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Integration of passenger and freight transport: A concept-centric literature review

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ABSTRACT

The integration of passenger and freight transport has been the subject of debate among scholars from the beginning of the century, with a peak observed in the last five years. Considering the relatively recent interest in the topic, most authors have highlighted the heterogeneous and explorative approaches adopted so far, indicating a lack of systematic analyses. This is confirmed by the different names given to the same concept (e.g., co-modality, cargo hitching, system with mixed passengers and goods, share-a-ride, integrated passenger and freight logistics, and collaborative passenger and freight transport). This study conducts a comprehensive literature review based on the scientific contributions indexed in *Scopus* and selected through a semiautomatic data extraction. First, a descriptive analysis is conducted, which includes types of publication, geographical areas, sources of publication, research methods, and research design adopted. Then, a text mining analysis identifies the main content-related aspects, including a semantic investigation of the most frequently occurring terms, their clustering in homogeneous groups, the transport means considered, and the territorial scales that have been investigated. This analysis is used to define the future challenges related to the topic, which span from the provision of more robust quantitative analyses (studies providing real data and adopting ad-hoc models are still very limited) to policy-related issues. However, the definition of a normative framework that integrates both systems is essential to deal with passenger–freight transport in a combined manner.

1. Introduction

More than a decade ago, the "Green Paper on Urban Mobility" suggested that a strong inter-modal and inter-sectorial passenger and freight transport integration can improve the overall efficiency of transport (European Commission, 2007), by "*consider[ing] all urban logistics related to passenger and freight transport together as a single logistics system.*" This integration in urban mobility can be achieved by adopting multiple initiatives developed at different levels. For example, spatial planning can contribute to this integration by reorganizing spaces, guaranteeing higher accessibility, and determining fewer conflicts between flows, which ultimately reduces the inequalities among users (Zhao & Li, 2016). Specific measures taken for passenger and freight transport form another alternative that can contribute to the rationalization of the system (Letnik, Marksel, Božičnik, Luppino, & Bardi, 2019). For instance, the development of Urban Consolidation Centers, besides providing environmental benefits (Nocera & Cavallaro, 2017), can reduce the number of heavy and light commercial vehicles in city centers, thus improving passenger mobility (Cui, Dodson, & Hall, 2015). Meanwhile, the development of efficient public transport, combined with the limitation of private traffic in city centers, can also benefit last-mile freight distribution (Schröder & Liedtke, 2017). Measures regarding these categories are common in contemporary transportation practice; they are pooled based on the fact that they operate on a single traffic component (either freight or passenger transport), indirectly influencing the other one.

The operational organization of an integrated passenger–freight system, which is the focus of this study, can be considered as an alternative potential approach. This is conceptually different from the solutions presented above, as it is expressly conceived as an attempt to improve both forms of transport by improving their performances through a shared approach. As it implies a tactical vision of transport, it may also require lower investments, focusing on a reorganization of the vehicular fleet and the habits related to mobility. This suggests that implications related to not only efficiency but also effectiveness must be considered. Although some authors do not consider this option

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effective—at least for the rail service (Huang et al., 2019), other studies have found opposite results (Ronald, Yang, & Thompson, 2016). Furthermore, some authors (e.g., Bruzzone, Cavallaro, & Nocera, 2021) have highlighted the social consequences of this service, especially for remote and low-density areas, thus including the three "Es" (efficiency, effectiveness, and equity) related to modern transport planning (Sinha & Labi, 2007).

The idea of bridging freight and passenger transport is not new, as the first academic discussions date back to more than a decade ago. Trentini and Mahléné (2010) proposed a classification of potential solutions to integrate passenger and freight transport. This classification is based on three main groups: shared road capacities (including multiuse lanes, night deliveries and shared bus and lorry lanes), shared public transport services (buses, subway, tramway, car sharing) and shared consolidation facilities (including delivery bays, lockers in car parks or underground stations, and delivery stations in car parks). For each of them, applications in specific contexts are presented, such as the use of specific lanes as priority bus lanes during peak hours, or the conversion of on-street parking spaces into unloading spaces during prescribed hours in Barcelona. In several cases, these solutions are experimental and related to the development of specific EU-funded projects. Nowadays, this scheme has already been adopted in long-haul transport, including airplanes, ferry, ships, and (few) long-distance trains with a mixed use of vehicles for passenger and freight transport (Ghilas, Demir, & Van Woensel, 2013). The Norwegian Hurtigruten (Hurtigruten, 2021) and Croatian ferries that connect islands to the mainland are illustrative of this integration, as well as some North American combi aircrafts. This integration is less common in urban areas, in short-haul transportation and, from the viewpoint of transport modes, in road transport. In these contexts, several technical and political issues have made this integration difficult; thus, its application in real cases is limited to specific sectors/type of journeys or to specific case studies (Van Duin, Wiegmans, Tavasszy, Hendriks, & He, 2019). The Freight*Bus is an example of a prototype allowing the transport of passenger and freight in urban areas (Frost, 2008). Other examples, which have been operational since 2003 in Zurich, are the Cargo-Tram and E-Tram (Stadt Zurich, 2021). They allow the transportation of large and heavy rubbish and electrical items, at stated times and stops on the line.

Coming back to the academia, a rigorous analysis of the integration of freight–passenger transport in the scientific literature is still lacking (Pimentel & Alvelos, 2018). A recent paper dealing with this theme (Van Duin et al., 2019) mentioned only four contributions; other papers are only sectorial and deal with the literature review of specific transport solutions, such as trams (Arvidsson & Browne, 2013) or urban rail (Alessandrini, Delle, Filippi, & Salucci, 2012). This paper presents a comprehensive overview of the integration of passenger–freight transport and defines its link to other solutions that may contribute to a better efficiency in the transport of freight and passengers. A concept-centric approach is adopted, which presents the nature of scientific contributions made so far and the most relevant challenges of this theme that still need to be addressed. All territorial scales, transport modes, and types of studies available in the scientific literature are included and the major open challenges are presented. The rest of this paper is organized as follows. Section 2 presents the methodology adopted for conducting the literature review. Sections 3 and 4 describe the results in terms of descriptive and semantic analyses. Section 5 highlights the main findings of the current literature and summarizes the future challenges that can be derived from the analyses. Finally, Section 6 concludes the paper with a connection to the main drivers related to freight and passenger transport.

