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Overview of Air-Rail Passenger Transport Relationship from 1997 to 2018 †

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Abstract: World international passenger transport nowadays is dominated by air transport, while domestic passenger transport in certain region relies on rail transport. Aviation and railroad industry have been a rivalry since the introduction of commercial airlines. Although the relationships between both modes are initially competition, there are several other forms of relationship including cooperation and integration. This paper identified and categorized research themes for air-rail passenger transport relationship from research papers published between 1997 and 2018 by using content-based analysis. The literatures included in this paper focused on transportation science disciplines, namely economic, social, environment, and operations. Other analysis context are the analysis of word frequency and trend analysis for geographical area of research. Air-rail transport research themes were identified as modal comparison, modal influence, modal competition, modal cooperation, and modal integration. It has been found that in the early years, Europe is the region that dominate the research on air-rail passenger transport. However, China is an emerging country over the past five years. Additionally, research theme relies heavily on modal competition and modal influence.

Keywords: air transport; air-rail transport; rail-transport; content-based analysis

1. Introduction

The earliest relationship between air-rail passenger transports is competition. Milan [1] compared the quality of rail and air passenger networks in Europe, particularly the West, Central and Eastern region. Givoni [2] further strengthened the competing distance between both modes, which is the route of 600 km or a one-hour flight. In another word, the high-speed train can be a substitution mode for the air carrier when the travelling distance does not exceed 600 km. The concept of integration of air transport and rail transport was discussed by Stubbs and Jegede [3]. The research described the situation in Britain when the air carrier and the rail operator can complement each other by linking airports and cities with rail networks to provide seamless journeys.

To classify the air-rail transport relationships, the work of Givoni and Banister [4] can be referred. The competition integration between air and rail means the situation when mode substitution and mode choice decision emerged. The cooperation between air and rail transport was identified as a complementary service occur between both modes and will happen only when the rail infrastructure is connected to the airport. As for air-rail integration, the entire journey can be viewed as a single booking or a single ticket. Passengers can transfer from airport to rail station which situated in the airport seamlessly.

Clewlow et al. [5] has indicated the relative influence of rail transport to air transport. It has been found that existence of high-speed railway would have negative influence on the domestic air passenger traffic while the improved rail travel times would also lower the short haul air traffic in

Europe. Similar relative influence of air transport to rail transport were also discovered by Dobruszkes et al. [6] by measuring impact of high-speed rail on the level of air service in European Union. From the research, the high-speed rail travel time was found to have significant influence on air service providing. More research on air-rail influence were carried out by Wan et al. [7], Chen [8], Zhang et al. [9], Yang et al. [10], and Zhang et al. [11].

Literature review on air-rail passenger transport was incorporated in many researches but all of them focus on specific issue. Dobruszkes et al. [6] summarized the literature review on high-speed rail induced intermodal effects including focus, markets, methodology (whether the research use econometric approach or not), and the main results. Wan et al. [7] provided an insightful air-rail transport research literature summary with focus on econometric methods. Chen [8] summarized the literature using quantitative method to study air-rail competition. Therefore, the comprehensive literature review on the air-rail transport relationships has not been complied. To fill this gap, researcher complied and analyzed research articles relating to air- rail transport from transportation and social science journal over a time span of 22 years to deliver research themes and trends in order to identify nature of relationships between both modes. Air transport in this research covers passenger air carriers (low cost and full service), airport, and air traffic. Rail transport in this research includes high-speed trains, intercity passenger trains, mass transit trains, and airport rail link.

The following section describes research methodology and paper classification. Section 3 presents findings and discussion of this research. Conclusions, limitations, and future adaptions of research are explained in Section 4.

2. Research Methodology

While literature review provides insights and research gaps for a particular research, it can also be used to identify research trend with large enough amount of literature over specific period of time. According to Hsieh and Shannon [12], content-based analysis can be applied to subjectively interpret "the content of text data through the systematic classification process of coding and identifying themes and patterns". This method has been employed in various research area including logistics and transportation as can be seen in Cullinane and Toy [13], Spens and Kovacs [14], Ahi and Searcy [15], Mahpula et al. [16], and Moldavska and Welo [17].

The content-based analysis in this research covers both qualitative and quantitative analysis. The qualitative analysis supports the capturing and interpretation of the analyzed text. The quantitative analysis provides numerical outcomes such as frequency of keywords. Since this method does not have a standardized measure for conducting the research, it is challenging to prove that the research findings are reliable and trustworthy. To make the analysis as thorough as possible, this research follows the two systematic literature review steps: preparation and analysis.

