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Analysis of the Air Transport Network Characteristics of Major Airports

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ABSTRACT

The world's major airports are directly connected to hundreds of airports without intermediate routes. This connectivity can be described as the network in which the airport becomes a node and the route becomes a connection line. In this regard, this study analyzes the air transport network of 1,060 airports using the social network analysis (SNA) methodology. We consolidated the data from three airline alliances and established a network of 1,060 airports and 5,580 routes in 173 countries. Many previous studies on air transport network examined several specific airports or regions and mainly utilized the internal indicators of airports. Conversely, this study conducted a comprehensive analysis covering 173 countries by using air route, which is an external indicator of airports. This study presented the general characteristics of major countries and regions from the perspective of SNA and compared the individual networks of the United States and China, which have the greatest influence on international air logistics within the scope of the entire network analysis. This study can aid in the understanding of air transport networks and logistics connectivity in inter-city and inter-country transport.

1. Introduction

According to the International Civil Aviation Organization (2016), the proportion of air transportation in Asia by 2015 was about 30.2% in the world, 29.5% in North America, and 24.7% in Europe. In terms of the share of major countries, the volume of air transportation in the United States was 37,219 million tons in 2015, accounting for 18.84% of the world's total volume. China ranked second with 19,806 million tons, accounting for about 10.02%. The United Arab Emirates (UAE) ranked third with 8.43%, followed by South Korea (5.72%) and Japan (4.49%). In terms of cargo transportation, air cargo is cost disadvantageous compared with sea and land cargo. The more that sea and land-based services improve and companies become interested in supply chain management, the more that air transportation tends to convert to sea and land cargo. However, the demand for multimodal transport is increasing because of the diversification of logistics strategies of companies, and the transportation demand for high-tech products, such as semiconductors, wireless communication devices, and computers, is increasing. Therefore, air cargo transportation will still play an important role in international logistics transportation. As a practical example, China, the influence of which in air transport is greatly expanding around the world, has grown to an average annual speed of over 10% in the past decades (Zhang et al., 2017). Moreover, major countries in the world are actively developing their own airports, such as airport enlargement and modernization of facilities, passenger, and cargo attraction for the development of air transportation.

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In particular, major airports in the world are characterized by the capability to connect directly with hundreds of airports without intermediate routes. The air transportation system can be represented as a network, in which nodes denote airports and an edge will be created if a direct flight exists between two airports. From this point of view, this study aims to analyze the characteristics of airports and countries based on the air routes that are connected to major airports around the world. This study helps in the general understanding of an air transport network. The analysis of logistics connectivity in inter-city or inter-country relations has implications for the diversified application of research methodology and international logistics research.

This paper is organized into five sections. Following this introduction, section 2 provides a literature review on the air transport network analysis. Section 3 presents the data collection and the proposed methodology. Section 4 discusses the analysis and findings. Section 5 gives the conclusion and future research opportunities.

2. Literature Review

Oriol et al. (2014) observed that research on air routes had begun to be modeled and analyzed as a complex network in recent years. He mentioned that research on air transport networks could be based on the analysis of a particular airport or a particular country's network, depending on the subject of the study, and could include a comparison of the airport and country networks. Bagler (2008) analyzed the airport network in India and found that airport network analysis progresses gradually on a regional basis, such as in a country or continent. Jia et al. (2014) examined the changes in the US airport network (USAN) from 1990 to 2000 and argued that the airport network plays an important role in US urban and regional development. Wang et al. (2011) analyzed the network structure of major airports in China and posited that network centrality is highly correlated with socioeconomic indicators, such as passenger numbers, population, and GRDP. Shao and Sun (2016) performed a network data envelopment analysis (DEA) for 477 air routes in China in 2013. Their efficiency analysis was conducted on four areas: airline route system, allocation, passenger transport, and freight transport. Hwang and Shiao (2011) analyzed the international freight transportation route of the Taiwan Taoyuan Airport from 2004 to 2007 and found that the liberalization of air cargo markets between the United States and Taiwan led to an increase in air cargo transactions between the two countries.