2. Method

This study conducts a literature review based on a concept-centric approach. This approach, as developed by Webster and Watson (2002), has been successfully adopted for other relevant topics related to transport. Li and Ryerson (2019) adopted it to analyze aviation datasets used in research. Mandják et al. (2019) conducted a literature review on port marketing to verify the contributions made by different disciplines. de la Peña Zarzuelo, Freire Soeane and Bermúdez, 2020 highlighted the contributions dealing with ports and terminals and digital transformation/alignment with Industry 4.0 practices. Recently, Cheung, Bell, and Bhattacharjya (2021) used a concept-centric approach to identify the key research terms related to cybersecurity in logistics and supply-chain management. All these issues have been characterized from two main aspects: 1) the topic is interdisciplinary or it combines two or more aspects that are usually not analyzed jointly and 2) the research on that topic is at an early stage, thus presenting a mix of contributions in terms of both types of studies (qualitative vs. quantitative, theoretical models vs. empirical studies). From the preliminary information presented in the Introduction, these conditions can characterize the integrated freight–passenger transport, thus suggesting the appropriateness of this approach for the purpose of our research.

Methodologically, a concept-centric review, independent of the field object of analysis, is composed of six parts (Durach, Kembro, & Wieland, 2017): (1) defining the research question; (2) determining the required characteristics of primary studies; (3) retrieving a sample of potentially relevant literature; (4) selecting the pertinent literature; (5) synthesizing the literature; and (6) reporting the results, verifying the initial hypothesis, and discussing future research directions. The scheme that adapts to the integration of passenger–freight transport is summarized in Fig. 1 and described as follows.

1) *Defining the research question*. A rigorous literature review implies that the researcher forms research question(s) before the review itself. According to Khan, Kunz, Kleijnen, and Antes (2003), this forms the basis for a pathway that leads to a meaningful literature survey. We initially hypothesize that the scientific contributions dealing with freight–passenger transport integration are still at an early stage, where rigorous research lines have not yet been identified. With this literature review, we aim to provide a systematic overview of the topic, in order to position future research lines in a more structured framework and define the main challenges to be faced.
2) *Determining the required characteristics of primary studies*. We limit our analysis to scientific articles, book chapters, or conference contributions published in refereed journals, book chapters, books, or conference papers indexed in *Scopus* (Elsevier), written in English, which can be linked to transport and mobility issues. Grey literature,

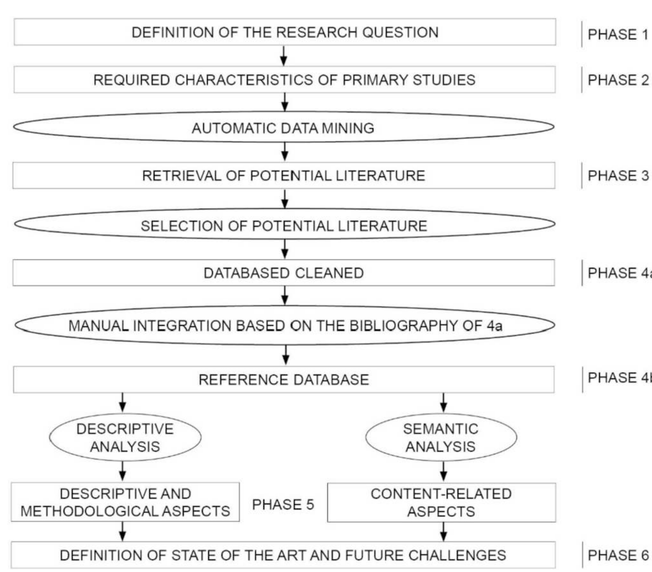

Fig. 1. Integration of passenger–freight transport: methodology adopted for the literature review.

including master's thesis, PhD dissertations, technical reports and deliverables produced for EU-funded projects, and other contributions, is not part of our analysis. The peer-reviewed process should guarantee a minimum level of quality of the analyzed paper while providing some useful indications about the differences between the contributions that are exploratory studies or first conceptualizations, in contrast to those that are more rigorous from a methodological perspective.

3) *Retrieving a sample of potentially relevant literature*. Research is conducted by retrieving from the *Scopus* database all documents in English that are related to integrated freight–passenger transport. The choice of the terms has to be rather extensive, at least in the initial phase. This is because the literature has not yet defined, in a univocal manner, passenger–freight transport integration, alternatively using co-modality (Ronald et al., 2016), cargo hitching (Ghilas et al., 2013), system with mixed passengers and goods (Masson et al., 2017), share-a-ride (Li, Krushinsky, Reijers, & Van Woensel, 2014), integrated passenger and freight logistics (Bruzzone et al., 2021), or collaborative passenger and freight transport (Li, Shalaby, Roorda, & Mao, 2021). At the same time, it should not be too generic, in order to exclude studies that are proximate in contents but are not directly related to the issue of freight–passenger integration. By considering general wording (**TITLE-ABS-KEY (passenger) AND TITLE-ABS-KEY (transport) AND TITLE-ABS-KEY (freight) OR TITLE-ABS-KEY (goods)**), the number of documents retrieved is too vast (thousands, as orders of magnitude) and the content of many of them is not specifically related to our research topic. In contrast, if we limit the research of documents to those containing exact wording (e.g., **TITLE-ABS-KEY ("passenger and freight transport") or TITLE-ABS-KEY ("passenger and goods transport")**), a more limited database can be found (less than 200 occurrences). Thus, after testing multiple combinations of keywords, the search is narrowed down to all documents in English whose abstracts, titles, or keywords follow the query syntax **TITLE-ABS-KEY (passenger W/3 freight W/5 transport) OR TITLE-ABS-KEY (passenger W/3 goods W/5 transport) AND LANGUAGE (english))**. W/n is a proximity operator which guarantees that the first word must be no more than (n) words apart from the second one (or vice versa), thus including contributions that may not have "passenger" and "transport" indicated consequently and overcoming the abovementioned issues of generality. Using this syntax, 472 articles are identified, which represent the first selection of articles useful for our analysis and are further refined by excluding the research fields not related to our purposes.[1] The syntax is **(TITLE-ABS-KEY (passenger W/3 freight W/5 transport) OR TITLE-ABS-KEY (passenger W/3 goods W/5 transport) AND LANGUAGE (english)) AND (EXCLUDE (SUBJAREA, "ENER") OR EXCLUDE (SUBJAREA, "EART") OR EXCLUDE (SUBJAREA, "MATE") OR EXCLUDE (SUBJAREA, "CENG") OR EXCLUDE (SUBJAREA, "PHYS") OR EXCLUDE (SUBJAREA, "CHEM") OR EXCLUDE (SUBJAREA, "ARTS") OR EXCLUDE (SUBJAREA, "MEDI") OR EXCLUDE (SUBJAREA, "AGRI") OR EXCLUDE (SUBJAREA, "BIOC") OR EXCLUDE (SUBJAREA, "HEAL") OR EXCLUDE (SUBJAREA, "IMMU") OR EXCLUDE (SUBJAREA, "MULT") OR EXCLUDE (SUBJAREA)**. At the end of this stage, 351 articles are available.

