

The geography of logistics facilities relative to airports: Taxonomy of literature and research agenda

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Background: The nexus between airports and the spatial distribution of economic activities is a topical research area. This interest is against the backdrop of the growing volumes and flow of goods, which are facilitated by the processes of logistics. It is typically assumed that logistics facilities have to be located in the vicinity of airports. This assumption is, however, not always correct.

Objective: The objectives of the study are two-fold, namely to establish the typology of literature on the locational patterns of logistics facilities relative to airports, and to identify gaps that require more attention towards analysing and appropriately planning for the location of airfreight-related facilities.

Method: To identify relevant studies, the article is based on snowballing method, which was supplemented with the search on the Internet databases of Academic Search Premier and Google Scholar, using 'logistics and airports' as keyword sieve. Following the perusal of titles and abstracts, 58 studies were reviewed.

Results: In establishing the typology of literature, a number of overlapping streams were identified, namely international locational patterns of logistics facilities, airfreight catchment of airports, concentration of logistics facilities in the vicinity of airports, and metropolitan areas and regions as logistics hubs.

Conclusion: A comprehensive understanding of the geography of logistics facilities is required so as to anticipate and appropriately cater for the growing flow of goods. Informed by the analysis of literature, areas for future research include the determination of airfreight facilities (from logistics facilities in general) as well as analysis of the airfreight catchment of airports.

Keywords: logistics; air cargo; airfreight; airports; airfreight catchment; locational patterns.

Introduction

Although there is no consensus on the direction of causality, the literature widely acknowledges the relationship between airports and urban development (for recent studies, refer to Bilotkach 2015; Brugnoli et al. 2018; Cidell 2015; Gibbons & Wu 2019; Sheard 2019). The nexus between airports and the location of economic activity accordingly attracts the attention of researchers with diverse disciplinary background, including logistics and supply chain management, urban and regional planning, human geography (particularly the sub-disciplines of economic geography and transportation geography) and economics. The topical facets of this interconnection include (1) empirical analysis of the spatial economic attributes of airports and their environs (undertaken to elucidate, inter alia, factors that drive the location and mix of economic activities that are related to airports), and (2) normative models that propose the ideal spatial form and economic activity mix of urban development that hinges on airports. Amid numerous airport-led development propositions (for a synthesis, refer to Freestone & Baker 2011), the normative models are epitomised by the so-called aerotropolis. The idealised urban form of aerotropolis has an airport as its core, surrounded by a periphery in which various economic activities (such as airport-related logistics and manufacturing businesses) situate to benefit from propinquity to the airport (Banai 2017).

The world is characterised by the increasing volumes and flow of goods (Verhetsel et al. 2015), which are largely driven by the growth of e-commerce activities (Kim & Lee 2019; Yang et al. 2022). The fundamental consideration not only pertains to the nature, origin and destination of freight but also relates to how freight moves across different geographical scales, bringing to the fore the concept of logistics (Hesse & Rodrigue 2004). Central to the vitality of cities

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(O'Connor, Derudder & Witlox 2016), processes of logistics are responsible for facilitating the constantly increasing flow of goods between points of origin and points of consumption (Li 2014; Verhetsel et al. 2015). Among the various modes of transport that are used in logistics processes, air cargo is one of the backbones of global trade (Schwarz 2006). International Air Transport Association (n.d.) reports that 35% of the value of global trade is transported by air, albeit it covers a volume of less than 1%. The air cargo market is growing because of the increasing e-commerce, and also possesses benefits in terms of the timeliness of deliveries (Kim & Lee 2019) compared to other modes of transport. Furthermore, high-value, light-weight products are typically shipped by air transport, whose cost has declined over time (Yuan, Low & Tang 2010).

The growing importance of air cargo calls for a comprehensive empirical understanding of the locational patterns of logistics facilities relative to airports – an understanding that could be used by planners, authorities and logistics companies to guide decision-making processes on the placement of logistics facilities. As a reflection of the importance of geographical location to the operations of logistics businesses, Jirsák and Kršňáková (2015) assert that facility location is a strategic decision taken by each logistics company. In the manner of the normative models of airport-led development mentioned earlier in this section, authorities and planners typically assume that economic activities that are presumed to be airport-related (such as logistics facilities) should be located in the vicinity of airports. Showing that this understanding is not always accurate, Peneda, Reis and Macario (2011) note that numerous airports across the world have failed to transform towards the so-called airport cities. However, to the best of our knowledge, there is no existing literature review on the geography of logistics facilities relative to airports, which identifies gaps that could be filled by further empirical research.

Aim and objectives of the article

The purpose of this article is to examine the literature towards formulating a research agenda that could ultimately be used by stakeholders to appropriately guide the positioning of logistics facilities relative to airports. Against this backdrop, the broad aim of the article is to review the empirical literature on the locational patterns of logistics facilities relative to airports. Given that the relevant literature is not always explicit on airfreight-related logistics, the article focuses on logistics facilities (in a broad sense) relative to airports. This limitation is discussed further in the section on potential areas for future research. Towards achieving the above-mentioned aim, this article intends to address the following specific objectives:

1. Establishing the typology of literature on the locational patterns of logistics facilities relative to airports.
2. Identifying knowledge gaps that require more attention on the topic of locational patterns of logistics facilities relative to airports.

On the background of the assertion that compared with papers that report on empirical research, literature review papers can be structured in numerous ways (Van Wee & Banister 2016) with no standard agreed-upon structure, the remainder of the article is organised as follows: the next section discusses the research methods employed towards identifying the relevant literature and achieving the aim and objectives of the study. The third section presents the findings on the taxonomy of literature (to address the first objective). The fourth section synthesises and discusses the findings, while the fifth section identifies areas for future research (to address the second objective). The last section concludes the article.

