

Article

The Role of the Top 50 US Cargo Airports and 25 Air Cargo Airlines in the Logistics of E-Commerce Companies

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Abstract: *Background:* The purpose of this study is to analyse the role of the main 50 US cargo airports and 25 air cargo airlines in the logistics of e-commerce companies from 2000 to 2020, to highlight the importance of airports in the logistics and e-commerce industries. *Methods:* A review of the relevant literature on airports, air cargo carriers, logistics, and e-commerce sectors was undertaken to understand the link between them. The data were collected using four criteria: airport category, airport location, top 25 air cargo carriers, and other relevant data from the Federal Aviation Administration, International Air Transport Association, Organization for Economic Co-operation and Development, US Department of Transportation, amongst many others. *Results:* The findings reveal that there is a consolidated relationship between airports, air cargo airlines, and e-commerce, which has been especially evident during the COVID-19 pandemic. Airports and air cargo carriers are identified as the most relevant partners in the e-commerce industry. This is because of the e-commerce sector and its users' demand for speed and reliability in the interaction between the demand for and supply of products and services. *Conclusions:* The pandemic has changed the way in which organizations operate and is likely to create new demand from companies and users in the aviation and e-commerce industries. E-commerce companies are highly dependent on the quality and efficiency of air cargo airlines and airports because they need to provide a good shipping service for their products to customers.

Keywords: airport; air cargo airlines; logistics; location; connectivity; e-commerce companies; airport reputation; retail; distribution



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1. Introduction

While many studies and organizations saw darkness in the COVID-19 pandemic period, this study shows how the pandemic crisis brought new challenges and opportunities to the aviation and e-commerce sectors. Airports encourage the establishment of companies in cities. They also play an important role in tourism, air cargo, the logistical development of companies around the airport, and global, regional, and local economies [1,2]. The development of e-commerce has promoted growing demand for air cargo around the world [3–6]. In 2019, e-commerce represented 15% of air cargo [7]. Airlines, forwarders, integrators, and airports are trying to increase their share in this growing market, and all of them are developing strategies to attract as many e-commerce activities as possible [8]. Indeed, the pandemic has highlighted the relevance of airports and the air cargo industry to e-commerce organizations and consumers. As stated by Leung et al., [9] it is necessary to provide a virtual market for agents of the air cargo industry, enabling them to develop and engage in logistics integration, with the aim of improving aviation logistics performance [10]. Collaboration between organizations relies on the development of appropriate performance measurement systems.

According to the Organization for Economic Co-operation and Development (OECD), the pandemic crisis has enhanced dynamism in the e-commerce landscape across countries and has expanded the scope of e-commerce worldwide [11]. It also indicates how e-commerce transactions by individuals in many countries have increased in essential goods

and services. Air cargo is an integral part of most passenger airline operations, although not in the case of low-cost airlines [12]. Further research in this regard is needed, which may assist stakeholders in global air cargo markets and international supply chains [13], where there is plenty of evidence that air transport creates opportunities as well as risks [14].

The ubiquitous pattern of online consumer purchases followed by the dispatch of products and services is revolutionizing the way in which airports, air cargo firms, and logistics industries are operating logistically. There is thus an opportunity for transformation in the symbiotic business relationship between the air cargo industry and e-commerce. According to the International Air Transport Association (IATA), 52% of consumers increased their online spending during the COVID-19 crisis. Air cargo is the most suitable means to deal with for this logistical challenge in distance–time terms [7]. Electronic forms of communication play a complementary role in the transport and infrastructure system, and show positive externalities like a high speed of accessibility and information, especially in peripheral areas. As regards negative externalities, an immediate effect is strong competition among the networks of transport modalities and worldwide pollution phenomena [15,16]. Airports' management must integrate the commercial perspective, since commercial income is a significant source of financing capabilities [17].

Baltazar et al. [18] revealed that airports create value in economic and social terms where these are operating. Notwithstanding, existing evidence of the economic effects of airports is limited, due in part to the difficulties inherent in measuring the effects [19]. A critical literature review is necessary to evaluate the impact of airports on the e-commerce industry. Many studies have been conducted to examine the direct effects of airports on the logistics of e-commerce companies' development; however, there is little solid evidence on spatial spillover effects, and much less in the context of airport systems and the business knowledge of air cargo logistics [10,20]. To fill this gap, the main challenge of this study is to analyze the role of the main 50 US cargo airports (see Figure 1) and air cargo airlines in the logistics of e-commerce companies from 2000 to 2020, to highlight the importance of airports in the logistics and e-commerce industries, before and during the pandemic crisis. Hence, this study uses a combination of qualitative and quantitative data from airports, air cargo firms, and e-commerce companies to tackle future issues in the business relationship between them, as well as to generate operational strategies for those who would like to manage aviation and e-commerce logistics in a more efficient and effective way.