4) *Selecting pertinent literature*. The next step is to identify articles that are actually related to the integration of freight–passenger transport and do not deal with passenger and freight transport as separate items. This is achieved in a two-step process: first (4a), by manually screening the titles, keywords, and abstracts found in 3) and selecting only the pertinent articles, and then (4b) by searching in their references articles that are not included in the semiautomatic analysis but are part of the *Scopus* database. After the first step, the number of articles is significantly reduced from 351 to 36. Most of the contributions that are left aside during this manual screening refer to demand modeling, environmental and operational performances of specific transport systems (e.g., Ghanem, Li, & Alam, 2020), and/or infrastructure, such as railways, inland waterways, and ports (e.g., Miloslavskaya, Plotnikova, & Myskina, 2019; Winkler & Mocanu, 2020), as well as technological or engine solutions that may be adopted for both passenger and freight vehicles (e.g., İlhak, Akansu, Kahraman and Ünalan, 2018) and fiscal measures that are most suitable either for freight or passenger transport (Calthrop, De Borger and Proost, 2007) or optimization of trajectories for air and sea transport (e.g., Vierhaus, Born, & Engler, 2012). All these contributions adopt a similar theoretical approach: they include both freight and passenger transport in the analysis but as separate or even competitive (e.g., Chistik, Nosov, Tsypin, Ivanov, & Permjakova, 2016) elements of a different issue, without considering any form of integration (physical or organizational). We then check the references of the 36 selected articles (phase 4b) to find those that are actually related to the integration of freight–passenger transport and indexed in *Scopus* but were not selected in 3). Thirty-three other contributions are identified, which enlarge our final database to 69 articles. They form the basis for a descriptive analysis.

5) *Descriptive analysis + content-related analysis*. To cover the descriptive analysis aspect, we adopt the emerging synthesis method (Schick-Makaroff, MacDonald, Plummer, Burgess, & Neander, 2016), which synthesizes the literature including both qualitative and quantitative studies, case studies, conceptual frameworks, and theoretical work. A descriptive analysis of the selected articles is conducted, including the years of publication, geographic area, type of publication (i.e., paper in a journal, book, or conference proceeding), adopted method (i.e., a qualitative or quantitative approach), and nature of the article (survey/interview, case study, concept, model/simulation, review). To perform this analysis, which is detailed in Section 3, we adapt the classification proposed for cybersecurity and freight transport by Cheung et al. (2021). Content-related aspects (Section 4) are addressed by adopting appropriate text-mining software. The VOS viewer (version 1.6.16; Van Eck & Waltman, 2010) constructs and visualizes bibliometric networks (including journals, researchers, or individual publications) and provides "*text mining functionality that can be used to construct and visualize co-occurrence networks of important terms extracted from a body of scientific literature*" (https://www.vosviewer.com/). The result of this phase is a clustering of words that occur with the highest frequencies in specific semantic groups, combined with specific analyses referring to the considered transport modes as well as the territorial scale of the analysis.

6) *Reporting the results and discussion of future research directions.* The results obtained from the previous phases are used to critically interpret the groups and define the state of the art and main challenges that the topic still needs to address. This allows the passage from the analytical phase to the definition of future research lines that are still to be covered. In this sense, the type of approach (vehicle, infrastructure, or policy), type of transport according to the distance, geographic scale, and transport means through which the integration is reached can be considered relevant aspects. However, they require a generalization and a critical analysis that includes the changes occurring in passenger and freight transport sectors.

3. Descriptive analysis of the literature

Of the 69 identified contributions, the majority are scientific articles (42) and conference papers (22), whereas the remaining five documents are classified either as chapters in books or books (4) or as reviews (1). The timeframe considered in this analysis is between 2003 and 2021

[1] They include Energy, Materials Science, Earth and Planetary Sciences, Chemistry, Physics and Astronomy, Chemical Engineering, Arts and Humanities, Medicine, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Health Professions, Immunology, and Microbiology.

(results related to the last year are only until the month of April excluded, when this analysis was conducted). The first contribution that we could find (Howe, 2003) deals with "boda boda," which is an informal bicycle- and motorcycle-based passenger and goods transport solution adopted in Uganda since the 20th century.

Fig. 2 presents the contributions regarding the integration of passenger–freight transport, divided by year and nature. Out of the 69 documents, 59 were published during 2012–2021, whereas some isolated contributions were published in the first decade of the century. The huge increase in the number of publications registered in the last five years (if summed, they are higher than all other years) confirms a growing interest in this topic.

Regarding the geographic dimension, we analyzed the affiliation of the first author of each contribution to understand the countries where this theme has been mostly discussed. China is the leading country, with 12 publications, followed by the Netherlands (8), Italy, the United Kingdom, Germany (6), and France (4). Fig. 3 shows the countries where at least two publications have been found; the darker the color, the higher is the number of publications associated with each country. Researchers from western countries and China have been the most interested in this topic, whereas other nations (e.g., Australia, Japan, Tunisia, Slovakia, and Czech Republic) are only occasionally involved, with only one publication associated with the university or research center of the first author.

If the contributions are grouped according to the co-authorships, eight clusters of author(s) who have published at least two documents on the topic can be found. The most numerous group is composed of Hwang, Chem, Hu, Dong, and Ren (China), which was active in this research field between 2019 and 2021. This group is followed by Marcucci, Gatta, Nigro, and Serafini (Italy), whose contributions date back to 2018. Ghilas, Demir, and van Woensel (Netherlands) are the authors who published earlier (between 2016 and 2018), followed by Roorda and Shalaby (Canada, 2019) and Nocera and Bruzzone (Italy), whose contributions are from 2020. Arvidsson (Sweden), He (China), and Thompson (Australia) are other authors who have at least two publications on the topic in the last five years.