Methodology: Identification of literature

The literature search targeted empirical studies that directly or indirectly analysed the geography or locational patterns of logistics facilities relative to airports. For the purposes of this literature review article, 'direct studies' were those whose aim or objectives were specifically to analyse the geography of logistics facilities relative to airports, while 'indirect studies' were incidentally relevant by having airports as some of the variables investigated. For comprehensiveness of the review, the literature search was not restricted to predefined airports, continents, countries, year of publication or academic discipline of the authors.

With regard to the technique used to search for the relevant literature, the study commenced with snowballing method wherein, in the manner of a snowball analogy, relevant citations were traced from the initial studies perused (Jalali & Wohlin 2012; Van Wee & Banister 2016; Webster & Watson 2002). However, similar to other literature search methods, snowballing has a risk of potentially omitting relevant studies. In order to reduce this risk, snowballing was supplemented with the search on the databases of Academic Search Premier and Google Scholar, using the words 'logistics and airports' as what Webster and Watson (2002:xvi) refer to as 'keyword sieve'. The search on Academic Search Premier, which yielded 464 items, was set up to retrieve only the peer-reviewed literature (journal articles and books). Google Scholar search, whose parameters could not be refined in great detail, yielded a higher number, of 2120 items. Following the perusal of the titles and abstracts, the majority of the studies were found irrelevant to the geography of logistics facilities relative to airports, and only 58 studies were subsequently used for the literature review (Figure 1). As alluded to earlier in this section, the literature search uncharacteristically commenced with snowballing and only incorporated database searches at a later stage. It was therefore impossible to accurately show, in Figure 1, the number of studies that remained post the removal of duplicates and screening of Academic Search Premier and Google Scholar items. The majority of the items that were retrieved from the databases had already been identified through the snowballing process.

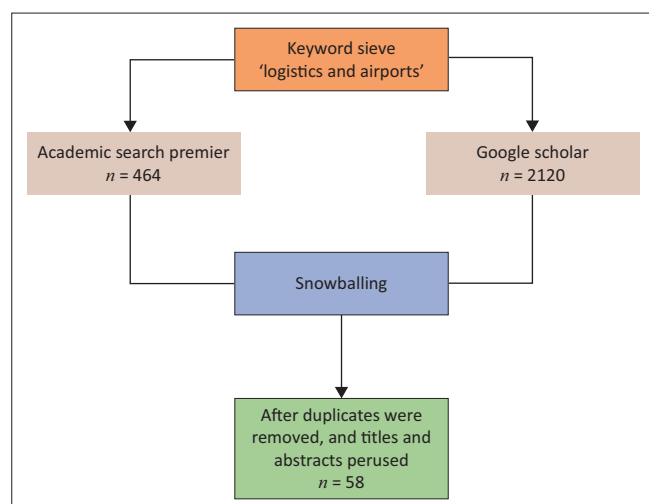


FIGURE 1: Literature search process.

Findings

Taxonomy of literature

The reviewed studies are catalogued in Table 1. To classify the literature, four overlapping streams were identified with the perusal of the studies, namely (1) international locational patterns of logistics facilities, (2) airfreight catchment of airports, (3) concentration of logistics facilities in the vicinity of airports, and (4) metropolitan areas and regions as logistics hubs. Applicable across these streams, the following components of logistics activities were identified in the literature: service activities; warehousing, distribution, wholesale and allied activities; and third-party logistics (3PLs).

As alluded to in the introduction, airports play important roles not only for their immediate surroundings, but also for larger territories (Matthiessen 2004). This consideration is particularly essential towards unravelling the problem, as mentioned in the introduction, of the assumption that economic activities that are presumed to be related to airports should be located in the vicinity of airports. It was therefore pertinent to introduce the following levels of analysis or geographic scales to the literature review:

1. Airports and their environs, that is, areas in the vicinity/ geographical proximity of an airport.
2. Municipal area to functional region, that is, other areas in the municipality within which the airport is located, including neighbouring municipalities that have strong economic linkages with the municipal area that accommodates the airport.
3. Country, that is, areas within the country that are beyond the municipality and functional region that accommodate the airport.
4. Multi-country, that is, locations in different countries.

Overview of literature

The presentation below, which is structured around the afore-mentioned streams of literature (viz. international locational patterns, airfreight catchment, concentration of

logistics facilities, and metropolitan areas and regions as logistics hubs) focuses on the narrative of the literature's findings. The findings are discussed and synthesised in the subsequent section so as to tease out the interconnections, and systematically work towards identifying possible areas for future research.

International locational patterns of logistics facilities

The first set of studies focused on the geography of logistics facilities wherein multiple countries were adopted as level of analysis. In the investigation of whether global cities were crucial locations for logistics services, O'Connor et al. (2016) found out that service firms typically operated from head offices in a global city – an attribute the authors argue could in part be explained by the presence of main airports and seaports in such cities. Relatedly, the investigations conducted by Akhavan et al. (2020) revealed that the choice of location of 3PLs management functions was influenced by, *inter alia*, world cities and the presence of major airports. Although closely related to the afore-cited, other studies analysed cities and regions other than the so-called global cities. In the analysis of airfreight and shipping networks, Rimmer (1997) uncovered that a number of the world's top freight airports were located in the Asia-Pacific region, aka Trans-Pacific oceanic economy. Rimmer (1997) subsequently identified what was referred to as distribution platforms, which were spaces that allowed firms in the said region to coordinate their operations, which could have a global reach.

