The Transformation of Airports into Hubs and the Lessons for Fortaleza Airport

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ABSTRACT

Civil aviation is experiencing consistent long-term growth, encouraging the formation of airport conglomerates offering multiple connections (hubs). These hubs have the power to promote development, but also to synchronously influence the structure of the cities that host them. However, there is little research on the long-term evolution of these hubs related to socioeconomic development and to city-airfield interaction. This study aims to identify the characteristics of the respective cities that most impact the transformation of airports into connection centers or international hubs, and to describe the initiatives and conditions that can generate sustainability in the city-airport relationship. A comparative, nonsequential multicase study is used, and a scenario for the evolution of world air transport is built from secondary sources. The results show that cities that have included the aeronautics value chain in their planning evolve faster and bring more benefits to the consolidation and growth of their aeronautical structures, as well as to the development of the cities themselves. The integration of urban planning to the planning of the local aeronautical chain could help airports such as the Fortaleza Airport, in Ceará, Brazil to sustainably evolve into an international hub.

Keywords: Aerial connections; Regional development; Urban planning; Airport planning; Aeronautical value chain.

INTRODUCTION

The advances of aeronautics during the 20th century have become determinant to understand the economic development of this period in which millions of people make daily use of the air transport service. This modal acts as a productive capital for thousands of companies which are responsible to the deployment of executives, technicians, mail and cargo, playing a fundamental role in social and cultural maintenance within a country (Oliveira 2007). In this context, aviation has become a truly global industry with airline conglomerates serving a global network of large hub airports (Passchier *et al.* 2000).

In countries of continental dimensions, with regional development imperatives, airport structures, which aerodrome and air traffic are complex in nature, have added other functions, especially commercial, followed by increased passenger capacity. Therefore, those airports require an even more elaborate planning for their insertion in the urban conjuncture (Ashford *et al.* 2015).

Expanding the planning limits beyond the borders of the countries gradually reinforced the idea of the structural need for articulated connections at certain airports to serve the evolving air network. This concept "of pole, or hub, converges on the

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airport, previously selected and programmed, numerous flights, where, after the reception and transfer, passengers, luggage and cargo depart again in aircrafts for specific destinations" (Silva 1991, p. 36, our translation).

Contemporaneity brings a peculiar economic context where global connectivity—either logically or virtually or physically—simultaneously promotes the basis for economic competition, social reform, regional development and social integration (Palhares 2002).

Despite the conceptual, economic and sociological conception, there are not many studies that associate development in cities—most of them focused on the country level—provoked or stimulated by airline connections, denoting that the urban planning of cities and even the planning of regions need to observe the air modal beyond the ground-to-air connector.

Research and Objective Problem

In this context, the questions involved here are: is the city-aerodrome relationship a parameter for contemporary urban planning? Considering the history of deploying hubs at high-traffic airports, are there lessons learned that allow you to optimize and expedite the return of these structures in the connectors deployed in the current century? Is there a need to improve regulatory decisions and incentives to optimize the city-airport relationship?

The general objective, by means of a multicase study of airports that have become connection centers or hubs with international influence, was to identify the characteristics of the respective cities that most impact the transformation of airports into connection centers or international hubs, and to describe the initiatives and conditions that could generate sustainability to the city-airport relationship. The specific objectives were: i) to verify the context and changes in the international air transport industry that influence the transformation of airports into hubs; ii) to extract lessons to guide the growth of the Fortaleza Airport, in Ceará, Brazil; and iii) to analyze the conditions under which urban planning influences the strengthening of these airports and the adequate development of the cities or regions that are housing, mitigating any negative impacts throughout their development, in the face of a scenario of changes in world air transport.

Theoretical Basis

Since the comprehension of global cities as the locations from where the world economy is administered and controlled (Sassen 2001), a well-connected geographic ecosystem became imperative to form a network economy through which people, services, products, money and knowledge flow—flow being what gives meaning to the geographical location (Allen 1999). Taylor (2000) already described that international airlines flights and electronic communication connections were necessary to support the formation of the network of global cities.

Along those lines, Witlox *et al.* (2004) mention that this network economy does not imply in the loss of identity by the cities, but in their transformation in spaces of flows of information, transactions, people, goods and services. Thus, the network economy promotes the cities form a static condition, a place, to a dynamic one, a space of flows.

