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Analysis of Connectivity and Mobility Changes for Mainliner Air Traffic on a Global Scale

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Abstract

When it comes to international mobility, air connections are crucial for transporting passengers over long distances in the fastest possible way. This paper provides an analysis with focus on the investigation of connectivity and mobility changes in relation to mainliner air traffic considering the 200 cities with the largest GDP per capita on global scale. Following the results of previous studies that have shown a linkage between air connectivity and GDP development, this analysis examines flight schedule data from 2000 and 2019. From these findings, non-, one- and two-stop connections originating from the airports located in the surrounding area of the 200 cities considered were analyzed. Connectivity between the 200 cities with largest GDP per capita on global scale has increased by about 20% considering non-stop and about 6% considering one-stop connections. Growth of the connections of the cities under consideration mainly affected Europe as well as North America with East Asia. Geographical location and the range of aircraft types play a role in the possibility of direct connections. European cities are well connected, and only the frequency of connections has increased noticeably between 2000 and 2019. The use of small air transport could further increase connectivity. Based on the East Asian growth figures of the past years, a trend for the future can be derived, according to which increasing demand on routes to Europe and North America will increase the need for long-haul aircraft to serve demand through direct flights.

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Keywords: Mainliner Air Transport; Connectivity; GDP per capita; Door-to-Door

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1. Introduction

With the strong increase in globalization in recent decades, a global trade network has been established that includes all regions of the world to varying degrees. A positive correlation between connectivity and productivity was identified by IATA (International Air Transport Association). It was found that a 10% increase in air connectivity, relative to a country's GDP (Gross Domestic Product), increases labor productivity by 0.07% globally and 0.09% for Europe only (IATA, 2007; IATA 2006). In addition to economic globalization from the perspective of world trade, other forms in globalization such as tourism have also risen sharply. An increasing number of people travel to other countries globally, with air transport often provides the fastest mode of connecting distant locations with each other. Despite global crises, the number of passengers has grown significantly (Gelhausen et al., 2019), and after a period of recovery from the Covid-19 pandemic, this growth will continue in the upcoming years (ACI, 2021).

In addition to the economic perspective, the focus should be on innovative air traffic and thus air traffic should be tailored to the needs and travel behavior of passengers. Different business models foster innovation and provide passengers with enhanced connectivity (ICAO, n.y.). Under this premise, this paper provides an analysis with focus on the investigation of connectivity and mobility changes in relation to mainliner air traffic on global scale, which is responsible for a significant share of total scheduled traffic.

There are various approaches to measure connectivity and assessing its impact. To determine the quality of connectivity and mobility benefits, factors such as travel time, directness, number and frequency of connections, or number of destinations can be used. For this purpose, connectivity is often issued as an index to compare it globally between countries, cities or airports. Studies by institutions such as The World Bank, IATA or Airport Council International Europe (ACI) have used different approaches to measure mainline air connectivity and aim for different impacts.

The World Bank's research focuses on analyzing the relationship between air connectivity and global trade. By tracking connectivity scores at the country level, the World Bank defines air connectivity in terms of a country's importance as a hub within the global air transportation system (The World Bank, 2011). IATA's air connectivity index aims to capture the extent to which air connectivity supports a country's economic development, with the degree and importance of air connectivity determined by the range and economic importance of destinations and the number of available global onward connections (IATA, 2020). ACI Europe focuses to which extend airports in Europe are connected within this world region and worldwide, with special focus on direct, indirect (one-stop) and hub connectivity (ACI 2019). Eurocontrol has launched a web-based interface that enables the exploration of flight connections within the European Union (EU) and between the EU and other countries (Eurocontrol, n.y.).

To put this analysis in an economic context, mainliner air traffic from the 200 largest cities by GDP per capita was analyzed on a global scale with the goal of finding out whether these cities are as well connected as their economic importance would suggest. In addition, a special focus is placed on cities located in Europe to more closely examine the development of connectivity in a region with a high density of cities and with relatively short distances to each other.