2.1. Preparation

Preparation phase involves with identifying the purpose of the literature review, and literature searching and screening. Since the purpose of this research was to identify the air-rail transport relationships based on existing research articles, the unit of analysis covered only the air-rail transport relationship appeared in the literature.

For literature's screening, this research followed steps discussed by Okoli and Schabram [18]. The content was limited to transportation sciences associated with social sciences, for example, transport economics, social and environmental impact on transportation.

The articles were collected from two databases: ScienceDirect and Scopus. Since there are enormous data in both databases, the following search criteria were applied:

2.1.1. Article Search Words

The search words in article databases are words associated with rail and air, such as "rail" AND "air", "railway" AND "airline", "high speed rail" AND "air", "high speed train" AND "air", "high speed rail" AND "airline", "high speed train" AND "airline", "HSR" AND "air", and "air-rail".

2.1.2. Publication Year

Data range was restricted between the beginning of 1997 (based on the work of Milan [1]) and the end of 2018. The articles that were excluded were articles published in 2019.

2.1.3. Language

Only articles written in English were included in this research.

2.1.4. Scope of articles

Only articles related to transportation sciences were considered.

In the literature searching and screening process, the search words were applied in the following fields: abstract, title, and keyword. Articles with matched search words but were not related to transportation sciences (for example, engineering), were removed. At the end of the screening process, 81 articles were selected from 25 journals for further review and analysis.

2.2. Analysis

The selected articles were carefully reviewed to identify research theme, if not pre-indicated as keywords of each article. Data extraction was performed to filtered unnecessary text from the analysis. As a result, research purposes, objectives, methodologies, outcomes, discussions and conclusions were included as sources for the text coding. A systematic literature review software, NVivo 11, was used to run query such as word frequency as well as to perform manual text coding for the theme classification.

3. Result and Discussion

3.1. Analysis of Word Frequency

NVivo 11 was used to run a query for word frequency with stemmed word grouping. It has been discovered that "hsr" is the word with the highest frequency (6718 counts). Figure 1 depicts the cluster analysis in a three-dimension diagram of the word frequency based on similarity. The larger the size of the bubble, the higher the word frequency. Only the words with frequency higher than 2000 are displayed in this diagram. The cluster analysis result shows resemblance to the descriptive statistics described earlier, which determined the most prevalent air-rail transport research theme: competition.

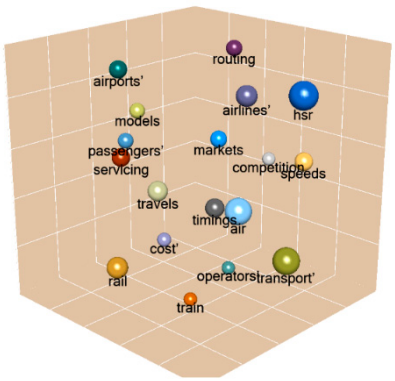

Figure 1. Cluster Analysis of the Word Frequency.

3.2. Classification of Research Theme

To classify research theme, manual text coding was performed. All articles were coded under the following themes: modal comparison, modal competition, modal cooperation, modal integration, and modal influence. Description of each theme are as follows.

Based on Milan [1], the modal comparison includes the articles focusing on comparing air transport and rail transport in certain dimension. The modal competition, modal cooperation and modal integration follow the concept described by Givoni and Banister [4]. Differences in the mentioned themes can be depicted as in Figure 2. For the modal competition, articles in this theme addressed either the mode choice decision—choosing either air or rail transport given both modes are available—or the mode substitution where passengers must travel from city (a) to city (b) by one mode if another is not in service.

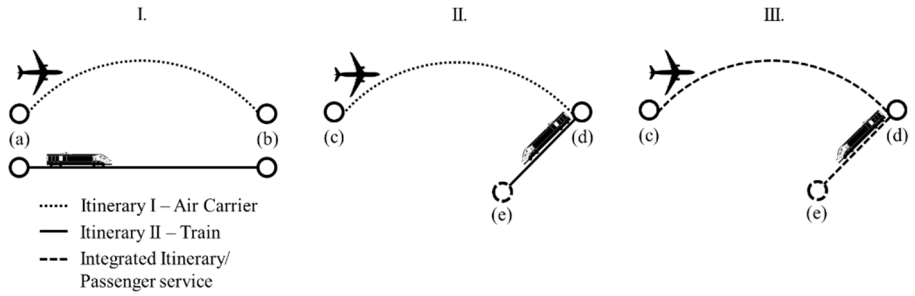

Figure 2. Travel pattern for I. Modal competition, II. Modal cooperation, and III. Modal integration.

