An Evaluation of Network Competitiveness and the Effects of LCCs on South Korea's Network Connectivity: Using Aviation Market Data

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Abstract: LCCs (low cost carriers) are expanding their routes, which is affecting airport network connectivity. The subsequent increases in market competition and the number of airlines operating in air network routes have made the centrality analysis more significant because it can be used to identify airport network connectivity competitiveness. This study analyzes the network connectivity competitiveness of South Korea among Asian airports using the MIDT (marketing information data transfer) dataset provided by OAG Traffic Analyser, which provides data collected from regional Asian airports since 2011. The network centrality of individual airports is estimated to compare network connectivity competitiveness in Asia. Measures for overall network centrality include degree, closeness and betweenness centrality. This network centrality analysis may be helpful for South Korean airports in identifying their network performance and competitive position in Asia and confirming the effects that LCCs have on airport network connectivity. The results indicate that South Korea's aviation market needs to expand its network via a strategy that prioritizes the strengthening of airport connectivity and the pursuit of liberalization. In addition, LCC operations will support Korea's network growth via the various strategies that they employ. Consequently, this in turn will bolster the overall market competitiveness of South Korean airports.

Key words: Air network connectivity competitiveness, network connectivity, centrality analysis, low-cost carrier effects.

1. Introduction

Recent increases in market competition and the number of airlines operating in air network routes have brought greater attention to the connectivity analysis because it can be used to identify airport network connectivity competitiveness. Connectivity analyses deliver the information necessary to design strategies to improve the competitive position of airports [1]. For example, these measures make it possible to demonstrate to what extent an airport plays a role as a connecting hub in a particular origin destination market in comparison to competing hubs [2].

Airport network connectivity is formed via the movement of products and people across a county. As such, it is a significant indicator of economic growth [2]. In addition, transportation networks are used as indicators to evaluate the socioeconomic development of countries or regions [3].

The air transport industry has experienced rapid growth, and air route networks are becoming increasingly complex. China's air transport network has developed rapidly, and hub airports in East Asian countries are being extended to increase their competitiveness. Recently, the Asian aviation market has grown, and this growth has resulted in a high level of competition. In 2015, the Asian aviation market accounted for 34.1% of the global market share, and 24.6% of that traffic was international.

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In strategic airline management, both FSCs (full service carriers) and LCCs (low cost carriers) are significant factors that determine network structure [4]. South Korea has 16 regional airports, and LCCs now have more than 50% of the domestic market share.

Moreover, because regional airports have increased the number of international routes operated by LCCs since 2011, LCCs have been able to boost their international market share from 3.5% in 2010 to 22.7% in 2015, as shown in Fig. 3.

Fig. 1 Market share of passenger traffic (international + domestic).

Source: ACI, 2015.

Fig. 2 Market share of passenger traffic (international).

Source: ACI, 2015.

Fig. 3 Market share of LCC passenger traffic (international).

Source: Air portal, <http://www.airportal.go.kr>.

Fig. 4 Market share of LCC passenger traffic (domestic).

Source: Air portal, <http://www.airportal.go.kr>.

LCCs have gradually changed their image in Korea. In the past, they were associated with low prices and short-distance routes. However, after recent developments such as the establishment of the Value Alliance in 2016, LCCs are increasingly recognized as long-distance options. Now, LCCs are striving to expand their routes, which will affect network connectivity in South Korea. Accordingly, big changes are expected with respect to the country's network of airports. With that in mind, the present network centrality analysis may be helpful for South Korean airports to identify their network performance and competitive position in Asia, and to confirm the effects that LCCs are having with respect to airport

network connectivity.

