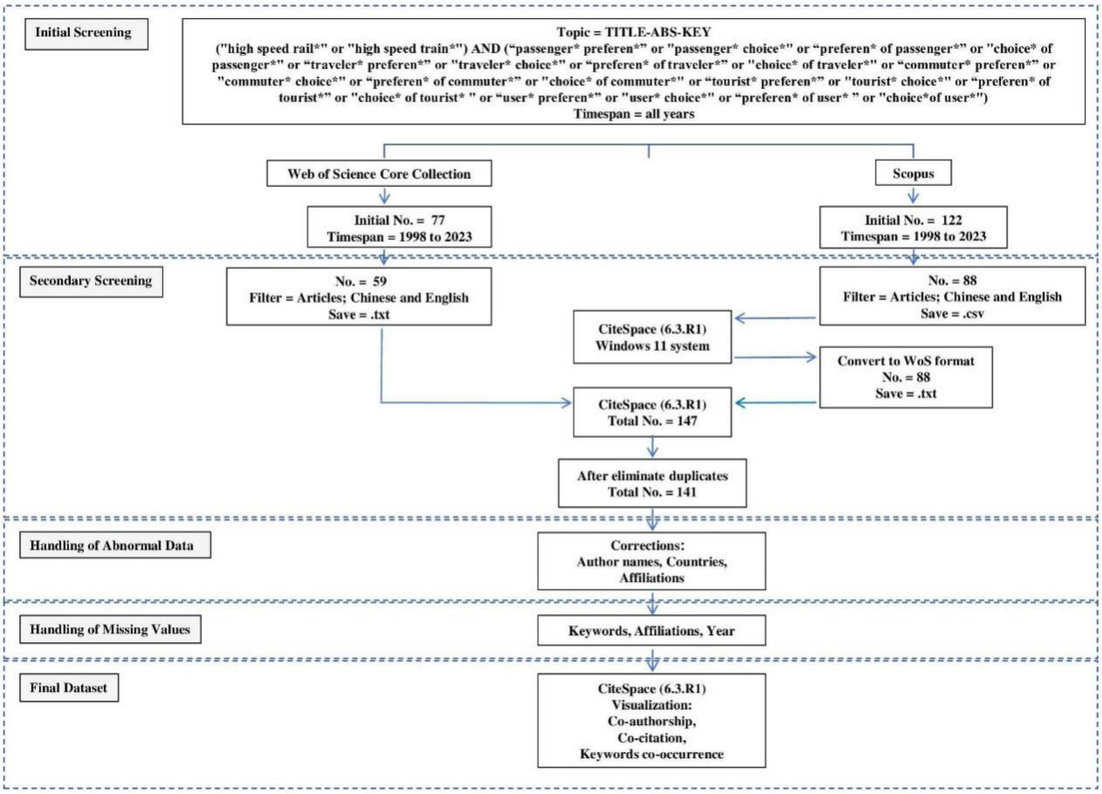


Figure 3. 1 Data collection and cleaning process.

·Initial Screening: The study retrieved document information from Web of Science Core Collection and Scopus by the search following strategies: Topic = TITLE-ABS-KEY ("high speed rail*" or "high speed train*") AND (“passenger* preferen*” or "passenger* choice*" or “preferen* of passenger*” or "choice* of passenger*" or “traveler* preferen*” or "traveler* choice*" or “preferen* of traveler*” or "choice* of traveler*" or “commuter* preferen*” or "commuter* choice*" or “preferen* of commuter*” or "choice* of commuter*" or “tourist* preferen*” or "tourist* choice*" or “preferen* of tourist*” or "choice* of tourist* " or “user* preferen*” or "user* choice*" or “preferen* of user* ” or "choice*of user*"). The wildcard * was used to capture related variations of a word, such as preference and preferences. A record was considered relevant if any of the terms occurred in the title, abstract, or keywords. We attempted to collect all articles related to PP for HSRs since the period of relevant publications in Scopus and WoS was not known. Hence, the timespan was all years. An initial dataset with 77 and 122 documents published from 1998 to 2023 was extracted from WoS and Scopus, respectively.

·Secondary Screening: We restrained the document type to articles, excluding other types such as conference papers, book chapters, short surveys, and editorial materials, and refined articles only written in English and Chinese. English is the most common academic language worldwide, and China is a leader in high-speed rail research. Based on the above retrieval strategy, we obtained 59 articles from WoS and 88 articles from Scopus with all fields (e.g., authors, document title, year, affiliation, abstract, keywords, references) of each article and exported as plain text (.txt) from WoS and .csv format from Scopus for further analysis. The 88 records from Scopus were converted to WoS format via CiteSpace. Next, 147 records in total were imported into CiteSpace to remove duplications, and 141 valid records remained.

·Handling of Abnormal Data: Before analyzing and visualizing the results, we manually checked the dataset and encountered certain anomalies, such as errors or spelling mistakes in authors' names, countries, and affiliations. In authors' names, we cross-referenced the original documents and corrected them for some names containing special symbols or garbled characters, such as Martín and Román or Mart□□n and Rom□□n. In countries, we unified the writing of the names of the same country. For example, Peoples R China and China were both written as China. In affiliations, we unified the full name and abbreviation of the same university to determine univocally the institution.

·Handling of Missing Values: Some papers had missing information, such as missing keywords, author affiliations, or year. For these missing values, we retrieved the missing information directly from the original databases (WoS and Scopus) and the original documents.

·Final Dataset: After the above data cleaning steps, we obtained a final dataset consisting of 141 articles, ensuring the accuracy and completeness of the data for the bibliometric analysis and visualization through CiteSpace.

3.3.3 Bibliometric Software

CiteSpace 6.3.R1 Basic (Free Version) in the Windows 11 system is used in the study to visualize the collected data and to analyze the knowledge maps of the articles on PP for HSRs. The whole analysis procedure contains the following steps:

(1) CiteSpace is developed to analyze data based on the WoS data format and specifically provides a data conversion interface for converting CNKI, CSSCI, and Scopus data into WoS data format. The .ris format is the preferred format for Scopus data files, but the CiteSpace 6.3.R1 Basic Version requires .csv format files. Thus, the saved .csv format file instead of .ris was converted to tab-delimited format using Excel and then run the Tab Delimited Converter in CitesSpace. The total number of references of the extracted 88 article records from Scopus was 2819. And 2675 of them were validly converted. The success convert rate was 94.0% and it was a reasonable rate according to The CiteSpace Manual (Chen, 2014a).

(2) All the information of 147 articles from Scopus and WoS was prepared in .txt format files. Cobo et al. (2011) suggested how to eliminate duplicates from the dataset to perform the analysis and get better results. Finally, we gained 141 unique article records for the next step of visualization analysis.

(3) A new project with the default properties was implemented with the input of the data of 141 articles with the full record in CiteSpace.

(4) This step sets parameters for visualization, as shown in Table 3.1. Generally, the Time Slicing was set, including Time Interval (1998-2023) based on the collected data, and the Time Slice (1 year). Node Types were Author, Institution, Country,

Keyword, Reference, Cited Author, and Cited Journal. Other parameters (Links, Selection Criteria, Pruning, and Visualization) were kept at the default setting. Thus, 135 records were qualified to visualize in CiteSpace based on the settings. In addition, a link retaining factor k, as one of the settings, is a parameter to adjust the link selection. Keep the strongest links k times the network size and eliminate the remaining ones. Due to the limitation of the network size (300) shown in the basic free version of CiteSpace, in some cases, reducing the size is needed, e.g., decreasing the number of years, or lowering the k value for g-index. Thus, the Time Interval and Selection Criteria were adjusted slightly for specific analysis of Node Types ensuring the largest size within the limitation. As shown in Table 3.2, the Time Interval was set from 2014 to 2023 for the analysis of References, Cited Authors, and Keywords. The k value was reduced from the default 25 to 16, 20, 10, and 15 for the analysis of Author, Cited Journal, References, and Cited Authors, respectively. Consequently, 117 qualified records were ready for the visualization analysis of References, Cited Authors, and Keywords.

Table 3. 1 Parameters settings for visualization analysis in CiteSpace.

No.	Parameters	Settings
1	Time Slicing	Time Interval (1998-2023), Time Slice (1 year)
2	Node Types	Author, Institution, Country, Keyword, Reference, Cited Author, Cited Journal
3	Links	Default
4	Selection Criteria	Default (g-index: k=25)
5	Pruning	Default
6	Visualization	Default

Source: Own elaboration based on the settings in CiteSpace.

Table 3. 2 Parameters settings of different node types for visualization analysis in CiteSpace.

No.	Node Types	Parameters	Settings	Qualified Records
1	Author	Selection Criteria	g-index: k=16	135
2	Cited Journal	Selection Criteria	g-index: k=20	135
3	Reference	Time Slicing	Time Interval (2014-2023)	117
		Selection Criteria	g-index: k=10	
4	Cited Author	Time Slicing	Time Interval (2014-2023)	117
		Selection Criteria	g-index: k=15	
5	Keyword	Time Slicing	Time Interval (2014-2023)	117

Source: Own elaboration based on the settings in CiteSpace.

(5) Finally, we conducted the analysis of co-authorship, co-citation, and the keywords co-occurrence and obtained the knowledge maps generated in CiteSpace.

3.4 Results

3.4.1 Co-authorship Analysis on PP for HSR

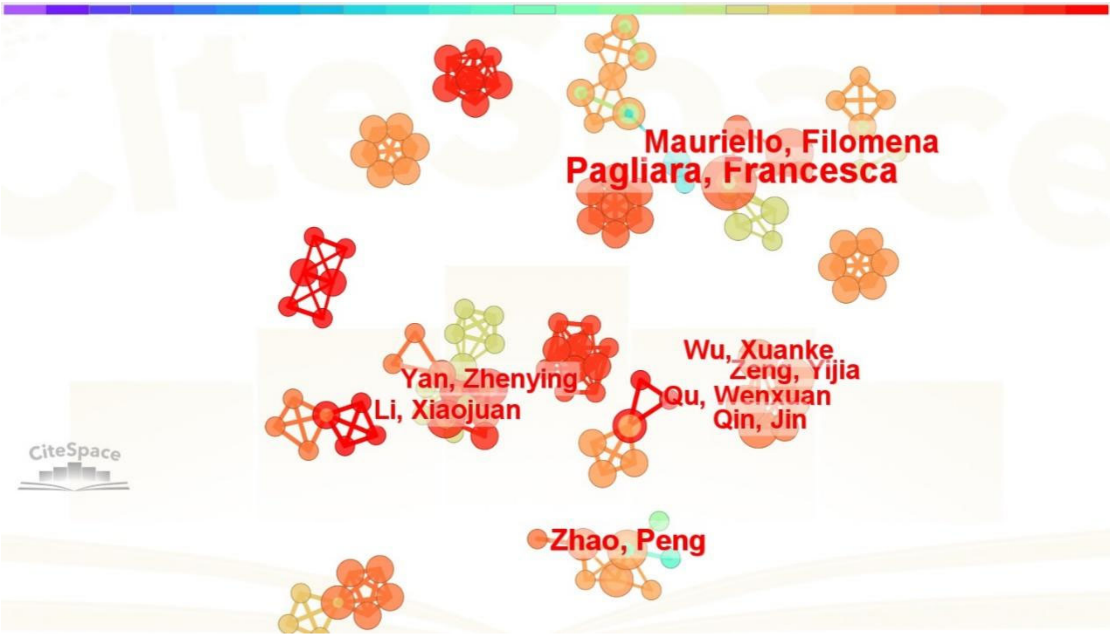
Co-authorship network analysis by bibliometrics methods can reliably track almost every aspect of scientific collaboration network (Glänzel & Schubert, 2004). Therefore, it is beneficial to determine the research production in the field from these three different perspectives namely authors, institutions, and countries.

3.4.1.1 Author Co-authorship Analysis

The network shown in Figure 3.2 presents the academic collaborations among authors established in small groups by setting the appropriate thresholds. Each color of the legend bar at the top of the figure represents each year from 1998 to 2023 and from left to right. Correspondingly, the color of the nodes and links illustrates the published year of the authors' work. The nodes' size indicates the number of papers those authors published. The more contributions, the larger the nodes, and vice versa. The nodes' distance and the links' thickness demonstrate the level of authors' cooperation. The more collaboration of the authors, the shorter the distance and the thicker the links, and vice versa. Small groups denote demonstrate the collaborative relationship between the authors. These similar notes go for the figures below.

Figure 3.2 contains 281 nodes and 428 links but only shows 16 sub-networks by setting the largest k equal to 16 for clarity and beauty of visualization. Authors who have published four or more articles are shown in Figure 3.2. According to the size of each node and the author's name, it is seen Pagliara Francesca and Mauriello Filomena were the most productive authors in the research field of PP for HSRs, who collaborated in one group, followed by Zhao Peng, who worked alone. Herein, a sub-network with four members, Wu Xuanke, Zeng Yijia, Qu Wenxuan, and Qin Jin, reflects the strong collaborative relationship.

Table 3.3 lists the top 9 prolific authors in the research field of PP for HSRs individually, sorted in descending order by the number of published articles. Regarding Table 3.3, Pagliara Francesca was the most productive author with eight contributions from 2015 to 2023, followed by Mauriello Filomena with six articles from 2019. And Zhao Peng ranked third with five contributions from 2009. The remaining, Wu Xuanke, Qin Jin, Yan Zhenying, Zeng, Yijia, Li Xiaojuan, and Qu Wenxuan, published four articles from 2019.



Notes: Each color of the legend bar at the top of the figure represents each year from 1998 to 2023 and from left to right. The color of the nodes and links illustrates the published year of the authors' work based on the bar. The nodes' size indicates the number of articles those authors published. The more the contributions, the larger the nodes, and vice versa. The nodes' distance and the links' thickness denote the level of authors' cooperation. The more collaboration of the authors, the shorter the distance and the thicker the links, and vice versa. Small groups demonstrate the collaborative relationship between the authors.

Figure 3. 2 Author co-authorship network of PP for HSRs.

Table 3. 3 Top 9 prolific authors of PP for HSRs.

Ranking	Counts	Authors	Year
1	8	Pagliara, Francesca	2015
2	6	Mauriello, Filomena	2019
3	5	Zhao, Peng	2009
4	4	Wu, Xuanke	2019
5	4	Qin, Jin	2019
6	4	Yan, Zhenying	2019
7	4	Zeng, Yijia	2019
8	4	Li, Xiaojuan	2019
9	4	Qu, Wenxuan	2019

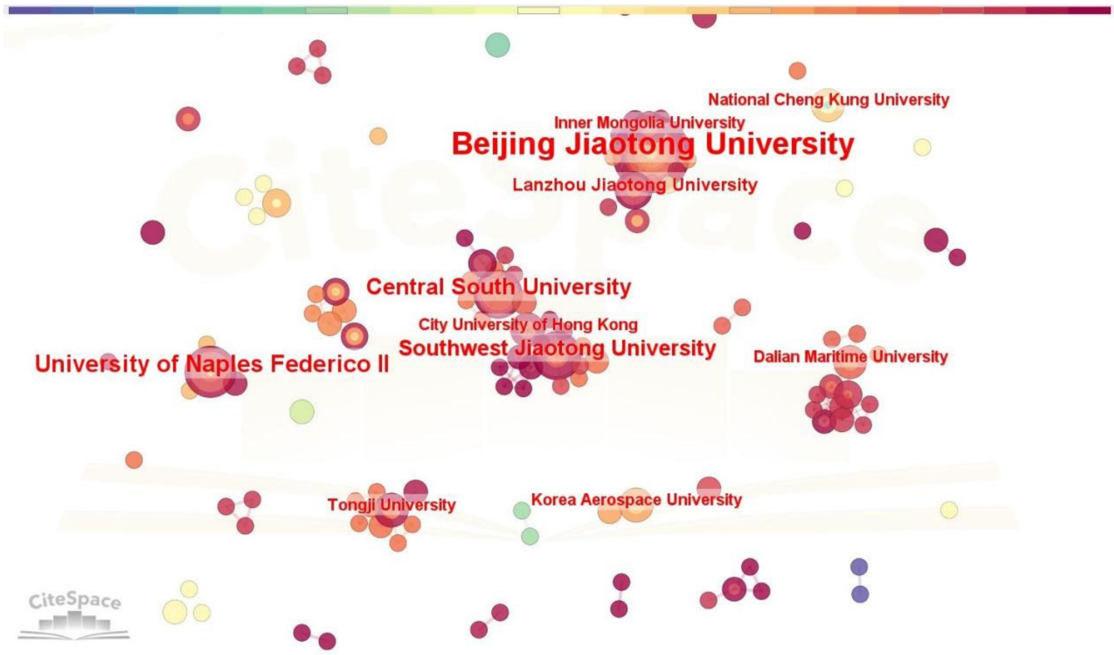
Source: Own elaboration based on the output of author co-authorship analysis in CiteSpace.

3.4.1.2 Institution Co-authorship Analysis

Figure 3.3 shows the academic collaborations among institutions on PP for HSRs. The networks are generated by following the instructions mentioned above. The size of the nodes denotes the number of articles an institution published, and the nodes' distances and the links' thickness indicate the collaboration level among institutions.

Figure 3.3 illustrates the collaborative network of institutions with four or more article and some sporadic sub-networks with 139 nodes and 175 links. As it shows, the biggest sub-network was Beijing Jiaotong University (BJTU), followed by the University of Naples Federico II, and Central South University ranked third. Correspondingly, Table 3.4 sorts the top 11 prolific institutions by the quantities of their published articles.