The modal cooperation is the situation when rail infrastructure exists in or nearby the airport and air passenger can use rail system to transfer to downtown or other cities where air passenger service does not take place. In another word, rail transport serves as air transport's feeder. In this situation, air ticket and train ticket are sold and handled separately. Passengers handle their own baggage when transit from one mode to another while traveling from airport (c) to airport (d) and use the airport rail link to transfer to (e).

The modal integration focuses on the situation when air carrier and train operator offer seamless journey within a single booking or through a rail-air ticketing under collaborative agreement from airport (c) to airport (d) with rail transfer to (e). Li et al. [19] indicated cases where air and rail transport can be collaborated through partnerships. Thirty-three air-rail partnership cases were investigated, with seven cases with rail station situated in the airport. Such cases offer partnership features including online reservation, delay and/or cancellation assistance, integrated ticketing, schedule coordination, frequent flyer program, baggage handling, and code-sharing. It was concluded that co-location of rail facility with airport is necessary for the success of air-rail partnership. However, the coordination between air and rail transports is still lacking in China. A research by Chen and Lin [20] supported in supposition and suggested that the level of air and rail integration in Shanghai's Hongqiao International Airport is limited due to separated air and rail facility, prohibiting the success of air and rail integration.

The modal influence can be described as a situation when one mode, once in operations, has a significant impact or affect to another mode, which may result in one or more of the following state of affairs: competition, cooperation, integration, and strategy adoption.

Text in each article were coded according to above themes (or nodes in the software). Total of 100 sources are coded with 157 references, which means that there are several articles that are coded in more than one theme. Figure 3 illustrates the dendrogram cluster analysis for air-rail transport research themes based on word similarity. The dendrogram represent similarity of node by clustering the similar nodes on the same branch and different nodes further apart. The Pearson correlation coefficients are applied as the similarity metric to show how each theme are correlated. It can be seen that "Influence" and "Competition" are clustered together on the same branch, indicating the close relationship between both nodes comparing to the others.

Table 1 exhibits the Pearson correlation coefficients between nodes. All coefficient values indicate positive correlations. Apparently, "Influence" and "Competition" which has correlation coefficient value of 0.698 has a strong positive correlation. Similarly, the correlation coefficient of "Integration" and "Competition" also has a strong positive correlation. This can be implied that most

research in modal competition theme would likely to carry out modal influence or modal integration context or output as well. On the other hand, the correlation coefficients of "Influence" and "Cooperation", and "Cooperation" and "Comparative" suggest a very low indication of positive correlation.

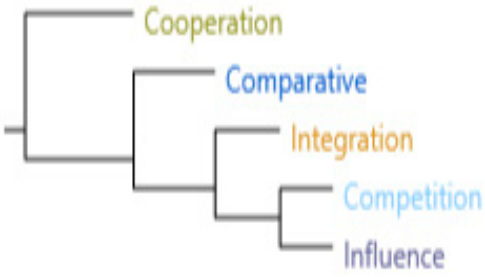

Figure 3. Research Themes.

Table 1. Pearson Correlation Coefficients for Research Theme.

Node A	Node B	Pearson Correlation Coefficients
Influence	Competition	0.698
Integration	Competition	0.688
Integration	Influence	0.583
Competition	Comparative	0.530
Integration	Comparative	0.449
Influence	Comparative	0.425
Integration	Cooperation	0.364
Cooperation	Competition	0.240
Influence	Cooperation	0.195
Cooperation	Comparative	0.172

On the one hand, "Competition" nodes contain text coding from 49 sources out of 99 sources, making the modal competition the most prevalent research theme. On the other hand, the modal cooperation discussed by Givoni and Banister [4] appeared only in the work of Mathur and Srinivasan [21], which suggested "synergistic relationships" between airport and high-speed rail to successfully launched the high-speed rail projects in the United States. It can be implied that modal cooperation alone may not be sufficient for both modes to beneficially and efficiently operate. Evidence from the modal competition and integration articles clarify that despite the fact the air-rail transport are by nature competitor, both modes can still create win-win situations under collaborative and partnership agreements.