2. Background

Empirical studies have adopted the centrality perspective in order to evaluate the performance of airline hubs in a certain origin destination market in comparison to competing hubs [5, 6]. A number of studies have analyzed connectivity with a focus on specific countries such as the US and, more recently, China, as well as regions such as the EU. Wang et al. [7] studied the evolution and growth of the ATNC (air transport network of China) from 1930 to 2012. Their network analysis indicated that the ATNC improved its connectivity over time. Its network structure evolved

through six stages from scattered development to an emerging multi-airport system. Wang, et al. [8] estimated both the network structure centrality, which included the degree distribution, average path length and clustering coefficient, and the centralities, which included the degree, closeness and betweenness of individual Chinese cities. The results showed that the structure of the ATNC was characterized by “small world” features. Jia et al. [3] analyzed the evolution of the US airport network from 1990 to 2010 from two perspectives—stable cities and new cities. They found that the US airport network preserved scale-free, small-world and disassortative mixing properties over time, and that stable cities showed regularity. Pere et al. [9] studied the role of London Heathrow and Southeast airports in providing connectivity for the UK. The authors relied on the MIDT (marketing information data transfer) dataset, and the results indicated that connectivity was dependent on foreign airlines, airports and governments.

A number of studies have analyzed network connectivity with a focus on influence factors. The network structure depends on various factors, including the size of the origin destination market, carriers' historical background, fleet composition, strategic airline management, hub capacity and the average stage length [4]. Pere et al. [9] studied the role of London Heathrow and Southeast airports as a way of measuring network connectivity, demonstrating that increases in liberalization and the intensity of hub competition can affect connectivity. Wang et al. [8] studied the network structure of China's air transport network. They found that centrality indices were correlated with passenger volume, population and GRDP (gross regional domestic product). The open skies agreements in multi-airport regions have given air passengers more diverse flight networks [7]. The growth of new services has resulted in larger transportation networks, which has made the market more attractive [10]. Bourghouwt and Hakfoort [11] found that the route level and hub-and-spoke network

structure had developed after deregulation, which indicated that deregulation policies affected network competition. Jimenez et al. [12] studied the effects of LCCs on airport networks in Lisbon, Faro and Porto. The results indicated that LCCs affected network size, and that for new airports, network concentration had even decreased after they began operations. Burghouwt [2] provided estimates for India's domestic airport network using a weighted network analysis and proposed that the operation of LCCs and the addition of new airports would spur India's network growth. Accordingly, LCC operation strategies affect transport networks.

Collectively, the literature offers numerous analyses on the network centrality of airports. These analyses have attempted to determine whether small-world and scale-free characteristics existed, and they have endeavored to estimate network positions and influence factors. The results of such studies allow policy makers, airports and airlines to identify and strengthen their network performance [1]. By understanding airport network evolution characteristics, industry decision makers and/or researchers can acquire beneficial information about their own potential as well insight into the competitive positions of their counterparts [3, 13].

The present study employs the MIDT dataset provided by OAG Traffic Analyser for Asian airports to analyze the airport network. The network centrality analysis is modeled as a weighted network with cities as nodes and airlines between cities as links. This paper studies the network connectivity competitiveness and the effects of LCCs on the network connectivity of South Korea.

3. Research Methodology

Small-world networks are characterized by a very small average shortest path length (L) and a high average clustering coefficient (C) [15, 16]. The average degree of a network is denoted as the average number of neighbors that a node has in the network.

The clustering coefficient of a node is indicated as the ratio of the number of links shared by neighboring nodes to the maximum number of possible links [17].

The centrality measure is the relative importance of a node within a network. This paper estimates the degree, closeness and betweenness centrality.

3.1 Degree Centrality

The degree is the number of edges that a node shares with other nodes, which reflects the importance of the current node [18].