Still in the Asian context, Bowen and Leinbach (2003) investigated the demand for knowledge-intensive advanced air cargo services by electronics manufacturers in Singapore, Malaysia and the Philippines, and found out that the demand for advanced air-cargo services was related to the scope and level of the internationalisation of the firms. As freighters are crucial for the flow of airfreight within and between countries, Bowen (2004) analysed the geography of scheduled freighter operations. The study discovered that approximately half of the cities with the highest capacity of scheduled freighter services were in the Pacific Rim, reflecting high volumes of cargo that moved between Asia and other parts of the world. It is however important to note that a number of routes with dense freighter services were identified within Asia-Pacific, pointing to higher internationalisation of production at a continental rather than a global scale, a sentiment that was in part shared by Rimmer (1997). As this section is strictly on international patterns, more recent intra-country literature of freighters is covered in the next section on the airfreight catchment of airports.

Airfreight catchment of airports

Closely associated with the foregoing exposition, a number of studies dwelled on the airfreight catchments of airports, which are applicable to inter-country and multi-country geographical scales. Focusing on China, Deng, Zhang and Wang (2022) analysed the network of scheduled freighter, and investigated how the system evolved after the COVID-19 pandemic. The analysis revealed that the network, which

TABLE 1: Studies reviewed.

Authors	Year	Focus	Theme	Country of focus
1 Akhavan; Ghiara; Mariotti; Sillig	2020	Logistics connectivity	International patterns	Multiple in Europe
2 Bombelli; Santos; Tavasszy	2020	Air cargo transport network	Airfreight catchment	Worldwide
3 Boonekamp	2014	Air cargo catchment	Airfreight catchment	Netherlands
4 Boonekamp; Burghouwt	2017	Connectivity of airfreight industry	Airfreight catchment	N/A
5 Bowen	2004	Geography of air freighter aircraft	International patterns	N/A
6 Bowen	2008	Geography of warehousing	Concentration	USA
7 Bowen; Leinbach; Mabazza	2002	Air cargo services	Concentration	Philippines
8 Bowen; Leinbach	2003	Advanced producer services of air cargo	International patterns	Singapore, Malaysia, Philippines
9 Chhetri; Butcher; Corbitt	2014	Logistics employment clusters	Concentration	Australia
10 Cidell	2013	Logistics sprawl	Concentration	USA
11 Gingerich; Maoh	2019	Warehousing location	Concentration	Canada
12 Coetzee; Swanepoel	2017	Density of cargo-related businesses	Concentration	South Africa
13 CPCS	2011	3PL supply chains	Concentration	Canada
14 Dablan; Frémont;	2013	Freight flows	Concentration	France
15 Dablan; Ogilvie; Goodchild	2014	Logistics sprawl	Concentration	USA
16 Dablan; Ross	2012	Spatial patterns of logistics activities	Concentration	USA
17 Deng; Zhang; Wang	2022	Scheduled freighter networks	Airfreight catchment	China
18 De Silva; Sano; Hatoyama	2020	Spatial organisation of fulfilment facilities	Concentration	UK and Japan
19 Flore-Fillo; García-López; Nicolini	2016	Service firms	Concentration	USA
20 Gingerich; Maoh	2019	Relationship between transport infrastructure & land use	Concentration	Canada
21 Giuliano; Kang	2018	Spatial patterns and trends of W&D location	Concentration	USA
22 Heinitz; Hirschberger; Westat	2013	Role of air transport in air cargo networks	Airfreight catchment	N/A
23 Heitz; Beziat	2016	Spatial organisation of logistics activities	Concentration	France
24 Heitz; Dablan	2015	Logistics spatial patterns	Concentration	France
25 Heitz; Dablan; Tavasszy	2017	Logistics sprawl	Concentration	France and The Netherlands
26 Heitz; Launay; Beziat	2017	Distribution of logistics activities	Concentration	France
27 Hoare	1974	Airports and growth poles	Airfreight catchment	UK
28 Holl; Mariotti	2018	Geography of logistics firms	Concentration	Spain
29 Hong	2007	Location of foreign logistics firms	Concentration	China
30 Hesse	2010	Clustering of air freight activities	Metropolitan areas as logistics hubs	Luxembourg
31 Kang	2018	Warehouse location choice	Concentration	USA
32 Kumar; Zhalnin; Kim; Beaulieu	2017	Logistics clustering	Concentration	US
33 Li; Sun; Yuan; Liu	2020	Logistics parks	Concentration	China
34 McKinnon	2009	Land requirements	Metropolitan areas as logistics hubs	UK
35 McMillen; McDonald	1998	Transport facilities and employment density	Concentration	USA
36 O'Connor; Derudder; Witlox	2016	Service firms	International patterns	Not country specific
37 Olsson; Woxenius	2014	Freight consolidation centres	Concentration	Belgium
38 Önden; Acar; Eldemir	2016	Location of logistics centres	Concentration	Turkey
39 Raguraman	1997	Air cargo hubbing	Concentration	Singapore
40 Raimbault; Andriankaja; Paffoni	2012	Geography of logistics facilities	Concentration	France
41 Rimmer	1997	Distribution platforms	International patterns	-
42 Rivera; Sheffi; Welsch	2014	Logistics clusters	Concentration	USA
43 Rodrigue	2003	Freight and mega-urban regions	Concentration	USA
44 Rodrigue	2012	Geography of supply chains	Concentration	USA
45 Rolko; Friedrich	2017	Location of logistics service providers	Concentration	Germany
46 Sakai; Beziat; Heitz	2020	Location of logistics facilities	Concentration	France
47 Shen; Rankin; Lee	2016	Multi-airport logistics	Metropolitan areas as logistics hubs	USA
48 Shukla; Waddell	1991	Location decisions of firms	Concentration	USA
49 Sivitanidou	1996	Warehousing and distribution facilities	Concentration	USA
50 Strale	2018	Logistics sprawl	Concentration	Belgium
51 Sundarakani	2017	Logistics corridor and logistics hub	Metropolitan areas as logistics hubs	UAE
52 Van Den Heuvel; Rivera; Van Donselaar; Sheffi; de Langen; Fransloo	2014	Accessibility and logistics	Concentration	USA
53 Wang; Gong; Yang	2018	Land use optimisation	Concentration	China
54 Warffemius	2007	Clustering of distribution centres	Concentration	The Netherlands
55 Woudsma; Jakubicek	2019	Spatial patterns of logistics activities	Concentration	Canada
56 Woudsma; Jensen; Kanaroglou; Maoh	2008	Logistics land use	Concentration	Canada
57 Yuan	2018	Location of warehouses	Concentration	Los Angeles
58 Zhang	2003	Air cargo hub	Airfreight catchment	Hong Kong