Referring to the sources where these products have been published, there is no leading transport journal specialized in this topic (Table 1). With the (partial) exception of the *European Journal of Operational Research* and *Transportation Research Part E: Logistics and Transportation Review*, many other journals (including the well-known *Transportation Research Part B*, *Transportation Research Part A*, *Transport Policy*, *Transport Reviews*, *Research in Transportation Business and Management*, and *Research in Transportation Economics*) have published no more than two articles each. In contrast, *Transportation Research Procedia* is the conference proceeding with the highest number of contributions published (6), followed by *Transport Means* (2). The relatively high number of publications in proceedings (~1/3 of our database) seems to confirm the exploratory nature of the contributions addressing the topic. The fact that about half of these contributions have been published from 2018 onward suggests that they have been used as a preliminary step for future in-depth contributions.

The last aspect focuses on the methodology adopted (which can be either qualitative or quantitative) and the research design (which has been distinguished among Survey/Interview, Case study, Concept, Model/Simulation, and Review). Table 2 presents a detailed classification of the selected articles according to these categories. There is a balance between the studies adopting a qualitative and those adopting a quantitative approach (37 vs. 32), with the latter mostly referring to optimization algorithms related to operational research (e.g., Molenbruch, Braekers, Hirsch, & Oberscheider, 2021; Pimentel & Alvelos, 2018) or the analysis of performance through the adoption of KPIs (e.g., Bruzzone et al., 2021). As for the research design, two main groups can be identified: the first group includes 25 studies and is characterized by an attempt to conceptualize the integration between passenger and freight transport from different perspectives, including social orientation (Horcas, Dehdari, Bäumer, & Wlcek, 2020), relation with transport externalities (Wosiyana, 2005), and urban infrastructure (Spickermann, Grienitz, & Von Der Gracht, 2014). The development of such vast conceptual frameworks suggests to both practitioners and researchers that the definition of the topic is still in its early stages. The second group (30 studies) includes studies addressing more specific issues, proposing a model to solve them, and in most cases, testing it in experimental case studies. Examples in this case can be associated with different transport modes, such as urban rail service (Behiri, Belmokhtar-Berraf, & Chu, 2018), underground (Dong, Hu, Yan, Ren, & Zhao, 2018), trams and cars (Galkin, Schlosser, Galkina, Hodáková, & Cápayová, 2019), and autonomous vehicles (Schlenther, Martins-Turner, Bischoff, & Nagel, 2020). Finally, regarding the literature reviews, only one has been formally assigned to this group by the *Scopus* classification (Arvidsson & Browne, 2013), whereas the other six have declared in their abstract the inclusion of an in-depth literature analysis. In all these cases, they refer to specific transport solutions or sectors and do not provide a

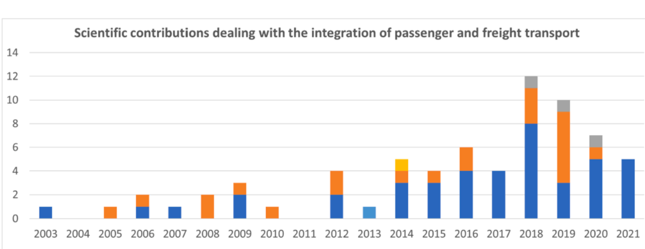

Fig. 2. Integration of passenger–freight transport, types of contributions and year of publication.

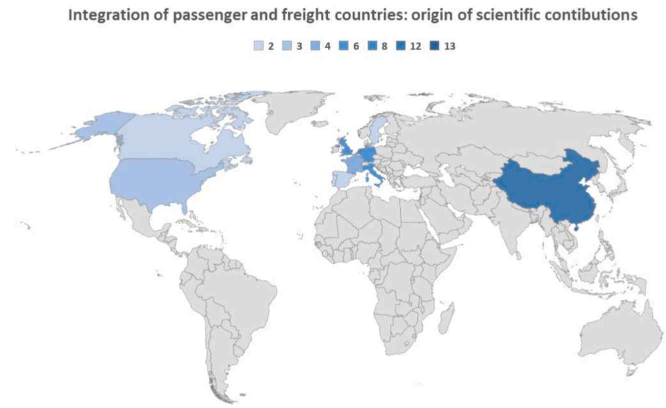

Fig. 3. Integration of passenger–freight transport, origin of contributions.

Table 1
Integration of passenger–freight transport, sources of publication.

a) Proceedings	n° of publications
Transportation Research Procedia	6
Transport Means - Proceedings of the International Conference	2
Others	14
b) Journals	
European Journal of Operational Research	4
Transportation Research Part E: Logistics and Transportation Review	3
Transportation Research Part B: Methodological	2
Transport Reviews	2
Transport Policy	2
Research in Transportation Economics	2
European Transport - Trasporti Europei	2
Sustainability	2
Others	23

Table 2
Studies dealing with the integration of freight and passenger transport: methodology and research design.

		Methodology		Design				
Authors	Year	Qualitative	Quantitative	Survey/interview	Case study	Concept	Model/simulation	Review
Howe	2003	x			x	x		
Wosiyana	2005	x			x			
Rodrigue	2006	x				x		
Roberg et al.	2006	x		x				
Westerheim et al.	2007	x		x		x		
Yubo et al.	2008	x				x		
He et al.	2008	x				x		
Cullinane S.	2009	x				x		
Cascetta et al.	2009		x				x	
Terzi and Ockels	2009	x			x	x		
Namgung et al.	2010	x		x	x			
Li et al.	2012		x		x			
Matschek et al.	2012	x			x			
Alessandrini et al.	2012		x		x		x	
Motraghi and Marinov	2012		x		x	x		
Arvidsson and Browne	2013	x		x		x		x
Piera et al.	2014		x			x		
Taniguchi and Thompson	2014	x				x		
Spickermann et al.	2014	x		x		x		
Li et al.	2014		x				x	
Strale	2014	x			x	x		x
Sousa and Mendes-Moreira	2015	x						x
Fumasoli et al.	2015		x				x	
Fatnassi et al.	2015		x			x	x	
Dampier and Marinov	2015		x				x	
Arvidsson et al.	2016	x						x
Ronald et al.	2016		x				x	
Ghilas et al.	2016a		x				x	
Ghilas et al.	2016b		x				x	
Ghilas et al.	2016c		x				x	
Chen and Pan	2016		x			x		
Schröder and Liedtke	2017		x				x	
De Langhe	2017		x				x	
Masson et al.	2017		x				x	
Cochrane et al.	2017	x		x	x			
Behiri et al.	2018		x		x		x	
Sourek and Seidlova	2018	x				x		
Bollapragada et al.	2018		x				x	
Gatta et al.	2018		x		x			
Sampaio et al.	2018	x						x
Akeb et al.	2018		x		x		x	
Visser	2018	x						x
Ghilas et al.	2018		x				x	
Ozturk and Patrick	2018		x				x	
Pimentel and Alvelos	2018		x				x	
Serafini et al.	2018	x			x			
Dong et al.	2018		x		x		x	
Huang et al.	2019		x		x			
He et al.	2019	x				x		
Larrodé and Muerza	2019	x				x		
Mazzarino and Rubini	2019	x			x			
Van Duin et al.	2019	x			x			
Vajdová et al.	2019	x					x	
Cieplińska	2019	x				x		
Cleophas et al.	2019	x				x		x
Zhou and Zhang	2019	x					x	
Galkin et al.	2019	x			x			
Schlenther et al.	2020		x		x		x	
Horcas et al.	2020	x				x		
Hu et al.	2020a	x				x		
Li et al.	2020	x				x		
Nocera et al.	2020	x				x		
Zhou et al.	2020		x				x	
Hu et al.	2020b	x			x		x	
Molenbruch et al.	2021		x				x	
Li et al.	2021		x				x	
Pernkopf and Gronalt	2021	x					x	
Manchella et al.	2021		x				x	
Bruzzone et al.	2021		x		x		x	
Total		37	32	6	22	23	30	7