Contributing to the network economy more importantly in the second half of the 20th century, the air transport industry has presented itself as innovative, with a strong influence on economic and social progress, but with the imposition of its environmental and urban impacts (ATAG 2008). Branco (2013) was accurate when comparing airport models, considering their roles, dimensions and implications to the immediate urban context and to regional development, but she did not consider city-aerodrome interactions over time.

Morphet and Bottini (2014) also highlight that airports provide the connectivity and access needed for a modern economy, allowing to explore opportunity globally in the commercial sphere and generating facilities for the flow of tourism, whether business, events, entertainment. The air infrastructure acts as a facilitator of growth by exploiting the powers of a given region. In addition, the improvement of transportation infrastructure, combined with the development of a regional or global airport network, results in cost optimization for the transportation of people and goods.

Mokhele (2017), in turn, notes that a planning based on airport-centric growth models tend to be consensus as the key to the development of cities, despite recognizing that there is a lack of literature analyzing the evolution of development in airports and their surroundings, and that such literature is essential to a better understanding of the driving forces of development in cities from their airports.

Hub airports, such as city airports, require urban planning and business planning so that development is economically efficient, enjoyable, and sustainable (Negri *et al.* 2017). In addition, Vasconcelos (2007, p. 54, our translation) reinforces the "fact that an airport be able to become a hub, for example, can make all the difference to the economy of a region". Campos *et al.* (2010) also conclude that hub airports are essential for production and distribution, which enables them to play a key role in promoting the development of cities, attracting companies and originating businesses in their vicinity.

Air connectivity is the key to unlocking the economic growth potential of a region, involving factors such as attracting business investments and qualified human capital. Another relevant factor is the stimulus to tourism, which has become a powerful source of development and prosperity for many places in the world, especially with the presence of airports in these locations. Understanding how air connectivity is measured, its impacts on the urban context, how it relates to economic growth measures, what drives it, are determinants that allow stakeholders (cities, airports and airlines) to build urban and investment plans that assist in strategic decisions to create the necessary conditions to unlock the connectivity potential of a city, state or country (Morphet and Bottini 2014).

METHODOLOGY

This research proposes a comparative, non-sequential multi-case study, characterized by descriptive bibliographic research as defined by Yin (2015, p. 4, our translation), where technically the applicability and plausibility to the selected methodology are in its versatility: "Case studies are found even in economics, in investigations about the structure of a particular industrial sector or the economy of a city or region" and "allows researchers to focus and retain a holistic and real-world perspective."

Considering the focus of descriptive comparison on the construction of elements that have repercussions for an optimal implementation of the hub at Fortaleza Airport (previously denominated Pinto Martins International Airport), in Fortaleza, state of Ceará, Brazil, the research was limited to cities in the world that had global characteristics and that were positively impacted by their airports to consolidate them in this ranking of cities in the world.

The cities selected for this comparison, defined as global cities, were extracted from the classification of the Globalization and World Cities (GaWC 2010) research network, which defines the world as a myriad of city-centered flows, in contrast to the world of state-centered borders most perceived.

Global cities are evaluated in terms of their advanced production services using the interconnected network model and are divided into three main groups: (i) Alpha cities, clearly more integrated than all other cities and constitute their own high level of global integration; (ii) Beta cities, major world cities to connect their region or state to the world economy; (iii) Gamma cities, world cities linking smaller regions or states to the world economy, or major world cities whose greatest global capacity is not in advanced production services (GaWC 2010).

For the selection of cases and characterization of the data collection protocol, the list of 88 global cities was based by GaWC in 2008—the year in which the classification methodology was consolidated and started to be biennial—classified as beta or gamma, and gradually the following delimiting clippings were imposed: to be among the first 100 in the Mercer quality of life index (Quality… 2019); to have a strong connection with the maritime modal; to have in the services sector, such as tourism, a relevant economic activity; cities with airports in operation for at least 50 years and which have been characterized as an international hub, with annual movement between 10 and 15 million passengers based in 2016 (except for this variable the cities that house the oldest airport and the newest of the selection, ignoring the volume of annual passengers in order to scrutinize into a parallel between these extremes).