Figure 3.3 shows that the central node of the largest sub-network is BJTU, determining that the institution could play a significant role in acting as a leader in the collaboration network. The central position allows BJTU to facilitate the flow of information, ideas, and resources across the network and access cutting-edge research, funding, and technology more quickly. Furthermore, the partnership among BJTU, Inner Mongolia University ((IMU), and Lanzhou Jiaotong University (LZJTU) reflects the shared research needs in northern and northwestern China in fields such as HSR. BJTU might further strengthen its partnership with IMU in other areas, such as intelligent transportation or sustainable transport. This sub-network may also be driven by the Chinese national policy of the Belt and Road Initiative, which promotes infrastructure development and transportation hubs.



Notes: Each color of the legend bar at the top of the figure represents each year from 1998 to 2023 and from left to right. The color of the nodes and links illustrates the published year of the institutions' work based on the bar. The size of the nodes denotes the number of published articles of an institution. The more the contributions, the larger the nodes, and vice versa. The distances between the nodes and the thickness of the links indicate the collaborative level among institutions. The more collaboration of the institutions, the shorter the distances and the thicker the links, and vice versa. Small groups demonstrate the collaborative relationship between the institutions.

Figure 3. 3 Institute co-authorship network of PP for HSRs.

Table 3. 4 Top 11 prolific institutions of PP for HSRs.

Ranking	Counts	Institutions	Year
1	24	Beijing Jiaotong University	2009

2	10	University of Naples Federico II	2015
3	9	Central South University	2018
4	8	Southwest Jiaotong University	2018
5	5	Lanzhou Jiaotong University	2019
6	4	Tongji University	2018
7	4	City University of Hong Kong	2019
8	4	Dalian Maritime University	2016
9	4	Inner Mongolia University	2019
10	4	National Cheng Kung University	2004
11	4	Korea Aerospace University	2014

Source: Own elaboration based on the output of institution co-authorship analysis in CiteSpace.

3.4.1.3 Country Co-authorship Analysis

The country co-authorship network of PP for HSRs is presented in Figure 3.4. The nodes represent various countries, and the size denotes the number of published articles from different countries. Also, the distances and the links represent the cooperation amongst countries, and the thickness of the links reflects the collaboration strength.

Figure 3.4 includes the labels of the countries that have a minimum of four articles each, and it illustrates that there are 24 nodes and 35 links. The largest node shows that China had made an enormous contribution to the research area of PP for HSRs and had close ties and cooperation with other countries, such as Italy, Spain, and the United States. However, South Korea and Indonesia are isolated countries lacking collaboration with the rest of the world.

Table 3.5 provides the top 9 productive countries. It shows that the most productive country was China with 83 published articles from 2004 to 2023, followed by Italy, which had 18 contributions from 2007. Then Spain published 14 works from 2004. All the remaining countries that had less than ten contributions were the United States (8, 2005), South Korea (6, 1998), Japan (5, 2021), Germany (4, 2018), Australia (4, 2011), and Indonesia (4, 2022).

Notes: Each color of the legend bar at the top of the figure represents each year from 1998 to 2023 and from left to right. The color of the nodes and links illustrates the published year of the countries' work based on the bar. The size of the nodes denotes the number of published articles in a country. The more the contributions, the larger the nodes, and vice versa. The distances between the nodes and the thickness of the links indicate the collaborative level among countries. The more collaboration of the countries, the shorter the distances and the thicker the links, and vice versa. Small groups demonstrate the collaborative relationship between the countries.

Figure 3. 4 Country co-authorship network of PP for HSRs.

Table 3. 5 Top 9 prolific countries of PP for HSRs.

Ranking	Counts	Countries	Year
1	83	CHINA	2004
2	18	ITALY	2007
3	14	SPAIN	2004
4	8	UNITED STATES	2005
5	6	SOUTH KOREA	1998
6	5	JAPAN	2021
7	4	GERMANY	2018
8	4	AUSTRALIA	2011
9	4	INDONESIA	2022

Source: Own elaboration based on the output of country co-authorship analysis in CiteSpace.

3.4.2 Co-citation Analysis on PP for HSRs

According to McCain (1991), journals are linked by the subsequent citation and co-citation of the published literature, while the titles of the journals denote all cited articles, and two journals would be co-cited if there is at least one document from each journal listed in the list of references included in the dataset under analysis. Small (1973) was the first author to present the co-citation analysis in the early 1970s to reveal the relationship and structure of an academic field and analyze the connection patterns through published documents.

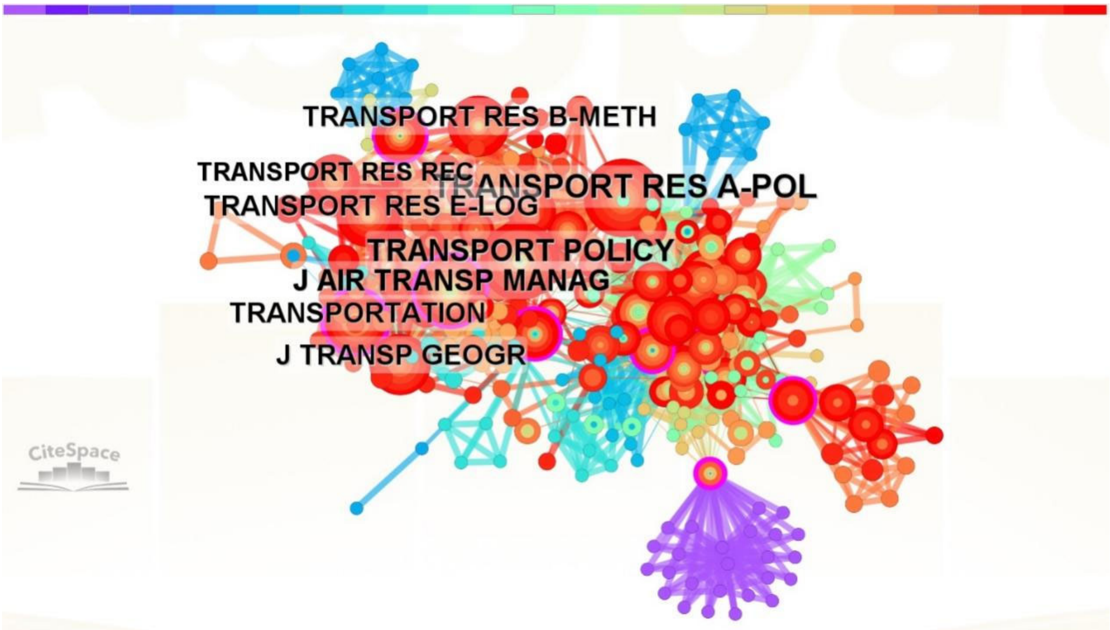
3.4.2.1 Journal Co-citation Analysis

To generate Figure 3.5 in CiteSpace successfully, we decreased the parameter k from the default value of 25 to 20. Thus, Figure 3.5 represents journal co-citation analysis with 298 nodes and 1588 links. The nodes indicate journals, and the links depict the co-citation relationship between them. Additionally, the nodes' sizes evidence the number of citations received by a journal, while the nodes' distance is the function of their frequency. Generally, the more crucial the journal is, the bigger the node is, and vice versa. Similarly, the shorter the distance is, the higher the co-citation frequency is, and vice versa.

Figure 3.5 labeled the journals with 20 or more co-citations. As shown, the closely connected nodes reflect the high collaborative relationship amongst journals related to PP for HSRs. It indicates that the related journals in this research field usually co-cite other journals in the same dataset. Therein, the essential journal was Transportation Research A.

Table 3.6 lists the top 8 core journals based on the co-citation counts. The top three ranked co-cited journals were Transportation Research Part A with a co-citation index of 48 from 2011 to 2023, and Transport Policy and Journal of Air Transport Management with 36 and 32 co-citation counts since 2007, respectively. The rest co-cited journals were Journal of Transport Geography (28, 2015), Transportation Research Part E-Logistics and Transportation Review (28, 2014), Transportation Research Part B-Methodological (26, 2011), Transportation (23, 2004), and Transportation Research Record (21, 2015).

Furthermore, Table 3.6 also represents the Impact Factor (IF) in 2022 and the subject coverage of each journal of Journal Citation Reports (JCR) in WoS. It shows that the top six journals have an impact factor greater than 6, and 5 of them focus on the T (Transportation) and E (Economics). In addition, some other characteristics can be highlighted: (1) They are typically leading journals. (2) Authors submitting to these journals have a certain academic influence in this research field. (3) The research published in these journals is of high quality and tends to be innovative and theoretically deep, contributing to academic progress or practical applications. (4) The intersection of T (Transportation) and E (Economics) is an area of substantial research value, especially with trends such as globalization, urbanization, and sustainable development.



Notes: Each color of the legend bar at the top of the figure represents each year from 1998 to 2023 and from left to right. The color of the nodes and links illustrates the published years of articles in the journals based on the bar. The size of a node evidences the number of citations received by a journal. The more crucial the journal is, the bigger the node is, and vice versa. The distance between two nodes is the function of their frequency. The shorter the distance between the two nodes is, the higher the co-citation frequency of the journals is, and vice versa.

Figure 3. 5 Journal co-citation network of PP for HSRs.

Table 3. 6 Top 8 co-cited journals of PP for HSRs.

Ranking	Counts	Co-Cited Journals	Year	Subject Coverage	IF (2022)
1	48	Transportation Research Part A-Policy and Practice	2011	T, E, TS&T	6.4
2	36	Transport Policy	2007	T, E	6.8
3	32	Journal of Air Transport Management	2007	T	6
4	28	Journal of Transport Geography	2015	T, E, G	6.1
5	28	Transportation Research Part E-Logistics and Transportation Review	2014	T, E, E&C, OR&MS, TS&T	10.6
6	26	Transportation Research Part B-Methodological	2011	T, E, E&C, OR&MS, TS&T	6.8
7	23	Transportation	2004	T, E&C, TS&T	4.3
8	21	Transportation Research Record	2015	E&C, TS&T	1.7

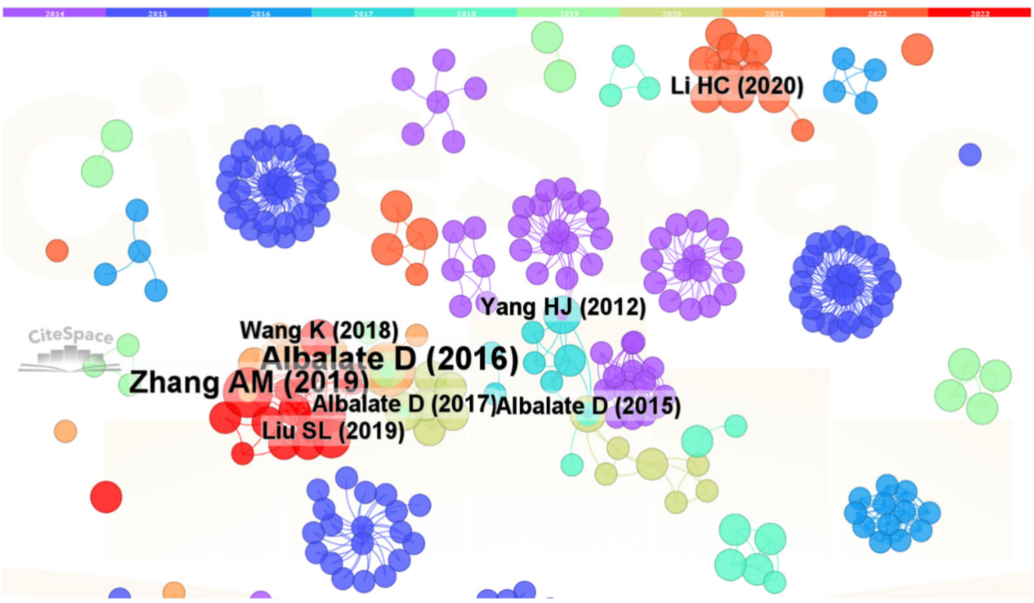
Source: Own elaboration based on the output of co-cited journals analysis in CiteSpace and the information of Journal Citation Reports (JCR) in WoS.
Abbreviations: IF, Impact Factor; E, Economics; E&C, Engineering, Civil; G, Geography; OR&MS, Operations Research & Management Science; T, Transportation; TS&T, Transportation Science & Technology.

3.4.2.2 Document Co-citation Analysis

The document co-citation analysis is an essential method to detect the structure, characteristics, and evolution path of research areas (Liao et al., 2018). Figure 3.6 was plotted by operating CiteSpace to present the document co-citation network with three or more co-citation counts, adjusting the time slice from 2014 to 2023. Therefore, 177 records with 297 nodes and 781 links were qualified. In Figure 3.6, each node represents a cited document, and those of more than three cited counts were labeled, including the first author and the year of publication. The bigger the node, the more essential the document, and vice versa. The shorter the distance, the higher the co-citation frequency, and vice versa. Moreover, the links connecting the nodes illustrate the co-citation relationship between them.

Figure 3.6 illustrates that the most co-cited references were (Albalate & Fageda, 2016) and (Zhang et al., 2019). Interestingly, three articles co-cited by other authors more than three times were all from Albalate D published in different years (2015, 2016, and 2017).

Table 3.7 presents the top 8 co-cited documents with citation counts and document information (including author, year, journal, etc.). As shown in Table 3.7, (Albalate & Fageda, 2016) ranked first with co-cited six times. (Zhang et al., 2019) ranked second with five cited times. The remaining documents were co-cited three times: (Wang et al., 2018), (Liu et al., 2019), (Yang & Zhang, 2012), (Wang, et al., 2020), (Albalate et al., 2015), and (Albalate et al., 2017).



Notes: Each color of the legend bar at the top of the figure represents each year from 2014 to 2023 and from left to right. The color of the nodes and links illustrates the published years of co-cited documents based on the bar. The size of a node evidences the number of citations of documents. The bigger the node, the more essential the document, and vice versa. The distance between two nodes is the function of their frequency. The shorter the distance, the higher the co-citation frequency, and vice versa.

Figure 3. 6 Document co-citation network of PP for HSRs.

Table 3. 7 Top 8 co-cited documents of PP on HSRs.

(1)	(2)	(3)	(1)	(2)	(3)
1	6	Albalate and Fageda (2016)	5	3	Yang and Zhang (2012)
2	5	Zhang et al. (2019)	6	3	Li et al. (2020)
3	3	Wang et al. (2018)	7	3	Albalate et al. (2015)
4	3	Liu et al. (2019)	8	3	Albalate et al. (2017)

Source: Own elaborated according to the output of co-cited documents analysis in CiteSpace. (1) Ranking; (2) Counts; (3) Co-cited document.

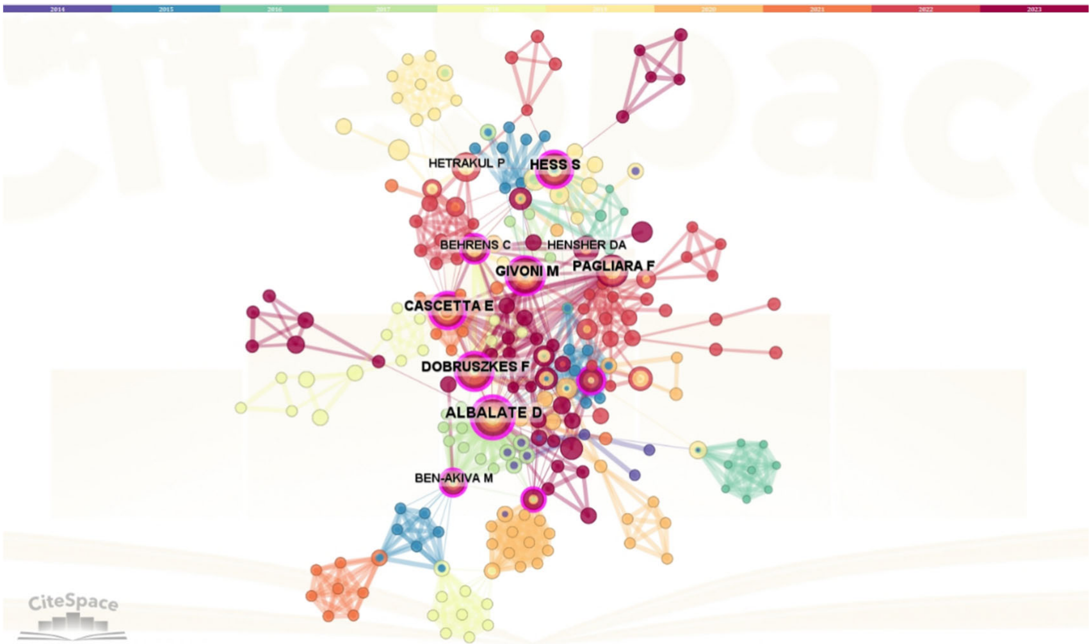
Based on the top articles and the authors' evolving research interests, three interesting time periods can be observed: (1) Early Period (pre-2015): Early research was mainly centered on examining the general effects of transportation infrastructure on regional economic growth, with particular attention to HSR in specific areas, such as China and Spain; (2) Intermediate period: The research started to delve deeper into the detailed effects of HSR on tourism and economic growth. In addition, an increasing interest in inequality and regional disparities occurred; and (3) Recent Trends Period (2018 onwards): The research increasingly places greater emphasis on environmental sustainability, the green potential of HSR, the unequal impacts of transportation networks on less-connected cities or smaller regions, and international comparisons.

3.4.2.3 Author Co-citation Analysis

Through the co-citation network of a particular research area, the author co-citation analysis can provide the distribution of the studies identifying the influence of the highest cited authors as well as a better understanding of the research topics of relevant authors and the distribution of the subject areas (Chen & Liu, 2020). Figure 3.7 shows the authors' co-citation network of PP for HSRs-related articles with 13 or more citations. As Figure 3.6, the k value was reduced from default 25 to 15 to meet the limitations and requirements of the CiteSpace basic version. Therefore, 177 records were qualified for visualization with 286 nodes and 1103 links. Herein, every node represents one author, and the links between them indicate the co-citation relationship of authors. The size of each node evidences the citation counts of the author, while the distance between two nodes illustrates the co-citation frequency of authors. The bigger the node, the more crucial the author; the shorter the distance between two nodes, the higher the frequency of the co-citation of the author; and vice versa.