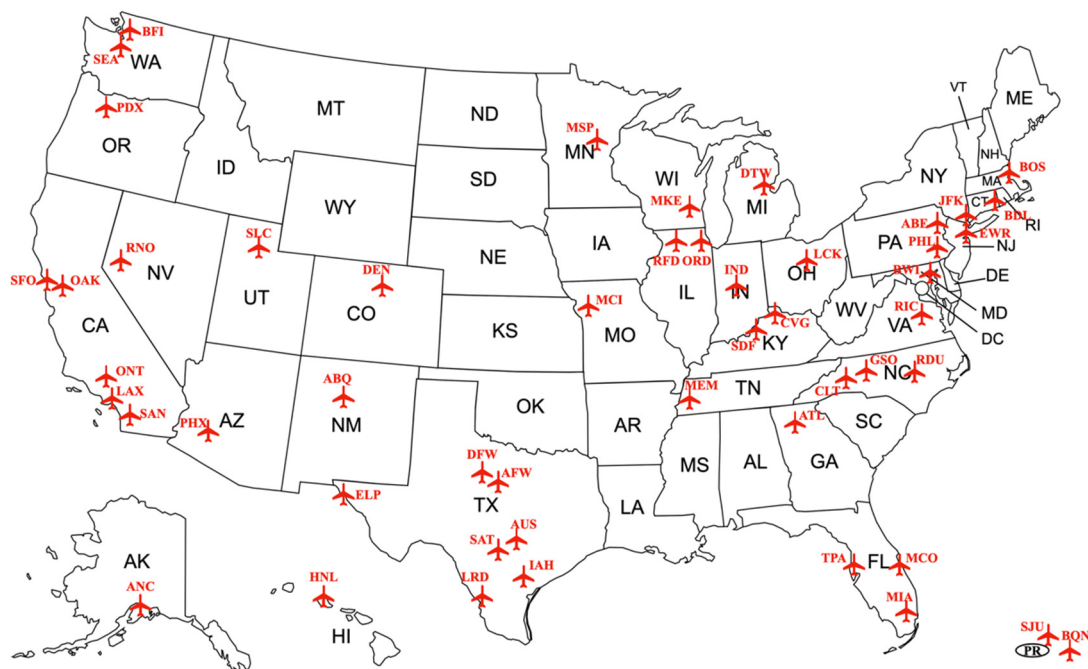


Figure 1. Location of top 50 US cargo airports analyzed in this study.

2. Literature Review

2.1. E-Commerce Companies in the Pandemic

The COVID-19 pandemic has caused significant changes in e-commerce companies like ZARA, Amazon, Ebay, TESCO, Walmart, Apple, Nike, Adidas, etc., and among users. Online firms are adapting to this new situation and firms are seeking digital solutions for their business-to-business (B2B) e-commerce challenges. Hussain et al. [21] indicate that B2B is essential for a rapidly changing business environment and increases companies' overall performance. Particularly, the Internet of Things (IoT) has created numerous opportunities and has extended supply chains; in fact, one of the outcomes of the combination of e-commerce and the IoT is the B2B spot commodity market [22,23]. For instance, Florido-Benítez [24] suggests universalizing firms' brand apps with the aim of increasing the number of users in direct contact with the firm, and promoting products and services internationally in a more immediate way. As stated by Kumar and Petersen [25], there is a direct correlation between the use of e-commerce and improved customer service. In particular, e-commerce companies have reduced response times and lower service costs, and have effectively raised customer satisfaction and the level of service that customers expect to receive. The growth in home deliveries is one of the most tangible impacts of e-commerce, as consumers switch a share of their consumption to purchases made online [26].

Considered as one of the world's most important consumer-driven economies, the United States (US) accounts for 13.6% of global imports. US consumers spent over US\$4.3 trillion on products in 2018 [27], with approximately 15% imported by air from foreign nations [28]. According to the OECD [11], in the US the share of e-commerce in total retail spiked to 16.1% between the first and second quarters of 2020. A similar development occurred in the United Kingdom, where the share of e-commerce in retail rose from 17.3% to 20.3% between the first quarter of 2018 and the first quarter of 2020, and then rose significantly to 31.3% between the first and second quarters of 2020 (see Panel A of Figure 2). The transition towards e-commerce is in direct competition with conventional retail outlets. Accordingly, Rodrigue [29] claims that significant changes in the footprint of the retail sector have taken place, which is shifting from commercially accessible locations towards transportation-accessible locations. Firms source goods and services in complex, global supply chains [30].

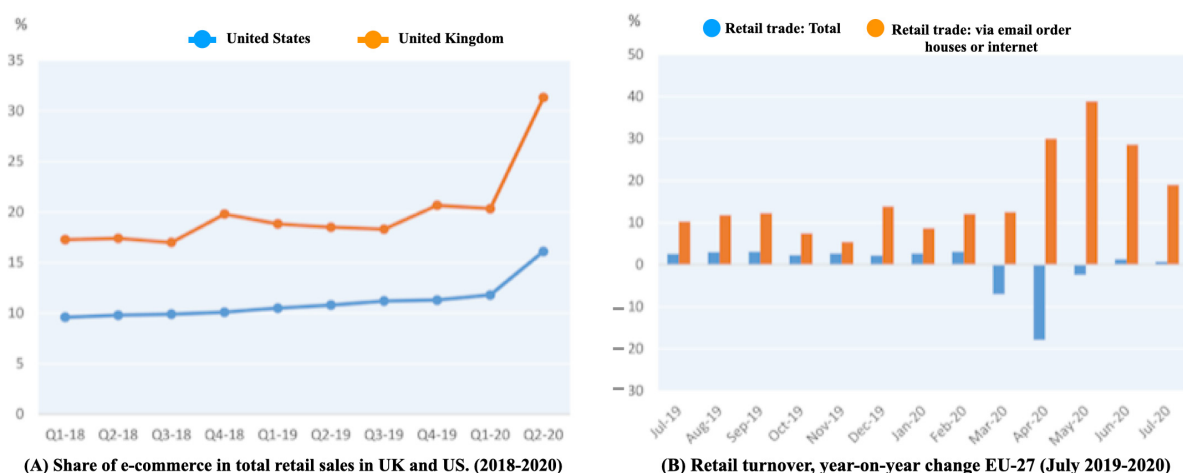


Figure 2. The increasing of e-commerce in total retail during the COVID-19 pandemic [11]. Author's own elaboration from OECD (2020).