RESULTS

Cape Town, South Africa: Cape Town International Airport

Cape Town is the capital of the Western Cape Province, and is also the legislative capital of South Africa, which has two other administrative capitals, with its executive capital in Pretoria, and Bloemfontein as judicial capital. Its attractions that mix uniquely exotic spots, wild species, and much natural life, in addition to other surprising tourist attractions, such as Mesa Mountain, Mesa

Bay and its naturally produced port, highlight it as an important world tourist region (Braga and Ribeiro 2021). The city was ranked 95th for its quality of life in a specific survey involving 231 cities (Quality… 2019).

Cape Town is the economic center of the Western Cape Province, the second main economic center of South Africa and the third main economic center of Africa. The city commonly contributes with 75% of the annual gross domestic product (GDP) of the Western Cape Province, which is equivalent to approximately 11% of South Africa's GDP, which is very significant for the country's economy (Cape Town's economy... 2001).

It is estimated that the air transport industry supported a gross value-added (GVA) contribution of US$ 7.4 billion to GDP in South Africa in 2014. Spending by foreign tourists supported a GVA contribution of US$ 5.1 billion to the country's GDP. This means that 3.5% of the country's GDP is underpinned by the air transport sector and foreign tourists arriving by plane. At least 25% of this economic repercussion is attributed to Cape Town Airport if the passenger volume for which it is responsible is considered.

Mokhele (2017), in a chronological study addressing the evolution of airports in Johannesburg and Cape Town, highlighted how the lack of planning focused on the potential of the air system caused an intense development delay due to the low use of the opportunities inherent in the airport-city system.

In the case of Cape Town, it has been almost four decades since its inauguration for urban planning to absorb the opportunities available there, breaking with the restrictive logic that airports should be disconnected from the city because of space requirements for air movement and issues such as the effect of noise pollution.

Panama City, Panama: Tocumen International Airport

Panama City is the capital, the most populous city, and the main financial, corporate, cultural and economic center of Panama. Situated right in the city center of the isthmus on the Pacific side, it is a city of the old and the new. The capital is famous for the Panama Canal, an artificial waterway that stretches for 77 km. It is an artificial junction between the Atlantic and the Pacific Oceans, and acts as a channel for maritime trade (Sigler 2011). The city was ranked 97th position in the 2019 Mercer quality of life survey (Quality… 2019).

The dynamics of Panama's economy is centered on service activities. It is estimated that 55% of the country's GDP originates in this municipality, and with an important emphasis on the activities of trade, communication, finance and transport, which together account for more than 75% of the wealth produced (Alcaldía de Panama 2012).

According to studies by the Oxford Business Group (2014), the country's growing status as an aviation hub stems mainly from the growth of its main international airport in Panama City. In fact, Panama's localization makes it an ideal candidate as an Inter-American center for its excellent weather conditions, a sea-level airport, and its relatively equidistant proximity to South and North America.

Jaimurzina and Sánchez (2017) define as preponderant to establish effective regional leadership and a mechanism of dialogue between actors involved in air mobility and logistics, both public and private. These measures will provide the institutional overview and tools necessary to achieve sustainable regional development objectives, always bearing in mind that the horizons of planning and implementation of some of these actions, in particular those that good governance is not only management of infrastructure expansion, mainly involves stimulating proactive actions to support the sustainable growth of the air sector and maximize the social benefits that resonate in the lives of citizens.

Hamburg, Germany: Helmut Schmidt International Airport

The city of Hamburg is in northern Germany and borders Schleswig-Holstein and Lower Saxony. With 1.8 million inhabitants in 2019, Hamburg is Germany's second largest city with a strong economy, with highly developed clusters in various economic sectors. Hamburg is the third largest port in Europe, after Rotterdam and Antwerp (McIntosh and Thomsen 2022). The city enjoys a remarkably high quality of life, being ranked 19th position in the 2019 Mercer quality of life survey.

The region faces major political challenges to improve the dynamics of the economy and increase productivity growth (OECD 2019). One of these main challenges is integrated planning involving policymakers, in close cooperation and consultation with representatives of the regional economy, its various sectors and their interactions and integrations.