Figure 3.7 displays a multi-point and short-distance sub-network, indicating the high co-citation frequencies and strong relationships between authors. The largest size of the node corresponds to Albalate D., as it echoes Figure 3.6 and Table 3.7.

Table 3.8 lists the top 10 co-cited authors in descending order by the counts of citations of their published articles. As shown in Table 3.8, the most cited author was Albalate D. with 31 counts since 2015. Following that, other nine highly cited authors are as follows: Givoni M (22, 2014), Dobruszkes F (21, 2015), Cascetta E (20, 2015), Hess S (20, 2014), Pagliara F (20, 2019), Behrens C (14, 2018), Hetrakul P (14, 2018), Ben-Akiva M (13, 2015), Hensher DA (13, 2014).



Notes: Each color of the legend bar at the top of the figure represents each year from 2014 to 2023 and from left to right. The color of the nodes and links illustrates the co-cited years of authors based on the bar. The size of a node evidences the citation counts of the author. The bigger the node, the more essential the author, and vice versa. The distance between two nodes illustrates the co-citation frequency of authors. The shorter the distance, the higher the co-citation frequency, and vice versa.

Figure 3. 7 Author co-citation network of PP for HSRs.

Table 3. 8 Top 10 co-cited authors of PP for HSRs.

Ranking	Counts	Co-Cited Authors	Year	Ranking	Counts	Co-Cited Authors	Year
1	31	Albalate D.	2015	6	20	Pagliara F.	2019
2	22	Givoni M.	2014	7	14	Behrens C.	2018
3	21	Dobruszkes F.	2015	8	14	Hetrakul P.	2018
4	20	Cascetta E.	2015	9	13	Ben-akiva M.	2015
5	20	Hess S.	2014	10	13	Hensher D.	2014

Source: Own elaboration based on the output of co-cited authors analysis in CiteSpace.

Authors listed among the Top 10 co-cited authors are typically considered key contributors or foundational figures within the research field. Their work is often cited together by other researchers and scholars, highlighting their major influence on the field's development. The authors' visibility suggests that their theories, methodologies, or empirical findings are widely adopted or discussed by the academic community.

3.4.3 Keywords Co-occurrence Analysis on PP for HSRs

A science map of keyword co-occurrence could detect hot topics cited frequently in a certain period and offer insights into the frontier topics over time from different perspectives (Yu et al., 2017).

3.4.3.1 Hot research topics

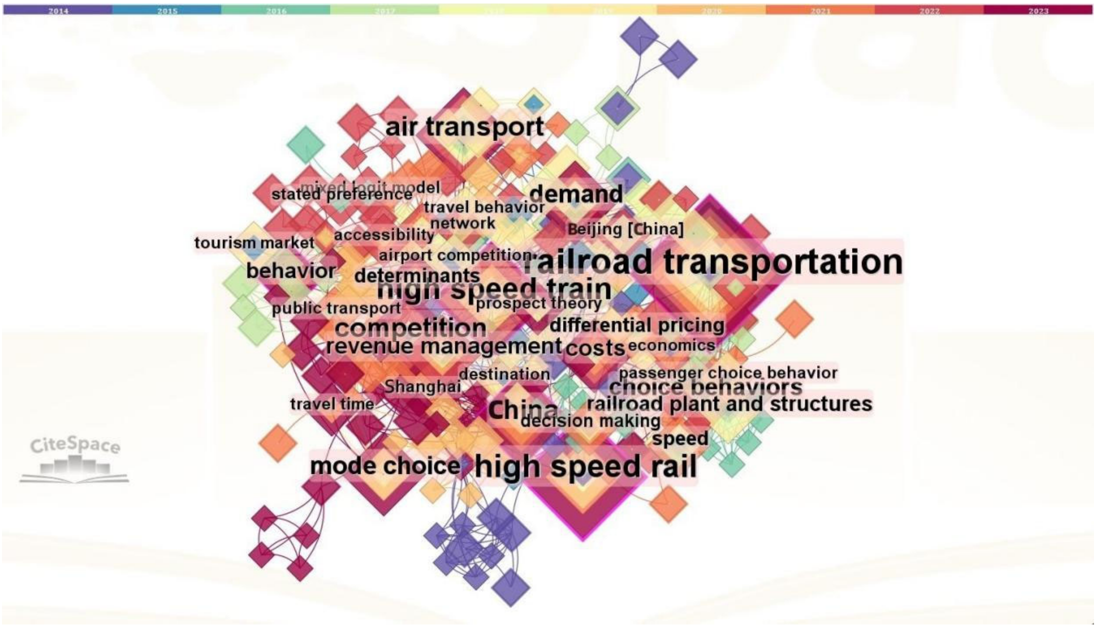
Figure 3.8 is formed by running CiteSpace containing 273 nodes and 1221 links from 2014 to 2023. Every node represents a keyword that has occurred more than four times, and the size of every node indicates the frequency of the co-occurrence. Table 3.9 exhibits the top 32 co-occurrent keywords in descending order according to the counts.

As observed jointly in Figure 3.8 and Table 3.9, except for the keywords railroad transportation, high speed rail, and high speed train, the three top-hot research topics with deeper analysis of PP for HSRs are addressed as follows:

(1) HSR network: Researchers focused on topics such as railroad plant and structure, the status quo, and development modes in different regions. This reflects that HSR development is shaped by specific regional contexts, focusing on cities like Beijing and Shanghai in China. It suggests that China plays a pivotal role in advancing HSR technology and policy on a global scale. The study of the competition between the HSR network, air transport mode, and public transport service highlights the importance of intermodal comparisons. This suggests that researchers are becoming more concerned with integrating HSR into wider transportation networks, examining how it can complement or compete with other modes based on cost, convenience, and sustainability.

(2) Research method: Modeling is one of the most effectively adopted research methods by researchers and scholars to conduct analysis, solve problems, and make decisions. In the research field of PP for HSRs, mixed logit models and stated preference surveys were highly used. These approaches are crucial for understanding complex passenger behaviors and making data-driven decisions related to transportation policies and infrastructure development.

(3) Attributes and variables: The multiple influences of PP for HSRs were due to the attributes (speed, accessibility, costs, travel time) of alternatives and passenger choice behavior. It indicates that researchers are taking a thorough approach to studying HSR, recognizing that passengers consider multiple factors when choosing between HSR and other modes of transportation. Variables like differential pricing highlight an emphasis on economic accessibility and the impact of pricing strategies on passenger behavior. It points to research into how to make HSR attractive to various income groups and regions.



Notes: Each color of the legend bar at the top of the figure represents each year from 2014 to 2023 and from left to right. The color of the nodes and links illustrates the co-occurrence of keywords based on the bar. The size of a node evidences the occurrence counts of keywords. The bigger the node, the more frequent keywords, and vice versa. The distance between two nodes illustrates the frequency of co-occurred keywords. The shorter the distance, the higher the frequency, and vice versa.

Figure 3. 8 Keywords co-occurrence network of PP for HSRs.

Table 3. 9 Top 32 co-occurrent keywords of PP for HSRs.

Ranking	Counts	Co-Occurrent Keywords	Year
1	39	railroad transportation	2014
2	24	high speed rail	2014
3	22	high speed train	2014
4	15	air transport	2014
5	14	China	2018
6	14	competition	2014
7	11	demand	2015
8	11	mode choice	2019
9	10	choice behaviors	2016
10	9	costs	2017
11	9	revenue management	2018
12	8	behavior	2017
13	7	railroad plant and structures	2016
14	6	determinants	2017
15	6	differential pricing	2017
16	6	speed	2017
17	5	decision making	2019
18	4	economics	2014

19	4	tourism market	2015
20	4	stated preference	2016
21	4	Shanghai	2019
22	4	public transport	2017
23	4	mixed logit model	2016
24	4	network	2020
25	4	travel behavior	2018
26	4	destination	2015
27	4	accessibility	2020
28	4	airport competition	2015
29	4	prospect theory	2019
30	4	travel time	2021
31	4	Beijing [China]	2018
32	4	passenger choice behavior	2016

Source: Own elaborated according to the output of keywords co-occurrence analysis in CiteSpace.

3.4.3.2 Research frontiers

Table 3.10 shows the 40 keywords that co-occurred in 2023 and 2022, which reflects the research frontiers of the study on PP for HSRs. Based on Table 3.10, Table 3.11 categorizes the keywords into four groups (Methodology, Economic Terms, Transportation Systems, and Geographical Factors) and displays the corresponding frontiers of each group.

In summary, the highlighted research frontiers of PP for HSRs are made as follows:

(1) Integration of air and HSR systems: As HSR becomes more widespread globally, there is significant research into how to better integrate air and HSR services, particularly through intermodal hubs and schedule optimization to encourage modal shifts.

(2) Consumer behavior and demand modeling: Understanding passenger preferences, demand, and pricing strategies are crucial, with models such as conjoint analysis and logit models. There is growing interest in applying machine learning tools to provide prediction and deeper insights into passenger behavior and market trends.

(3) Transportation infrastructure and capacity: Expanding airports and optimizing rail networks to handle growing demand is a critical research area, especially for mitigating congestion and addressing environmental challenges, as researchers explore strategies to increase capacity and improve the efficiency of transportation systems.

Table 3. 10 40 co-occurrent keywords of PP for HSRs in 2023 and 2022.

No.	Counts	Co-Occurrent Keywords	Year	No.	Counts	Co-Occurrent Keywords	Year
1	3	low cost carriers	2023	21	2	passenger flow equilibrium	2022
2	3	air transport demand	2023	22	2	choice behavior analysis	2022

3	3	airline competition	2023	23	2	trains of common lines	2022
4	2	conjoint analysis	2023	24	2	passenger flows	2022
5	2	frequent flyer programs	2023	25	2	passenger choice behavior	2022
6	2	marginal willingness to pay	2023	26	2	conditional logit model	2022
7	2	optimization models	2023	27	2	sp survey	2022
8	2	preference behavior	2023	28	2	intercity travel	2022
9	2	travel demand	2023	29	2	user preferences	2022
10	2	behavioral research	2023	30	2	technology adoption	2022
11	2	air-hsr integration	2023	31	2	logit model	2022
12	2	price	2023	32	2	regression models	2022
13	2	air-to-rail modal shift	2023	33	2	lda model	2022
14	1	airline scheduling	2023	34	2	logistics industry	2022
15	1	artificial neural networks	2023	35	2	itinerary choice	2022
16	1	airport expansion	2023	36	2	empirical analysis	2022
17	1	air traffic congestion	2023	37	2	nested logit model	2022
18	1	air speed	2023	38	1	cumulative prospect theory	2022
19	5	high speed railway	2022	39	1	distance	2022
20	5	railway transportation	2022	40	1	construction	2022

Source: Own elaboration based on the output of keywords co-occurrence analysis in CiteSpace.

Table 3. 11 Keywords categories and research frontiers.

Categories	Keywords	Frontiers
Methodology	conjoint analysis; optimization models; behavioral research; conditional logit model; sp survey; logit model; regression models; lda model; empirical analysis; nested logit model; cumulative prospect theory; artificial neural networks	1. Predicting passenger choice behavior is essential for understanding mode preferences between HSR, air, and other transportation modes. 2. Machine learning and data mining techniques are increasingly used to model complex transportation networks and analyze large amounts of data for demand forecasting. 3. Understanding how passengers make choices based on various attributes is a growing interest.
Economic Terms	air transport demand; low cost carriers; airline competition; frequent flyer programs; marginal willingness to pay; preference behavior; travel demand; price; user preferences; itinerary choice; technology adoption; choice behavior analysis; passenger choice behavior; passenger flows	1. The competitive strategies of airlines are attracting attention, especially as low-cost carriers gain market share. 2. There is an increasing interest in quantifying how much passengers are willing to pay for certain services. 3. Emphasizing how passengers make decisions between different travel options is crucial for designing better transportation services.
Transportation Systems	air-hsr integration; air-to-rail modal shift; airline scheduling; high speed railway; railway transportation; airport expansion; air traffic congestion; air speed; passenger flow equilibrium; trains of common lines; intercity travel; logistics industry	1. Studies are focusing on intermodal transportation systems and exploring how seamless integration between air and rail can promote a shift from air to rail. 2. It is important to optimize the use of infrastructure to maximize efficiency and minimize delays in heavily congested air and rail corridors.

Geographical Factors	distance; construction	1. Researchers are exploring what distance thresholds passengers prefer rail over air, and vice versa. 2. Centering on the development of construction and infrastructure is a research frontier to optimize investment and improve overall network efficiency.

Source: Own elaboration based on the output of keywords co-occurrence analysis in CiteSpace.

3.5 Conclusions

To determine the research status quo, identify influential authors and significant research themes, and explore the research frontiers and hot spots of passengers' preferences (PP) for high-speed railways (HSRs), this study firstly conducted a bibliometric analysis by adopting CiteSpace (6.3.R1) software for visualization. 135 valid published articles (1998-2023) were used, from the extraction of Scopus and WoS with the searching strategy: TITLE-ABS-KEY ("high speed rail*" or "high speed train*") AND ("passenger* preferen*" or "passenger* choice*" or "preferen* of passenger*" or "choice* of passenger*" or "traveler* preferen*" or "traveler* choice*" or "preferen* of traveler*" or "choice* of traveler*" or "commuter* preferen*" or "commuter* choice*" or "preferen* of commuter*" or "choice* of commuter*" or "tourist* preferen*" or "tourist* choice*" or "preferen* of tourist*" or "choice* of tourist* " or "user* preferen*" or "user* choice*" or "preferen* of user* " or "choice*of user*"). Interesting insights were obtained with the analysis of co-authorship, co-citation, and keywords co-occurrence.

At the author level, the prolific authors were Pagliara Francesca, Mauriello Filomena, and Zhao Peng, while the highly cited authors were Albalate Daniel, Givoni Moshe, and Dobruszkes Frederick. The articles of these authors had made a significant contribution and could inspire new researchers in this research field. At the institutional level, the core research forces were mainly taken from Beijing Jiaotong University, the University of Naples Federico II, and Central South University. The interaction between the institutions could be vital in strengthening current relationships and identifying potential collaborators for future research work. At the country level, China, Italy, and Spain were the most influential.

The core journals with a high number of citations were Transportation Research Part A, Transport Policy, and Journal of Air Transport Management. The most cited documents were the studies of Albalate and Fageda (2016) and Zhang et al. (2019). Regarding the keyword analysis, the top keywords were air transport, China, and competition; and without considering railroad transportation, and high speed rail/train, the hot topics were related to the "HSR network", "research method", and "attributes and variables"; and the research frontiers are "integration of air and HSR systems", "consumer behavior and demand modeling", and "transportation infrastructure and capacity".

This study provides the following key contributions: (1) helps scholars, policymakers, and stakeholders interpret and comprehend the HSRs PP state-of-the-art; (2) identifies the most influential authors and academic research in the field to serve as a valuable resource for future researchers; (3) analyzes contributions from different institutions and countries to highlight the global nature of HSR; (4) uncovers hidden relationships and connections between authors, institutions, countries, journals, and keywords to produce potential scholarly opportunities and international collaborations; (5) reveals the emerging trends and offers insights into the future directions of HSR research. However, some drawbacks exist. For example, the original data was extracted from Scopus and WoS, but other sources such as Google Scholar and CNKI can also complement the dataset. The data collected from Scopus needs to be converted into WoS format before conducting further analysis using CiteSpace, and the data conversion process is not straightforward, which may cause damage or loss of some data. In addition, though the basic version of CiteSpace is completely free to use and includes the most crucial functions, it has limitations in handling large datasets. It offers fewer options for customizing graphical outputs. Furthermore, a linguistic bias exists in the articles since all articles analyzed were restricted to English and Chinese only.

4

4 PAPER 3: High-Speed Rail and Resilience: An Overview of the Literature (2019-2024)

Abstract

High-speed rail (HSR) and resilience are becoming two interconnected topics, as there is an increasing recognition that HSR can play a critical role in enhancing the resilience of transportation systems and the communities they serve. This study breaks new ground by offering the first comprehensive bibliometric analysis of the resilience of high-speed rail (HSR) from 2019 to 2024, collecting data in Chinese and English from Web of Science and Scopus databases. By using CiteSpace to visualize knowledge maps (co-authorship networks, co-institution collaborations, cited references, and keyword co-occurrence patterns), this study uncovers critical trends, influential research themes, and underexplored gaps in the field. This review emphasizes the increasing importance of HSR on spatial resilience and economic recovery, resilience through transportation mode integration, resilient transportation systems, and resilient environmental infrastructure. This study also detects gaps in addressing long-term resilience, climate adaptation, and the equitable distribution of HSR benefits. The findings provide valuable insights for policymakers and practitioners on designing updated plans to foster international collaboration, facilitate sustainable regional development, and maximize the resilience and societal benefits of HSR systems. Future studies should focus on the research topics of diverse geographic and socioeconomic contexts, the integration of HSR and other transport modes, technological innovation, and the socio-environmental dimensions of HSR development.

Keywords: High-speed rail; Resilience; Bibliometric analysis; CiteSpace

4.1 Introduction

The emergence of high-speed rail (HSR) heralds an era of change in transportation and urban development. Characterized by its remarkable speed, efficient connectivity, and reduced travel times, HSR has become a cornerstone of modern infrastructure, reshaping economic, social, and environmental landscapes. However, as HSR systems become increasingly integrated into the fabric of contemporary societies, their ability to endure and recover from disruptions—whether caused by natural disasters, technical glitches, or broader socioeconomic and environmental pressures—has emerged as a pressing issue. This underscores the importance of resilience, a concept that has gained widespread attention across fields as diverse as engineering, economics, and urban planning, as societies seek to strengthen their systems against unexpected shocks and disturbances.