comprehensive overview of the topic. For instance, Strale (2014) referred to cargo trams; Arvidsson, Givoni, and Woxenius (2016) and Sampaio, Savelsbergh, Veelenturf, and van Woensel (2018) analyzed some examples of integrations for the last mile at the urban scale; and Cleophas, Cottrill, Ehmke, and Tierney (2019) limited their analysis to road transport. Incidentally, this confirms the importance of a comprehensive analysis that embraces all aspects in a single overview.

4. Content-related analysis of the literature

4.1. Semantic analysis

According to the method presented in Section 3, a semantic analysis is performed using VOSviewer (Van Eck & Waltman, 2010).[2] This text mining aims to visualize co-occurrence networks of important terms, to associate them with the topic "freight and passenger transport," and to cluster them in thematic groups. Initially, the search engine identified 2025 concepts that were included in the titles, abstracts, or keywords of the selected documents. Among them, only 53 relevant and nongeneric keywords (e.g., words as "number" or "paper" have been left aside) with a minimum of five occurrences were selected and are shown in Fig. 4. To interpret this figure, we need to consider that the size of a dot increases with the occurrence of the associated keyword and only the 1000 most frequent connections among the concepts are displayed. In absolute terms, following are the 10 dominant keywords (the numbers between the brackets indicate the number of occurrences): "[transport] system" (42); "passenger" (34); "model" (27); "service" (25); "freight"/"freight transport" (23); "problem" (23); "vehicle" (22); "good" (21); "cost" (20); "city" (17).

The selection of these 53 words allows the first interpretation, especially if we compare them with absent words or words with fewer occurrences. The first aspect worth mentioning is that, when dealing with the integration of passenger and freight transport, the literature considers the transport operation rather than the infrastructural operation. The focus appears more on "vehicle" (22) and "(transport) mode" (16) rather than on "infrastructure" (11), which is mostly given as the essential background to guarantee the integration of the two components. Recalling the classification of Trentini and Malhene (2012), this means focusing on the group of solutions that they identified as "shared public transport services". A more detailed analysis of the specific

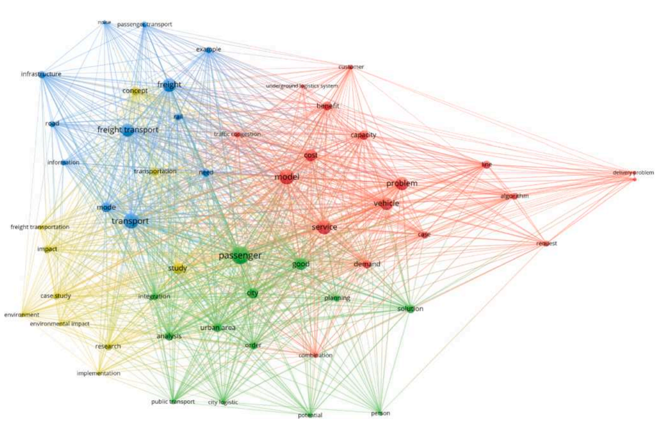

Fig. 4. Semantic clustering of keywords related to passenger and freight transport.

transport modes considered can be found in Section 4.2.

A second relevant aspect is the pre-eminent role of the urban dimension ("city," 17; "urban area," 14; "city logistic," 6), associated with specific transport solutions and modes that are typically related to the first–last mile distribution. This is partially attributed to the fact that some integrations for long-distance transport are already operational (see Introduction); however, at the same time, it would reveal limited research on peripheral/marginal areas (Section 4.3).

Another important component is associated with the nature of the study: words such as "model" (27), "problem" (23), "concept" (13), and "algorithm" (10) suggest the important role assigned to theoretical studies and operational approaches aimed at defining a generalizable solution. This is somehow visible from Table 2, where more than 50 studies are identified under the categories "concept" and "simulation/ model." This approach is partially counterbalanced or integrated by the analysis of concrete examples, as confirmed by terms such as "case" (11) and "case study" (10), which however are less frequent. The higher number of conceptual contributions is attributable to the fact that this research line is in its early stages and theoretical contributions need to define the main research lines to be followed.

Besides the technical aspects, the economic aspects are also part of the analysis. In this category, we include all aspects related to the evaluation of the impacts and externalities generated by the transport system. From this aspect, we may identify words such as "cost" (21), "benefit" (14), "impact" (12), "traffic congestion" (8), "environment" (7), "environmental impact" (6), and "noise" (5).

These general comments are presented in Fig. 4. VOSviewer clusters the most frequent words into proximal groups according to the number of connections (in our case, these groups are four and represented by different colors). They can be helpful in identifying the major meta-categories associated with the integration of passenger and freight transport. However, each word, even if formally belonging to one group only, has several connections with other words in other groups, as confirmed by the arrows (only the main 1000 connections are shown), which means that these classes are not mutually exclusive but rather represent a guide in the interpretation of results. The group with the most numbers is the red group (18 elements). Under this cluster, we can identify aspects related to the technical definition and solution of the issue, as confirmed by concepts such as "(delivery) problem," "model," "request," "algorithm," and "service." Main contributors to this clusters are those papers based on a quantitative approach, and whose research design is based on models/simulations (see Table 2). The second group in terms of number of items (13) is the green one, which includes aspects associated with the integration of different transport systems in the urban context ("urban area," "city," "urban logistics," and "public transport"). The urban dimension is particularly important for the freight/passenger integration, also considering that examples of solutions implemented at this scale successfully are quite limited (see introduction). The third group (blue; 12 items) is more related to the system characteristics, including the infrastructure, modes, and vehicles, as confirmed by words such as "road," "mode," "freight transport," "passenger transport," and "rail". Finally, the last group (10 items) is the yellow one, which focuses mostly on the expected results achieved by the studies ("impact," "environmental impact," "study," "implementation," "research," and "case study"). Such results may be related to the operational performances of the proposed solutions, but also to the impacts on transport externalities (including reduction of accidents, air and noise emissions and congestion).