In this paper, the node refers to the number of arrival airport routes having flights from current airports. g is the number of nodes in the network. This is written as

$$C_D(n_i) = \frac{d(n_i)}{g-1} \quad (1)$$

3.2 Weighted Degree Centrality

The number of passengers is considered to include information regarding the amount of traffic flow on the network as weighted centrality. This is written as

$$C_{w \cdot D}(n_i) = \frac{d_{\text{number of pax}}(n_i)}{g-1} \quad (2)$$

3.3 Closeness Centrality

Closeness is defined as how close a node is to all of the other nodes along the shortest path in the set of routes. A node is deemed central if it can quickly interact with all other nodes [18]. This is written as

$$C_c(n_i) = (g-1) \left[\sum_{j=1} d_{ij} \right]^{-1} \quad (3)$$

3.4 Betweenness Centrality

Betweenness is the ratio of the nodes passing through the shortest paths. A node tends to be more powerful if it is on the shortest paths connecting many node-pairs. This indicates that the node may be in a position to broker or mediate connections between these pairs [8]. This is written as

$$C_B(n_i) = \frac{\sum_{j < k} [g_{jk}(i)/g_{jk}]}{[(g-1)(g-2)/2]} \quad (4)$$

4. Centrality Analysis Results of Asian Airports

This study analyzes the network connectivity competitiveness of Asian airports using the MIDT dataset provided by OAG Traffic Analyser. In particular, the dataset is mined for one-way data on Asian and South Korean airports from 2011 to 2015. Measures for the overall network centrality include degree, weighted degree, closeness and betweenness centrality. The network centrality of individual airports is estimated to compare the network competitiveness in Asia by using NetMiner 4 software.

In Table 1, the node changes, average density and clustering coefficient indicate that the network of Asian airports has increased in size since 2011.

4.1 Degree Centrality

Degree centrality is defined as the number of nodes directly pointed at by the current node [4]. In 2015, the top five Asian airports ranked by network degree centrality were SIN (Singapore Changi International Airport), BKK (Suvarnabhumi International Airport), NRT (Narita International Airport), HKG (Hong Kong International Airport), ICN (Incheon International Airport) and MLN (Manila Ninoy Aquino International Airport), in that order.

In terms of international network degree centrality, SIN and BKK were ranked lower than HKG despite the fact that SIN and BKK appeared higher than HKG on the list of total network degree centrality rankings. This suggests that the Southeast Asian airport market achieved a large amount of latent competitiveness after developing its international network.

4.2 Weighted Degree Centrality

The weighted centrality index includes information on the amount of traffic flow in the network, indicated by the thickness of the link. In general, because the number of passengers is not reflected in the degree centrality index, airports operating smaller numbers of

Table 1 Characteristics of the Asian network.

Year	No. of link	Average density	Average degree	Clustering coefficient
2011	66,758	0.015	22.149	0.802
2012	69,869	0.015	23.181	0.796
2013	72,618	0.016	24.094	0.799
2014	131,092	0.029	43.494	0.782
2015	113,170	0.025	37.548	0.797

Source: OAG Traffic Analyser, 2016.

Table 2 Top 10 airports by degree centrality index.

Rank	Total (Inter. + Dom.) network				International network			
	2011		2015		2011		2015	
	Airport	Degree centrality index	Airport	Degree centrality index	Airport	Degree centrality index	Airport	Degree centrality index
1	HKG	0.597	SIN	0.640	HKG	0.523	SIN	0.647
2	PEK	0.572	BKK	0.638	SIN	0.498	BKK	0.639
3	SIN	0.568	NRT	0.632	BKK	0.487	HKG	0.637
4	BKK	0.567	HKG	0.629	NRT	0.483	NRT	0.627
5	NRT	0.565	ICN	0.622	ICN	0.477	ICN	0.626
6	ICN	0.548	MNL	0.616	PEK	0.446	MNL	0.609
7	PVG	0.482	PEK	0.595	DEL	0.389	DEL	0.574
8	DEL	0.477	PVG	0.592	PVG	0.377	KUL	0.559
9	BOM	0.434	DEL	0.592	KUL	0.352	PEK	0.538
10	KUL	0.413	KUL	0.563	BOM	0.350	PVG	0.537

routes rank lower even if they process large numbers of passengers. Bagler [19] constructed a weighted network that considered the number of flights that defined the strengths of the links. Bagler's network also represented each airport's connectivity architecture. In 2015, PEK ranked first on the total network weighted degree centrality index, which was influenced by the number of passengers (90 million in 2015). PEK's domestic market share was higher than its international market share. Thus, on the international weighted degree centrality index, PEK ranked ninth. It is assumed that at present, PEK's ranking in terms of the weighted degree centrality index has improved due to China's efforts to increase its international network. For HKG and SIN, on the other hand, 100% of the air traffic is international, and this is reflected in their rankings for the weighted degree centrality index.