Resilience, in the context of HSR, refers to the system's capacity to maintain functionality, adapt to disruptions, and recover swiftly, thereby ensuring continuous service and minimizing adverse impacts on communities and regions. A resilient HSR system not only ensures consistent service but also contributes significantly to maintaining economic stability, social equity, and environmental sustainability.

Although there is growing interest in transportation resilience, studies focusing on HSR and its resilience remain limited compared with other transport modes' resiliency. As recognized by Zhang et al. (2022), the research on HSR mainly focuses on risk management which includes construction risk (He et al., 2021; Huang et al., 2022; Lin et al., 2021), railway inherent risk (Chen et al., 2016; Feng et al., 2017), safety risk (Liu et al., 2022; Montenegro et al., 2021; Peixer et al., 2021; Zhang et al., 2020), ecological risk (Chen et al., 2020; Dong et al., 2018; Guo et al., 2017; He et al., 2015; Liu et al., 2021; Marincioni & Appiotti, 2009; Sa'adin et al., 2016), and social risk (Dong et al., 2018; Li et al., 2020; Xue & Xiang, 2020), political risk (Chang et al., 2019), and demand risk (Bugalia et al., 2021). However, resilience involves not only the ability to recover from disruptions but also to anticipate and adapt to future challenges. The intersection of HSR and resilience remains underexplored in the literature, leaving a gap in understanding how HSR systems can be designed and managed to enhance resilience in the face of growing uncertainties.

This study addresses this gap by conducting a comprehensive bibliometric analysis of existing literature on HSR and resilience from 2019 to 2024. CiteSpace is used to visualize co-occurrence patterns and identify emerging research frontiers based on 634 validated articles in English and Chinese collected from the Web of Science (WoS) and Scopus. By synthesizing the current state of knowledge, this study aims to provide valuable insights into the resilience of HSR systems and propose future research directions. The findings desire to guide practitioners, scholars, and decision-makers in designing and implementing resilient HSR systems that foster international collaboration, facilitate sustainable regional development, and maximize the resilience and societal benefits of HSR systems.

The remainder of this study is organized as follows: The next section briefly reviews the relevant literature on HSR and resilience. Section 3 describes the methodology and data-collecting process. Section 4 illustrates the results by displaying the figures and tables and provides critical analysis. Section 5 concludes the study and presents its main limitations.

4.2 Literature Review

4.2.1 Definitions of Resilience in HSR

The term resilience was first introduced and defined in ecology as “the amount of disturbance a system could take before it shifted into an alternative configuration” by Holling (1973) cited in (Fang et al., 2022; Holling, 1973; Li et al., 2022; Lin et al., 2021). Since then, the concept of resilience started to be developed in various application areas (Zhang et al., 2022; Zhou & Chen, 2020). Nevertheless, no unified definition of resilience exists. According to the United Nations Office for Disaster Risk Reduction (UNDRR, https://www.undrr.org/terminology/resilience), the widely accepted definition of resilience is: “the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management”. Lin et al. (2021) first defined high-speed electric multiple units (EMUs) resilience and illustrated the basic resilience process with phased embodied. Li et al. (2022) focused on earthquake resilience assessment and adapting it for the analysis of resilience in HSR based on train timetable rescheduling, therein the illustration of the basic resilience curve was slightly modified from Lin et al. (2021). Bešinović (2020) conducted a literature review on resilience in railway transport systems using quantitative approaches to set up a field-specific definition of resilience, in which he diagramed the resilience of railway transport systems including vulnerability, survivability, response, and recovery, and claimed that no resilience papers occurred before 2008. Therefore, this study can be conceptualized as a continuation and expansion of Bešinović’s but specifically focusing on resilience in the HSR system.

4.2.2 Technological Innovations and Resilience

Technological advancements play an essential role in enhancing the resilience of HSR. Recent research highlights the integration of machine learning techniques and applications for predictive resilience analysis in HSR systems. The use of artificial intelligence (AI) and big data analytics has also gained attention in addressing delays and operational challenges in HSR networks. Xiao et al. (2024) propose a novel control framework for virtually coupled high-speed trains, ensuring the safety and coordination of train convoys even under stochastic disturbances and cyberattacks. Hao et al. (2024) take a network-based approach to improving the robustness of HSR systems by optimizing their structural designs. They model the HSR system as an interdependent network of machine, electricity, and communication networks, using advanced algorithms to enhance system resilience. Chen et al. (2023) examine the role of HSR in promoting green technology innovation in China. The results show that HSR expansion positively influences local and surrounding areas' green technology innovation, particularly in cities with high marketization and through creative class flows.

4.2.3 Climate Change Resilience

Climate change presents a significant threat to the resilience of HSR systems. Multiple studies have explored the vulnerability of HSR networks to climate-related disruptions such as extreme weather events and emphasized the role of the environmental benefits of HSR in reducing carbon emissions and substituting high-pollution transport methods. Yang et al. (2024) and Chen et al. (2024) address how the expansion of HSR can support low-carbon economic development. Liu et al. (2023) find that HSR reduces pollution emissions by decreasing transportation costs and encouraging innovation in firms. Yan et al. (2023) explore that HSR reduces SO2 emissions in cities through technological innovation and industrial optimization.

4.2.4 Spatial Resilience and Regional Connectivity

Spatial resilience refers to the ability of a region to adapt to shifts in transportation patterns, population growth, and economic changes. Chi & Han (2023) highlight that HSR reduces congestion in major urban centers and helps to distribute economic growth more evenly, which enhances spatial resilience. Hiramatsu (2023) explores that the demographic impact of HSR encourages population migration to areas with improved rail connections, allowing for more sustainable urban development and enhancing the resilience of urban infrastructures. Cai et al. (2023) examine how HSR contributes to spatial economic resilience by promoting balanced regional development. Liu et al. (2024) emphasize the economic resilience provided by HSR through improved connectivity between regions.

4.3 Methodology and Data Collection

4.3.1 Methodology

In 1969, the term “bibliometrics” was first defined by Alan Pritchard as a mathematical and statistical analysis of large quantities of scientific publications and literature (Lawani, 1981). Bibliometric analysis uses quantitative methods to assess academic literature, providing valuable insights into publication patterns, citation frequencies, co-authorship networks, and keyword distributions. This approach is frequently applied to identify key authors, leading institutions, and collaborative relationships, as well as to detect emerging topics and trends within a specific field of study. Thus, in this study, bibliometric analysis is employed as the primary method to explore the intellectual structure and research trends within the field of HSR and resilience.

4.3.2 Data Collection and Preprocessing

Two widely available databases, Web of Science (WoS) and Scopus, were selected to collect data on December 15, 2024. To strengthen the analytical framework and discover valuable insights, in addition to the terms of HSR and resilience, we included "accessibility", "equity", and "economic assessment" which are closely related to the main topic as the search query. The search period was set based on (Bešinović, 2020), whose literature review was from January 2008 to August 2019. We followed the five stages outlined below for data collection and preprocessing.

Stage 1: Initial Screening.

We retrieved the document records from the Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) of Web of Science Core Collection (WoS CC) and Scopus by using the search query: Topic = ("high speed rail*" OR "high speed train*") AND (resilien* OR accessib* OR equity OR "economic assess*"), in which, the "Topic" means that the search will cover the Title, Abstract, and Keywords of a paper to identify relevant articles; and the wildcard was a symbol to represent one or more unknown characters for matching various variations of a word or phrase, such as resilient or resilience. The time range was set from September 1, 2019, to December 15, 2024, in WoS, and 2019 to 2024 in Scopus since the specific month or day cannot be set in Scopus. Thus, an initial dataset with 513 and 397 records was obtained from WoS and Scopus, respectively.

Stage 2: Secondary Screening.

We refined the document type to articles and language to English and Chinese, since English is a commonly used language in scientific work and Chinese has good contributions in the research field of HSR in recent years. Then, we obtained 502 articles from WoS and 394 from Scopus with complete information (e.g., Title, Abstract, Keywords, Author, Country, Affiliation, and Year). In total, we retained 896 article results. Next, we identified and removed duplicates based on the DOI, resulting in a reduction of 639 records.

Stage 3: Handling of Abnormal Data.

To avoid errors and acquire precise visualization results, we checked the two datasets and manually modified and unified the names of authors, affiliations, and countries. Special symbols in some authors' names need to be corrected, such as Belén and Ágata. The names of countries need to be standardized, for example, Peoples R China and China, United States and USA. We unified both the full name and abbreviation of the same university to unambiguously identify the institution, such as Beijing Jiaotong Univ and Beijing Jiaotong University.

Stage 4: Handling of Missing Values.

For the records with missing information in some of the fields, such as author affiliations or year, we found the corresponding information directly from each original article.

Stage 5: Final Dataset.

According to Citespace software's requirements for data preparation, the dataset exported from Scopus was converted to a WoS version with a 94.0% success conversion rate. Thus, we obtained a final dataset with 634 qualified records for further exploration covering the period from 2019 to 2024.

4.3.3 Bibliometric Software

Citespace is a Java-based scientific tool developed by Dr. Chaomei Chen at Drexel University (USA) (Chen, 2014) for visualizing and analyzing the citation relationships between academic papers, which can provide insights into the structure and dynamics of research domains. Citespace (Basic version) is available downloaded freely at https://citespace.podia.com/. Citespace, as a valuable tool, has been widely used across various academic research fields, such as science and technology (Chen et al., 2016; Tho et al., 2017), information science and bibliometrics (Jia et al., 2020; Liu, Che & Zhu, 2022), medicine and healthcare (Guo et al., 2019; Liang et al., 2017; Zhang et al., 2020), social sciences (Chen & Liu, 2020b; Liu et al., 2022; Wang et al., 2021; Wu & Martín, 2025a), computer science and data science (Wang et al., 2020; Wei et al., 2015; Zhang et al., 2021), environmental science and sustainability (Fang et al., 2018; Hu et al., 2019; Shi & Liu, 2019), and oceanography and marine biology (Cantillo et al., 2022; Wu et al., 2020).

In this study, CiteSpace 6.3.R1 (64-bit) Basic (Free Version) in the Windows 11 (CN/zh) system is adopted to conduct the analysis and generate the visualization of co-authorship networks, co-institution collaborations, cited references, and keyword co-occurrence patterns based on the collected dataset of HSR and resilience.

4.4 Result and Critical Analysis

This section presents the knowledge mapping of co-authorship networks, co-institution collaborations, cited references, and keyword co-occurrence patterns based on Citespace visualization. These network mapping have unique abilities to provide a comprehensive and multi-dimensional understanding of the research landscape in HSR and resilience and help to reveal interdisciplinary collaborations, identify influences, and understand the structure of scientific communities within a specific research domain. In addition, this section proposes critical analysis based on the statistical analysis of the existing literature.

All the figures shown in this section were set in the Tree Ring History visualization mode generated by Citespace. The Tree Ring History mode visually represents the nodes' historical evolution and helps researchers identify trends or emerging topics in a research area. Furthermore, all the figures share the following properties that need to be taken into account: (1) The colored bar displayed at the top of each map and the color of each node and link represents the year of the appearance of each item, that is the same year, the same color; (2) The size of each node or each name indicates the frequency of each item. The higher the frequency, the larger the node, and vice-versa; (3) The distance of links between nodes illustrates the degree of their connection. The shorter the distance, the tighter the connection, and vice-versa; (4) The thickness of links between nodes denotes the degree of their cooperation. The thicker the link, the more the cooperation, and vice-versa; (5) The groups in each map demonstrate the clusters of items.

4.4.1 Author

4.4.1.1 Co-authorship Network

Figure 4.1 shows the map of the author's co-authorship analysis of resilience of HSR. The authors who collaborated on more than four records were displayed. Table 4.1 lists the most collaborative authors ordered by the counts of their collaborated articles.

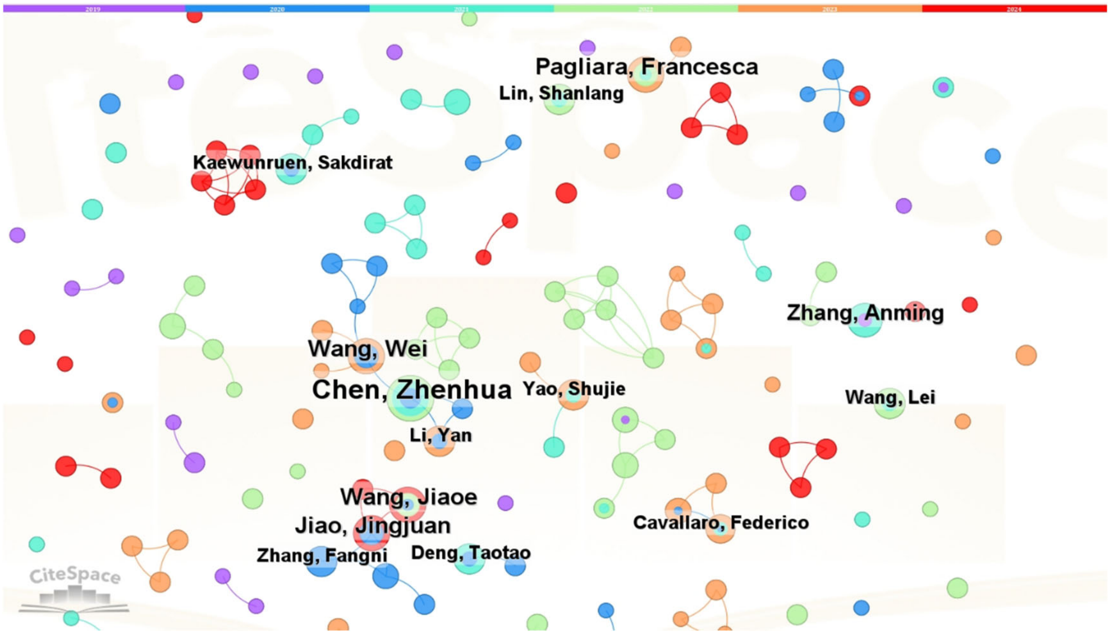


Figure 4. 1 Map of the author co-authorship network of HSR and resilience-related articles.

Table 4. 1 Most collaborative authors of HSR and resilience-related articles.

Ranking	Counts	Authors	Year	Ranking	Counts	Authors	Year
1	9	Chen, Zhenhua	2020	8	4	Cavallaro, Federico	2020
2	6	Pagliara, Francesca	2021	9	4	Lin, Shanlang	2021
3	6	Jiao, Jingjuan	2020	10	4	Zhang, Fangni	2020
4	6	Wang, Wei	2020	11	4	Li, Yan	2020
5	6	Wang, Jiaoe	2020	12	4	Kaewunruen, Sakdirat	2020
6	5	Zhang, Anming	2019	13	4	Wang, Lei	2021
7	4	Yao, Shujie	2021	14	4	Deng, Taotao	2020

Source: Own elaboration based on the output of author analysis in CiteSpace.

4.4.1.2 Critical Analysis of Author Co-authorship Network

Figure 4.1 highlights two distinct research groups and several independent contributors, which provide insights into the structure of academic collaboration in the research field of HSR and resilience. Based on this co-author network and the collaborative works of the top five key authors (Chen Zhenhua, Pagliara Francesca, Jiao Jingjuan, Wang Wei, and Wang Jiaoe) shown in Table 4.2, we present the following critical analysis.

·Research Groups and Collaboration Patterns

The group, with Chen Zhenhua being the most active author (9 co-authorships in 2020), is highly collaborative. The research focuses on the socioeconomic impacts of HSR, including social equity, accessibility, and regional economic growth. Their contributions indirectly address resilience by emphasizing the role of HSR in enhancing commercial stability and adaptability to disruptions. The other group also reflects significant collaboration. Their studies concentrate on the economic and spatial impacts of HSR, including urban development, tourism, and network effects. Their contributions provide insights into how HSR can strengthen resilience by improving connectivity and facilitating resource allocation during disruptions. Authors like Pagliara Francesca are dispersed in the network, suggesting their works independently or across multiple research groups. Complementing the two main groups, Pagliara Francesca's research on social equity and geographical inclusivity of HSR supplies a broader perspective on the social dimensions of resilience.

·Interdisciplinary Insights and Methodological Contributions

The collaborative works of these authors demonstrate a strong interdisciplinary approach, combining econometric modeling, spatial analysis, and complex network methods. For example, Chen Zhenhua and Wang Wei's use of Bayesian multinomial logistic regression to analyze intercity travel behavior provides a robust methodological framework for understanding passenger preferences and resilience. Jiao Jingjuan and Wang Jiaoe's application of spatial panel data models to study the economic impacts of HSR offers valuable insights into the spatial dimensions of resilience. Pagliara Francesca's use of the Gini index to assess geographical inclusivity highlights the importance of equity considerations in resilience planning.

·Policy Implications and Future Research Directions

The research of these authors provides valuable insights for policymakers on how to design and implement HSR systems that promote economic resilience, social equity, and operational reliability. Future research could: pay more attention to the long-term resilience of HSR systems, such as climate change and other global challenges; explore the potential benefits of the integration between HSR and other transport modes (air and conventional rail) to strengthen the overall system resilience; address the equity implications of HSR investments in less developed countries and regions; expand the collaboration network to foster innovation, open up new research opportunities, and provide greater visibility and interdisciplinary advancements.

Table 4. 2 Contributions of the Top 5 collaborative authors.