An additional air-rail transport relationship would be how both modes influence each other. Interestingly, all articles in modal influence theme indicated that the airlines are influenced by the high-speed trains, while the high-speed trains adopted strategies, particularly low-cost operations, from the air carriers. Therefore, the influence may have taken effects on the modal integration incentive for one mode, as discussed by Takebayashi [22].

3.3. Trend Analysis

During 1990s and 2000s, there are few articles discussing about the air-rail transport relationships. Number of publications has risen continuously after 2010. Seventy-two percent of articles were published between 2014 and 2018. The geographical area of research are mainly China and Europe, as presented in Table 2. Both areas have one characteristic in common, a sufficient air and rail infrastructure that can accommodate research for data collection and analysis.

It can be seen that Europe, as a geographical research area, clearly dominate the air-rail transport research for the entire period of study, while in China, research in air-rail transport appear after 2010. Although Europe remains the dominant geographical research area during 2010s, China has become the emerging research trend in air-rail transport in the last two years (2017–2018), with number of

publications involving Chinese air-rail transports exceeding European air-rail transports. It can be inferred that this development is the consequence of extended high-speed rail network as well as better air infrastructure in China.

Table 2. Geographical Area of Research.

Area	1990s		2000s		2010s		Last 2 Years		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
China	0	0.0%	0	0.0%	16	19.8%	10	12.3%	16	19.8%
Europe	2	2.5%	6	7.4%	31	38.3%	6	7.4%	39	48.1%
Other	0	0.0%	2	2.5%	24	29.6%	10	12.3%	26	32.1%
Total	2	2.5%	8	9.9%	71	87.7%	26	32.1%	81	

Figure 4 visualizes the trend of research theme over time span of 22 years. From 2014 to 2018, research in the modal competition is prevalent while modal integration and modal influence gradually gains attention from researchers due to more active air-rail collaborations and technology advancement which leads to better coordination between both modes. This coincide with the theme analysis in Section 3.2 that research on air-rail competition are recently carried out together with modal integration as well as modal influence.

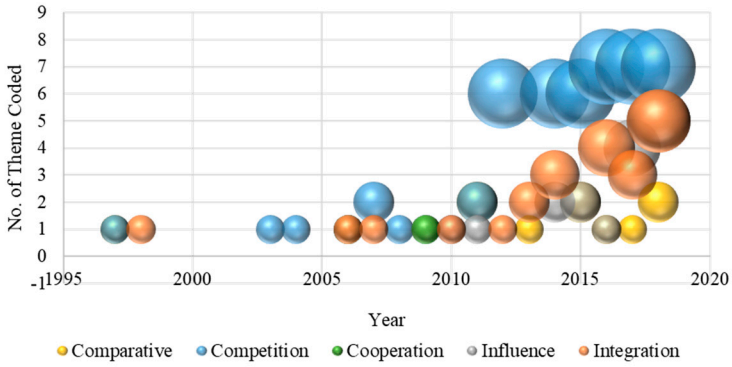

Figure 4. Trend in Research Theme.

4. Conclusions

This study has addressed research development in the air-rail transport relationships. First, geographical area of research mainly covers China and Europe due to the extensiveness in rail network and air infrastructure. Second, the modal competition has been the majority research theme over 22 years of time span. From the content analysis, two pairs of research themes—the modal competition and modal influence; and modal competition and modal integration—have a strong, positive correlation. This can be concluded that the air-rail transport relationships are not straightforwardly competitive. Both modes can compete, become partner, and influence each other at the same time. In addition, modal cooperation is clearly neither a recent research trend, nor the direction of future air-rail transport relationship. This can be an alert message for ineffective air-rail link network. For the case that air-rail infrastructure in which the air-rail transport relationship is classified as the modal cooperation, that system would have the necessary infrastructures for air-rail integration. In that case, establishment of collaborative agreements along with practical and realistic business model could have elevated the air-rail transport relationships to the higher level and resulted in a win-win situation for both modes. Finally, the significant number of publications over the last five years suggest that air-rail transports and their relationships has been increasingly acknowledged as important research area.

Apart from challenging issue about trustworthiness and reliability of content analysis that was mentioned earlier, this research also has other limitations. This research mainly focuses on the air-rail transport relationships and does not address the analysis on methodology applied in each research. Furthermore, the number of collected articles was not enormous since about three-quarter

of articles were published over the past five year, making research trends somewhat ambiguous. Therefore, it may be useful to repeat the study in the future when more air-rail transport articles are published to see if there is any development in research trend as well as to identify new research theme.

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