In comparing airport- or country-based networks, Paleari et al. (2010) compared the connectivity of air transportation in China, Europe, and the United States in terms of service provision to passengers. He found that China provides the fastest route, the United States is the most coordinated network, and Europe has the highest quality level. Chung and Han (2013) selected the international airports of Incheon, Narita, and Pudong to analyze the competitiveness of transshipment cargo airport. His conjoint analysis showed that Incheon, Narita, and Pudong airports accounted for 44%, 29%, and 27% of the market share, respectively. Walcott and Fan (2017) analyzed the air cargo network hubs in the United States and China, examined the FedEx and UPS networks in the United States, and presented Zhengzhou in Henan Province as a hub in China. Pere et al. (2016) observed that London's Heathrow Airport and the United Kingdom's regional airports contribute to national connectivity. The authors mentioned that low-cost airlines in the provincial cities of the United Kingdom have expanded connectivity with many cities in Europe but lack long-haul routes and that Heathrow Airport is losing markets to Amsterdam and Dubai.

In terms of airline alliance and continent-based analysis, Thelle and Sonne (2017) examined the competitive landscape and development of European airports caused by changes in the European aviation market in 20 years. They found that passengers have more options and airports are actively responding to market changes, and asserted that airports have to compete to maintain and attract traffic. Oriol et al. (2015) analyzed the robustness of three aviation alliances and found that Star Alliance had the most resilient route network, followed by Sky Team and Oneworld. Halpern and Graham (2015) conducted online surveys on 124 airports around the world to examine the route development of the airports. The authors observed that 54% of airports have a dedicated route development team and that most airports are actively involved in path development with emphasis on attracting new airlines and routes.

Table 1

Previous studies on air transport network

Network Scope	Author (Year)	Keyword
Country (United States)	Jia et al. (2014)	Complex network, US airport network (USAN), Evolution, Exploration, Densification
Country (India)	Bagler (2008)	Complex network, Transportation, Airport network
Country (China)	Wang et al. (2011)	Air transport network, Complex Network, Centrality, China
Country (China)	Shao and Sun (2016)	Network DEA, Air route, Efficiency, Passenger transport, Freight transport
Airport (Taoyuan Airport, Taiwan)	Hwang and Shiao (2011)	Air cargo, Gravity model, International trade, Panel data
Comparison between countries (China, US, and Europe)	Paleari et al. (2010)	Airport connectivity, Network features, Travel time
Comparison between airports (Incheon, Narita, and Pudong)	Chung and Han (2013)	Transshipment, Competitiveness, International Airport, Air Cargo, Brand
Airport (London, UK) Analysis in Europe	Pere et al. (2016)	Airport policy, Hub competition, Regional airports, Connectivity
Comparison between countries (China and US)	Walcott and Fan (2017)	Air freight, Network hub
Airline Alliance (Star Alliance, One world and Sky Team)	Oriol et al. (2015)	Alliance route network, Complex networks, Robustness, Airline alliances, Airport disclosure, Intentional attacks
Trend Survey (124 airports)	Halpern and Graham (2015)	Route development, Air service development, Airport marketing, Airport airline relationship
Region (Europe)	Thelle and Sonne (2017)	Airport competition, Competitive constraints, Regulation

Table 1 presents previous studies according to network coverage. The research topics on air transport network were extensive, and most studies were conducted on the relationship between airports, the roles of airports in cities and regions, and influence. In the analysis of airports or national-based networks, most previous studies examined several specific airports or regions and utilized internal indicators, such as airport size, number of passengers, and volume of traffic, among others. The differences between the current study and previous studies are as follows: (1) This study conducted a comprehensive analysis on a broad range of 173 countries and used the external indicator of air route. (2) The results of the network centrality analyzed at the airport level were categorized by country, and