2. Data and Methodology

The focal point of the analysis is the connectivity from and between the 200 largest cities by GDP per capita worldwide in 2000 and 2019. In 2000, connections from airports in the vicinity of the 200 cities accounted for 70% of global air connections – in 2019, this share was 60% (Sabre, 2019). Thus, by examining the 200 cities with the highest GDP per capita, a large part of the global connection is covered. Connectivity in this context refers only to the existing connection between two airports. In a first approach, global connections from the 200 cities considered respectively from the airports with scheduled air traffic in the surrounding area with a radius of 150 km great circle distance from the center to all other airports on a global scale were examined. The fastest connection was always chosen. In the second approach, the global connections between the 200 largest cities by GDP per capita worldwide were investigated. The fastest connection, which could be a non-, one- or two-stop connection between two airports located in the vicinity of the considered 200 cities was selected. Based on these results, the degree of connectivity was analyzed, where a degree of 100% means that a city was connected to all other of the remaining 199 cities. In the latter part of this paper, this approach was applied to the European cities among the 200 largest cities by GDP per capita worldwide, where alternative travel modes were also analyzed.

The examinations were performed for non-stop, one-stop and two-stop connections, where the frequency of a connection was not considered. It was assessed to which extent the number of global connections from and between the cities under consideration has changed between the years of 2000 and 2019. Also it was analyzed to which extent the connectivity of the world regions has changed and what insights can be derived from this analysis for the future. Real passenger data was not taken into calculation and therefore the actual passenger demand was not investigated. All possible transfer connections within a predefined time frame were considered, without taking affiliations with the same airline or alliance into account. A minimum connecting time between two flights of 00:45 hours and a maximum time of 04:00 hours were applied. However, 45 minutes is a short period of time for transfer passengers traveling with checked baggage who, for example, are not traveling with the same airline or not within the same alliance, making it necessary to retrieve their baggage after a flight and go through the airport check-in processes again. Connections with short transfer times are aimed for passengers who do not need to run through all the processes at an airport when changing planes. Data for GDP per capita values at city level was derived from The Brookings Institution where the largest metro economies were examined by two economic indicators which are annualized growth rate of real GDP per capita and annualized growth rate of employment (Brookings, 2015). Values were compared to the European Commission's Global Human Settlement Layer (European Commission, n.y.). The flight schedule for the third week of June in 2000 and 2019 were obtained from Sabre Market Intelligence (Sabre, 2019). However, there are many different references for rankings and values of cities by GDP per capita, which makes it challenging to use the data that most reflects reality. In the following, the description of the "200 largest cities by GDP per capita" is abbreviated to "Top 200 cities".

3. Connectivity development on global level

For the analysis, airports that offer scheduled air connections and are located no more than 150 km great circle distance from the respective city center were considered. This distance was chosen to include airports in the larger surrounding area, most of which can be reached in a moderate amount of time by car - in 81% of the cases up to 2 hours driving time considering all airports and assigned city in this study. The chosen distance is well suited for world regions where the density of "Top 200 cities" considered within this 150 km radius area is small. Thus, airports in other cities that are not among the "Top 200 Cities" worldwide are also within the catchment area of the city under consideration. This leads to an increase in the number of connections due to the number of airports in the vicinity, which are reached by moderate access and egress times. In regions of the world where the density of cities among the "Top 200 cities" is high, the consideration of 150 km leads to an overlap between considered cities and airports in the surrounding area. As a result, the connectivity of a single airport can increase the connectivity of several cities in the given surrounding at the same time. Considering a smaller radius than 150 km, especially in Europe, would result in reducing overlap with other cities, which would have the effect of only considering the main airport(s) of a city being assigned and evaluated in the analysis. Especially in Europe, the transport infrastructure between cities is well developed, and a distance of 150 km can be covered in a reasonable time, allowing passengers to benefit from the connections of several airports. If an airport is located in the surrounding area of several cities, the connections of this airport are included in the connectivity assessment of these cities to which the airport is assigned in each case. The flight connections originating from the "Top 200 cities" worldwide were analyzed for the years 2000 and 2019. Within these years, the GDP per capita of the cities considered has changed, which has an impact on the selection of the "Top 200 cities". Table 1 shows the number of cities and the number of airports located in the vicinity of the designated cities.184 cities remained in the analysis with 16 new cities joining the "Top 200 cities" and replacing others due to the increase in economic output per capita. The newly added cities are mainly located in China and mostly replaced cities in Europe especially in the United Kingdom.