4.3 Closeness Centrality

The closeness centrality index focuses on how short the distance is between the self-node and all of the other nodes. However, it also lists the SPL (shortest path length). This value represents the minimum number of steps needed to connect nodes [20]. In 2015, in terms of the total network closeness centrality rankings, the top six airports were SIN, BKK, NRT, HJK, ICN and MNL. This shows that SIN, NRT, BKK and HKG have a geographical advantage, enabling easier connections with other countries.

4.4 Betweenness Centrality

The betweenness centrality index indicates the degree of power that an airport wields to broker or mediate connections between the shortest paths connecting node-pairs. In 2015, in terms of the total

network betweenness centrality rankings, the top six airports were NRT, BKK, SIN, MNL, DEL and ICN. From 2011 to 2015, MNL climbed the rankings because more passengers were flying in and out of the country.

This paper also conducts a correlation analysis between the number of transfer passengers and centralities by using data on the domestic and international transfer passengers at NRT, BKK, SIN, BKK, ICN, HKG and other airports. The results indicate that the correlation between the number of transfer passengers and centrality, including degree, closeness and betweenness, is statistically significant

in the positive (+) direction, as shown in Table 6. In particular, among these parameters, the betweenness centrality has the strongest correlation with the number of transfer passengers.

Accordingly, the competition to improve betweenness centrality increased between 2011 and 2015. In other words, the trend indicates that the competition among airports in Asia will increase significantly. The Japanese and Chinese governments intend to extend their international connection networks to serve as Asian hubs. Therefore, it is necessary for ICN to make efforts to strengthen the competitiveness of Korean airports.

Table 3 Top 10 airports by weighted degree centrality index.

Rank	Total (Inter. + Dom.) network				International network			
	2011		2015		2011		2015	
	Airport	Weighted degree centrality index	Airport	Weighted degree centrality index	Airport	Weighted degree centrality index	Airport	Weighted degree centrality index
1	PEK	22,490	PEK	27,563	HKG	11,765	HKG	15,357
2	HND	17,851	HND	19,931	SIN	10,950	SIN	13,859
3	CGK	15,301	CGK	18,226	ICN	8,830	ICN	12,901
4	CAN	13,678	PVG	17,419	BKK	8,031	TPE	11,299
5	HKG	13,425	CAN	16,530	TPE	7,555	BKK	10,766
6	SIN	12,494	HKG	15,173	KUL	5,993	KUL	8,627
7	BKK	12,285	SIN	13,693	NRT	5,772	PVG	8,044
8	PVG	11,937	SZX	13,353	PVG	5,110	NRT	6,924
9	SHA	11,042	SHA	13,144	PEK	4,128	PEK	5,668
10	DEL	10,735	CTU	12,963	MNL	3,386	KIX	5,176

Table 4 Top 10 airports by closeness centrality index.

Rank	Total (Inter. + Dom.) network				International network			
	2011		2015		2011		2015	
	Airport	Closeness centrality index	Airport	Closeness centrality index	Airport	Closeness centrality index	Airport	Closeness centrality index
1	HKG	0.7028	SIN	0.700	HKG	0.597	SIN	0.694
2	PEK	0.6892	BKK	0.700	SIN	0.584	BKK	0.689
3	BKK	0.6888	NRT	0.696	BKK	0.579	HKG	0.687
4	SIN	0.6878	HKG	0.695	NRT	0.575	ICN	0.681
5	NRT	0.6860	ICN	0.690	ICN	0.574	NRT	0.679
6	ICN	0.6791	MNL	0.687	PEK	0.556	MNL	0.671
7	PVG	0.6487	PEK	0.675	DEL	0.528	DEL	0.648
8	DEL	0.6449	PVG	0.674	PVG	0.522	KUL	0.643
9	BOM	0.6247	DEL	0.673	KUL	0.517	PEK	0.630
10	KUL	0.6203	KUL	0.656	BOM	0.510	PVG	0.630

Table 5 Top 10 airports by betweenness centrality index.