Similar changes were also observed for the 27 European Union countries, where retail sales via mail order firms or the Internet in April 2020 increased by 30% compared with April 2019, while total retail sales diminished by 17.9% (see Panel B of Figure 2). Many authors have acknowledged how the advent of e-commerce has profoundly affected logistics

in most industrialized nations [31,32]. Jiao [33] claims that a developing e-commerce market heavily depends on logistics for the successful execution of online transactions. Thanks to the increasing globalization of world trade, the logistics industry has been reshaped by burgeoning freight demand, expanded regional markets, and enhanced transportation connections [34]. Sometimes, we must rethink the policy imperative of improving accessibility, connectivity, and mobility [35,36], because the supplier is an important resource for managing product variety and complexity [37].

2.2. Airport Location: An Added Value to Airlines and Company Logistics

From a strategic point of view, the location of airports is essential in economic and intermodal accessibility, and in tourist and air cargo terms, to negotiate with airlines seeking to make the airport more internationally accessible [38]. The location of logistics companies and warehouses is highly dependent on the proximity of airports [39,40]. Logistics systems are the conveyor belts of the global system of trade, commerce, and production [41]. Airports need to share the potential market in their catchment area with an increasing number of other airports [42]. The larger catchment area of cargo airports relies on road feeder services for the ground leg, owing to the soaring importance of e-commerce and next-day delivery [43]. A comprehensive study undertaken by Azadian [44] demonstrated that larger airports tended to attract cargo traffic away from smaller airports in their proximity. For instance, the main hubs of FedEx and UPS are localized in Memphis and Louisville respectively, because these cities provide geographically good access to the rest of the US. Hall [45] notes that the central location relative to the US population was a key factor for FedEx and UPS managers when they decided to settle on these two cities.

A market economy could not function without the capacity of transportation to link supply and demand [46]. The airport' location is used to analyze indicators such as the influence that local demand and weather have on the initial location decision of freight operators. Gardiner et al. [47] revealed that the location of an airport was the top-level factor that first attracts the attention of a freight operator, 'being that one of the main motives why airport operators are constantly on the lookout for new niche markets, with the aim of increasing revenue' [4]. A good relationship with management and interoperability in the improvement of air connectivity by airports and stakeholders provide added value for business and operability knowledge-sharing [48]. Airports are considered as particularly strategic because of the increasing importance of air transport in connecting territories [49]. On the contrary, the number of connections with other airports is not the best proxy to assess the relevance of an airport in the air cargo transport network [43,50]. However, airports need to act beyond their daily operations by collaborating with different stakeholders who are part of the airport ecosystem and thus influence it [51].

Other relevant indicators of overall air cargo volumes for most airports are the size and scope of the local origin–destination market. This is because freight operators choose airports that will yield more cargo to make better use of their fleet capacity [52,53], and local demand. In fact, air cargo transport is subject to unpredictable changes in expected demand, necessitating adjustments to itinerary planning to recover from such disruptions [47,54–57], and operational availability. For example, the weather record of an airport is very important for cargo operators, as shipments tend to be time-sensitive, with the carriers having to offer a reliable and efficient service, often at night. The unique feature of overnight air transportation is the requirement that all shipments be completed within a limited time-frame [12]. Moreover, the relevance of 24/7 operations for cargo activities [4,48,58,59] must be taken into account. Freight movements are an increasingly important determinant of warehouse and distribution space demand. In particular, the rising use of marine container terminals in the global movement of goods is a major contributor to demand in the US [60]. The importance of ports as critical nodes in global transport networks and supply chains has been researched in multiple disciplines [61,62].

Nevertheless, Larrodé et al. [59] found that the growth of air cargo logistics at airports was influenced by many factors like the presence of logistics operators inside and outside

of airports, airports charges, and competition between cargo airlines. Another factor to consider is sales tax in the US. States with low sales taxes or small customer bases are especially attractive locations for e-retail logistics [63]. For instance, in the state of California, combined shipping and handling charges are generally taxable, while charges for electronic delivery are generally exempt [64], or the tax rate applied to user's order will be the combined state and local rates of the address to which the user's order is delivered, or from where it is fulfilled [65]. IATA and the International Civil Aviation Organization (ICAO) are concerned with the problems faced by international airlines in relation to taxation on income imposed by States in which they operate other than their own fiscal domicile [66]. Figure 3 shows the main factors in air cargo logistics according to the literature review, with the aim of increasing its attractiveness at cargo airports. Durach et al. [67] argue that the effectiveness of a review type depends on the prior state of theory, which ranges from nascent, to intermediate, to mature.