From a global perspective, cities with the highest GDP per capita are primarily located in three regions of the world. These regions are North America (USA, Canada), Europe and, at a distance, North-East Asia (China, Japan, Taiwan and South Korea). The number of connections is shown in Table 2. The connection for an airport pair can be maximum two, once for the outbound flight and once for the return flight. The fastest connection in each direction was always considered. The world regions South America, Central America and Caribbean and South West Asia are not listed separately in Table 2, as they are not of significant relevance when considering the "Top 200 cities", but are still included in the analysis.

In 2000, connections from airports in the vicinity of the 200 cities accounted for 70% of global air connections – in 2019, this share was 60% (Sabre, 2019), which shows that within this period, connections from airports not located in the defined surrounding of the 200 cities under consideration, have grown more strongly. Furthermore, Table 2 shows how the number of corresponding connections has changed between the years 2000 and 2019, with classification by world region. Growth can be seen in all of the listed world regions. At this point, it must be stated that the increase in one-stop and two-stop connections depends to a large extent on the growth of direct connections between the years 2000 and 2019. The growth of direct connections is often associated with the increasing number of low-cost carriers offering point-to-point connections. International relationships also benefit from direct intercontinental flights, which are an important component for the economic growth of regions and for better connectivity with the target destination (BER, 2021). The global development of direct connection was growing by 73% between 2000 and 2019, considering all direct connection worldwide without focusing on the "Top 200 cities". Thus, it can be determined that in comparison to the global growth, only the growth emanating from the considered cities among the "Top 200 cities" in Europe and East Asia could keep up with the global figures, whereas the growth of the considered cities in East Asia was three times higher than the one of direct flights in global comparison.

Table 1. Number of cities and airports of the "Top 200 cities"

World Region	**Number of Cities**[1]		**Number of Airports**[2]	
	2000	2019	2000	2019
North America	88	88	290	254
Europe	72	65	223	193
East Asia	23	35	70	97
Pacific and South East Asia	8	7	24	22
Middle East	6	4	22	11
South America	2	0	4	0
Central America and Caribbean	1	0	2	0
South West Asia	0	1	0	2

Table 2. Development of air connections originating from the "Top 200 cities"

Origin World Region	**Non-Stop**			**One-Stop**[3]			**Two-Stops**[3]		
	2000	2019	Δ	2000	2019	Δ	2000	2019	Δ
Global development[3]	29,480	51,092	+73%	*Values were not determined*					
North America[4]	5,636	7,191	+28%	69,248	80,057	+16%	197,506	248,996	+26%
Europe[4]	5,928	10,719	+81%	54,754	68,064	+24%	142,360	201,881	+42%
East Asia[4]	1,025	3,191	+211%	8,403	22,826	+172%	25,580	93,724	+266%
Pacific and South East Asia[4]	505	642	+27%	3,591	5,570	+55%	10,144	19,056	+88%
Middle East[4]	501	645	+29%	3,877	5,320	+37%	8,128	10,921	+34%

[1] Number of the "Top 200 cities".
[2] Number of airports localized within 150 km great circle distance from the center of the designated city.
[3] Including all non-stop connections worldwide, without focusing on the "Top 200 cities". Connection on a city pair is counted twice, once for the outbound flight and once for the return flight if the connections exist.
[4] Originating from the "Top 200 cities" and connecting all other airports worldwide.

The growing mobility behavior can be assigned to several reasons. For example, demand increases with growing incomes but also the with expansion of infrastructure and new business models in air transport. Another particularly important point is the decline of air travel costs in recent years. This was partly due to efficiency improvements and the introduction of new technologies. The savings have been passed on to the customer, which has a positive impact on costs (IATA, 2020). Although the number of airports near the cities under consideration in North America and Europe declined, an overall increase in the number of connections was observed, especially for non-stop connections. In Europe, the growth in non-stop connections stands out. This was partly due to the expansion of low-cost carrier services, which serve cities via point-to-point connections.

The East Asian market is characterized by high growth figures. Compared to all other world regions, the number of cities among the "Top 200 cities" increased, as did the number of airports (see Table 1). This growth is also reflected in the number of flights, which increased significantly faster than in other regions of the world. Growth in Asia is largely attributable to the development in China, which is shown in Table 3. Flights within North America have mainly developed in favor of direct flights. While two-stop connections declined, direct connections increased at almost the same rate. The moderate growth figures for connections within North America compared to other regions of the world suggest that the market is well served. Connections with destinations outside North America grew more strongly. It should be noted that direct connections also grew the most. On the European market, growth has also developed in favor of direct connections. Between the years 2000 and 2019, non-stop connections have increased by 86% and have thus made a significant contribution to improving connectivity in terms of accessibility and travel time savings within Europe. Grimme et al. (2019) found that in 2018, about 93% of intra-European travelers were flying non-stop to reach their destination, as passengers are more likely to choose a direct flight instead of a transfer connection (e.g. Hagmann et al., 2015). Destinations outside Europe were growing at a similar rate, and here as well, the market has developed in favor of direct connections.