comprised 45 cities and 132 air routes, was not randomly formed but offered a good coverage of the country. The network was characterised by a layering feature comprising national and intermediate level hubs, as well as numerous small nodes in peripheral cities (Deng et al. 2022). These layers served different catchments of the system. In the investigation of the airfreight catchment of selected airports in Europe, Boonekamp (2014) found out that 95% of the freight processed at Amsterdam Schiphol Airport originated within a distance of approximately 1250 km of the airport, which included adjoining countries. Further pointing to multi-country catchments, Heinitz, Hirschberger and Westat (2013) analysed the geography of the hinterlands of air cargo hubs in Europe wherein it was discovered that the majority of road feeder service connections stretched from as far as England to Italy. Supplementing (and in a way expounding) the work of Boonekamp (2014) on the airfreight catchment of Schiphol, Heinitz et al. (2013) discerned a dense schedule between Schiphol, London Heathrow and Paris Charles De Gaulle airports, while Frankfurt, Copenhagen, Milan Malpensa and Vienna airports also attracted further freight via overland movement.

Bombelli, Santos and Tavasszy (2020) assert that the airport airfreight catchment area is much larger than for passengers, because it is served by road feeder services (for the ground leg) that are not available in passenger networks. Boonekamp and Burghouwt (2017) add that large hub carriers contend for airfreight via road-based feeder system, which is important for conveying consignments (from other airports and/ or consolidation points) to the applicable hubs. Concentrating on one of the aforesaid airports at a different geographical scope, in a prior analysis, Hoare (1974) had mapped Heathrow Airport's portion of cargo so as to ascertain the expanse of the catchment, and it was discovered that the breakpoint for the agents' consignments was approximately 240 km. Depicting the dominance of Heathrow, it was beyond the bounds of the South-East region that it became viable for the cargo to be shipped via alternative airports. In the examination of airfreight movement relative to the Hong Kong International Airport, Zhang (2003) found out that even though Hong Kong was a significant origin of freight, its importance centred predominantly on its function as a hub for freight emanating from the wider region of Pearl River Delta. For such movement of goods, Hong Kong Airport encountered competition from adjacent airports, which shared the region's catchment. While acknowledging considerable differences in the time the analyses were undertaken, Hong Kong Airport was not a definite monopoly in the territory in contrast to Heathrow in terms of Hoare's (1974) study.

Concentration of logistics facilities in the vicinity of airports

The extensive literature on the concentration of logistics facilities in the vicinity of airports revolves around the following closely intertwined aspects: airports and logistics sprawl; logistics parks and logistics clusters; concentration of service firms; concentration of

warehousing, distribution, wholesale and allied activities; and concentration of 3PLs.

Airports and logistics sprawl: A number of studies analysed the connection between airports and logistics sprawl, which is a process wherein logistics facilities change location from central urban areas to outlying suburban and exurban areas (Dablanc & Browne 2019), such as the environs of airports. Focusing on Paris and Ile-de-France, Dablanc and Frémont (2013) examined the trends of freight movement and warehouse developments, and found out that warehouses were being established further from Paris, at areas like the environs of Charles De Gaulle Airport. In a related study, Heitz and Dablanc (2015) analysed the spatial distribution of freight and logistics facilities in the Paris region and mega region between 2000 and 2012, and discovered the emergence of warehouse clusters in the suburbs around airports and ports. In part supporting the findings of Dablanc and Frémont (2013), a concentration around Charles De Gaulle Airport had expanded to cover a wider footprint in 2012 than in 2000. Heitz, Dablanc and Tavasszy (2017) compared the Paris region and the Randstad in the Netherlands. In Paris, it was discovered that the clusters of warehouses and other logistics facilities were associated with the location of major transport nodes in the peripheral areas, including Charles De Gaulle and Orly airports as noted elsewhere by Dablanc and Frémont (2013) and Heitz and Dablanc (2015). In the Netherlands, it was similarly found that the port of Rotterdam and Schiphol Airport were home to logistics clusters, which accommodated a high number of warehouses and other logistics facilities.