4.2. Means of transport

The transport solutions are numerous and include all transport modes (air, sea, and land). In some studies, the analysis is general or conceptual and does not consider a specific transport mean; thus, the generic voice "public transport" or "private transport" has been assigned (e.g., Sousa & Mendes-Moreira, 2015; Spickermann et al., 2014).

[2] In general terms, semantic analysis is the process of analyzing the context of words, pulling out the relevant information and compare it against prior experience.

However, in most cases, specific transport solutions are investigated. For our purposes, only the most relevant ones are highlighted (i.e., those that are widely discussed throughout the paper and not just seldom mentioned). However, in some cases, these solutions are not unique in a paper and an integration of more means is considered. For instance, Larrodé and Muerza (2019) proposed a solution in which rail transport is combined with urban road transport. In such cases, both solutions are considered as part of the analysis, and in other cases, the analysis is limited to a specific transport solution (e.g., rail; Behiri et al., 2018). Terrestrial transport is the most analyzed mode: with 15 occurrences, rail transport (mostly in urban contexts, see below) is the most frequent solution (e.g., Hu et al., 2020a; Motraghi & Marinov, 2012; Yubo, Ketai, Jie, & Yihang, 2008), followed by buses (13 occurrences) and subways (8 occurrences). In contrast, light-duty vehicles should have been included in almost all studies, as they are the most diffuse solution adopted so far when dealing with freight distribution in urban contexts. However, their inclusion in our database has been limited to studies that deal concretely with innovative solutions and integrations with passenger transport. Finally, some innovative solutions are investigated only as exploratory studies and appear only once or twice in our database. For instance, Mazzarino and Rubini (2019) and Bruzzone et al. (2021) analyzed the integration of passenger–freight transport by boats, whereas Molenbruch et al. (2021) focused on the dial-a-ride service in rural areas.

4.3. Territorial scale

The territorial scales considered in the analyses are strictly related to the above-described transport modes. The studies on airplanes (e.g., Sourek & Seidlova, 2018; Vajdová et al., 2019), (high-speed) railways (e.g., Bollapragada et al., 2018; Huang et al., 2019), and extra-urban buses (Terzi & Ockels, 2009) have exclusively considered long-distance journeys. Other studies have focused on the rural dimension, with an attempt to identify innovative operative solutions to combine the transport of goods and passengers by using specific vehicles. This is illustrated by the following three examples selected from different parts of the world. Wosiyana (2005) analyzed the use of light delivery vehicles in South Africa to transport goods, workers, and school children. Namgung et al. (2010) investigated factors affecting the choice of integrated passengers and transport in rural areas of Japan. Bruzzone et al. (2021) assessed the performance of a combined freight–passenger vessel to serve dispersed islands in the northern lagoon of Venice.

However, the correspondence between transport modes and territorial scales becomes more complex when dealing with metropolitan or urban dimensions. These areas include transport solutions typical of high-density contexts, such as the subway system (e.g., Cochrane et al., 2017; Visser, 2018), trams (e.g., Alessandrini et al., 2012; Arvidsson & Browne, 2013; Strale, 2014), urban rapid buses (e.g., Fatnassi et al., 2015), and buses (e.g., Masson et al., 2017). Moreover, they include other very different solutions in terms of capacity and operational performance, such as trains (e.g., De Langhe, 2017; Fumasoli et al., 2015; Zhou & Zhang, 2019) and autonomous vehicles (e.g., Manchella et al., 2021; Schlenther et al., 2020).

Another distinction related to the geographical scale considers a specific part of the trip chain. In this sense, first- and last-mile solutions have been focused on by adopting different approaches. Nocera et al. (2020) conceptualized the issue of first- and last-mile distribution, with an eye on the possible integration of freight and passengers. Arvidsson et al. (2016) conducted a literature review and provided several examples of integrated systems at an urban scale. Chen and Pan (2016) developed a methodology for crowdsourcing e-commerce. Serafini et al. (2018) presented a case study in Rome to understand the willingness of passengers to act as crowd shippers through the stated preferences.

For simplicity, we divide our database into three main classes: "urban," "non-urban" (which includes the above-described rural and long-distance components), and "urban and non-urban," if the analysis is (or can be, given the conceptual nature of the contribution) performed in both territorial contexts. The urban component is the most numerous class, covering 56 out of the 69 identified studies, whereas studies dealing with non-urban contexts are more limited (26 out of 69).

5. Findings and challenges

The descriptive and content-related analyses presented in the previous section allow the generalization of some aspects related to the integration of passenger–freight transport in the scientific literature. Such aspects can appropriately summarize the state of the art of the topic. Moreover, if combined with a critical interpretation of the documents, they may represent a starting point for defining the major challenges that need to be investigated in the future. These evidence and challenges are summarized as follows.