Table 3. Development of air connections within and beyond the world regions originating from the "Top 200 cities"

Origin World Region	**Stops**	**Development of connections within the world region[5]**	**Development of connections beyond the world region[5]**
		2000 – 2019	2000 – 2019
North America	Non-Stop	+18%	+97%
	One-Stop	+3%	+44%
	Two-Stop	(-22%)	+53%
Europe	Non-Stop	+84%	+74%
	One-Stop	+20%	+30%
	Two-Stop	+19%	+51%
East Asia (China, Japan, Korea, Taiwan)	Non-Stop	+210%	+214%
	One-Stop	+161%	+176%
	Two-Stop	+196%	+270%
China alone	Non-Stop	+632%	+440%
	One-Stop	+936%	+418%
	Two-Stop	+752%	+681%
Pacific and South East Asia	Non-Stop	+15%	+70%
	One-Stop	+26%	+83%
	Two-Stop	+54%	+96%
Middle East	Non-Stop	(-36%)	+65%
	One-Stop	(-14%)	+42%
	Two-Stop	+23%	+35%

[5] Originating from the "Top 200 cities" and connecting to all other airports within or beyond the world region.

Of all the world's regions, the strongest growth has been recorded in East Asia and in China in particular. Connections to destinations outside China have grown particularly strongly. Originating in Pacific and South East Asia, connections beyond this region increased stronger than within this world region. In the Middle East, the number of domestic connections has declined, which is certainly related to the fact that the number of cities considered has decreased between the years 2000 and 2019, and the number of airports considered has halved. With the increasing importance of hub airports such as in Dubai, Doha and Abu Dhabi (e.g. Maertens et al., 2020), growth is shifting to destinations outside the Middle East. Overall, cities with the highest number of direct connections were London (136) followed by Chicago (133) in 2000 and New York (150) followed by London (141) in 2019.

3.1. Connectivity between the "Top 200 cities"

From 2000 to 2019, connectivity between the "Top 200 cities" has improved. The average number of city pairs by a non-stop connection has increased by about 20% from 62 to 74. In terms of connectivity through a maximum one-stop connection, which includes direct connections, the numbers have improved by about 6% from 162 connected cities in 2000 to 172 in 2019. In general, cities in North America and Europe connected a higher number of cities among the "Top 200 cities" via a direct flight than other world regions. In this consideration this is due to the fact that the number of North American and European cities among the "Top-200 cities" is more frequent (see Table 1). Distances between the cities, which are located within the same world region can be covered by short- and medium-haul flights and therefore appropriate demand can be served by smaller aircraft with appropriate range compared to long-haul flights. Gelhausen, M. et al. (2019) forecast that the average number of passengers per flight in 2030 will be 144 on intra-Europe flights and 112 on intra-North America flights. Connections between Europe and Asia and North America and Asia are served by aircraft carrying 246 and 289 passengers, respectively. Economic relations and geographical location can be decisive factors for demand and thus for the connections offered. City pairs for which there is sufficient demand and the connection is economically viable are most likely to be connected by direct flights. Often, an airport is assigned to more than one city listed in the "Top 200 cities" dataset, since it also happens that there are many cities with high GDP per capita within a given region. Thus, these cities can benefit from being located near many or particularly large airports. Examples include New York and Philadelphia, regions in Central Europe, and especially the region in the south of China, which includes the cities of Guangzhou, Hong Kong, Macau, and Shenzhen and a total population of over 50 million people.

The development of direct connections between the years 2000 and 2019 specifically for the world regions North America, Europe and East Asia is shown in Table 4, which displays the number of connections originating from the "Top 200 cities" to all possible destinations in the respective world regions. Growth figures of the "Top 200 cities" for non-stop connections from North America and Europe to East Asia have developed most strongly in percentage terms, without considering the development of East Asia's domestic connections.