Author	Contributions
Chen, Zhenhua	(Chen et al., 2020; Chen et al., 2021; Chen et al., 2021; Cheng & Chen, 2021, 2022; Li et al., 2020; Ren et al., 2020; Yang & Chen, 2022; Zhou & Chen, 2020)
Pagliara, Francesca	(Dobruszkes et al., 2022; Henke et al., 2023; Pagliara, 2021; Pagliara et al., 2021, 2022, 2023)
Jiao, Jingjuan	(Jiao et al., 2024; Jiao et al., 2020; Jiao et al., 2020; Lyu et al., 2024; Yang et al., 2020; Zhang et al., 2020)
Wang, Wei	(Li et al., 2020; Ren et al., 2020b; Wang et al., 2023; Wang et al., 2020; Yue et al., 2023; Zhang et al., 2020)
Wang, Jiaoe	(Gou et al., 2022; Hu et al., 2024; Jiao et al., 2020b; Lyu et al., 2024; Wang et al., 2020; Xiao et al., 2022)

Source: Own elaboration based on the output of author analysis in CiteSpace.

4.4.2 Institution

4.4.2.1 Co-institution Collaboration

Figure 4.2 shows the academic collaboration among institutions with ten or more contributions of HSR and resilience. The most prolific institutions are sorted by the number of publications in Table 4.3.

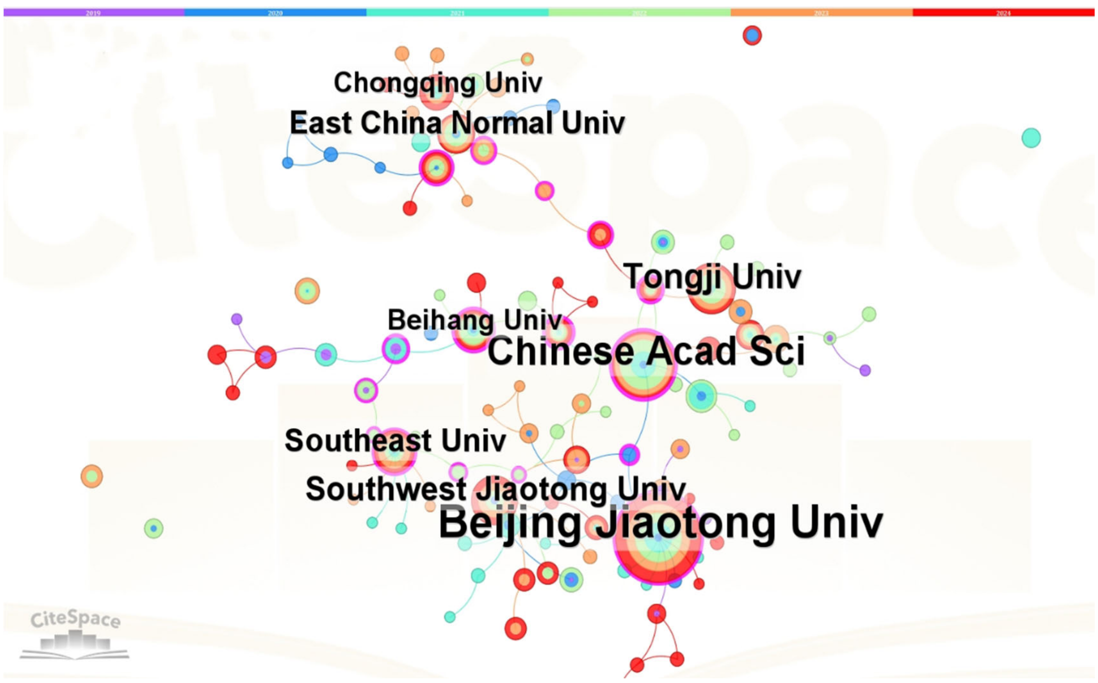


Figure 4. 2 Map of the co-institution network of HSR and resilience-related articles.

Table 4. 3 Most prolific institutions of HSR and resilience-related articles.

Ranking	Counts	Institutions	Year
1	70	Beijing Jiaotong University	2019
2	38	Chinese Academy of Sciences	2019
3	23	Tongji University	2020
4	20	Southwest Jiaotong University	2019
5	16	Southeast University	2020
6	15	East China Normal University	2019
7	12	Beihang University	2020
8	11	Chongqing University	2021

Source: Own elaboration based on the output of institution analysis in CiteSpace.

4.4.2.2 Critical Analysis of Co-institution Collaboration

·Central Role of Beijing Jiaotong University (BJU)

In Figure 4.2, Beijing Jiaotong University (BJTU) stands as the central node underscoring that BJTU is a well-established institution with significant academic influence and is at the heart of the research efforts in HSR and resilience. BJTU is known for its strengths in transportation and engineering, and its centrality might suggest that BJTU makes it a hub for related research topics. However, the over-centralization of research in one institution may limit the diversity of perspectives and approaches, which suggests that significant international collaborations are needed to acquire potential global insights and best practices.

·Limited International Collaboration

Figure 4.2 reveals a highly concentrated research landscape on HSR and resilience dominated by Chinese institutions. This indicates China's continued development and innovation in the research sector of HSR and the increasing global recognition of Chinese research. Nevertheless, it reflects a lack of international institutions in the network, which may result in a narrow focus on worldwide challenges, such as climate change, natural disasters, and human operational disruptions.

·Policy Implications

(1) National policies should pay more attention to regional institutions, like Southwest Jiaotong University and Chongqing University, considering their valuable localized perspectives in addressing region-specific challenges, such as mountainous terrain and environmental vulnerabilities. Taking measures, such as funding and training programs, to strengthen the capacity of regional institutions would ensure that resilience strategies are contextually specific and inclusive. (2) Governments and funding agencies should incentivize international collaboration in the research of HSR and resilience to obtain diverse perspectives and innovative methodologies from other countries. The supporting activities could include joint research grants, international conferences,

exchange internships, and partnerships between Chinese institutions and global leaders in transportation research. (3) Policymakers should encourage interdisciplinary research since HSR resilience is a multifaceted challenge that requires integrated solutions. The methods include creating platforms for collaboration between different disciplines, such as engineering, environmental science, social sciences, and data analytics.

·Future Research Directions

(1) Future research should include comparative studies of HSR resilience across different countries and regions to understand the universal principles and strategies. (2) In this technological era, research should explore and use emerging technologies, such as artificial intelligence (AI) and big data analytics, to ensure HSR resilience. (3) Future research should focus on improving climate-resilient HSR systems regarding the increasing impact of climate change (extreme weather, rising temperatures, and sea-level rise) on transportation infrastructure. (4) Considering the impact of disruptions on passengers, communities, and regional economies, future research should address the socio-economic dimensions of HSR resilience.

4.4.3 Reference

4.4.3.1 Document Co-citation Network

Figure 4.3 labels the network of references co-cited in 28 or more papers. Table 4.4 presents ten high-co-cited documents on the research of HSR and resilience.

For better understanding the research themes of these authors, we carefully studied their contributions and made a summary of the topics.

·Economic Growth and Accessibility

Cascetta et al. (2020) focused on the study of Italy shows a 32% increase in transport accessibility along HSR corridors, contributing to a 2.6% rise in per capita GDP over a decade. Jiao et al. highlighted that the economic impact of HSR is realized through network effects, such as improved accessibility and connectivity, rather than the mere presence of HSR infrastructure. Diao (2018) and Liu & Zhang (2018) showed that HSR reduces travel times and enhances accessibility, particularly in second-tier cities, which benefit more from increased fixed asset investment and economic productivity.

·Regional Disparities and Equity

Cascetta et al. (2020) also addressed equity, noting that HSR in Italy has increased regional inequalities by favoring zones served by HSR, with a 29% increase in equity indices projected under a completed HSR network scenario. Liu et al. (2020) found that HSR reduces disparities within city clusters, it exacerbates inequalities between core and non-core cities. Chen & Haynes (2017) argued that HSR has generally reduced regional economic disparity in China, promoting convergence, especially in less developed regions.

·Urbanizaiton

Wang et al. (2019) found that HSR promotes short-term population mobility but negatively affects long-term migration and population urbanization. Shao et al. (2017) highlighted the positive effect of HSR on urban service industry agglomeration, particularly in producer services, driven by higher service intensity.

·Intermodal Competition

Zhang et al. (2019) conducted a comprehensive review of HSR's impacts on airlines, airports, and regional economies and emphasized the potential for air-HSR intermodal services to mitigate congestion at hub airports.

·Agglomeration

Ahlfeldt & Feddersen (2018) examined the agglomeration effects of HSR in Germany, finding an 8.5% increase in GDP for counties with intermediate HSR stops and identifying a strong spatial scope for agglomeration forces, with productivity gains declining as travel time increases.

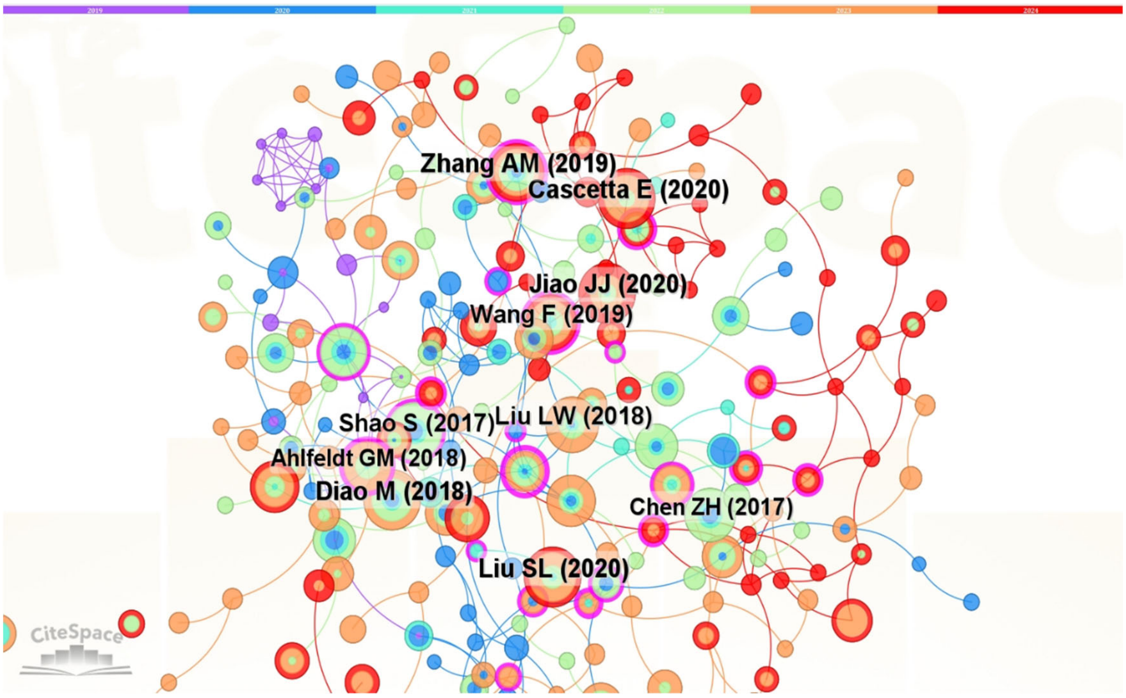


Figure 4. 3 Map of the reference co-citation network of HSR and resilience-related articles.

Table 4. 4 Top 10 co-cited documents of HSR and resilience-related articles.

Ranking	Counts	Co-Cited Documents	Ranking	Counts	Co-Cited Documents
1	36	(Cascetta et al., 2020a)	6	33	(Wang et al., 2019)
2	35	(Zhang et al., 2019)	7	31	(Shao et al., 2017)

3	35	(Diao, 2018)	8	31	(Liu & Zhang, 2018)
4	34	(Liu et al., 2020)	9	28	(Ahlfeldt & Feddersen, 2018)
5	34	(Jiao et al., 2020a)	10	28	(Chen & Haynes, 2017)

Source: Own elaboration based on the output of co-cited documents analysis in CiteSpace.

4.4.3.2 Critical Analysis of Document Co-citation network

·Strengths of the Co-cited Literature

Documents are widely referenced and applied by other researchers, which suggests providing essential theoretical frameworks, innovative methodologies, or case studies in the research area. Specific themes can be explored by reviewing the topics covered in these papers. These articles may lead to new studies or advancing discussion in the field. Even though we collected data from 2019 to 2024, the influential papers from slightly earlier years (2017 and 2018) do continuously play a major role in shaping academic co-citation patterns.

·Limitations and Gaps

(1) Most of the co-cited references focus on China and Italy, with the remaining geographic bias of findings from other countries and regions with different socioeconomic contexts. (2) Most co-cited research studies on short-to-medium-term impacts were lacking in exploring the long-term effects of HSR and resilience. (3) Based on the summary of the co-cited documents, they extensively discussed economic and spatial impacts, ignoring external shocks, such as climate change and economic crises.

·Policy Implications

(1) Policymakers should consider compensatory measures to address regional inequalities aggravated by the development of HSR systems. They should ensure that smaller cities and rural areas benefit from improved connectivity. (2) The integration of HSR and other transport modes should be promoted to maximize accessibility and economic benefits. Air-HSR intermodal services can alleviate congestion and enhance overall transportation efficiency. (3) Policies should be made strategically targeted to maximize the agglomeration effects, for example, supporting small and medium-sized businesses in HSR-connected areas to foster local economic development. (4) Policymakers should develop predicament plans to leverage HSR for disaster relief and recovery efforts.

·Future Research Directions

(1) Future research should explore how HSR contributes to regional resilience. (2) Future studies should pay more attention to the long-term impacts of HSR on regional economic development, equity, and environmental sustainability. (3) More comparative analyses across different geographic and socioeconomic contexts are needed to get deeper insights into HSR and resilience.

4.4.4 Keyword

4.4.4.1 Popular Research Keywords

Keyword co-occurrence analysis is a technique often applied in academic research to identify closed relationships between terms or keywords that appear together in the literature. It is feasible to investigate popular topics and uncover new insights.

Table 4.5 sorts the top 50 most frequently occurring keywords in descending order by eliminating stop words (such as high speed rail, high-speed rail, high speed train, railroad transportation, railroads, railway transport, impacts, growth, model, investment, performance, systems, gis, article, etc.) refined by authors.

Table 4. 5 Top 50 co-occurrent keywords of HSR and resilience-related articles.

Ranking	Counts	Co-Occurrent Keywords	Year
1	239	accessibility	2019
2	174	China	2019
3	43	travel time	2020
4	42	economic growth	2020
5	39	integration	2020
6	35	economic development	2020
7	35	equity	2019
8	34	network	2020
9	32	infrastructure	2020
10	30	yangtze river delta	2019
11	30	productivity	2020
12	26	urban transport	2019
13	24	transportation infrastructure	2020
14	23	transportation planning	2020
15	23	railroad cars	2020
16	22	urbanization	2019
17	21	economic and social effects	2020
18	21	air transport	2019
19	21	transportation development	2020
20	21	resilience	2020
21	20	transportation system	2020
22	19	air transportation	2019
23	19	mobility	2019
24	18	public transport	2020
25	17	empirical analysis	2020
26	17	urban area	2019
27	17	spatial analysis	2019
28	16	urban development	2022

29	14	economics	2020
30	14	efficiency	2020
31	12	spatial distribution	2020
32	12	speed	2020
33	12	connectivity	2020
34	11	costs	2020
35	11	regional planning	2020
36	11	regional development	2021
37	11	urban economy	2022
38	11	innovation	2021
39	11	location	2022
40	11	sustainable development	2020
41	10	economic impact	2020
42	10	geography	2020
43	10	construction	2021
44	10	disparity	2023
45	10	spillover effect	2022
46	10	spatiotemporal analysis	2021
47	10	decision making	2021
48	10	time	2020
49	9	urban agglomerations	2019
50	9	cost benefit analysis	2021

Source: Own elaboration based on the output of keywords co-occurrence analysis in CiteSpace.

4.4.3.2 Critical Analysis of Popular Research Keywords

To help scholars stay informed about the latest developments and future directions in the studies of HSR and resilience, we divided the 50 popular research keywords listed in Table 4.6 into different categories to conduct critical analysis, including research frontiers.

·Current State Insights

(1) The economic-related keywords sorted from Table 4.4 suggest that most of the research is driven by the economic benefits of HSR. (2) Much emphasis on accessibility and mobility reflects the potential of HSR in reshaping urban and regional transport systems. (3) Many focus on the HSR infrastructure and network planning, which highlights the technical and engineering aspects of HSR. (4) The spatial and regional keywords indicate that HSR has broader geographical impacts. (5) The resilience and sustainability of keywords demonstrate the increasing awareness of the need for sustainable and resilient transport systems. (6) The keywords related to decision-making show that the policies developed by the government and policymakers are essential in HSR and resilience.

·Policy Implications

(1) Policymakers should consider not only the economic benefits of HSR but also its social and environmental impacts. (2) Integrated plans are needed to align HSR infrastructure with urban and regional development goals. (3) Policymakers should invest in more green technologies to enhance the resilience of HSR infrastructure to climate change and other disruptions. (4) Strategies and plans should be developed based on the equity distributed across different areas and population groups. (5) Academic research on technology innovation should be supported.

·Future Research Directions

(1) Future studies should explore the social and environmental impacts of HSR, such as community well-being, land use, and environmental sustainability. (2) Future research should pay more attention to the equitable distribution and accessibility of HSR services to different population groups. (3) There is still a need for researchers to focus on the resilience and sustainability of HSR. (4) High-tech HSR operations and services, such as digitalization, automation, and smart technologies, are in urgent need of attention and study.

Table 4. 6 Keywords categories.

Categories	Keywords
Economic Impacts and Development	economic growth, economic development, productivity, economic and social effects, economic impact, urban economy, cost benefit analysis
Accessibility and Mobility	accessibility, travel time, mobility, public transport, urban transport, transportation system
Infrastructure and Network	network, infrastructure, transportation infrastructure, transportation planning, railroad cars, air transport, air transportation
Spatial and Regional Analysis	spatial analysis, spatial distribution, regional planning, regional development, urban agglomerations, yangtze river delta
Resilience and Sustainability	resilience, sustainable development, disparity, spillover effect, spatiotemporal analysis
Policy and Decision-Making	decision making, transportation development, equity, innovation, location

Source: Own elaboration based on the output of keywords co-occurrence analysis in CiteSpace.