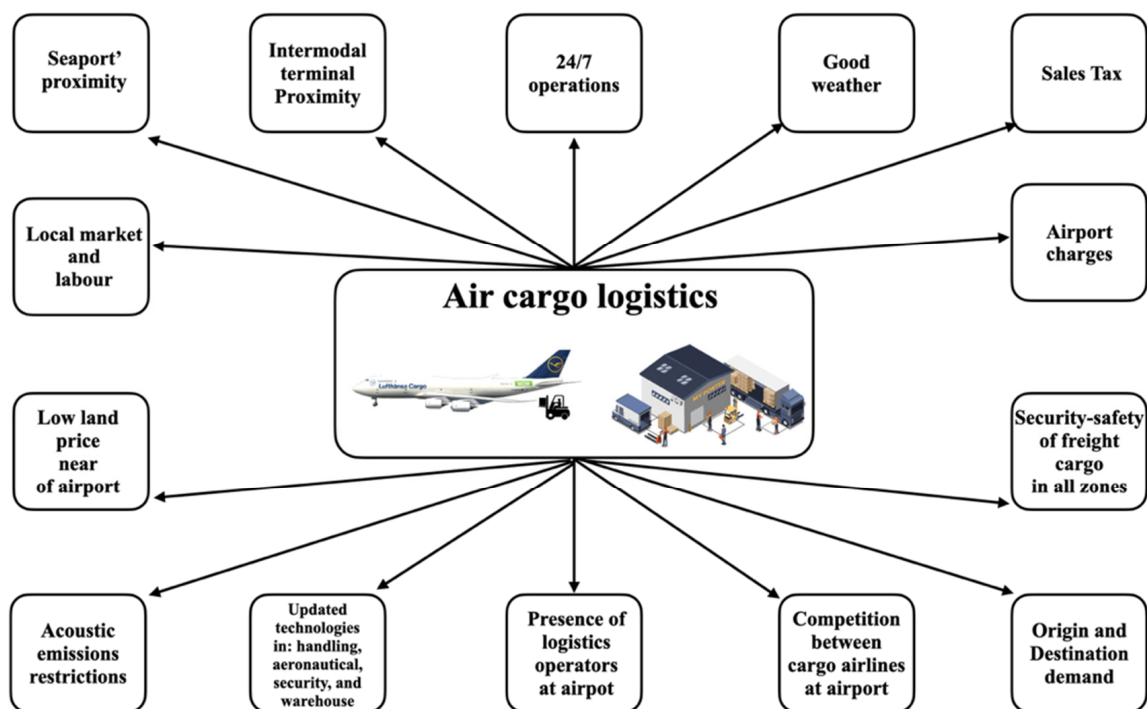


Figure 3. The main factors in the growth of air cargo logistics. Source. Own elaboration.

Kang [68] examined the location choices of warehousing facilities in Los Angeles (US), and found that the most influential factors were local market, labour, the proximity of seaports, lower land price and airport charges, and intermodal terminal proximity. The location of warehouses, as part of supply chains, are strategically chosen based on productivity-enhancing location attributes [69,70]. The organization of modern economies is built upon an efficient transport system and the logistics sector plays an important role in time and distance terms in supply chains [71].

Distribution refers to the steps involved in the transportation and storage of goods, from supplier to customer in a supply chain [72,73]. A supply chain is a network of suppliers, manufacturers, warehouses, and retailers intended to minimize total cost and satisfy service level requirements by producing and distributing the right quantity of goods at the right time [74]. The performance of a supply chain deeply relies on the efficient management of logistics decisions and operations [75,76]. Based on a review of the previous literature, Figure 4 presents the e-commerce process from consumer to parcel delivery. The pandemic and the relevant precautionary measures to limit its spread had clear implications for the aviation, e-commerce, and logistics sectors. For example, manufacturing industries show a preference for all-cargo carriers [44].

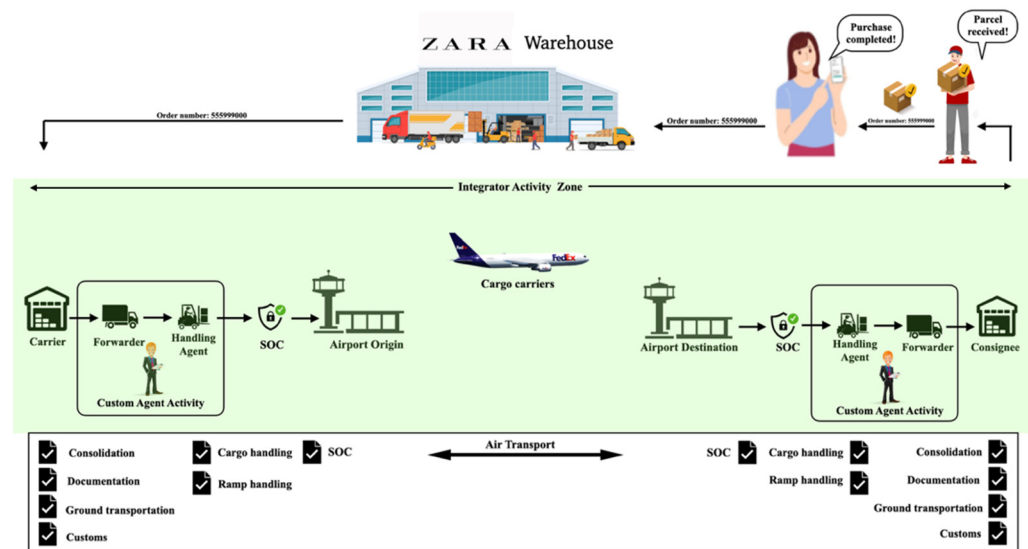


Figure 4. E-commerce process from consumer to parcel delivery. Source: Author's own elaboration.

Regarding safety and security at airports, the security and safety departments of airports are designing strategic cybersecurity plans and implementing Security Operations Centres (SOC) to guarantee all the air and land operations of their airports, and the safety of all passengers [77]. Moreover, Florido-Benítez [77] detected an interoperability deficit between public and private organizations. Cybersecurity protocols facilitate the internationalization of large companies. Among the many decisions involved in internationalization of companies, one of the first is the choice of airport location. 'Managing international operations is a critical component of many firms' strategy nowadays' [78]. In order to optimize air cargo connectivity, supporting operations are needed like e-freight implementation, airport facilitation, airline activities, and ramp operations, as well as the enhanced optimal use of airport and airline operations [79]. Airports, trucking, rail, and supporting logistics facilities contribute to improving a country's logistics systems [80].