Rank	Total (Inter. + Dom.) network				International network			
	2011		2015		2011		2015	
	Airport	Betweenness centrality index	Airport	Betweenness centrality index	Airport	Betweenness centrality index	Airport	Betweenness centrality index
1	HKG	0.099	NRT	0.069	HKG	0.078	NRT	0.057
2	PEK	0.086	BKK	0.058	NRT	0.062	SIN	0.054
3	NRT	0.083	SIN	0.056	BKK	0.061	BKK	0.051
4	BKK	0.082	MNL	0.051	SIN	0.056	ICN	0.044
5	SIN	0.070	DEL	0.050	PEK	0.054	HKG	0.043
6	ICN	0.065	ICN	0.050	ICN	0.050	MNL	0.041
7	DEL	0.058	HKG	0.047	DEL	0.041	DEL	0.040
8	BOM	0.048	BOM	0.037	BOM	0.032	BOM	0.029
9	PVG	0.035	PEK	0.036	PVG	0.022	PEK	0.025
10	KUL	0.030	PVG	0.035	KUL	0.022	PVG	0.025

Table 6 Correlation analysis results.

	Number of transfer passengers	Degree centrality	Closeness centrality	Betweenness centrality
Number of transfer passengers	1	.803**	.800**	.873**
Degree centrality	0.803**	1	0.966**	0.855**
Closeness centrality	0.800**	0.966**	1	0.863**
Betweenness centrality	0.873**	0.855**	0.863**	1

Source: OAG Traffic Analyser, 2014.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Discussion

5.1 Centrality Analysis Results of South Korean Airports

In South Korea, there are 16 airports. Regional airports in the country have been increasing the number of international routes operated by LCCs since 2011. LCCs are striving to expand their routes, which affects Korea's airport network connectivity, as shown in Fig. 5. Accordingly, big changes are expected for Korea's airport network. In this paper, the centralities are estimated to compare the network competitiveness of individual airports in South Korea with cities as nodes. The effects of LCCs on airport network connectivity are also estimated. The centrality analysis, including the degree, weighted degree, closeness and betweenness centrality of airports, is estimated to compare network competitiveness.

The emergence of LCCs has resulted in route level changes in South Korean airports, with LCCs taking

on more domestic and international routes. As a result, airports are being influenced by LCC market strategies. Recently, regional airports such as PUS, TAE and CJU have begun operating more international routes. In terms of network degree centrality, these three airports, as well as other South Korean airports, have increased their total route numbers based on the extension of LCC routes, and this has affected the node characteristics of each airport, as shown in Table 7.

The closeness centrality rankings prioritize airports based on the shortest paths connecting node-pairs. The betweenness centrality ranking indicates nodes that are in a position to broker or mediate connections between network pairs. As the number of routes in an airport increases, their nodes close in on other nodes and pass through shorter paths. Accordingly, it is possible for each airport to increase its closeness centrality and betweenness centrality rankings. For instance, CJU and TAE operate short routes between

Fig. 5 LCC market share of regional airports for international routes.

Source: OAG Traffic Analyser, 2011-2015.

Table 7 Degree centrality ranking of South Korean airports.

Total (Inter. + Dom.) network				International network			
Airport	2011	2015	△Ranking	Airport	2011	2015	△Ranking
ICN	6	5	1	ICN	5	5	0
PUS	35	24	11	PUS	32	23	9
GMP	107	109	-2	GMP	80	94	-14
CJU	133	98	35	CJU	108	86	22
TAE	165	99	66	TAE	134	83	51

self-nodes and other nodes operated by LCCs.