4.5 Conclusions

To uncover the multifaceted dimensions of the resilience of High-speed rail (HSR), gain a better knowledge of the state-of-the-art research, and offer suggestions for research frontiers, this study, for the first time, provides a comprehensive overview of the existing literature that delves into the relationship between HSR and resilience, spanning from September 1, 2019, to December 15, 2024.

We collected 634 validated articles in English and Chinese from Web of Science (WoS) and Scopus. We visualized the knowledge maps of co-authorship networks, co-institution collaborations, cited references, and keyword co-occurrence patterns using CiteSpace software. The co-authorship network illustrates the most collaborative authors and highlights the socio-economic and spatial impacts of HSR. The institutional analysis demonstrates the dominant role of Chinese institutions in the research of HSR and resilience, which underscores the need for international collaboration to enrich the global perspective on this research field. The analysis of the most co-cited documents identifies the previous central research themes of economic growth, accessibility, and equity. The keyword co-occurrence patterns reflect a strong focus on economic impacts, infrastructure, and emerging interests in sustainability and resilience.

This review emphasizes the increasing importance of HSR on spatial resilience and economic recovery, resilience through transportation mode integration, resilient transportation systems, and resilient environmental infrastructure. This study also detects gaps in addressing long-term resilience, climate adaptation, and the equitable distribution of HSR benefits. The findings provide valuable insights for policymakers and practitioners on designing updated plans to foster international collaboration, facilitate sustainable regional development, and maximize the resilience and societal benefits of HSR systems. Future studies should focus on the research topics of diverse geographic and socioeconomic contexts, the integration of HSR and other transport modes, technological innovation, and the socio-environmental dimensions of HSR development.

However, there are limitations to this study presented herein, which could also be the future research directions. First, we only collected articles from two platforms, WoS and Scopus, written in English and Chinese. Like other data-driven literature reviews, we could not cover all relevant literature, which might miss valuable insights from unpublished studies, literature from different sources, or research written in other languages. Second, we used the Citaspace basic version as the visualization tool, limiting the interactive features and advanced analysis functions. Interpretation of Citespace visualizations can be subjective and dependent on the researcher's familiarity with the field. Different researchers might derive slightly different insights from the same visualization.

5

5 PAPER 4: Bridging the Gaps: Exploring Air-Rail Intermodal Transport Research Trends and Comparative Insights from CNKI, WoS, and Scopus

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Abstract

The concept of integrating air and rail transportation modes has been explored for decades. However, "Air-rail intermodal transport (ARIT)" as a research topic has gained increasing attention in recent years worldwide, as scholars and practitioners increasingly recognize the potential benefits, such as enhancing efficiency, sustainability, and connectivity in passenger and freight movements, of combining air and high-speed rail (HSR) within a single seamless transportation journey. As China is widely recognized as a global leader in the HSR sector, research on HSR in China holds significant importance in academic and industrial fields. The study has a fourfold objective: (1) to understand the state-of-the-art ARIT research by adopting a bibliometric analysis; (2) to conduct a comparative analysis between research from China and other countries; (3) to explore research trends of existing literature; and (4) to draw insights for future research on ARIT. The results showed (1) Xu Feng and Nie Lei are the prolific authors of ARIT; (2) Nanjing University of Aeronautics and Astronautics, Civil Aviation University of China, and Beijing Jiaotong University are the core research institutions; (3) China leads this research topic worldwide; (4) Railway Transportation and Economy ranked first among other high-quality journals; (5) Currently, both Chinese and international research are focusing on the studies of transportation network, travel time, passenger demand, and transfer hub. Chinese studies focus more on infrastructure, technology development, and the integration among various transportation modes, while international ones have broader perspectives, such as social welfare, environmental sustainability, passenger satisfaction, and service quality; (6) The keywords, such as cross-border transportation, e-commerce, and passenger groups, reflect the emerging research directions. The study for the first time provides a holistic understanding of the current state of knowledge on ARIT from the perspectives of Chinese and international scholars and identifies avenues for future research.

Keywords: Air transport; High-speed rail; Air-Rail Intermodal Transport (ARIT); 空铁联运; CNKI; Python

5.1 Introduction

The integrated air and rail transportation modes have been explored for decades. However, "Air-rail intermodal transport (ARIT)" as a research topic has gained increasing attention in recent years worldwide, as scholars and practitioners increasingly recognize the potential benefits, such as enhancing efficiency, sustainability, and connectivity in passenger and freight movements, of combining air and high-speed rail (HSR) within a single seamless transportation journey.

From the international perspective, for example, in Europe, several air-rail integration services have been operated successfully for years, such as AiRail and Rail & Fly (Germany), TGV Air (France), and FlugZug Basel and Fly Rail Baggage (Switzerland) (Jiang et al., 2022). In China, the performance between HSR and civil aviation is gradually changing from a competitive relationship to a cooperative relationship. ARIT has been recognized as an essential element of national transportation planning, and a growing number of passengers are choosing the integrated travel mode of HSR and aviation. Chen and Lin (2016) claimed that although several major cities in China have established ARIT hubs, the development of China's ARIS is still in its early stages, which needs optimizing and improving.

This study, for the first time, conducted a bibliometric analysis on the research of "Air-rail intermodal transport (ARIT)" by collecting data from three prominent databases: China National Knowledge Infrastructure (CNKI), Web of Science (WoS), and Scopus, and adopting Python (3.12.5) (a programming language) and Visual Studio Code (1.92.2) (a code editor) for visualization. The study has a fourfold objective: (1) to understand the state-of-the-art ARIT research by adopting a bibliometric analysis; (2) to conduct a comparative analysis between research from China and other countries; (3) to explore research trends of existing literature; and (4) to draw insights for future research on ARIT.

The remainder of the paper is organized as follows: Section 2 introduces the reviews from the existing literature. Section 3 provides the research method and data collection process. Next, in section 4, we display the visualization results with figures and tables. In the last section, the conclusions and limitations are presented.

5.2 Literature Review

5.2.1 Research on ARIT from CNKI

As China is widely recognized as a global leader in the HSR sector, research on HSR in China holds significant importance in academic and industrial fields. The literature from CNKI focused on key areas such as infrastructure integration, timetable optimization, network design, passenger behavior, and pricing mechanisms

Infrastructure integration is fundamental to the success of ARIT, Li (2015) emphasizes the need for infrastructure integration in the Beijing-Tianjin-Hebei region, highlighting the importance of developing intercity rail transit and integrating airport resources to create a seamless transportation network. Timetable optimization and network design play a crucial role in maximizing the efficiency of ARIT, Ke et al. (2021) developed a timetable optimization model based on the accessibility of Origin-Destination (OD) pairs, aiming to adjust high-speed rail schedules to align with fixed flight timetables. Understanding passenger behavior is essential for designing effective ARIT systems. Xiao et al. (2019) investigated passenger preferences in choosing between air-rail combined travel or aviation-only travel, revealing that factors like seamless luggage transfer and minimized delays are critical in attracting passengers to air-rail services. The pricing of air-rail services is another critical factor influencing passenger adoption and the overall success of the intermodal system. Li et al (2016) explore the pricing strategies for air-rail intermodal services by focusing on the value of passengers' time. They develop a pricing model that combines both aviation and high-speed rail elements, showing that by setting prices that reflect the value of time for passengers, the appeal of air-rail services can be significantly increased.

5.2.2 Research on ARIT from WoS/Scopus

The studies from WoS/Scopus are more international and have more perspectives on investigating a specific research area. The integration of air and rail services has garnered increasing attention as a solution for enhancing intermodal travel efficiency and reducing environmental impacts. The literature concentrates on infrastructure, passenger behavior and willingness-to-pay (WTP), social welfare, and environmental benefits.

Chen and Lin (2016) investigated Shanghai's Hongqiao Integrated Transport Hub and recommend streamlining operations through joint ticketing, code-sharing, and luggage transfer, as well as enhancing the air-rail connection between Hongqiao and Pudong International Airport, which reflects the broader need for integrated transport infrastructure to facilitate seamless intermodal travel. Passenger WTP for air-rail services is a critical determinant of their success. Chiambaretto et al. (2013) measured WTP for intermodal services in Europe, finding that passengers are willing to pay more for integrated services such as joint ticketing and luggage through handling. However, WTP varies by socio-demographic characteristics, suggesting that service providers should segment their offerings to cater to different customer groups. The social welfare implications of air-rail integration have also been a focus of academic inquiry. Xia and Zhang (2017) evaluated the effects of air-rail connection times on operators' profitability as well as the broader implications for social welfare. While reducing transfer times benefits consumers, transport operators may resist integration unless the costs are sufficiently low. The environmental benefits of air-rail intermodality are well-documented. Givoni (2007) suggested that airlines stand to gain from air-rail substitution, as long as it is implemented through collaboration with rail operators rather than in direct competition. The findings suggest that air-rail integration not only mitigates environmental impacts but also provides a strategic advantage for airlines.

5.3 Methods and Data

5.3.1 Bibliometric Analysis

The term 'bibliometrics' was first introduced by Alan Pritchard in 1969, referring to the mathematical and statistical study of patterns in the publication and use of scientific literature (Lawani, 1981; Ramos-Rodrígue & Ruíz-Navarro, 2004) Since then, bibliometric analysis has become a commonly used method to investigate, analyze, and summarize large amounts of academic literature (Donthu et al., 2021). The goal is to shed light on the progression of scientific knowledge, identify emerging topics and trends, highlight the significant and influential researchers, institutions, or countries in a particular field, and map collaboration networks. The key elements of bibliometric analysis include publication count, citation analysis, co-authorship analysis, co-citation analysis, and keyword co-occurrence analysis.

This study selected Python (3.12.5), a programming language, as the visualization tool due to its flexibility, powerful libraries, and ability to handle large datasets and integrate bibliometric data with other types of data, which have several advantages over other specialized tools, such as VOSviewer, CiteSpace, and Bibliometrix (R package). Meanwhile, Visual Studio Code (1.92.2), a free and open-source code editor developed by Microsoft, was adopted for programming in Python.

5.3.2 Data Collection and Cleaning Process

As shown in Figure 5.1, the data collection and cleaning process has five stages: Initial Screening, Secondary Screening, Handling of Abnormal Data, Handling of Missing Values, and Final Dataset.

· Initial Screening: The data was retrieved from the Chinese Social Sciences Citation Index (CSSCI) and Peking University Core Journals (PKU Core) of China National Knowledge Infrastructure (CNKI), Science Citation Index Expanded (SCIE) and Social Sciences Citation Index (SSCI) of the Web of Science Core Collection (WoSCC), and Scopus, respectively. The Title-Keywords-Abstract strategy was used in the three databases to search for the results on May 8, 2024. To obtain as much relevant data as possible, we kept the initial timespan as all years.

A unified Chinese term "空铁联运" was used as the search word in CNKI from the digital library of Changzhou University (CZU), China. Initially, 278 academic journals were acquired. Meanwhile, to obtain more comprehensive and precise data, we included the more commonly used synonyms of "intermodal" (interconnected and combined) by the previous authors as the search keywords. Thus, the terms "air-rail* and intermodal* or interconnect* or combin* and transport*" were used as the search words both in the SCIE and SSCI of the WoSCC and Scopus from the digital library of Universidad de Las Palmas de Gran Canaria (ULPGC), Spain. Consequently, 28 and 48 original results were obtained from WoS and Scopus, respectively.

· Secondary Screening: In this stage, the initial results were further filtered.

In the platform of CNKI, firstly, the datasets Chinese Social Sciences Citation Index (CSSCI) and Peking University Core Journals (PKU Core) were specifically selected. Certainly, Chinese was the academic language of the article-type documents. Thus, 66 articles met the standards and were saved as .xls files with the full information (including author, keywords, abstract, published year, affiliation, country, etc.). Secondly, after manually reading through the abstracts of collected records from CNKI, the articles that were not closely related to the topic and those dealing with more transport modes (waterborne, coach, bus, conventional rail) were ignored. Thus, 51 valid documents from the year 2011 to 2024 were selected. Thirdly, the Google Translate API through the "googletrans" library in Python (3.12.5) was leveraged to translate the information from Chinese into English for visualization.

For the original results searched in the WoS/Scopus, the retrieved criterion was article-type publications and written in English, which was because, on the one hand, English is the worldwide used language in academics; on the other hand, the Chinese articles obtained in both WoS and Scopus were duplications of those occurred in the CNKI. Then, we got 27 and 36 filtered article information from WoS and Scopus and exported them as .xls and .csv files, respectively. Next, we unified the column names of the two datasets and saved them as the same type of file (.csv) for combining and removing duplications between them by adopting Python (3.12.5). After eliminating 19 duplications, 44 validated article records in total remained. Then, 28 topic-related articles from the year 2007 to 2024 were selected after carefully reading the abstracts for further analysis.

· Handling of Abnormal Data: We manually checked the datasets we got from the CNKI and jointly from WoS and Scopus before analyzing and visualization. We updated some anomalies in the names of authors, countries, and affiliations by correcting spelling mistakes or errors in the names, unifying the full names or abbreviations, and standardizing the written ways of the names.

· Handling of Missing Values: The datasets contained some missing values. We retrieved the important missing values (keywords, affiliations, and years) directly from the original documents. In the meantime, we kept the unimportant ones missing since they would not be used for deeper analysis.

· Final Dataset: After completing the above data cleaning steps, we obtained two final datasets. As shown in Figure 5.2, the red line represents the dataset from CNKI with 51 topic-related article records (2011 to 2024), and the blue line illustrates the joint dataset from WoS/Scopus with 28 topic-related article records (2007 to 2024). It is observed that even though the published date of the first article on ARIT published in CNKI was later than that in WoS/Scopus, the number of publications per year in CNKI was larger than those in WoS/Scopus in recent years, which further proves the importance of collecting literature information on CNKI. Both datasets were used for the bibliometric analysis and visualization of co-authorship, co-citation, and the keywords co-occurrence through Python (3.12.5).

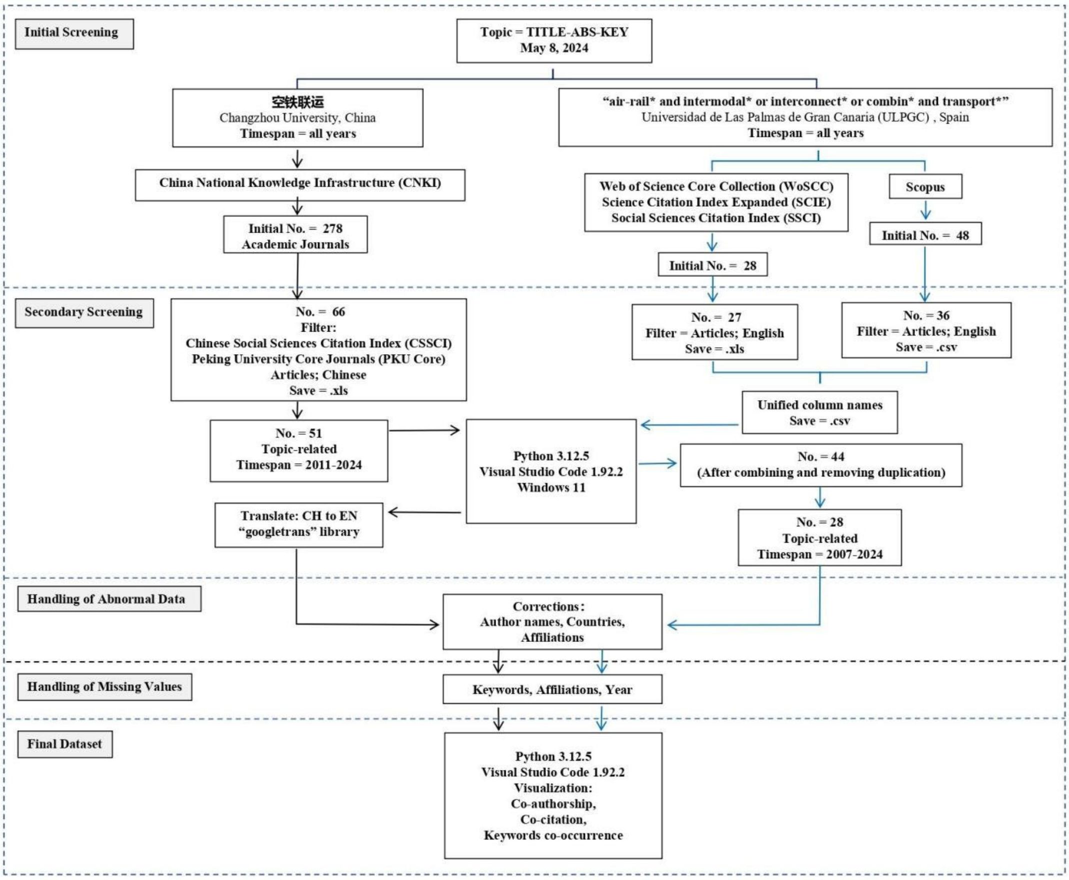

Figure 5. 1 Data collection and cleaning process.