Table 4. Non-stop connections originating from the "Top 200 cities" in 2000 and 2019

Non-stop connectivity[6]	**North America**			**Europe**			**East Asia**		
	2000	2019	Δ	2000	2019	Δ	2000	2019	Δ
North America	4,883	5,778	+18%	241	441	+83%	65	133	+105%
Europe	216	397	+84%	4,822	8,874	+84%	62	196	+216%
East Asia	62	103	+66%	51	151	+196%	665	2,061	+210%

Technological progress and new aircraft with a long range improve the connectivity of very distant cities. For example, in 2000, the connection between Hong Kong and New York was served only by a stopover at Tokyo-Narita

[6] Originating from the "Top 200 cities".

Airport with a Boeing 747-400, while in 2019, these two cities were connected by a direct flight with a Boeing 777-300ER which has a greater range than the 747-400 (Boeing, 2010). Technological advances and the development of aircraft types with increasing ranges have enabled connections that previously required a stopover to now be linked by direct flights with aircraft such as the Boeing 777-300ER, 787-9 or Airbus A350. Overall, it can be seen that connectivity between the "Top 200 cities" has improved considerably between the years 2000 and 2019. Figure 1 depicts the connectivity that results from direct connections. A general shift towards higher levels of connectivity can be identified. While in 2000, 13 cities were connected by 60%-70% to each of the other 199 cities via a direct flight - without connecting themselves - this number increased to 15 in 2019. In addition, 11 cities reached a level of 70-80% in 2019. However, the most non-stop connections for this consideration were still within and between North America and Europe. On the one hand, domestic short-haul routes within North America and Europe dominate, while on the other hand, moderate long-haul routes connect Europe and North America. However, between 2000 and 2019, East Asian cities in particular have increased among the "Top 200 Cities," resulting in a significant growth in non-stop connections.

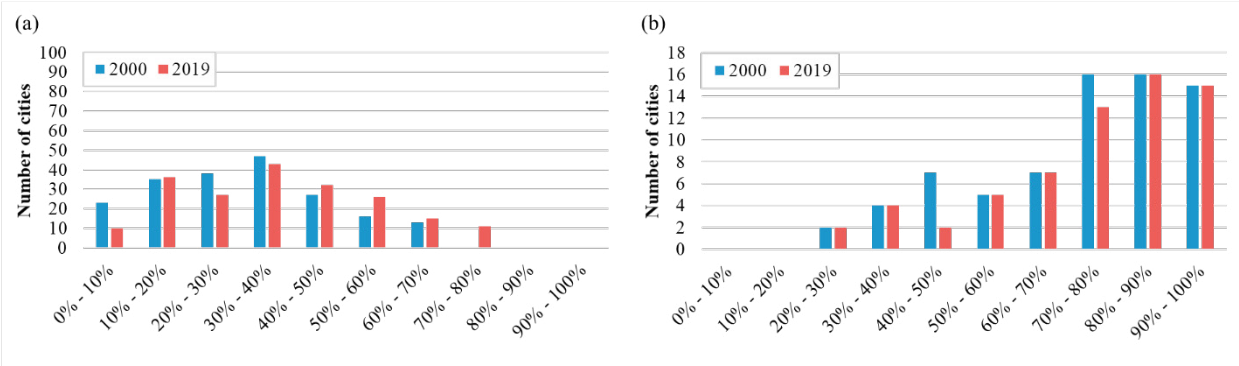

Fig. 1. (a) Degree of non-stop connectivity between the "Top 200 cities"; (b) Degree of one-stop connectivity between the "Top 200 cities".

As expected, one-stop connectivity also increased between 2000 and 2019, as shown in Figure 1. Although the development is not quite as clear as for non-stop connections, the trend towards a high degree of connectivity can also be identified. Among the cities where one-stop connectivity has increased the most are cities in remote countries such as Australia. A major contributor to this has been the development of hub airports, particularly in the Middle East. The example of Adelaide in Australia illustrates how the connectivity of a remote region has developed between the years 2000 and 2019. Whereas in 2000 Adelaide was only connected to 8 cities in Europe via Kuala Lumpur and Singapore, the connection to Europe via hubs in the Middle East like Doha or Dubai connected Adelaide with 41 cities in Europe in 2019.