One example treated as successful is the Hamburg aviation cluster, which is one of the world's most important centers for the civil aviation industry. Hamburg's aviation cluster brings together more than 40,000 highly qualified specialists, 300 small and medium-sized enterprises, major international players in the aviation industry and institutions in the metropolitan region (Economic Clusters… 2018).

The international airport serving Hamburg, Hamburg Airport Helmut Schmidt, was established in 1911, making it the oldest commercial airport in the world still in operation, located about 8 km from the city center, connecting with the Americas, Africa, and Asia.

Noting the relevance of the theme of the development of the city and regional imbricated to the aviation production chain in Hamburg is that Johann (2020) undertook a study focused on its potential of urban development linked to the ground-to-air transition between the city and the airport. The thesis points out that, with the growth of the city, the airport is under pressure to adapt, culminating in important challenges to the various actors involved—district administrations, the airport company, the municipality of Norderstedt and commercial and business representatives of the area of influence of the airport and its production chain.

In summary, the *FlugHafenCity* (Johann 2020) highlights how the integrated and long-term planning can result in economic development, a perspective of sustainability and quality of life for citizens. The study explains the main economic, planning and airport-specific technical terms based on the history of German airports.

Dubai, United Arab Emirates: Dubai International Airport

The city of Dubai, the most populous city in the United Arab Emirates (UAE) and the capital of the Emirate of Dubai, was founded in the 18th century, being a small fishing village, in the middle of a desert region of the Middle East with few attractions. Before the discovery of oil in 1966, Dubai was basically a common port in the Persian Gulf region (Davidson 2022).

The nature of being a transition point of these trade routes provided the vision that may have been a lever for the rapid development of the city. The city also stands out for the level of quality of life offered occupying the 74th position in the Mercer quality of life survey ranking.

Dubai is one of seven autonomous and independent emirates that since 1971 have teamed up to form a nation structure with a clear focus on development. Oil was important to support these economic and social growth plans, but the insight that drove the emirate's vision of the future was to give central attention to the development of infrastructure in the form of transportation, construction and power generation (Jha and Tandon 2019).

Hilal (2020) describes another segment that has a high potential to promote the region—tourism. One of the main characteristics of tourism is its resilience and an inherent contradiction in relation to oil prices, since tourism, by its nature, reacts negatively to the increase in oil prices, as this impacts on the cost of travel, the reverse being true as well, providing excellent tourist exploration when oil is low. Dubai has taken the lead position in the implementation of tourism as an alternative economic diversification sector, resulting factor imbricated with investments in the aviation production chain.

To Khan *et al.* (2017), the advent of innovative technologies has brought about the emergence of smart cities, and points to Dubai as an example, with the aim of providing its stakeholders with technology-based solutions that are effective. To the extent that the goal of smart cities is to improve the results of those who are connected whether people, systems and business processes, governments and other public sectors and private entities, the focus is on improving the quality of life of all residents.

The fact is that in the first 10 years of history, it was clear that Dubai Airport would play a key role in transforming the desert city of an Arab Emirate into one of the world's leading global *knots*, connecting today in 4 h of flight radius to the eastern parts of Europe and Africa, as well as India's highly populated market. A variety of destinations are within the scope of a 12-h flight from Dubai, including China, Southeast Asia, Australia and across much of the African continent (Morphet and Bottini 2014).

Dubai Airports (2015) highlights a 2011 study conducted by Oxford Economics that showed that aviation supports 250,000 jobs, 19% of Dubai jobs and US$ 22 billion or 28% of Dubai's GDP. By 2020 one predicted that this would increase to 32% of Dubai's GDP (US$ 45.4 billion), 22% of jobs or 372,900 jobs, was it not for the impact of the pandemic.

Alkhodary and Shehada (2017) estimated that the overall economic impact of aviation and tourism-related activities would increase to US$ 53.1 billion by 2020 or 37.5% of Dubai's GDP and will support 754,500 Dubai-based jobs. The authors record the prediction that by 2030 these numbers will grow further and can reach US$ 88 billion or 44.7% of GDP.

Urban planning, to stimulate positive factors and creativity, to circumvent limiting factors, has transformed the city of Dubai. This transformation is so imbricated with the logic of air connectivity that Dubai Airports' strategic planning for 2050 is properly aligned with city planning.