2.3. Cargo Airline Connectivity Improves E-Commerce Companies' Dispatch Services

Improved air connectivity is a significant component of economic growth and development through air cargo transport [79], as the goal is to achieve a distributional hierarchy of facilities to access consumer markets. Indeed, Boonekamp and Burghouwt [81] claim that a few studies have addressed connectivity in air freight networks. The air cargo industry consists of time-sensitive air express couriers and time-insensitive airlines. Federal Express, UPS, and DHL are the top three global air express delivery couriers [55]. The airline's core physical products are in-flight products, the customer service infrastructure in the airport, and the destinations in a route network, and these cannot be digitized [82]. The relationship between sector distance and unit costs is one of the fundamental rules of airline economics [12]. One of the key strengths of air cargo carriers is the transport of perishable products around the world, in distance-time terms [13,83,84]. Synchronizing and optimizing cargo traffic flows during the planned period on the airline network is vital for cargo carriers to make a profit [85]. Full-service carriers tend to localize in airport hubs, to distinguish their brand image by providing more connectivity and frequency, and premium in-flight services [86].

High frequencies provide airlines with greater flexibility in planning schedules, thereby enabling them to increase aircraft and crew utilization [12]. A shipper is concerned that the shipment arrives at destination within the expected time [87]. For instance, procurement and fulfilment requires multiple steps, so Amazon's e-commerce platform has the capability to offer goods as a function of stochastic demand [29]. According to Jindal et al. [88], delivering on a 'promised' date is as effective as, if not better than, quicker delivery. Moreover, these authors showed that, in the omnichannel battle between Amazon

and Walmart in the US, the home delivery of online orders placed at Amazon.com seemed to be preferred by customers, who placed high importance on assortment, price, convenience, freshness, and quality validation of products and services, as well as on purchase experience, customer service, and product delivery. As stated by Suwanwong et al. [79], the aviation sector needs to improve competitiveness and to provide customers with enriched shipping quality and service, and better predictability.

In the NetScan connectivity model of air freight, the most relevant network characteristics of a single connection are frequency, transport time, and connecting time, all of which are brought together into a single indicator: the connectivity index. This indicator expresses the connectivity of an airport (see Figure 5) and to what extent an airport connects the local market to the rest of the world, directly or indirectly, as well as the extent to which different world regions are connected via hub connectivity [81,89]. In this study, we added subsidiary connectivity as a new factor to improve organizations (e.g., forwarders, integrators, cargo airlines, airports, online companies, amongst many others) in their operational processes, business performance, customer experience, and safety and security. For example, Brussels airport (BRU) in Belgium has launched a new consultancy subsidiary, Airport Intelligence, to share its operational and commercial expertise with other companies globally [90], or the international connectivity enlargement and infrastructures of regional airports, with the aim of ensuring sufficient capacity to meet the expected growth of air freight by local and regional territories.

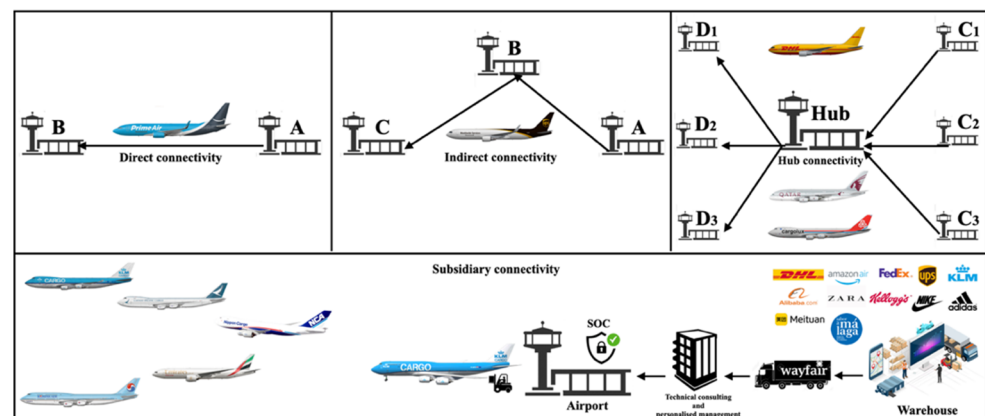


Figure 5. The choice of Cargo airport connectivity category by freight forwarders and online companies. Source: Author's own elaboration.

3. Methods

3.1. Data Collection

This research focuses on the role of the top 50 US cargo airports and air cargo airlines, and how they interact with the logistics and e-commerce sectors. This study uses direct content analysis to identify and analyse airports' and cargo airlines' impact on e-commerce companies, with the aim of improving operational strategies for those who would like to manage airports, cargo airlines, and e-commerce logistics in a more efficient and effective way. In the literature review, this study has shown some factors that may increase the competitive advantage of airports to host e-commerce operations. In addition, this research suggests that the improvement of air connectivity is a relevant factor of e-commerce growth and development through air cargo transportation. From a strategic point of view, the methodology of this research tries to analyse the commercial relationship amongst actors involved in the air cargo, logistics, and e-commerce sectors, to get a better global vision of their operability, and recognize the importance of these sectors for their country's socio-economic development, and for consumers.

When airports and airlines operators share their information, it is good for the aviation industry. Tracking differences and fluctuations in data helps the industry recognize what

drives changes in their management processes and business activities. Wong et al. [91] claim that collaboration and resources orchestration can be more effective when process integration and information systems are in place to facilitate the exchange of information (knowledge) and tracking of activity performance. The benchmarking of airports has gained considerable interest in both the academic literature and within the practitioner community [92]. The 50 US airports selected for this research were chosen from a database provided by the Federal Aviation Administration (FAA). We collected US airport data from 2000 to 2020 because data from 2021 was not available. Indeed, we decided to rely on the most recent and best dataset available. Data were collected on the basis of four criteria:

1. **Airport category:** Airports were selected according to their categories. US law categorizes airports by type of activities, including commercial service, primary, cargo service, reliever, and general aviation [93]. Table 1 shows the category of the top 50 US cargo airports selected in this study. Airport categorizations offer a basis to derive representative scenarios for air-traffic-related simulation purposes [94] and competitive advantage that are related to passenger and cargo activities like spatial and facility factors [95,96]. Kazda et al. [97] suggest a five-parameter classification: geography of the airport, size/capacity of the airport, airport territory, connectivity, ownership, and participation in an airport network. The choice of an airport for freight forwarders depends on the type of air freight: local cargo, gateway cargo, or hub cargo. Local cargo includes shipments to or from the local market, whereas gateway cargo is shipments transported to the respective airport from another area by other modes of transport. Hub cargo is transshipped air-to-air cargo [98]. Moreover, the overall proportion of total freight tons carried by 50 airports (2000–2020) is shown in Table 2, and Figure 6 displays the evolution of total freight tons carried in % by 50 airports.
2. **Airport location:** The proximity of the airport to distribution facilities and smaller airports at a distance from major metropolitan areas are part of vertical integration between airports and cargo airlines. In Figure 1 the location map of 50 US airports is shown. Mueller and Aravazhi [99] found that the geographical location of an airport was a driver of an airport's connectivity. Highly accessible airports are more competitive [96]. Table 2 displays the location of the top 50 US cargo airports by state, with each airport category according to FAA, and cargo airlines that operate at the 50 airports selected for this study. Specifically, we show characteristics linked to airport location and total freight of major tenants in landed weight terms from 2000 to 2020. The latest available data was extracted from the FAA, which represented a bonanza period when the aviation industry reported positive operating profits for the first time since the effects of the 2008 recession.
3. **Top 25 cargo airlines:** The data showed in the cargo and freight traffic ranking were collected from the IATA, FAA, and US Department of Transportation [100]. These are shown in Table 3. These data present the total scheduled traffic (domestic + international), excluding no scheduled or charter traffic that did not have pre-established schedules according to the IATA [101]. The US air cargo industry is among the most developed air cargo industries in the world [102], meaning it heavily influences the growth in or reduction of global air cargo [103]. Some cargo airlines are opening new markets and routes to new hubs and cities [104,105]. We focused on the top 25 air cargo airlines because they operate in the 50 US airports analysed in this research, and these are part of the value chain of US airports.
4. **Other data relevant to the study:** E-commerce retail in the US, UK, and EU-27, global air cargo, global goods growth, air cargo rates and revenues, the main cargo airlines operating in the US, US air cargo revenue, the global increase in cargo demand, amongst many other data from the US and worldwide were included, drawn from the Bureau of Transportation Statistics, Aircargo News, FAA, IATA, the US Department of Transportation, Airport Technology, Bureau of Economic Advice, OECD, and United States Census Bureau organizations, with the aim of giving readers a

global vision of the aviation industry and e-commerce sectors. As stated by Lam and Mckercher [106], having relevant and high-quality market information is critical in today's competitive environment. In the air logistics industry, data are an important indicator to manage the operations of the company because these help with quick response operations [107].

Table 1. Airport category.

Primary Airport Category	By Passengers	50 US Airports Analysed
Large hub (L)	6,610,695 or greater	24
Medium hub (M)	6,610,694–1,652,674	13
Small hub (S)	1,652,674–330,534	6
Non-hub (N)	330,534–10,001	6
Not categorized	–	1
Total airports		50

Source: Author's own elaboration from FAA [93]. AFW airport is not categorized by the FAA, and this airport is number 50.

Table 2. Top 50 US cargo airports and cargo airline operations (2000–2020).

Rank	IATA Code	Airport Name	City	State	Category	Total Freight * (2000–2020) Major Tenants	Total % by Airport	Cargo Airlines Operations
1	MEM	Memphis International	Memphis	Tennessee (TN)	S	424,745,667,831	15.4%	DHL; FedEx; UPS; Kalitta Air; Atlas Air
2	ANC	Ted Stevens Anchorage Int.	Anchorage	Alaska (AL)	M	380,473,643,985	13.8%	FedEx; UPS; AirBridgeCargo; Air China Cargo; Alaska Air Cargo; Alaska Central Express; Amazon Air; Asiana Cargo; Atlas Air; Cargolux; Cathay Pacific Cargo; China Airlines Cargo; China Cargo Airlines; China Southern Cargo; Etihad Cargo; EVA Air Cargo; Everts Air Cargo; Kalitta Air; Korean Air Cargo; Lynden Air Cargo; National Airlines; Nippon Cargo Airlines; Northern Air Cargo; Polar Air Cargo; Qantas Freight; Singapore Airlines Cargo; Sky Lease Cargo; Suparna Airlines; TransNorthern Aviation; Western Global Airlines
3	SDF	Louisville Int.-Standiford Field	Louisville	Kentucky (KY)	S	232,730,191,418	8.5%	FedEx; UPS; Air Cargo Carriers; Ameriflight; SkyLink Express
4	MIA	Miami International	Miami	Florida (FL)	L	152,478,087,716	5.5%	Amazon Air; FedEx; UPS; DHL; ABX Air; AeroUnion; Ameriflight; Amerijet Inter; Asiana Cargo; Atlas Air; Avianca Cargo; Cargojet Airways; Cargolux; Cathay Pacific Cargo; China Airlines Cargo; Ethiopian Airlines Cargo; ibc Airways; Kalitta Air; Korean Air Cargo; LATAM Cargo; Lufthansa Cargo; Martinair; Mas Air; Northern Air Cargo; Qatar Airways Cargo; Southern Air; Transportes Aéreos Bolivianos; Turkish Airlines Cargo; Western Global Airlines

Table 2. Cont.