- The integration of passenger–freight transport appears to be a research field still in its early phase but with some interesting potentialities. This is confirmed by the fact that only eight authors (or groups of authors) have published more than two articles on this topic (Section 3). Most of the contributions available in our database are explorative attempts from different groups of authors, which have not yet been followed up. Our analysis of the research methodologies and design (Table 2) revealed that several studies deal with the conceptualization of the theme or the definition of qualitative analyses, which are typical of a preliminary phase of study; documents with more robust quantitative approaches are more limited and refer mostly to algorithms for the optimization of specific services, applied in virtual contexts (see the point below). In contrast, the constant increase in the number of articles in the last five years (Fig. 2) confirms the growing interest in this theme and the debate can be further fed with innovative contributions.
- Real data and concrete case studies that have implemented the scheme of integrated passenger–freight transport are still exceptions in the scientific panorama. Besides some rare exceptions (e.g., Van Duin et al., 2019; Wosiyana, 2005), most of the contributions presenting a case study have adopted either simulations or scenarios to forecast future transport conditions. This was already underlined by Strale (2014) and may also depend on different issues, including the regulatory system. Indeed, passenger and freight transport systems are conceived as independent sectors, and a legislative framework that promotes their integration is still missing (Jansen, 2014). This has important consequences in terms of transport planning (see the last point); however, the legislative framework is a fundamental requisite that cannot be ignored. Some contributions belonging to the grey literature, such as technical reports or master's/PhD theses (e.g., Bakker, 2015; Chiffi, 2015; He, 2017), which have not been considered in our analysis, can be further developed and made more rigorous, in order to include these aspects in the scientific debate and provide potential solutions to this aspect.
- Studies dealing with KPIs and quantitative evaluation of the impacts generated by the new integrated system, also in terms of transport externalities, need more *stimuli*. So far, the focus of the research is primarily on the operational modeling of the system, as confirmed by the list of journals and conference proceedings where contributions have been submitted (Table 1). Some theoretical contributions have already underlined the need for more contributions in this direction (e.g., Hu et al., 2020b); however, studies addressing this issue are still limited (e.g., Bruzzone et al., 2021; Cullinane, 2009; De Langhe, 2017).
- The effects of transport policies on the development of an integrated passenger–freight scheme are still defective. To date, this research line has been limited to selected policies, such as low emission zones (Schröder & Liedtke, 2017), infrastructural development (Huang et al., 2019), and comprehensive information systems developed at the national level (Roberg et al., 2006; Westerheim et al., 2007). A

more rigorous investigation of the available policies and transport measures may be helpful in this case. The role of ICT solutions in making the system more competitive is particularly worthy of investigation and can be combined with existing studies that have tried to systematize them (Antonissen et al., 2013). Indeed, the integration of passenger and transport flows optimizes the use of vehicles; however, it requires adequate digital and tools that provide real-time information, thus allowing service optimization and making the system more competitive from the viewpoint of users. In this field, some explorative studies are available (e.g., Matschek et al., 2012; Ronald et al., 2016; Taniguchi & Thompson, 2014), which constitute a suitable starting point for future research.

- The integration of different transport solutions within a more comprehensive framework is required in the future. In many cases, only single means or the integration of two different means are considered. The studies dealing with "public transport" and "private transport" (Table 3) are still generic and do not include an analysis of concrete transport solutions. In addition, based on the numerous studies conducted on the urban scale (Table 4), sustainable urban mobility plans (Rupprecht, Brand, Böhler, & Brunner, 2019) may be an appropriate plan that can merge these aspects. This would contribute to including freight transport within this framework more consistently, with two important consequences. First, a strategic dimension is given to the practice of integrating passenger and freight transport in a single system, thus overcoming the tactical/operational dimension, often used in emergency situations but not part of long-term visions about the future of mobility. Second, it would contribute to avoiding the parallel directions sometimes taken by passenger and freight transport at the urban scale, which is well-exemplified by the coexistent development of sustainable urban mobility plans recalled above and sustainable urban logistic plans (Aifandopoulou & Xenou, 2019).

6. Conclusions

Tavasszy (2020) identified five main groups of innovations related to freight transport: mass-individualized logistics services, freight network integration, globalization dynamics, digitalization, and advanced transport technologies. They have to be added to other well-known drivers of change, which are not directly related to transport. Rodrigue (2010) clustered them into the following six major categories: policy, demography & society, energy & environment, technology, economics, and finance. When dealing with integrated freight–passenger transport, these aspects are still valid, but need to be flanked by those derived specifically from the integration of the two systems. The aim of the literature review conducted in this study was to shed light on the difficulties encountered so far in this last category as well as to identify future research lines that can be deepened to have a clearer vision of the potentialities guaranteed by such an integrated approach.

The fact that there is no univocal approach to refer to this practice (as mentioned above, authors have named it as co-modality, cargo hitching, system with mixed passengers and goods, share-a-ride, integrated passenger and freight logistics, or collaborative passenger and freight transport) has led to our initial hypothesis that this issue has been investigated mostly through exploratory studies; however, a theoretical comprehensive phenomenon is not yet available. This hypothesis has been confirmed by the qualitative and semantic analyses presented in Sections 4 and 5, respectively, which revealed the conceptual nature of several studies, limited to specific combinations of solutions, along with a lack of models dealing with the operational management of this system and real-life case studies that provide quantitative data.

Methodologically, this literature review has not analyzed each contribution independently. Coherently with the concept-centric approach, a semiautomatic data extraction followed by a semantic analysis has highlighted the common content-related aspects of the papers dealing with the integration of passenger and freight transport. In parallel, this process has been complemented by a descriptive analysis based on the emerging synthesis method. This has allowed a better understanding of the nature of contributions, the geographical context where they have been developed and the methodology adopted, leading to the common open challenges presented in Section 5.

In interpreting the results, some caveats need to be mentioned. A first aspect refers to the selection of the initial sources. As explained thoroughly in Section 2, only the documents available in the Scopus database have been analyzed. Since such materials are for the most part peer reviewed, this should guarantee a certain validation by the scientific community about their contents. The use of an automatic data

Table 3
Studies dealing with the integration of freight–passenger transport: transport means.