In summary, Dubai has managed to bring together the most relevant elements, having achieved in record time an expressive worldwide highlight as a global city: focus on development; modern infrastructure and connectivity; engagement of citizens and stakeholders; and, enhanced regulatory framework associated with committed and state-planned initiatives.

Development of cities through aviation and implications for Fortaleza Airport

The city of Fortaleza is the capital of the state of Ceará, in the Northeastern region of Brazil. It is the fifth city in the country by population and is in 55th position in the ranking of the Municipal Management Challenges Index, which brings together comparatively the Brazilian cities that account for 48% of the country's GDP (DGM 2021).

The main economic source of the municipality is centered on the tertiary sector (68% of wealth generation). According to a survey by the Brazilian Institute of Geography and Statistics (IBGE 2019), Fortaleza is the municipality of the Brazilian Northeast with the highest GDP, surpassing Salvador, Bahia. The capital of Ceará occupies the 9th position in the ranking of the largest economies in Brazil, as per 2018 data.

Fortaleza had, in 2016, more than 25% of its GDP from tourism with privileged geographical location, with 34 km of coastline, being the closest Brazilian capital to Europe, located 5,608 km distant from Lisbon, making it globally attractive as a connecting point with the world (Prefeitura de Fortaleza 2018).

Connectivity has been a watchword in the last decade of Ceará and its capital, Fortaleza. Enterprises in the air, maritime and data sectors should transform the profile of the economy of Ceará, generating more wealth for the state and opening employment possibilities for the population, highlighting in this study the hub of air companies Air France-KLM-Gol, focusing on connecting Fortaleza with North and Central America, Europe and Africa (Secretário Cesar... 2018).

These combined elements have gradually transformed Fortaleza into one of the main cities in Brazil, with consistent possibilities of appearing as a global city, a common characteristic among the four cities that were described in this study (GaWC 2010), added to an important beacon: international connectivity, which has worked, for all, in a catalytic way in regional development.

These factors led Fortaleza to feature prominently in a study by Oxford Economics (2015) regarding the implementation of a hub in one of three cities in the Northeast Brazil (Fortaleza, Natal or Recife). The study pointed out that, in the second year of operation of the multiconnection structure, the total impact on the economy in terms of contribution of added value to GDP would be US$ 353–481 million, distributed in each city as follows: Fortaleza, US$ 481 million in GVA contribution to GDP and 33,700 jobs; Recife, US$ 471 million of GVA contribution to GDP and 27,500 jobs; Natal, US$ 353 million GVA contribution to GDP and 23,300 jobs.

In addition to defining the hub, a relevant government decision, in 2015, had repercussions for the strengthening of the aeronautical production chain in the state of Ceará: implementation of the partnership between the Technological Institute of Aeronautics (ITA), the Government of Ceará, and the Federal University of Ceará (UFC) that culminated in the first ITA course outside its headquarters in São José dos Campos, providing the conditions for a more robust ecosystem for the aeronautical segment (Gomes 2019).

Other aspects denoted the state government's commitment to strengthening the aeronautical production chain in Ceará, highlighting the reform and modernization of airport structures in the interior of Ceará through the Air Plan of the State of Ceará (PAECE) (Paula 2018), as well as investments in strategic bases in five regions of the State that served public security and health.

There was a government determination for a multisectoral effort to favor a local environment conducive to development that strongly permeated the strengthening of the local aeronautical value chain evidenced by the guideline of the modernization of regional airports to guarantee the improvement of the flow within Ceará, highlighting here those located in São Benedito, Cruz, Sobral and Aracati (Paula 2018).

In summary, the public authorities in Ceará were aware that air transport has increasingly become an extremely important part of the economy, facilitating business travel, tourism, and domestic and international trade.

The International Air Transport Association, through a study conducted by Oxford Economics (2015), presented the results of the evaluation of economic and social impacts of the implementation of a hub in northeastern Brazil, where it pointed out that every dollar invested for the implementation of the center and connections should generate between US$ 5.20 and 5.80 in new economic activities, as an average of the first five years of operations. It also estimated additional GDP growth involving the dispute for the hub of around 5–7%, considering the average of its five years of operation. During this period, the hub is expected to generate 34,000 to 42,000 new jobs in Northeastern Brazil.