5.2 Effects of LCCs on the Network of South Korean Airports

Since 2011, airports have opened more LCC-operated international routes, and thus, the total number of LCC routes has increased, as shown in Table 10. At ICN, LCC-operated routes increased in number from 124 in 2011 to 181 in 2015 (an increase of 57 routes). CJU and TAE added 23 and 33 routes, respectively, over the same time period. However, GMP added just one route because its decision-making in this regard was influenced by government policy.

The penetration of LCCs into the South Korean market resulted in a change at the route level, as shown in Fig. 6. The total network and international network had expanded significantly by 2015. This expansion

was influenced by the route strategies of the LCCs, including point-to-point flights, new destinations and low price strategies in regional airports, which propelled growth in terms of network size [12]. In addition, it has been shown that LCCs contribute significantly to increases in passenger latency in a given region [21]. Therefore, it is reasonable to assume that liberalization is necessary in order to attract greater numbers of latent passengers.

The network structure depends on various factors, including the size of the origin destination market, carriers' historical background, fleet composition, strategic airline management, hub capacity and the average stage length [4]. This study is limited in its reliance on factor effects in the centrality analysis. For example, centrality rankings are analyzed without considering additional factors. This point should be considered in future studies.

Table 8 Closeness centrality ranking of South Korean airports.

Total (Inter. + Dom.) network				International network			
Airport	2011	2015	Δ Ranking	Airport	2011	2015	Δ Ranking
ICN	6	5	1	ICN	5	4	1
PUS	35	24	11	PUS	35	23	12
GMP	123	115	8	GMP	87	94	-7
CJU	148	95	53	CJU	113	85	28
TAE	186	100	86	TAE	152	86	66

Table 9 Betweenness centrality ranking of South Korean airports.

Total (Inter. + Dom.) network				International network			
Airport	2011	2015	Δ Ranking	Airport	2011	2015	Δ Ranking
ICN	6	6	0	ICN	6	4	2
PUS	65	32	33	PUS	44	26	18
CJU	168	171	-3	GMP	128	100	28
GMP	189	158	31	CJU	135	134	1
TAE	305	172	133	TAE	205	127	78

Table 10 Route development of LCCs in South Korean airports.

2011		2015	
Airport	Number of routes	Airport	Number of routes
ICN	124	ICN	181
PUS	125	PUS	139
GMP	31	GMP	32
CJU	51	CJU	74
TAE	10	TAE	43

Total LCC network in 2011 and 2015

International LCC network in 2011 and 2015

Fig. 6 LCC network alterations.

6. Conclusion

This study analyzed the network competitiveness of airports in Asia using OAG data for regional Asian airports between 2011 and 2015. The network centrality of individual airports was estimated to investigate network competitiveness in Asia. The network centrality measure allows policy makers and industry professionals to benchmark and monitor the network performance against that of other airports and airline networks [1, 3]. Furthermore, the results of the centrality measures will allow policy makers, airports and airlines to monitor and maintain or enhance

network performance over time [1]. Such analyses may be helpful for South Korean airports to identify their network performance and competitive position in Asia and to confirm the effects that LCCs have on airport network connectivity in the evolution of the network over time.

The results of the present analysis indicated that the weighted centrality reflected real traffic flows. In terms of total weighted centrality, PEK and HND were highly ranked in spite of other centralities achieving lower rankings. This indicated that they possessed large latent competitiveness in terms of network centrality, as evidenced by their efforts to extend their international

networks. In addition, in terms of network centrality, ICN was competing with SIN, BKK, HKG, NRT, MNL and PEK. This made it clear that South Korea's aviation market also needs to expand its network via a strategy that prioritizes the strengthening of airport connectivity and the pursuit of liberalization. In addition, LCC operations will further spur the growth of Korea's network via the variety of strategies that they employ. Consequently, this in turn will bolster the overall market competitiveness of South Korean airports.