With a two-stop connection, all of the "Top 200 cities" could be connected with each other in 2000 as well as in 2019. In this case, the level of connectivity is 100%.

3.2. Connectivity among cities with highest GDP per capita in Europe in 2000 and 2019

With 72 cities (2000) and 65 cities (2019) considered in this paper, a large proportion of the world's 200 largest cities by GDP per capita are located in Europe. This allows for a separate consideration of connectivity between these cities in Europe. Furthermore, all possible variants of non-, one- and two-stop connections are examined and the shortest connection in time is chosen for further analysis. Due to the fact that a different number of cities is considered for both years, the direct comparability is not fully given.

However, Figure 2 shows that the level of connectivity has generally not changed between the 72 cities (2000) and the 65 cities (2019). Cities with particularly high non-stop connectivity to the largest cities by GDP per capita in Europe are mainly those with large hub airports in the immediate vicinity, such as London, Paris or Frankfurt. However, cities with the highest values are Eindhoven in The Netherlands and Karlsruhe in Germany, in 2000 and

2019 respectively. The city of Eindhoven benefits from the fact that there are six airports within the chosen radius of 150 km, including the major hub airport Amsterdam-Schiphol. In the surrounding area of Karlsruhe there are five airports including Frankfurt Airport, the largest airport in Germany. In addition, smaller as well as regional airports are located within the selected vicinity, resulting in a diverse range of non-stop flights and destinations.

It is striking that in addition to a large proportion of cities with a degree of non-stop connectivity of at least 70%, there are also a few cities in the scope of analysis where non-stop connectivity is comparatively low. These include cities such as Nantes in France or Glasgow in Scotland, which are geographically located on the periphery of Europe and are mostly connected to the other considered cities via a transfer at one of the major hub airports such as Paris Charles de Gaulle or London Heathrow. In the years 2000 and 2019, however, it can be noted that when considering non- and one-stop connections, all cities considered are connected with each other. Overall, the degree of connectivity defined as existing connection between two cities considering the top cities in Europe by GDP per capita has not changed significantly between 2000 and 2019, as it is shown in Figure 2. However, the overall number of flights and thus also the frequency increased significantly (see Table 4).

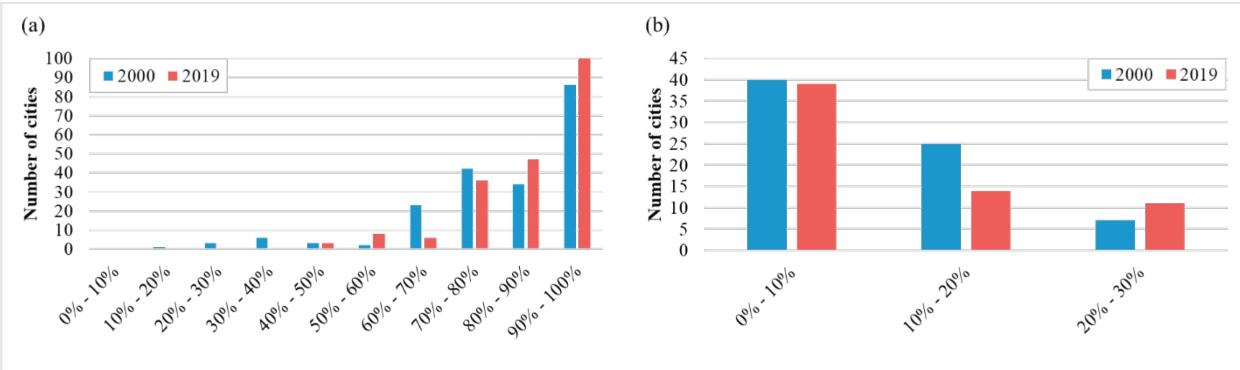

Fig. 2. (a) Degree of non-stop connectivity between European cities within the “Top 200 cities”; (b) Proportion of cities for which a door-to-door connection by car is faster than by aircraft.