In the analysis of Piedmont Atlantic megaregion in the United States of America (USA), Dablanc and Ross (2012) found out that although warehousing historically located close to city centres and rail stations, it had over time shifted towards airports and highway junctions. Elsewhere in the USA, Dablanc, Ogilvie and Goodchild (2014) compared the geographic distribution of warehouses in Los Angeles and Seattle during the period 1998 to 2009. It was discovered that warehousing in Los Angeles had increased in the metropolitan centre as well as in the counties located further from the city, including zones that accommodated Ontario, Seattle-Tacoma and SeaTac airports. In a related study on the decentralisation of logistics activities in Los Angeles, San Francisco, San Diego and Sacramento metropolitan areas, Giuliano and Kang (2018) examined changes in the spatial pattern of warehouse and distribution activities between 2003 and 2013. It was discovered that for average distance to the central business district (CBD), airport, and employment geo-centre, differences were significant for all four areas analysed. Similarly, Kang (2018) analysed the changing location of warehouses to peripheral areas, wherein among other findings, airport travel time (especially for large warehouses established between 1981 and 2016) was found to be one of the important location factors. Somewhere else in the USA, Cidell (2013) discovered that for freight establishments that were introduced in the suburban counties between 1986 and 2005, Chicago had a significantly large number compared

with other metropolitan areas, wherein some of the growth had occurred near O'Hare Airport. The studies presented in this section show that airports and their environs are some of the factors that influence the patterns of logistics sprawl.

Logistics parks and logistics clusters: Several studies dwelled on the establishment of methods for discerning logistics clusters (Rivera, Sheffi & Welsch 2014), some employ the methods developed, while others present recommendations on ways the clustering of logistics facilities can be realised in the environs of airports. Önden, Acar and Eldemir (2016) developed a method for assessing the location of logistics centres, in which the determinants scrutinised encompassed propinquity to airports, seaports, railways and highways. In a similar fashion, Rivera et al. (2014) established and employed a method for discerning logistics clusters in the USA and discovered seven biggest clusters, which included the vicinity of the following airports: Hartfield-Jackson Atlanta, Dallas-Fort Worth (notably the core of the Dallas cluster) and Miami. Hong (2007) investigated the location behaviour of foreign logistics services in Shanghai, China, wherein after applying six variables to measure transport linkages, accessibility to an airport was discovered to be one of the determinants of the clustering of logistics facilities. Concentrating on the airport economic zone relative to Dalian Airport in China, Wang, Gong and Yang (2018) developed a method for establishing the structure of a basic airport industry cluster, wherein it was discovered that airport-related logistics predominantly situated within 10 km of the airport. This outcome was acquired after the following relationships were considered: logistical relationships, non-logistical relationships, and equal consideration of logistical and non-logistical relationships (Wang et al. 2018).

Using the study area of Singapore, Raguraman (1997) examined ways in which hubbing can occur in the logistical chain of cargo movement, through the clustering of logistics activities. In order to facilitate the movement and handling of cargo, the proposal hinged on the integration of essential facilities in an airfreight composite located on the airport premises so as to allow for the effective handling of freight. In Germany, Rolko and Friedrich (2017) examined the patterns (structural and spatial) of logistics locations, wherein among other areas, a cluster was uncovered in the environs of Frankfurt Airport. In the state of Victoria, Australia, Chhetri, Butcher and Corbitt (2014) outlined spatial logistics employment clusters, and identified airport dependent logistics services around the suburbs in the vicinity of Tullamarine and Essendon airports. These clusters accommodated freight business parks, freight transshipment activities, business activity centres, freight storage and handling activities. Kumar et al. (2017) analysed the transportation and logistics clusters across the US, and investigated whether jobs in the clusters could be explained by the intensity of transport infrastructure in the region. It was discovered that airports, following intermodals, had a large impact on jobs. In Spain, Holl and Marioti (2018) complemented the afore-cited studies with a discovery that on average, logistics establishments situated

in the vicinity of airports, highways and seaports than firms in other sectors.

Focusing on Chongqing, China, Li et al. (2020) analysed whether planned logistics parks attracted companies in a way that was important enough to influence the locational patterns of logistics activities. One of the logistics parks examined was located in the proximity of Jiangbei International Airport, in a suburban setting. It was discovered that the majority of logistics establishments in the suburban area had low co-location, reflecting that the logistics parks in those areas were not popular among the establishments. In Sweden, Olsson and Woxenius (2014) analysed the potential of developing urban freight consolidation centres for small road hauliers transporting goods to the retail sector in the Gothenburg region. Although the analysis was not specifically devoted to the airport, the maps produced by Olsson and Woxenius (2014) reflected that the environs of the airport was home to fewer freight forwarders compared to other locations in the region.

Concentration of service firms: Related to the aforementioned literature, a number of studies analysed the location of service firms relative to airports. Flore-Fillo, Garcia-López and Nicolini (2016) investigated the competition (between, among others, service operators and commercial firms) for land in the vicinity of Memphis, Louisville, Los Angeles and Newark Liberty airports in the USA. Reflecting the propensity of service firms to be located closer to airports, the findings revealed the following patterns: at Memphis, service operators settled closer to the airport than commercial firms. At Louisville, service operators were replacing commercial firms on the airport premises. With respect to Los Angeles, locations of service operators tended to overlap with those of commercial firms. Finally, at Newark, service operators in the transportation sector showed a strong propensity for settling close to the airport. In the analysis of Dalian Airport, China, the aforementioned model of Wang et al. (2018) identified a number of patterns with respect to service activities. Firstly, if only the logistical relationships were considered, the industries of the airport service would be mainly located within 10 km of the airport. Secondly, if non-logistical relationships were factored in, the service industries would mainly locate 12 km from the airport. Thirdly, if logistical and non-logistical relationships were considered equally, the airport service industry would be concentrated within 5 km of the airport. The connection between airports and the location of service firms is also reflected in the earlier work of Bowen, Leinbach and Mabazza (2002), who analysed the development of FedEx hub in Subic Bay, the Philippines. It was discovered that Subic Bay had prevailed as a suitable area because of the airport infrastructure, wherein the hub evolved into a significant concentration of producer services with logistics chain with global reach.