The city of Fortaleza presents some characteristics of the cities analyzed in this study, such as privileged geographical location, a strong tertiary sector in the economy and tourist attractiveness, in addition to an expressive regional influence (Gonçalves *et al.* 2021). In the last decade, the Metropolitan Region of Fortaleza has managed to improve its economic performance and implemented improvements in the quality of life of its citizens and focused on connectivity to leverage its development and be open to the planet.

In 2016, Fortaleza City Hall published an extensive multisectoral plan that was called *Fortaleza 2040*, which looked at the city, its strengths and weaknesses, in such a way that, once the former be put it into practice, it should produce substantial and excellent results.

The plan for the city foresees that the next two decades should witness the actions that allow the continuous viability of the air hub, centered on its international airport, facing real problems. The latter involve need for expansion and new runways; improvement of access and intermodal connections that allow the agile flow of people, goods and services; the confrontation of environmental and social issues, in time, so that it does not deconstruct the possibilities of the city to grow for the world, along with the target of maintaining itself a good place to live and visit, valuing, protecting and multiplying its natural wealth and expanding its cultural, entertainment and economic possibilities.

When Gomes (2019, p. 45, our translation) applied the Value Chain SCP framework to the aeronautical value chain segment, he warned that "intentions, however, need alignment between the levels of government and their long-term strategic understanding. Such initiatives are policies to be adopted," in a reference to the need for a commitment to a broad planning that can connect the various elements of the various production chains that lead to optimal performance for the network itself and for the city.

Among these planning initiatives, Gonçalves *et al.* (2021) exemplified the public policies aimed at tourism in Fortaleza that, when implemented, has repercussions on the local economy, on the generation of employment and income, in the expansion of hotel enterprises, in the local transportation sector and in the requalification of tourist equipment to serve a larger consumer public.

DISCUSSION

Comparative Analysis

In the four cases analyzed, respectively Cape Town, Panama City, Hamburg and Dubai, all global cities, it was clear that their geographical positions were determinant for the implementation and consolidation of airport structures, just as the consequent economic development is notorious. This reciprocal influence airport-city on the ladder of development in the multicase study is a visible part of the planning and actions elaborated and motivated by municipal, regional governments and multilateral organizations.

It was found that, such as Fortaleza, the cities analyzed had their airports born as ground-to-air connectors, at a time when it was not imagined the proportion and economic impulse that those structures would provide. As observed, there were decades until they consolidated as large airport connectors (ranging from 23 to 45 years), making it clear that this interval proved long, mainly due to the needs of regulatory adaptations that would propitiate this conversion and in turn bring economic and social development, conditions that contributed to Cape Town, Panama City, Hamburg and Dubai becoming global cities (Table 1).

Table 1. Global Comparative Cities and Fortaleza.

Parameters	Global comparative cities				Fortaleza
	Cape Town (South Africa) - CPT Airport	Panama City (Panama) - PTY Airport	Hamburg (Germany) - HAM Airport	Dubai (UAE) - DXB Airport	Fortaleza (Brazil) - FOR Airport
Economy Base	Services, Tourism	Trade, Services, Tourism	Trade, Services,	Trade, Services, Tourism	Trade, Services, Tourism
Contribution of the City to the Country's	11%	55%	4%	38%	1%
Ranking in the GDP Mercer quality of life index	95	97	19	74	Not present in the ranking
GaWC Global City Classification (2008)	Gamma +	Gamma +	Beta	Beta +	Does not figure as a global city
Estimated Population (2019)	4,524,000	1,889,091	1,841,000	3,137,463	2,452,185
Airport opening year	1954	1947	1911	1959	1955
Year that airport became a hub	1977	1992	1955	1985	2018
Passenger Traffic (2016)	10,211,390	14,741,937	16,223,968	83,654,250	5,706,489
Year the airport reached 8 million annual passengers	2009	2011	1995	1995	did not reach
Time to reach the 8 million passenger annual mark	55 years since opening and 32 years since it became hub	64 years since opening and 19 years since it became hub	84 years since opening and 40 years since it became hub	36 years since opening and 10 years since it became hub	did not reach

Source: Elaborated by the authors.