Transport mean	Occurrences	Sources
Rail	15	Yubo et al., 2008; Li, Liang, & Zhou, 2012; Alessandrini et al., 2012; Motraghi & Marinov, 2012; Fumasoli, Bruckmann, & Weidmann, 2015; Dampier & Marinov, 2015; De Langhe, 2017; Behiri et al., 2018; Bollapragada et al., 2018; Ozturk & Patrick, 2018; Huang et al., 2019; Larrodé & Muerza, 2019; Zhou & Zhang, 2019; Hu, Dong, Hwang, Ren, Chen, & Chen, 2020; Li et al., 2021
Bus	13	Cascetta, Marzano, & Papola, 2009; Terzi & Ockels, 2009; Fatnassi, Chaouachi, & Klibi, 2015; Ghilas, Demir, & Van Woensel, 2016a; Ghilas, Demir, & Van Woensel, 2016b; Ghilas, Demir, & Van Woensel, 2016c; Masson et al., 2017; Ghilas, Cordeau, Demir, & Van Woensel, 2018; Pimentel & Alvelos, 2018; Van Duin et al., 2019; Li, Hu, & Zhou, 2020; Bruzzone et al., 2021; Molenbruch et al., 2021
Public Transport	11	Roberg, Lindqvist, Ekdahl, & Jacobsson, 2006; Westerheim, Haugset, & Natvig, 2007; Namgung, Fujiwara, & Chikaraishi, 2010; Matschek, Herrmann, & Jumar, 2012; Spickermann et al., 2014; Sousa & Mendes-Moreira, 2015; Arvidsson et al., 2016; Cochrane, Saxe, Roorda, & Shalaby, 2017; Gatta, Marcucci, Nigro, Patella, & Serafini, 2018; Cieplińska, 2019; Nocera, Pungillo, & Bruzzone, 2020
Light Duty Vehicles	9	Wosiyana, 2005; Cullinane, 2009; Ronald et al., 2016; Schröder & Liedtke, 2017; Sampaio et al., 2018; Akeb, Moncef, & Durand, 2018; Cleophas et al., 2019; Larrodé & Muerza, 2019; Horcas et al., 2020
Subway	8	He, Shao, Liu, & Dong, 2008; Visser, 2018; Serafini, Nigro, Gatta, & Marcucci, 2018; Dong et al., 2018; He, Wang, Chen, & Gao, 2019; Zhou & Zhang, 2019; Hu, Dong, Hwang, Ren, Chen, & Chen, 2020; Zhou, Cui, He, Ma, & Wang, 2020
Private Transport	6	Cullinane, 2009; Spickermann et al., 2014; Taniguchi & Thompson, 2014; Sousa & Mendes-Moreira, 2015; Cieplińska, 2019; Galkin et al., 2019
Tram	4	Arvidsson & Browne, 2013; Strale, 2014; De Langhe, 2017; Galkin et al., 2019
Airplane	3	Piera, Leal, Castelli, & Aizstrauta, 2014; Sourek & Seidlova, 2018; Vajdová, Jenčová, Liptáková, & Lučanská, 2019
Taxi	3	Li et al., 2014; Chen & Pan, 2016; Ronald et al., 2016
Autonomous Vehicles	2	Schlenther et al., 2020; Manchella, Umrawal, & Aggarwal, 2021
Boat	2	Mazzarino & Rubini, 2019; Bruzzone et al., 2021
Ropeway	1	Pernkopf & Gronalt, 2021
Bicycle	1	Howe, 2003
Motorcycle	1	Howe, 2003
Dial-A-Ride	1	Molenbruch et al., 2021
N.a.	1	Rodrigue, 2006

Table 4
Studies dealing with the integration of freight–passenger transport: territorial scale.

Territorial scale	Occurrences	Sources
Urban	43	Yubo et al., 2008; He et al., 2008; Namgung et al., 2010; Alessandrini et al., 2012; Motraghi & Marinov, 2012; Arvidsson & Browne, 2013; Taniguchi & Thompson, 2014; Spickermann et al., 2014; Li et al., 2014; Strale, 2014; Fumasoli et al., 2015; Fatnassi et al., 2015; Dampier & Marinov, 2015; Sousa & Mendes-Moreira, 2015; Ghilas et al., 2016b; Ghilas et al., 2016c; Chen & Pan, 2016; Schröder & Liedtke, 2017; De Langhe, 2017; Masson et al., 2017; Cochrane et al., 2017; Behiri et al., 2018; Gatta et al., 2018; Sampaio et al., 2018; Akeb et al., 2018; Visser, 2018; Ghilas et al., 2018; Ozturk & Patrick, 2018; Pimentel & Alvelos, 2018; Serafini et al., 2018; Dong et al., 2018; He et al., 2019; Cieplińska, 2019; Cleophas et al., 2019; Zhou & Zhang, 2019; Galkin et al., 2019; Schlenther et al., 2020; Horcas et al., 2020; Zhou et al., 2020; Hu, Dong, Hwang, Ren, & Chen, 2020; Hu, Dong, Hwang, Ren & Chen, 2020; Li et al., 2021; Manchella et al., 2021.
Urban and non-urban	13	Howe, 2003; Wosiyana, 2005; Roberg et al., 2006; Rodrigue, 2006; Westerheim et al., 2007; Cullinane, 2009; Matschek et al., 2012; Ronald et al., 2016; Arvidsson et al., 2016; Ghilas et al., 2016a; Larrodé & Muerza, 2019; Li et al., 2020; Nocera et al., 2020.
Non-urban	13	Cascetta et al., 2009; Terzi & Ockels, 2009; Li et al., 2012; Piera et al., 2014; Sourek & Seidlova, 2018; Bollapragada et al., 2018; Huang et al., 2019; Van Duin et al., 2019; Vajdová et al., 2019; Mazzarino & Rubini, 2019; Molenbruch et al., 2021; Pernkopf & Gronalt, 2021; Bruzzone et al., 2021.

extraction method does not totally exclude the risks of ignoring some substantial contributions, and/or including some items that are only marginally pertinent. Such risks have been reduced thanks to the subsequent cleaning and integration of the database (phase 4a of the method presented in Fig. 1), and it is lower if compared to the alternative of manually searching the documents (Felizardo & Carver, 2020). A third aspect refers to the clustering process of the semantic analysis: the technical aspects related to the use of VOSviewer depend on the choice of the text mining software and may be considered as an ontological source of uncertainty that cannot be eliminated (Salling, Leleur, & Jensen, 2007). A manual check revealed however that some generic terms resulting from the automatic analysis made by the software have occasionally been omitted, since considered not specific for our purposes. This could have influenced some of the connections between keywords and their clustering. A promising line of further research may focus on a more traditional author-centric literature review, to analyze the contents of single contributions independently, and hence to verify, complement or integrate our findings.

In addition to such technical issues, interactions among actors must also be considered. Complex issues, such as the combination of passenger and freight transport, require the integration of different social components into the process according to the quadruple helix approach (Carayannis & Campbell, 2009). These components include a) policy and decision-makers; b) forwarders/transport and railway companies, terminals, infrastructure providers, and shippers; c) universities and research centers; and d) civil society. The instances of each group have to be considered, not forgetting that the suitability of the proposed schemes is derived not only from the technical and operational aspects but also from the interactions among actors. This aspect, which is studied by social sciences, must be evaluated with utmost attention and can represent a further challenge for the implementation of the combined passenger–freight scheme.

A wide and heterogeneous deal of interest in the literature is identified in the theme of this review. The key point proposed here is that the competitive battle among different transport systems to serve certain demand shares may increasingly become a concrete alliance, as general concerns on cost control may lead the different transport operators to consider the potential of cooperating with each other. Even if a volatile market segment, such as travel demand, may not be very conducive to creating stable scenarios in terms of organizational and operative factors, the trends identified in this research highlight the necessity for some policy-makers to define suitable normative frameworks that can integrate both systems. Thus, developing reliable and accurate policy measures to favor co-modality can be a potential direction for future studies.

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