Concentration of warehousing, distribution and/ or wholesale activities: A great number of studies examine the location of warehousing, distribution, wholesale and allied

activities relative to airports. In the investigation of the reasons why European distribution centres (EDCs) were located around Schiphol Airport, Warffemius (2007) discovered the use of air cargo services not to be a conclusive factor that influenced the location of EDCs. Rather, most EDCs highlighted the need for proximity to the former warehouse as important in location decision-making. In South Africa, Coetzee and Swanepoel (2017) found out that warehouse businesses had the lowest airport inclination factor of the air cargo-related businesses analysed relative to OR Tambo International Airport. In Los Angeles, Yuan (2018) analysed the connection between the spatial distribution of warehouses and neighbourhoods with varying demographic and socioeconomic characteristics. Among the transport access variables analysed, access to the nearest airport was found to be marginally significant.

On this background, a large number of studies identified a strong tendency of the location of warehousing facilities in the environs of airports. The pioneering study of Bowen (2008) analysed the extent to which warehousing establishments were inclined to move towards areas with good accessibility to air, sea, rail and highway networks in the USA. It was found out that the number of establishments in 2005, and the increase (between 1998 and 2005) in the number of establishments were correlated with access to air and/or highway networks. Related to the work of Bowen, Van Den Heuvel et al. (2014) examined the correlation between freight accessibility and the patterns of employment in the USA. Taking into consideration four transportation modes (road, air, maritime and rail), the investigations discovered that at a county level, there was a connection between freight accessibility and employment, conveying the impression that territories with good accessibility had more logistics-related jobs. Similarly, Sivitanidou (1996) analysed factors that attracted 812 warehousing and distribution establishments in the USA, considering the factors of distances to Los Angeles, Glendale-Burbank-Pasadena and John Wayne airports, the nearest seaport, and rail infrastructure. The findings produced statistical significance of distance to airports, reflecting the significance of air transport to the location-choice decisions of warehousing and distribution firms. Relatedly, in the analysis of warehousing and distribution activities, Woudsma et al. (2008) found out that the patterns of logistics land development were affected by access to airports and highways.

McMillen and McDonald (1998) analysed the impact that access to transportation facilities had on employment density in the Chicago metropolitan area in the USA. The factors analysed included distances to O'Hare Airport, Chicago CBD, the closest commuter station, and highway interchanges. Twenty subcentres were identified, of which two (Addison and O'Hare) were positioned in the vicinity of O'Hare Airport. Reflecting a connection between airports and the location of warehousing, manufacturing and transportation, communications, utilities and warehousing activities predominated the economic activity composition of these two centres. Heitz, Launay and Beziat (2017) developed a method for gathering information on logistics facilities, and

established a database of warehouse and transport termini in the Paris region for 2015. It was discovered that transport infrastructure, such as Charles de Gaulle Airport (and highway intersections), encouraged the clustering of warehousing facilities. In the analysis of the spatial patterns of freight in Canada, Woudsma and Jakubicek (2019) discovered the emergence of logistics facilities in the vicinity of Calgary Airport. Similarly, in Winnipeg, there was an increase of warehousing in the environs of the airport. In Montreal, there was a marginal growth in the number of establishments in the vicinity of Mirabel Airport although a decline in the concentration of warehousing facilities was identified in the vicinity of Trudeau International Airport (Woudsma & Jakubicek 2019). Still in the Canadian context, in the examination of a connection between transportation infrastructure and land use, Gingerich and Maoh (2019) found a significant concentration of warehouses within 7 km of Pearson International Airport. Notably, there are studies that found the inclination of warehouses to locate in the environs of decommissioned airports. As an example, McKinnon (2009) identified a concentration of warehousing and distribution establishments at obsolescent military airfield in the West Midlands, UK.

Related to the aforementioned literature, some studies focused particularly on the location of wholesale, parcel and allied activities relative to airports. Shukla and Waddell (1991) analysed the location decisions of firms in Dallas-Fort Worth (USA), with Dallas-Fort Worth Airport, highways and the CBDs investigated to discern their influence on the location of firms. Among others, the study found that in the light of the role of Dallas as a distribution centre of regional and national importance, access to the airport was significant for wholesale firms because of their function in storage and distribution processes. In Belgium, Strale (2019) discovered that while most wholesale jobs were situated in the central part of Brussels region, other logistics facilities (such as freight forwarding and warehousing) desired to locate in the suburbs, particularly areas in the vicinity of highways and the airport. Sakai, Beziat and Heitz (2020) analysed the location choices for logistics facility development in the Paris region, and found out that areas with the highest wholesale job accessibilities were clusters of wholesale establishments in the vicinity of Charles de Gaulle and Paris Orly airports. Relatedly, De Silva, Sano and Hatoyama (2020) analysed the spatial organisation and locational characteristics of e-commerce logistics in Japan and the UK. In the UK, logistics facilities were, among other locations, found to situate within 20 km radius of an airport. Because during busy shopping seasons Amazon used dedicated cargo aircraft, access to airport infrastructure was important. Raimbault Andriankaja and Paffoni (2012) compared the spatial logics in the Paris region with regard to parcel service terminals, distribution centres and inland ports. The study found out that parcel service facilities typically located around zones such as airports, ports and logistics parks. A similar pattern was discovered by Heitz and Beziat (2016) in a study of the location of parcel logistics activities in the Paris region, with a high concentration of the parcel industry identified in the

vicinity of transport infrastructure, such as Charles de Gaulle and Orly airports.