Other factors and characteristics inherent to these cities became preponderant to consolidate their respective airport structures in international hubs. Their global geographical positions strategically include them at consistent distances from many other cities in various countries and continents, which made them as gateways to their countries and sometimes on their continent. Cape Town and Dubai comply with this perspective: their economies are based on the trade in goods, services and tourism that favors the condition of logistical knots of these chains of relationship with the world, segments that were strengthened through hubs and feedback the demand for increased airflow whether passenger (business, entertainment) or cargo.

Even after the transition of airports, in the cities studied, in international hubs and the gradual repercussions on urban development from this state, in general, a relatively slow curve of passenger volume increase was observed. For example, for at least three of these airports, it took an average of 30 years to reach the 8-million-passenger annual mark (potential volume of Fortaleza before becoming an international hub) after becoming international connectors, namely: Cape Town (32 years), Panama City (19 years) and Hamburg (40 years). The clear exception was for the city of Dubai, which reached this mark in just 10 years after becoming hub, which greatly accelerated its development escalation. This speed denotes some important actions in this city: a strategic government focus on providing optimal conditions for regional development, the recognition of air connectivity as a driver of this growth; urban planning aimed at offering an infrastructure that allows a growing tourist interest; regulatory and incentive measures to promote business and attract investments.

The cities of the study presented a strong governmental position in generating the stimuli for the aeronautical production chain when they realized the promising economic return of these investments. Highlights for: (i) Hamburg, which despite hosting the oldest commercial airport in operation in the world, in the last three decades alone has fostered the strengthening of its aeronautical cluster, have brought together more than 40,000 highly qualified specialists, about 300 small and medium-sized enterprises, major international aviation players and institutions in the metropolitan region; and (ii) Dubai, that promoted an entire dynamics of

development of the city centered on the flow that aviation could provide, making this production chain currently account for almost 1/3 of its GDP, surpassing by more than four times the contribution of oil to the local economy.

Another relevant factor is the dynamics of connectivity between intermediate cities from these large connectors, fostering another arm of the exploration of aerial connectivity: intraregional. Here is a highlight for Panama City, which has recently accomplished this market and has promoted the discussion for investment application in strengthening the network internally, stimulating cooperation with other countries in the region to strengthen from its airport.

The positive impacts for development in the cities studied from urban planning matrices with centrality to the promotion of the aviation production chain are consistent, requiring the active involvement of local authorities to make investments and appropriate interventions to achieve this balanced development. This commitment and the ability of local authorities to monitor goals and indicators depend on a relationship between municipal governments and the production chain and its actors producing governance arrangements at various levels, as observed in the municipal planning of Cape Town and Panama; in the centrality of the aeronautical cluster in Hamburg; and in the absolute insertion of aviation in the planning of the city of Dubai, which transformed it into one of the largest air connectors in the world and catapulted the city, in a very short time interval compared to other cities in the world, being the only global city that came out of the condition of Beta, in 2008, for Alpha + in 2018, since when this classification began.

When transposing the experiences and trajectories of the cities analyzed in this study to Fortaleza, the following lessons seem to be quite consistent: (i) recognizing that the strengthening of the aeronautical production chain is essential to leverage the local and regional economy through direct investments in this cluster that materialize direct infrastructure actions and incentives for private investments that strengthen this network; (ii) understand and assume tourism, with all its fronts (business, entertainment, cultural, knowledge, among others) as a driving force to feed this air connector function; (iii) understand and assume environmental sustainability as an important factor to define the effectiveness and efficiency matrices of airport structures and their entire value chain, and that this issue strongly depends on solutions based on new technologies, whether materials or processes, which promotes another positive consequence for cities, by making them smart cities beyond just connected cities.

Each of the cities in this comparative study presented a common factor that stands out as being strongly responsible for the optimized city-airport relationship: an integrated urban planning oriented towards inserting the connectivity provided by aviation as an inducer of city-airport development. This comprehensive and integrated planning was decisive for accelerating results, considering that we are talking about airports with several decades since the beginning of operations in the respective cities.