References

- [1] Burghouwt, G., and Veldhuis, J. 2006. "The Competitive Position of Hub Airports in the Transatlantic Market." *Journal of Air Transportation* 11 (1): 107-30.
- [2] Burghouwt, G., Redondi, R. 2013. "Connectivity in Air Transport Networks: An Assessment of Models and Applications." *Journal of Transport Economics and Policy* 47 (1): 35-53.
- [3] Burghouwt, G. 2008. "Analysis of the Airport Network of India as a Complex Weighted Network." *Physica A* 387 (12): 2972-80.
- [4] Jia, T., Qin, K., and Shan, J. 2014. "An Exploratory Analysis on the Evolution of the US Airport Network." *Physica A* 413: 266-79.
- [5] Burghouwt, G., Hakfoort, J., and Eck, J. R. 2003. "The Spatial Configuration of Airline Networks in Europe." *Journal of Air Transportation Management* 9 (5): 309-23.
- [6] Boostma, P. D. 1997. "Airline Flight Schedule Development; Analysis and Design Tools for European Hinterland Hubs." A thesis of University of Twente, Utrecht.
- [7] Budde, A., Burghouwt, G., and de Wit, J. 2008. "Borrowing from Behavioral Science: A Novel Method for the Analysis of Indirect Temporal Connectivity at Airport Hubs." Paper presented at Air Transport Research Society Conference (ATRS), Athens.
- [8] Wang, J., Mo, H., and Wang, F. 2014. "Evolution of Air Transport Network of China 1930-2012." *Journal of Transport Geography* 40: 145-58.
- [9] Wang, J., Mo, H., Wang, F., and Jin, F. 2011. "Exploring the Network Structure and Nodal Centrality of China's Air Transport Network: A Complex Network Approach." *Journal of Transport Geography* 19 (4): 712-21.
- [10] Pere S. S., Augusto, V. D., and Hector, R. D. 2016. "The Role of London Airports in Providing Connectivity for the UK: Regional Dependence on Foreign Hubs." *Journal of Transport Geography* 50: 94-104.
- [11] Karmer, L., Fowler, P., Hazel, R., Ureksoy, M., and Harig, G. 2010. *ACRP Report 28: Marketing Guide Book for Small Airports*. Washington D.C.: Transportation Research Board.
- [12] Burghouwt, G., and Hakfoort, J. 2001. "The Evolution of the European Aviation Network, 1990-1998." *Journal of Air Transport Management* 7 (5): 311-8.
- [13] Jimenez, E., Claro, J., and de Sousa, P. J. 2012. "Spatial and Commercial Evolution of Aviation Networks: A Case Study in Mainland Portugal." *Journal of transport geography* 24: 383-95.
- [14] Ciftci, M. E., and Sevkli, M. 2015. "A New Hub and Spoke System Proposal: A Case Study for Turkey's Aviation Industry." *Journal of Air Transport Management* 47: 190-8.
- [15] Watts, D. J. 1999. *Small Worlds—The Dynamics of Networks between Order and Randomness*. Princeton University Press.
- [16] Watts, D. J., and Strogatz, S. H. 1999. "Collective Dynamics of 'Small-World' Networks." *Nature* 393: 440-2.
- [17] Ganesh, B. 2008. "Analysis of the Airport Network of India as a Complex Weighted Network." *Physica A* 387 (12): 2972-80.
- [18] Wasserman, S., and Faust, K. 2009. *Social Network Analysis*. Cambridge University Press.
- [19] Bagler, G. 2008. "Analysis of the Airport Network of India as a Complex Weighted Network." *Physica A* 387 (12): 2972-80.
- [20] ICCSAI. 2012. *ICCSAI FactBook 2012*. USA, p.212.
- [21] Hsu, C. J., Yen, J. R., Chang, Y. C., and Woon, H. K. 2016. "How Do the Services of Low Cost Carriers Affect Passengers' Behavioral Intentions to Revisit a Destination?." *Journal of Air Transport Management* 52: 111-6.