Concentration of third-party logistics: Some of the aforementioned studies could overlap with the literature that focused specifically on 3PLs. In the analysis of the geographical distribution of 3PLs in Canada, CPCS (2011) discovered that Pearson International Airport attracted a significant concentration of 3PLs. This resonates with the findings of Gingerich and Maoh (2019) on the concentration of warehousing in the vicinity of the said airport. Similarly, 3PL activities in Montreal were mainly clustered around the airport (as well as at marine and intermodal terminals). Furthermore, a cluster of 3PLs was identified near Vancouver International Airport, and the Calgary, Edmonton and Regina 3PLs tended to cluster, among others, around airports and intermodal terminals. A significant number of 3PLs was also discovered in Winnipeg, with a large concentration found around the airport (CPCS 2011). In a similar study focusing on North America, Rodrigue (2012) discovered the propensity of 3PL providers to cluster around airports (and other terminal facilities); hence, one of the location patterns suggested by the author for 3PLs is airport centric, that is, a location in the vicinity of a major airport, which enabled the firms to effectively deal with the time sensitivity of air cargo.

Metropolitan areas and regions as logistics hubs

As opposed to restricting the analysis to the environs of airports, some researchers focussed on corridors, metropolitan territories and functional regions. Hesse (2010) examined the city of Luxembourg (in the country of Luxembourg), which became an airfreight hub because of the presence of aviation infrastructure in addition to its good geographical position in Western Europe. Airfreight establishments were also found to utilise the old airbase, a situation that resembled the findings of McKinnon (2009), with respect to the location of logistics facilities in the environs of airports that are out of commission. Notably, Hesse (2010) contends that Luxembourg flourished as airfreight hub despite the competition posed by airports in the adjacent countries, including Paris Charles de Gaulle, Frankfurt and Amsterdam airports. In a related study, Sundarakani (2017) examined the factors that strengthened Dubai as a fitting place for the establishment of a logistics hub. The factors identified included Jebel Ali Port, which is located in the environs of Dubai International Airport. Another significant influence was Al Maktoum International Airport, which is one of the world's busiest airports. At a regional scale, Rodrigue (2003) examined freight transportation relative to Boston-Washington Corridor, which was home to 13 major airports, seaports and other intermodal facilities. These facilities afforded continuity of global, national and regional cargo distribution, and conduced to the articulation role in their territories. The two major airports in the New York area were found to be especially crucial in processing a large percentage of cargo (Rodrigue 2003). In a similar study, Shen, Rankin and Lee (2016) analysed the concept of multi-airport logistics system

(MLS), which is found in territories that accommodate several airports. MLS denotes a network established by a unified group of airports, logistics parks and free/ foreign trade zones encompassing different aspects of the air cargo industry. One form of aggregation in the MLS is spatial concentration, which augments the interconnections between logistics stakeholders located at various airports.

Discussion of the findings

From the studies presented in the preceding section, a connection can be discerned between airports and the spatial distribution of logistics facilities at different geographical scales, viz. airports and their environs, metropolitan areas, functional regions, countrywide, across national borders and even intercontinentally. This connection pertains to a number of closely related components of logistics, namely service firms, warehouse, distribution, wholesale and allied activities, and the overarching 3PLs. Further reflecting the relevance of different geographical scales (as levels of analysis), the aforesaid components of logistics are applicable to the following closely related themes or streams: international patterns of logistics facilities, airfreight catchment of airports, concentration of logistics facilities in the vicinity of airports, and metropolitan areas and regions as logistics hubs (Table 2).

Of the literature themes identified, the majority of the literature (72%) is on the description of the concentration of logistics activities in the vicinity of airports, particularly the establishments inclined to warehousing, distribution and allied activities. This concentration in part results from the sprawling of logistics activities from centrally located urban areas towards, among other suburban areas, the environs of airports, or a tendency where new firms or branches locate in the environs of airports at the first go. The theme on the concentration of logistics facilities also includes studies on another topical aspect, that is, the notion of logistics parks and/ or logistical clusters, which further cements the literature's preoccupation with the analysis of logistics facilities that are geographically proximate to airports. Relatedly, airports feature prominently as one of the variables in the methods devised and empirically employed to identify logistics clusters. The outcome of such methods is typically used by the authorities, developers and other stakeholders to motivate

TABLE 2: A summary of the literature.

Literature themes	Level of analysis			
	Airport and environs	Municipal area and functional region	Country	Multi-country
International locational patterns of logistics activities <i>n</i> = 5	-	-	-	x
Airfreight catchment of airports <i>n</i> = 7	x	x	x	x
Concentration of logistics facilities in the vicinity of airports <i>n</i> = 42	x	x	-	-
Metropolitan areas and regions as logistics hubs <i>n</i> = 4	x	x	-	-

for the establishment of logistics facilities in the vicinity of airports à la the normative models of airport-led development mentioned in the introduction.

It should however be noted that despite the propensity of airports to be the centres of the concentration of logistics facilities, there are instances where logistics parks in the environs of airports are less successful in attracting logistics establishments compared to the parks situated elsewhere. This situation raises a question on the need for logistics activities to be geographically proximate to airports despite their relationship with the airports. This may arguably be the case because the literature review has shown that the airfreight catchment is not limited to the environs of airports, implying that logistics establishments can be located at various areas within the catchment, and transport cargo to and from the airport via road and/ or other modes of transport. This is a function that is typically fulfilled by 3PL providers. The literature has provided evidence that the role of road-based movement of cargo destined for airports is even pivotal in cases where the catchment of a given airport transcends numerous countries and potentially overlaps with the catchment of other airports. In this regard, the catchment of airports is the only literature theme that is applicable to all geographical scales used in the literature review, that is, the environs of airport, metropolitan area, functional region, countrywide and across national boundaries (Table 2).