Rank	IATA Code	Airport Name	City	State	Category	Total Freight * (2000–2020) Major Tenants	Total % by Airport	Cargo Airlines Operations
5	LAX	Los Angeles International	Los Angeles	California (CA)	L	128,932,387,057	4.7%	DHL; FedEx; UPS; AeroUnion; AirBridgeCargo Airlines; Air China Cargo; Aloha Air Cargo; Ameriflight; Asiana Cargo; Cargolux; Cathay Pacific Cargo; China Airlines Cargo; China Cargo Airlines; China Southern Cargo; Emirates SkyCargo; EVA Air Cargo; Garuda Cargo; Kalitta Air; Korean Air Cargo; Lufthansa Cargo; Mas Air; National Airlines (N8); Nippon Cargo Airlines; Qantas Freight; Qatar Airways Cargo; SF Airlines; Singapore Airlines Cargo; Southern Air; Sky Lease Cargo; Western Global Airlines
6	ORD	Chicago O'Hare Int.	Chicago	Illinois (IL)	L	121,757,716,800	4.4%	DHL; FedEx; UPS; AeroUnion; AirBridge Airlines; Air China Cargo; Air France Cargo; ANA Cargo; Asiana Cargo; ASL Airlines Belgium; Atlas Air; Cargolux; Cathay Pacific Cargo; China Airlines Cargo; China Cargo Airlines; China Southern Cargo; Emirates Sky Cargo; EVA Air Cargo; Garuda Cargo; Korean Air Cargo; LATAM Cargo; LOT Polish Airlines; Lufthansa Cargo; Nippon Cargo Airlines; Qantas Freight; Qatar Airways Cargo; Qantas Freight; Silk Way Airlines; Singapore Airlines Cargo; Suparna Airlines; Turkish Cargo;
7	IND	Indianapolis Int.	Indianapolis	Indiana (IN)	M	108,406,986,021	3.9%	Cargolux; FedEx
8	JFK	John F Kennedy Int.	New York	New York (NY)	L	88,967,841,311	3.2%	Amazon Air; DHL; UPS; FedEx; Cargolux; Air China Cargo; Asiana Airlines Cargo; ASL Airlines Belgium; Atlas Air; AeroUnion; CAL Cargo Air Lines; Cathay Pacific Cargo; China Airlines Cargo; EL Al Cargo; Emirates Sky Cargo; Garuda Cargo; Kalitta Air; Korean Air Cargo; Longtail Aviation; Lufthansa Cargo; Nippon Cargo Airlines; Qantas Freight; Qatar Airways Cargo; Royal Jordanian Cargo; Saudia Cargo; SF Airlines; SkyLink Express; Turkish Airlines Cargo;

Table 2. Cont.

Rank	IATA Code	Airport Name	City	State	Category	Total Freight * (2000–2020) Major Tenants	Total % by Airport	Cargo Airlines Operations
9	DFW	Dallas/Fort Worth Int.	Fort Worth	Texas (TX)	L	71,912,449,789	2.6%	Amazon Air; Cargolux; DHL; FedEx; Aerologic; AirBridgeCargo; Ameriflight; Amerijet Inter.; Asiana Cargo; ASL Airlines Belgium; Avianca Cargo; Cargojet; Cathay Pacific Cargo; China Airlines Cargo; Empire Airlines; EVA Air Cargo; FedEx Cargo; Korean Air Cargo; Lufthansa Cargo; Martinaire; Nippon Cargo Airlines; Qantas Freight; Qatar Airways Cargo; Silk Way West Airlines; Singapore Airlines Cargo; UPS
10	OAK	Metropolitan Oakland Int.	Oakland	California (CA)	M	68,268,815,332	2.5%	FedEx; UPS
11	EWR	Newark Liberty Int.	Newark	New Jersey (NJ)	L	67,373,588,544	2.4%	FedEx; UPS; DHL; Cargojet; Ameriflight; Emirates SkyCargo; Kalitta Air; Northern Air Cargo
12	CVG	Cincinnati/Northern Kentucky Inte.	Covington/Cincinnati	Kentucky (KY)	M	65,686,578,833	2.4%	Amazon Air; FedEx; DHL; AirBridgeCargo; Cargojet; Castle Aviation
13	ONT	Ontario International	Ontario	California (CA)	M	62,965,075,350	2.3%	Amazon Air; FedEx; UPS; Aloha Air Cargo; Alpine Air Express; Ameriflight; Amerijet Inter. Asia Pacific Airlines; Kalitta Air
14	ATL	The William B Hartsfield Atlanta Inter.	Atlanta	Georgia (GA)	L	51,987,094,886	1.9%	Amazon Air; Cargolux; DHL; FedEx; UPS; Aerologic; Asiana Cargo; AirBridgeCargo; ASL Airlines Belgium; CAL Cargo Air Lines; Cathay Pacific Cargo; China Airlines Cargo; China Cargo Airlines; EVA Air Cargo; Garuda Cargo; Korean Air Cargo; Lufthansa Cargo; Qatar Airways Cargo; Turkish Airlines Cargo
15	PHL	Philadelphia Int.	Philadelphia	Pennsylvania (PA)	L	49,954,892,444	1.8%	FedEx; DHL; UPS; Kalitta Air; Amerijet Int.
16	HNL	Honolulu International	Honolulu	Hawaii (HI)	L	45,596,161,034	1.7%	Amazon Air; FedEx; DHL; UPS; Aloha Air Cargo; Asia Pacific Airlines; Corporate Air; Qantas Freight; Qatar Airways Cargo; Transair
17	SEA	Seattle-Tacoma International	Seattle	Washington (WA)	L	36,195,451,256	1.3%	Amazon Air; FedEx; DHL; Cargolux; AeroLogic; Ameriflight; Alaska Air Cargo; Asiana Cargo; China Airlines Cargo; China Cargo Airlines; EVA Air Cargo; Kalitta Air; Korean Air Cargo; Lufthansa Cargo; Singapore Airlines Cargo
18	PHX	Phoenix Sky Harbor International	Phoenix	Arizona (AZ)	L	33,506,400,633	1.2%	Amazon Air; DHL; FedEx; UPS; Air Cargo Carriers; Ameriflight

Table 2. Cont.