In summary, only after a strong strategic direction in the urban planning of the analyzed cities is its potential as a major airport connector explored and strengthened as a fundamental contribution to the development of the respective cities. As Taylor (2000) suggests, the social relations of this global network of cities are economic and particularly structuring, which qualifies as an unusual social network, denoting the imperative that the theme of aerial connectivity is intertwined with the theme of urban planning and not as an appendix.

Air connectivity is the key to unlocking the potential for economic growth in a given region, involving factors such as attracting business investment and qualified human capital. Another relevant factor in the cities observed is the stimulus to tourism, which has become a powerful source of development and prosperity.

Understanding the centrality of air connectivity for urban development is a common point among the cities analyzed for the consolidation of their hubs, which involved the direct action of airports, airlines and, above all, governments, because the absence of any of these stakeholders in the planning can lead to failures, which is an alert for new projects such as Fortaleza Airport.

The methodological approach made it impossible to observe the hypothesis of failures in the implementation of hubs even when integrated planning may have taken place, which gives rise to the possibility of future works exploring this approach.

CONCLUSION

A little more than a century marks the first steps of the aeronautical industry and the intricate network that this industry permeates, nowadays, in virtually all human activities such as entertainment to rescue, from the transport of goods to the transport

of organs. The aviation industry is one of these complex webs that require a differentiated planning process due to the high degree of repercussion at all stages of its chain, including the potential damages that can be generated, inherent to any process.

There is a vast literature that covers the processes in isolation and details the procedures in each of the links of this aeronautical production chain. It is essential for the high level achieved by the industry. With respect to the direct or indirect repercussions of this production chain at the level of cities, they have been incipient or insufficient, especially when seeking a homogenization of indicators or criteria to better measure the impact based on comparative analyses that contribute to the definition of a standard that allows classifying or generating prognoses about the development of cities from airport structures.

In an innovative perspective, the present study highlights the mutual—social, economic, environmental—repercussions of the city-airport binary and how fundamental integrated planning is to extract the maximum benefit from interaction, which, using a comparative and nonsequential multicase study, proposes to collaborate with the consolidation of the air hub in the city of Fortaleza, assuming the premise that the optimal result depends on integrated interventions that are beyond the presence and power of the aerodrome itself.

By transposition the experiences and trajectories of the cities analyzed in this study for Fortaleza, the following learnings seem very consistent: (i) recognize that the strengthening of the aeronautical production chain is essential to leverage the local and regional economy through direct investments in this cluster that materialize in direct infrastructure actions and incentives for private investments that strengthen this network; (ii) understand tourism, with all its fronts (business, entertainment, cultural, knowledge, among others) as a driving force to feed this function of aerial connector; (iii) understand environmental sustainability as an important factor to define the matrices of effectiveness and efficiency of airport structures and their entire production chain, and that this theme depends heavily on solutions based on new technologies, whether material or process, which promotes for cities another positive consequence, by making them smart cities beyond only connected cities.

Each of the cities in this comparative study presented a common factor that stands out as a strong responsible for the optimized city-airport relationship: an integrated and oriented urban planning to insert the connectivity provided by aviation as an inducer of city-airport development. This comprehensive and integrated planning has presented itself decisively for the acceleration of results, considering that we are talking about airports with several decades since the beginning of operations in the respective cities.

AUTHORS' CONTRIBUTION

Conceptualization: Sousa HJJ and Figueirêdo Junior HS; **Methodology:** Sousa HJJ, Figueirêdo Junior HS and de Andrade D; **Validation:** Sousa HJJ, Figueirêdo Junior HS and de Andrade D; **Formal analysis:** Sousa HJJ and Figueirêdo Junior HS; **Investigation:** Sousa HJJ and Figueirêdo Junior HS; **Resources:** Sousa HJJ, Figueirêdo Junior HS and de Andrade D; **Data Curation:** Sousa HJJ and Figueirêdo Junior HS; **Writing – Original Draft:** Sousa HJJ; **Writing – Review & Editing:** Sousa HJJ, Figueirêdo Junior HS and de Andrade D; **Visualization:** Sousa HJJ; **Supervision:** Figueirêdo Junior HS and de Andrade D; **Project administration:** Sousa HJJ; **Funding acquisition:** Figueirêdo Junior HS and de Andrade D.

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