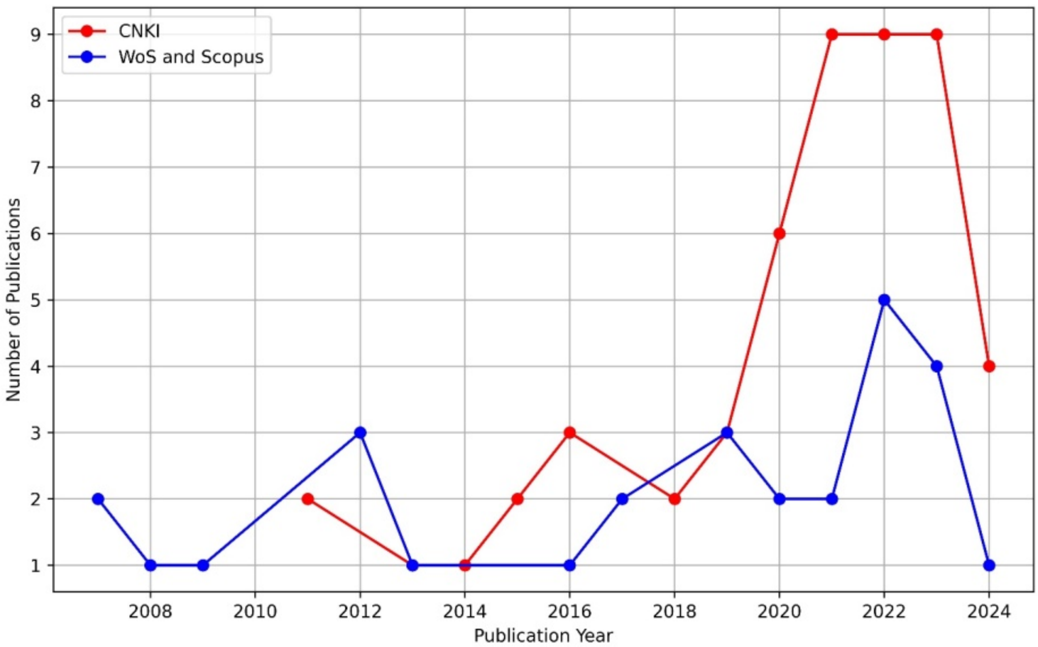

Figure 5. 2 Publications per year (CNKI vs WoS/Scopus).

5.4 Results

In this section, the results of the analysis of co-authorship (author, institution, and country), co-citation (journal and document), and the keywords co-occurrence (hot research topics and research frontiers) will be illustrated and compared between CNKI and WoS-Scopus.

5.4.1 Co-authorship Analysis on ARIT

5.4.1.1 Author Co-authorship Analysis

Table 5.1 lists the prolific authors who published at least two articles on ARIT from CNKI and WoS/Scopus individually, sorted in descending order by the publication counts. Regarding Table 5.1, the top three prolific authors on ARIT from CNKI were Xu Feng, Nie Lei, and Zhu Jinfu, with five, five, and four published articles, respectively, followed by Yang Wendong, Ke Yu, and Ouyang Jie with three publications each. And all the rest had two publication counts. Comparatively, from WoS/Scopus, no authors have published more than two articles on ARIT. Interestingly, all the top eight authors were Chinese according to their names.

Table 5. 1 The most prolific authors on ARIT from CNKI vs WoS/Scopus.

No.	**Authors (CNKI)**	**Publications （>=2）**	**Authors (WoS/Scopus)**	**Publications （>=2 ）**
1	Xu Feng	5	Jiang Changmin	2
2	Nie Lei	5	Xia Wenyi	2
3	Zhu Jinfu	4	Yuan Yalong	2
4	Yang Wendong	3	Feng Tao	2
5	Ke Yu	3	Ruan Xinpei	2
6	Ouyang Jie	3	Zhang Anming	2
7	Sun Tingting	2	Yang Min	2
8	Weng Yiyuan	2	Wan Yulai	2
9	Liang Xu	2		
10	Shao Quan	2		
11	Li Xiaojin	2		
12	Mei Zhengnan	2		
13	Miao Jianjun	2		
14	Chen Dan	2		
15	Zhang Qiong	2		

5.4.1.2 Institution Co-authorship Analysis

Table 5.2 provides the top five institutions on ARIT from CNKI, and the institutions had more than two publications on ARIT from WoS/Scopus. As shown, the top three institutions from CNKI were Nanjing University of Aeronautics and Astronautics, Civil Aviation University of China, and Beijing Jiaotong University, with eight articles published each. Undoubtedly, the five institutions were all from China. From WoS/Scopus, the most influential institution was Southeast University, which had four publications, followed by the University of Manitoba and Beijing Jiaotong University, with three article counts. Three of the six institutions were from China, which reflected that the Chinese institutions stood at the dominant place in the research of ARIT.

Table 5. 2 The most influential institutions on ARIT from CNKI vs WoS/Scopus.

	Institutions	Counts
CNKI	Nanjing University of Aeronautics and Astronautics	8
	Civil Aviation University of China	8
	Beijing Jiaotong University	8
	Nanjing Institute of Technology	3
	Southwest Jiaotong University	3
WoS/Scopus	Southeast University, China	4
	University of Manitoba, Canada	3
	Beijing Jiaotong University, China	3
	Hong Kong Polytechnic University, China	2
	University of British Columbia, Canada	2
	Eindhoven University of Technology, Netherlands	2

Figure 5.3 and Figure 5.4 illustrate the institution co-authorship network on ARIT from CNKI and WoS/Scopus. The nodes denote various institutions, and the size represents the number of contributions from different institutions. The more the counts, the larger the nodes, and vice versa. The distances and the thickness of the links between the nodes illustrate the strength of cooperation among institutions. The more collaborations, the shorter the distances and the thicker the links, and vice versa.

Taking the blue groups as an example in both figures. As shown in Figure 5.3, the members of this institution's co-authorship network on ARIT from CNKI were Beijing Jiaotong University, Southwest Jiaotong University, National Engineering Laboratory, National and Local Joint Engineering Laboratory, Professional Committee of China Transportation System Engineering, China Railway Second Institute of Engineering Group Co., Ltd., Transportation Office of the China Railway Shanghai Bureau Group Corporation, and Nanjing Railway Vocational and Technical College. The cooperative institutions on ARIT from WoS/Scopus of the blue subnetwork shown in Figure 5.4 were the University of Manitoba (Canada), Hong Kong Polytechnic University (China), University of British Columbia (Canada), University of International Business & Economics (China), and Sapienza University Rome (Italy).

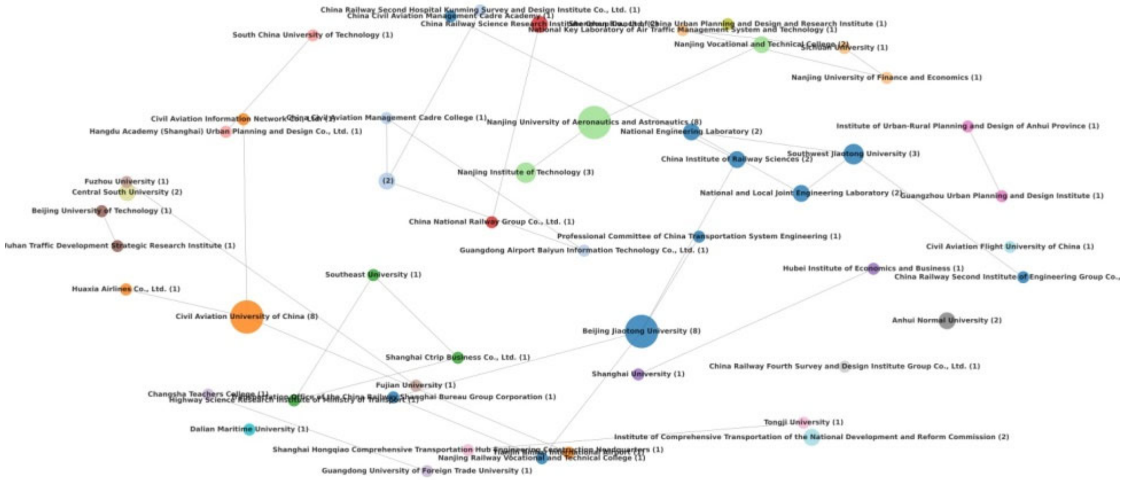

Figure 5. 3 Institution collaboration network on ARIT from CNKI.

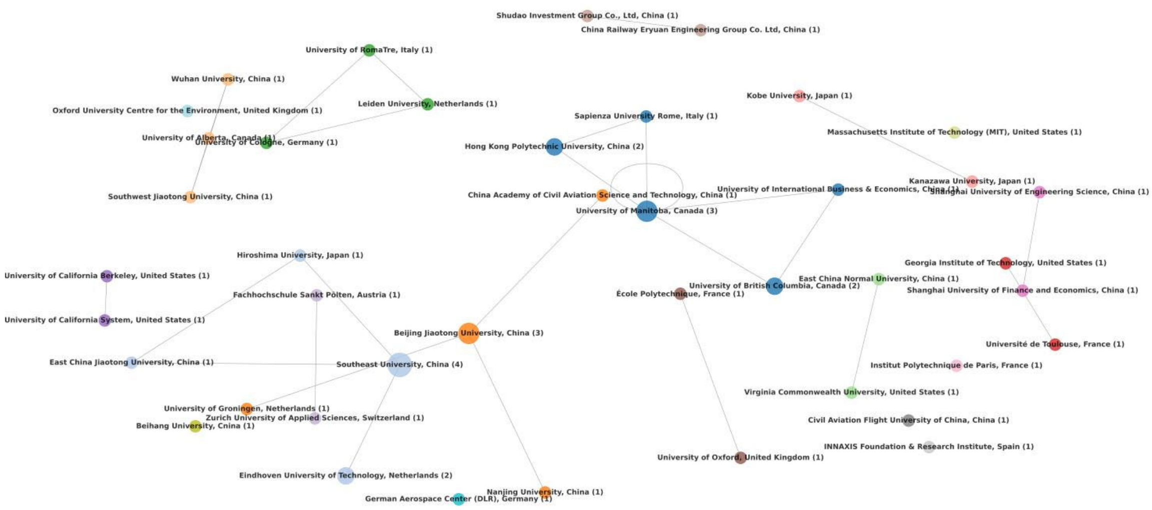

Figure 5. 4 Institution collaboration network on ARIT from WoS/Scopus.

By comparing the subgroups of the two institution co-authorship networks, the following points were detected: (1) The institutions in the CNKI network are mainly concentrated in Chinese domestic research organizations. However, the institutions in the WoS/Scopus network show broader international cooperation. (2) The institutions in the CNKI network are primarily government-backed research centers, national laboratories, and railway companies. The institutions in the WoS/Scopus network are mostly among universities from countries, such as China, Canada, and Italy. (3) The CNKI network's structure indicates that domestic research primarily focuses on addressing the specific needs of China's transportation system, which could accelerate the development of ARIT projects within the country. The WoS/Scopus network's international collaboration facilitates the global sharing of research in this field, encourages the exchange of ideas, and brings diverse perspectives and technological innovations.

5.4.1.3 Country Co-authorship Analysis

Table 5.3 only provides all countries on ARIT from WoS/Scopus since all the articles collected from CNKI were from China. It shows that the most productive country was China with 22 contributions, followed by Canada and the United States with six and five published articles, respectively. All the rest countries were Netherlands (4), France (3), Japan (3), Italy (2), United Kingdom (2), Germany (2), Spain (1), Switzerland (1), and Austria (1). Figure 5.5 demonstrates the visual distribution of all these countries.

Table 5. 3 All countries on ARIT from WoS/Scopus.

No.	Countries	Counts	No.	Countries	Counts
1	China	22	7	Italy	2
2	Canada	6	8	United Kingdom	2
3	United States	5	9	Germany	2
4	Netherlands	4	10	Spain	1
5	France	3	11	Switzerland	1
6	Japan	3	12	Austria	1

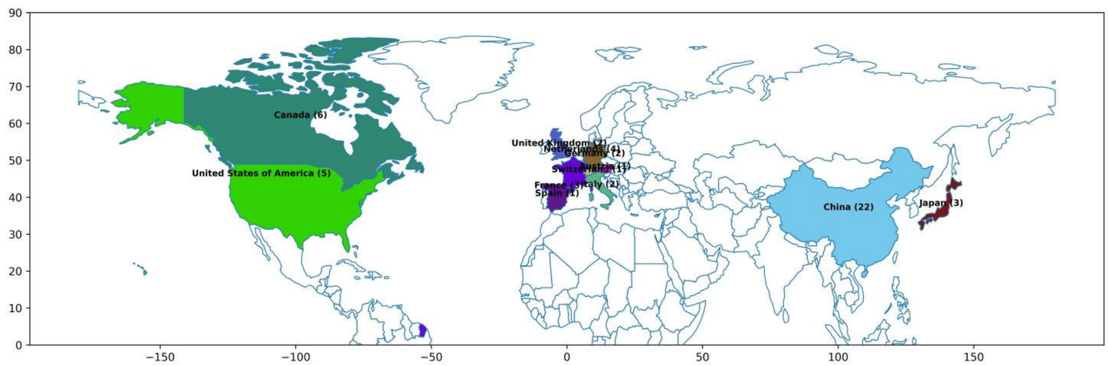

Figure 5. 5 Country co-authorship network on ARIT from WoS/Scopus.

Analyzing these countries in the research field of ARIT can lead to the following insights: (1) China has seen significant growth in research output on HSR-related topics in recent years, focusing more on infrastructure and technology development. Other countries, for example, the United States and the Netherlands, often rank high in research output in various disciplines. (2) Funding and policy support of a country, such as China, can cultivate more researchers, promote multinational research projects, and lead to new research hotspots. (3) European countries have historically been powerhouses in academics but may now face challenges in emerging economies and high-tech fields. China could expand and enhance its international collaboration to achieve win-win or multi-win.

5.4.2 Co-citation Analysis on ARIT

5.4.2.1 Journal Co-citation Analysis

Figures 5.6 and 5.7 list the top 10 core journals by publication counts on ARIT from CNKI and WoS/Scopus, respectively. As shown in Figure 5.6, the top three journals were Railway Transportation and Economy with 15 contributions in this research field, followed by Journal of Railway Science and Engineering, and Transportation System Engineering and Information, with four publications each. In Figure 5.7, the Journal of Air Transport Management ranked first with five contributions, and the Transportation Research Record ranked second with three publications. The following five journals had two contributions each: World Review of Intermodal Transportation Research, Transportation Research Part A: Policy and Practice, Transportation Research Part B-Methodological, Transport Policy, and Sustainability.

The journals in Figures 5.6 and 5.7 reflect the following points: (1) These journals play an important role in the research fields. (2) The studies featured in these journals have higher quality and are valuable academic references. (3) Based on the journal names in the list from CNKI, the scopes of more journals specifically concentrated on railway-related studies. However, the journals in the list from WoS/Scopus generally focus on the whole transport system.

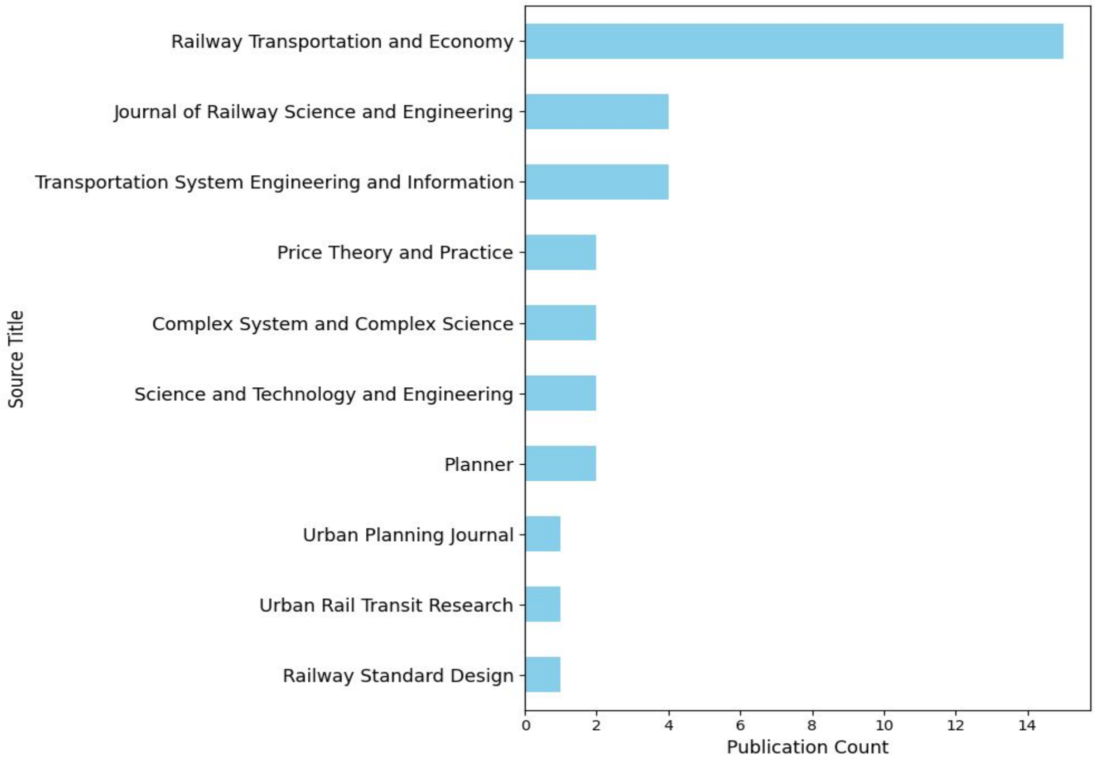

Figure 5. 6 Top 10 journals by publication counts on ARIT from CNKI.