Especially in the center of Europe the cities considered are located relatively close to each other. For this reason, in comparison to the previous analysis at the world level, the travel time by aircraft was compared with an alternative car connection. A door-to-door connection was simulated using arrival and departure times between the city center and the airport (in the vicinity of 150km great circle), as well as process and waiting times at the airport. Travel times by car were determined using the HERE API (HERE, 2021). Process and waiting times before departure were assumed to be 60 minutes and 45 minutes after arrival. From these findings, a percentage is calculated that indicates on how many occasions travel time by car is the fastest alternative compared to the shortest flight connection for the same city pair. In each case, the shortest door-to-door connection from between city centers is included in the analysis. Figure 2 shows that in 2000, for 7 out of 72 cities it was faster to connect to all other cities considered by car than by air (including non-, one-, two-stops) in 20-30% of the cases. In 2019, this was the case for 11 of the 65 cities considered.

The fact that for some cities in 20-30% of the cases a direct car connection is more worthwhile in terms of travel time than an air connection is mainly due to two reasons. On the one hand, as mentioned above and with the example of the city Eindhoven in The Netherlands, the central location and thus the shorter distances to the cities under consideration lead to the fact that in these cases the connection by car in some cases is the faster mode of travel than by aircraft. On the other hand, a relatively central geographic location, but lower density of the cities under consideration and few direct air connections also ensure that the share of connections by car is comparatively high. Due to the fact that the respective airports with a large number of destinations are located further away, this also means that those have to be connected either by car resulting in longer travel times or via a flight, which in the end leads to a time-consuming one-stop connection to reach the final destination. This is illustrated by the example of the city of Braunschweig in Germany, where there is also a comparatively moderate number of direct connections from airports in the surrounding area but without the location of a hub airport. In this case, a door-to-door connection by car offers a shorter travel time in about a quarter of the cases compared to the fastest non-stop and one-stop flight connections considered in 2000 as well as in 2019.

4. Conclusion

In this paper, connectivity was analyzed for the 200 cities with the highest GDP per capita in the world between the years 2000 and 2019. Connectivity was defined as the number of existing city connections originating from airports surrounding the 200 cities, where only the fastest of possible non-, one- or two-stop connections was used in the analysis. The aim was to derive from this analysis which trends can be expected in the future on the basis of developments in recent decades. Among the 200 cities considered in both years, the majority were cities from North America and Europe, followed by cities in East Asia. In the development between the years, it can be seen that the share of East Asian cities has increased strongly. The analysis found that, overall, the number of direct connections increased by 73% globally between the years 2000 and 2019. Only the European and Asian cities included in the study were able to surpass this growth, with the Asian cities included in the study surpassing this growth particularly strongly.

Considering only the connectivity between the “Top 200 cities”, the average number of non-stop connections between the cities considered has increased by about 20% from 62 in 2000 to 74 in 2019. In terms of connectivity through a maximum one-stop connection, which includes direct connections, the numbers have improved by about 6% from 162 connected cities in 2000 to 172 in 2019. Geographical location and range of aircraft types play their part in the possibility of direct connections. It was found that for cities with a geographical remoteness, the importance of large hub airports as well as the range of aircraft contribute a crucial amount to connectivity. Whereas for Europe with a high density of the “Top 200 cities”, the frequency has increased between 2000 and 2019, but not the accessibility of the economically strongest cities to each other.

Looking at growth between specific world regions, namely the three world regions most represented by the “Top 200 cities” which are North America, Europe and East Asia, growth to and from East Asia has increased significantly.

The increase in GDP per capita in East Asian cities and also the increase in global terms will continue the trends shown and are expected to intensify in the future. Therefore, the routes between East Asia and Europe and East Asia and North America have a high potential to be offered more frequently in the future and at the same time to be expanded by the connection of new city pairs to the airlines' services. Both of these factors mean that airlines operating in this segment will have to adapt their long-haul fleets accordingly resulting in an increasing number of efficient long-haul aircraft to offer direct connections on routes with sufficient demand. As strong growth continues on East Asian domestic routes, rising demand for efficient medium-haul aircraft will emerge in this world region.

In Europe, where mainliner connectivity is at a high level, overall connectivity can be improved by using small air transport and connect cities with lower demand and on the short-haul for example smaller and remote cities which are currently less well connected. Due to the large number of airports and moderate access and egress times especially in the center of Europe, the use of small air transport is suitable from less congested airports in the surrounding areas of the cities under consideration.

Limitations of this approach are that there are many different references for rankings and values of cities by GDP per capita. Therefore, using a different dataset that includes other cities than the once considered in this analysis will produce different results. Also, choosing a smaller or larger radius to identify the airports in the surrounding of a city will produce a different number of airports and therefore different results.

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