The literature also unveiled instances where particular airports act as airfreight monopolies in their respective regions, while in other cases there is some level of competition and cooperation between airports (and their associated logistics establishments) in a region. This aspect also has relevance to the notion of MLS wherein logistics establishments at various airports complement each other and cooperate towards improving the role of a metropolitan area or region as a logistics hub. In this regard, there are cases where metropolitan areas or regions thrive as logistics hubs despite the competition from other airports in the region, country and even major airports in neighbouring countries that may share the catchment. In some instances, the success of logistics hubs at a city or metropolitan scale hinges on the presence of one or a few big logistics firms (i.e. integrators and/or 3PL providers), which provide competitive advantage compared to other areas that may also aspire to be logistics hubs.

All in all, at the environs of airports to the functional region, the concentration of logistics facilities points to the possibility that the facilities benefit from agglomeration economies (based on external economies) because of the geographical proximity to airports. The findings that are applicable at countrywide scale and across international boundaries point to the possible existence of organisational clustering, which is influenced by organisational proximity (to airports and/ or related logistics establishments) as opposed to geographical proximity. This particularly pertains to the considerations of international locational patterns and the

airfreight catchment of airports, which encompass a number of regions and/ or countries.

Recommendations

Despite the insights provided by the literature as discussed in the preceding section, it is pertinent that the following interrelated aspects be considered in the future research on the interconnections between airports and the geographical distribution of logistics facilities:

1. The literature does not explicitly make a distinction between airfreight facilities and logistics facilities, in general; hence the article focused on the patterns of logistics facilities in a broad sense relative to airports. This lack of focused attention is unexpected given the role of airfreight in contemporary economies amid the growing e-commerce activities. To improve the understanding of the geographical aspects of air cargo, future studies should empirically identify airfreight facilities. This would among others be based on the airport relatedness of the facilities analysed.
2. Although the majority of the literature focuses on the description of the location of logistics facilities in the environs of airports, only a few studies delve into analysing factors that influence the location of such establishments. This gap can be explained by the fact that the focus of a number of studies is not on airports per se; they rather have airports and/ or surrounds as part of the variables investigated.
3. It is not clear-cut from the literature whether agglomeration economies drive the location of logistics facilities in the vicinity of airports or whether the location of such facilities is, for instance, simply a service sector response. This uncertainty is also in part reflected in situations where service firms and other logistics facilities locate in the environs of decommissioned airports.
4. Little is known about the catchment of airports with regard to the distribution and flow of airfreight. Further research is thus required on the locational patterns of logistics facilities beyond airports and their immediate surrounds, including the subject of metropolitan areas and regions as logistics hubs. The importance of this theme is reflected by the fact that airfreight catchment is the only focus that transcends all geographical scales, from the environs of airports to cross-border interactions.
5. In terms of logistics sprawl from relatively central areas towards outlying areas (including airports and their environs), it is not clear whether logistics facilities move because of the relationship with (or dependence on) the airport infrastructure or whether they move because of other push and/ or pull factors. Such factors could include negative externalities (e.g. traffic congestion in central areas), the availability of land in the environs of airports, and low land values or land cost in the vicinity of airports compared to centrally located areas. In part pointing to the possibility of some logistics facilities being attracted by other factors, some studies discovered the presence of logistics activities around disused or decommissioned airports, which might reflect land

availability as a pull factor. It would also be insightful to explore the relocation of logistics facilities from the environs of airports, which are in their own right significant nodes in towns, cities and regions.

6. Large cargo specialist firms (integrators and 3PL providers) do not serve all airports, and accordingly not all metropolitan areas have such firms. It is, however, not clear whether the need for associated facilities to locate in the vicinity of airports is nullified by the operations of 3PL firms, which can use road-based mode of transport to collect and deliver shipments regardless of the location of warehousing and allied facilities.

Conclusion

Following the use of snowballing method and the Internet search of Academic Search Premier and Google Scholar databases, the article reviewed 58 studies on the geographical or locational patterns of logistics facilities relative to airports. Specifically, the article intended to establish the typology of literature on the geography of logistics facilities relative to airports, and thereafter identify knowledge gaps that require more attention on the topic. The literature was grouped into a number of related themes, namely (1) international patterns of logistics facilities, (2) airfreight catchment of airports, (3) concentration of logistics facilities in the vicinity of airports, and (4) metropolitan areas and regions as logistics hubs. These themes of literature, which transcend different geographical scales, show that contrary to a popular assertion of some models of airport-led development, logistics facilities (or other economic activities that are presumed to be linked to airports) do not necessarily have to be located in the immediate vicinity of airports. Informed by the synthesis and discussion of literature, it was noted that further empirical research is required to comprehensively understand the locational patterns of logistics facilities relative to airports. One of the areas that require attention is the identification of airfreight-related logistics facilities from logistics facilities, in general, followed by the analysis of the airfreight catchment of airports. The improved understanding of the catchment would be used by the authorities, managers of logistics companies and other stakeholders to inform decision-making processes pertaining to the location of logistics facilities, in general, and specifically the location of airport-related logistics facilities. This analysis would set the scene for other research on the topic.

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The author declared that no competing interest exists.

Author's contributions

The author conceptualised and drafted the manuscript.

Ethical considerations

This study followed all ethical standards for research without direct contact with human or animal subjects.

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Data availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Disclaimer

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