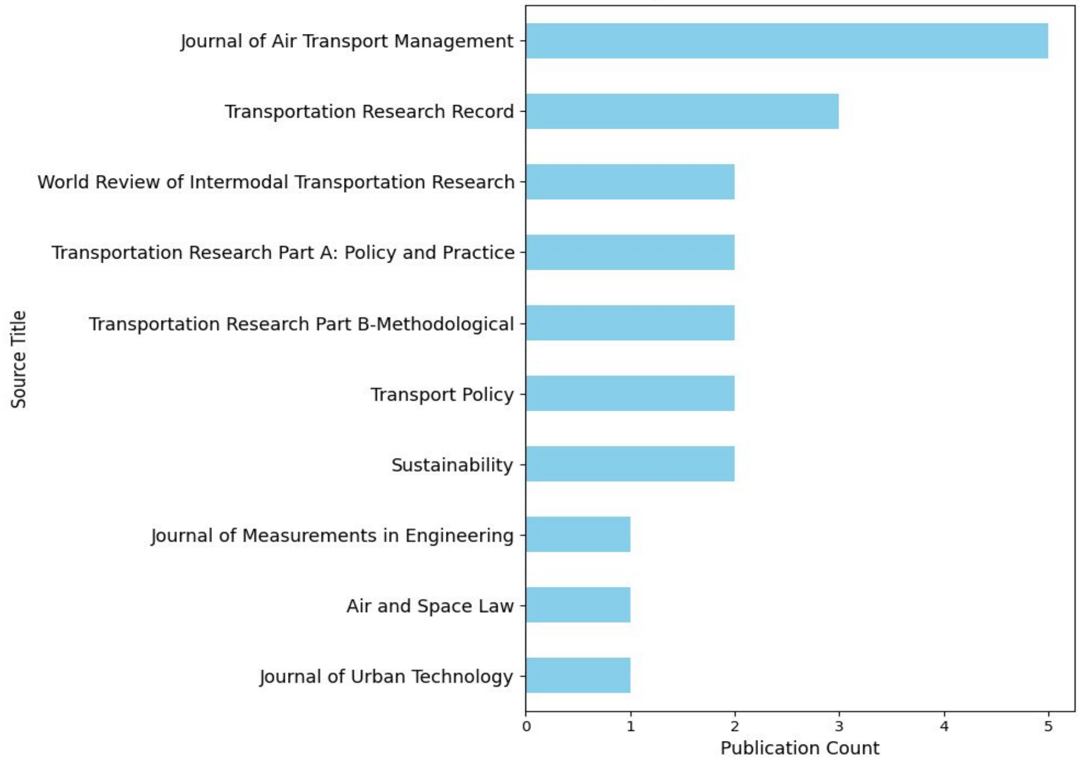

Figure 5. 7 Top 10 journals by publication counts on ARIT from WoS/Scopus.

5.4.2.2 Document Co-citation Analysis

Tables 5.4 and 5.5 separately sorted the top ten co-cited documents on ARIT from CNKI and WoS/Scopus, which provide rich perspectives on ARIT research: (1) The articles from CNKI focus heavily on the competition between HSR and aviation, how optimized transport networks can increase the attractiveness of rail services, infrastructure integration, and pricing and empirical analysis of passenger time value. The international studies from WoS/Scopus emphasize air-rail cooperation and market structure, environmental and social welfare impacts of air-rail intermodal transport, and creating a balanced competitive environment. (2) Both Chinese and international articles consider passenger behavior and preferences and the heterogeneity of passenger satisfaction with air-rail integration.

Table 5. 4 Top 10 co-cited documents on ARIT from CNKI.

No.	Author	Title	Counts
1	(Xiao, 2011)	Competition Advantages Comparison in Passenger Transportation Between High-speed Railway and Air in China	40
2	(Li et al., 2016)	The Research on Air-HSR Transport Pricing In	36

		China based on the Time Value of Passengers	
3	(Cheng et al., 2021)	Travel Mode Choice Behavior Model of Intercity Passengers with Medium and Long Haul — A Case Study of High-Speed Railway and Air Transport	34
4	(Wu et al., 2020)	Optimization of cross -domain aviation service networks under air -rail joint transport	34
5	(Xu et al., 2016)	The model construction and algorithm design of the air rail transportation network	29
6	(Li, 2015)	Research on Integrity Construction of Infrastructure in Beijing, Tianjin-Hebei	29
7	(Ke et al., 2021)	A Timetabling Model for High-speed Railway Based on Accessibility of Air and High-speed Rail Intermodality Service	29
8	(Zhao et al., 2013)	High-speed railway and aviation passenger travel selection feature research	27
9	(Zhu & Pan, 2014)	High Speed Rail Station Planning and Design	26
10	(Xiao et al., 2019)	Passenger portfolio travel methods in the air-rail composite network selection of behavior research	24

Table 5. 5 Top 10 co-cited documents on ARIT from WoS/Scopus.

No.	Author	Title	Counts
1	(Xia & Zhang, 2017)	Air and high-speed rail transport integration on profits and welfare: Effects of air-rail connecting time	59
2	(Jiang et al., 2017)	Air-rail cooperation: Partnership level, market structure and welfare implications	56
3	(Chiambaretto & Decker, 2012)	Air-rail intermodal agreements: Balancing the competition and environmental effects	49
4	(Xia et al., 2019)	Air-rail revenue sharing in a multi-airport system: Effects on traffic and social welfare	48
5	(Zhang & Hansen, 2008)	Real-Time Intermodal Substitution Strategy for Airline Recovery from Schedule Perturbation and for Mitigation of Airport Congestion	46
6	(Chiambaretto et al., 2013)	Measuring the willingness-to-pay of air-rail intermodal passengers	38
7	(Givoni, 2007)	Air-rail intermodality from airlines’ perspective	29
8	(Yuan et al., 2021)	Heterogeneity in passenger satisfaction with air-rail integration services: Results of a finite mixture partial least squares model	24
9	(Clewlow et al., 2012)	Interaction of High-Speed Rail and Aviation Exploring Air-Rail Connectivity	21
10	(Chen & Lin, 2016)	The Integration of Air and Rail Technologies:	21

5.4.3 Keywords Co-occurrence Analysis on ARIT

Figures 5.8 and 5.9 list the top 30 co-occurrences on ARIT from CNKI and WoS/Scopus in descending order. After analyzing these keywords, the following summaries can be made.

· Common focus areas: (1) Transportation network: CNKI and WoS/Scopus emphasize optimizing transportation networks within air-rail intermodal systems to enhance overall system performance. (2) Travel time: Studies from both databases demonstrate that reducing transfer time is critical to making the services of ARIT more attractive. (3) Passenger demand: Both Chinese and international researchers concentrate on predicting passenger demand and flow to optimize the services of ARIT to enhance passenger experience. (4) Transfer hub and transfer behavior: Seamless connections, efficient transfer hubs, and studying passengers' transfer behavior are essential topics for the ARIT systems.

· Unique focus in Chinese and international research: (1) Some unique keywords (Beijing-Tianjin-Hebei, comprehensive transportation, airport group, and transfer hub) from the CNKI dataset reflect the specific topics in Chinese research on ARIT. Researchers from China tend to focus on how to integrate various transportation modes (such as HSR, civil aviation, and urban rail) to build a comprehensive transportation system that meets the needs of urban and regional development. (2) The keywords from WoS/Scopus reflect a broader research perspective, particularly emphasis on social welfare, environmental sustainability, passenger satisfaction, and service quality.

· Emerging research directions: (1) Cross-border transportation: Researchers from China are examining the role of ARIT in facilitating cross-border trade and transit, especially in the context of the Belt and Road Initiative, to connect infrastructure at both regional and global levels. (2) E-commerce: This keyword appeared in the CNKI dataset showing the potential role of ARIT in supporting modern logistics and the growing demand for fast transportation and express delivery services. (3) Passenger groups: Studies from WoS/Scopus are paying increasing attention to the needs of different passenger groups and exploring how to customize ARIT services through market segmentation.

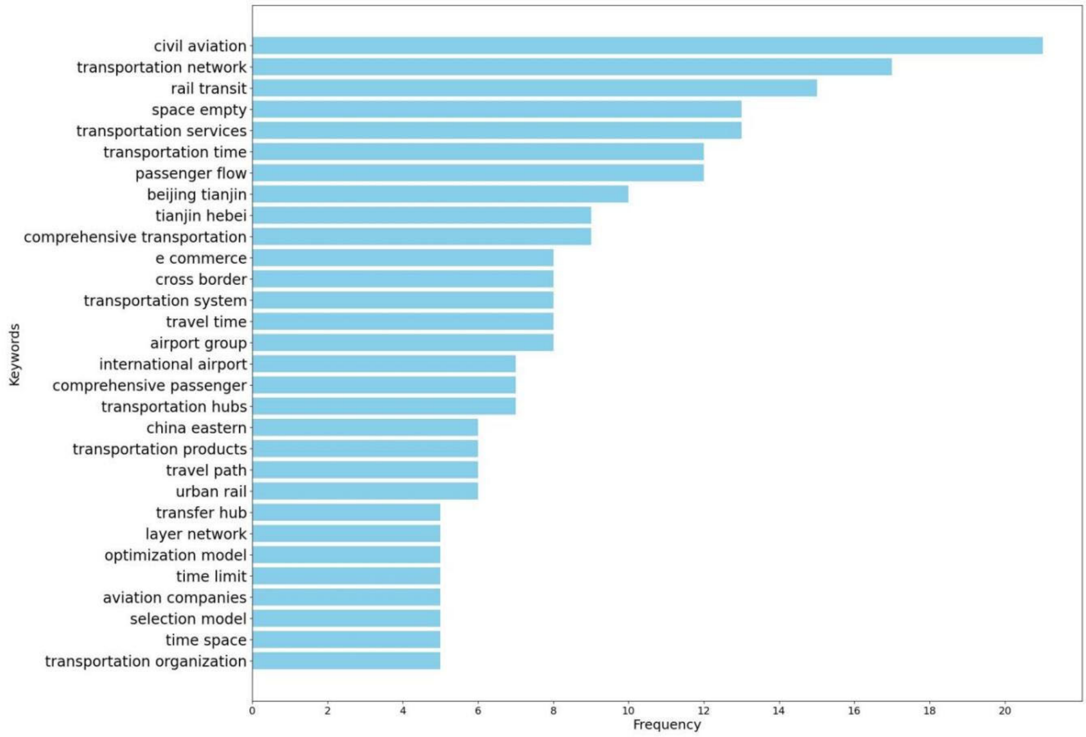

Figure 5. 9 Top 30 co-occurrent keywords on ARIT from CNKI.

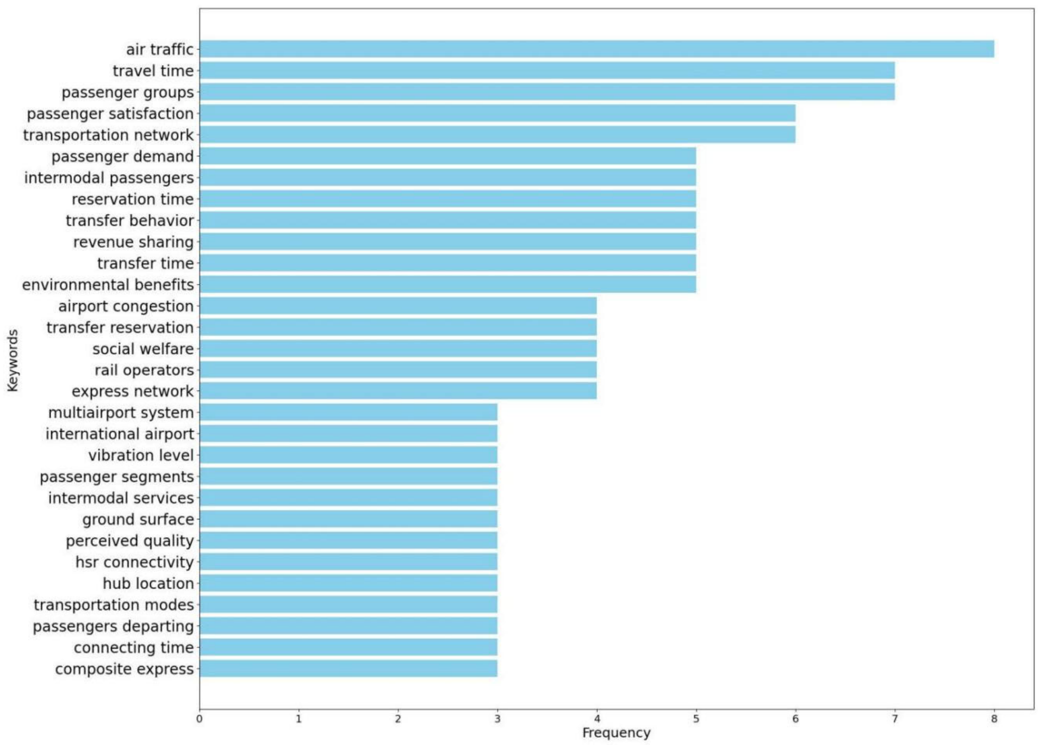

Figure 5. 8 Top 30 co-occurrent keywords on ARIT from WoS/Scopus.

5.5 Conclusions

To understand the state-of-the-art Air-rail intermodal transport (ARIT) research, explore research trends of existing literature, compare the research from China and other countries, and draw insights for future research on ARIT, this study for the first time conducted a bibliometric analysis by adopting Python (3.12.5) (a programming language) and Visual Studio Code (1.92.2) (a code editor) for visualization. This study collected data from three prominent databases: China National Knowledge Infrastructure (CNKI), Web of Science (WoS), and Scopus. The Title-Keywords-Abstract strategy was used in the three databases to collect relevant data from the digital library of Changzhou University (CZU, China) and Universidad de Las Palmas de Gran Canaria (ULPGC, Spain) on May 8, 2024, and the full information (including author, keywords, abstract, published year, affiliation, country, etc.) were exported. A unified Chinese term "空铁联运" was used as the search word in CNKI to search for article-type documents in Chinese, and the terms "air-rail* and intermodal* or interconnect* or combin* and transport*" were used as the searching words both in WoS and Scopus to collect the documents of article type in English. 51 topic-related article records (2011 to 2024) were collected from CNKI, and 28 topic-related article records (2007 to 2024) from WoS/Scopus were validated for visualization.

The results showed (1) Xu Feng and Nie Lei are the prolific authors of ARIT; (2) Nanjing University of Aeronautics and Astronautics, Civil Aviation University of China, and Beijing Jiaotong University are the core research institutions; (3) China leads this research topic worldwide; (4) Railway Transportation and Economy ranked first among other high-quality journals; (5) Currently, both Chinese and international research are focusing on the studies of transportation network, travel time, passenger demand, and transfer hub. Chinese studies focus more on infrastructure, technology development, and the integration among various transportation modes, while international ones have broader perspectives, such as social welfare, environmental sustainability, passenger satisfaction, and service quality; (6) The keywords, such as cross-border transportation, e-commerce, and passenger groups, reflect the emerging research directions.

Though the study for the first time provides a holistic understanding of the current state of knowledge on ARIT from the perspectives of Chinese and international scholars and identifies avenues for future research, some drawbacks exist. Firstly, we only collected data in Chinese and English. Even though these language sources cover a broad range of research, some research might be published in other languages (e.g., French, German, Spanish, or Japanese), and focusing solely on the two languages could limit the diversity of perspectives, methodologies, and findings incorporated into the literature review. Secondly, during the stage of the secondary screening, we used the "googletrans" library in Python (3.12.5) to translate the information from Chinese into English, which is a useful tool for quick and general translations. However, Google Translate often provides literal translations, which makes it less suitable for high-quality, professional, or specialized translations, especially for complex or domain-specific content like academic papers, technical terms, or idiomatic expressions. Thirdly, the current study only analyzed the collaboration network between journals, and future studies will detect more and deeper analysis of collaboration networks between the authors, journals, countries, etc. Lastly, this bibliometric analysis relies on metadata (titles, abstracts, keywords, authors, institutions, countries, years), and future research will make efforts on full-text reading of the most influential articles for extracting relevant content, such as methods, findings, and theoretical models.

6

6 Conclusions

This doctoral dissertation concludes providing the main gaps of research that exist on HSR: (1) lack of exploration for emerging factors (such as environmental attitudes, flexible ticketing systems, and multimodal integration) that affect passengers' preference for choosing transport mode; (2) overlook of the potential of HSR—as a "green alternative"—in freight logistics; (3) underexplore of the resilience of HSR systems to endure and recover from disruptions (such as natural disasters, technical glitches, or broader socioeconomic and environmental pressures); and (4) the infant stage for understanding the "Air-Rail Intermodal Transport (ARIT)", especially in China. The four papers presented in this dissertation cover the topics of passengers' preferences, bibliometric trends, resilience of HSR systems, and ARIT. By using tools (such as Latent Dirichlet Allocation (LDA) modeling, CiteSpace, Python, and Visual Studio Code), the four studies conducted a systematic and bibliometric literature review based on the data from WoS, Scopus, and CNKI in Chinese and English.

Synthetically, the key findings of the four research topics on HSR are: (1) passengers prioritise travel time, travel cost, frequency, and in-vehicle time; (2) a significant gap in coping with freight logistics and emerging competitors (such as maglev trains) exists; (3) China holds a dominant position in the HSR sector; (4) Beijing Jiaotong University leads in institutional contributions; (5) Transportation Research Part A and Transport Policy are core journals; (6) Pagliara Francesca and Albalate Daniel are prolific authors; (7) the resilience of HSR systems lack standardisation; (8) the resilience of HSR systems have been mainly focused on spatial resilience and economic recovery, resilience through transportation mode integration, resilient transportation systems, and resilient environmental infrastructure; and (9) China places greater focus on infrastructure optimization, while the global emphasis is on sustainability and passenger satisfaction; (10) emerging trends include cross-border transportation, e-commerce logistics, and climate adaptation strategies.

Future studies should pay more attention to the research topics, such as: the freight logistics using HSR, diverse geographic and socioeconomic contexts, the integration of HSR and other transport modes, consumer behaviour and demand modelling, technological innovation, transportation infrastructure and capacity, and the socio-environmental dimensions of HSR development. This work is also subject to some limitations, which could also be the future research directions. First, there is a lack of databases; more academic repositories (such as Google Scholar) could complement the existing databases for obtaining more data. Second, a linguistic bias exists since all articles analyzed were restricted to English and the Chinese language only. Third, we only analysed published articles, which might miss valuable insights from unpublished studies and literature from different sources. Fourth, the tools we used for programming and visualization are the free basic version, limiting the interactive features and advanced analysis functions.

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