Rank	IATA Code	Airport Name	City	State	Category	Total Freight * (2000–2020) Major Tenants	Total % by Airport	Cargo Airlines Operations
19	IAH	George Bush Intercontinental	Houston	Texas (TX)	L	33,356,329,253	1.2%	Amazon Air; Cargolux; DHL; FedEx; UPS; Aerologic; AirBridgeCargo Airlines; Ameristar Air Cargo; Baron Aviation Services; CAL Cargo Air Lines; CargoLogicAir; Cathay Pacific Cargo; China Airlines Cargo; Emirates SkyCargo; Kalitta Air; Lufthansa Cargo; Martinaire; Qatar Airways Cargo; Turkish Airlines Cargo
20	SFO	San Francisco International	San Francisco	California (CA)	L	32,250,040,658	1.2%	FedEx; UPS; ABX Air; Asiana Cargo; China Airlines Cargo; DHL; EVA Air Cargo; Garuda Cargo; Kalitta Air; Korean Air Cargo; Nippon Cargo Airlines; United Airlines
21	PDX	Portland International	Portland	Oregon (OR)	L	30,111,753,077	1.1%	Amazon Air; DHL; FedEx; UPS; Ameriflight; AirNet Express; Cathay Pacific Cargo; Kalitta Air; Martinaire; Western Global Airlines
22	DEN	Denver International	Denver	Colorado (CO)	L	30,094,539,089	1.1%	Amazon Air; FedEx; DHL; UPS; AirNet Express; Bemidji Airlines; IAG Cargo; Lufthansa Cargo
23	RFD	Greater Rockford	Rockford	Illinois (IL)	N	27,902,833,570	1%	Amazon Air; Korean Air Cargo; UPS
24	MSP	Minneapolis-St Paul Inter.	Minneapolis	Minnesota (MN)	L	23,221,188,670	0.8%	Amazon Air; DHL; FedEx; UPS
25	SLC	Salt Lake City International	Salt Lake City	Utah (UT)	L	23,066,253,734	0.8%	FedEx; Alpine Air Express; Ameriflight; DHL; Northern Air Cargo; UPS
26	SJU	Luis Munoz Marin International	San Juan	Puerto Rico (PR)	M	22,096,933,102	0.8%	Amazon Air; FedEx; DHL; UPS; Cargolux; Air Cargo Carriers; Air Sunshine; Ameriflight; Amerijet Int.; Avianca Cargo; Contract Air Cargo; Northern Air Cargo; Swift Air Cargo
27	BOS	General Edward Lawrence Logan	Boston	Massachusetts (MA)	L	21,764,162,672	0.8%	Atlas Air; Ameriflight; FedEx; UPS
28	MCO	Orlando International	Orlando	Florida (FL)	L	21,039,988,261	0.8%	FedEx; DHL; UPS; Amerijet Int.; Kalitta Air
29	ABE	Lehigh Valley International	Allentown	Pennsylvania (PA)	N	19,302,491,013	0.7%	Amazon Air; Ameriflight; FedEx; Sun Country; Wiggins Airways
30	BDL	Bradley International	Windsor Locks	Connecticut (CT)	M	18,722,735,330	0.7%	Amazon Air; DHL; FedEx; UPS
31	AFW	Fort Worth Alliance	Fort Worth	Texas (TX)	N/A	18,722,401,976	0.7%	Amazon Air; FedEx
32	BFI	Boeing Field/King County Inter.	Seattle	Washington (WA)	N	16,973,802,432	0.6%	Ameriflight; SkyLink Express; UPS

Table 2. Cont.

Rank	IATA Code	Airport Name	City	State	Category	Total Freight * (2000–2020) Major Tenants	Total % by Airport	Cargo Airlines Operations
33	LCK	Rickenbacker International	Columbus	Ohio (OH)	N	16,797,694,262	0.6%	AirBridgeCargo; Cargolux; Castle Aviation; Cathay Pacific Cargo; Emirates SkyCargo; Etihad Cargo; FedEx; Kalitta Air; Korean Air Cargo; National Airlines; Qatar Airways; Turkish Airlines; UPS
34	SAT	San Antonio International	San Antonio	Texas (TX)	M	16,179,772,355	0.6%	FedEx; UPS; Ameriflight; Martinaire
35	DTW	Detroit Metropolitan Wayne County	Detroit	Michigan (MI)	L	15,325,487,072	0.6%	Atlas Air; Delta Air Lines; FedEx; UPS
36	BWI	Baltimore-Washington International	Glen Burnie	Maryland (MD)	L	13,927,999,206	0.5%	Amazon Air; FedEx; DHL; UPS; Atlas Air; Omni Air Int.
37	SAN	San Diego Int-Lindbergh Field	San Diego	California (CA)	L	13,842,462,138	0.5%	Ameriflight; ABX Air; FedEx; UPS; West Air
38	MCI	Kansas City International	Kansas City	Missouri (MO)	M	13,596,590,494	0.5%	Amazon Air; FedEx; DHL; UPS
39	ABQ	Albuquerque International Sunport	Albuquerque	New Mexico (NM)	M	12,615,211,344	0.5%	Ameriflight; FedEx; Empire Airlines; UPS
40	CLT	Charlotte/Douglas International	Charlotte	North Carolina (NC)	L	12,364,339,769	0.4%	Amazon Air; FedEx; UPS
41	AUS	Austin-Bergstrom International	Austin	Texas (TX)	M	12,327,696,425	0.4%	DHL; FedEx; UPS
42	GSO	Piedmont Triad International	Greensboro	North Carolina (NC)	S	12,073,205,274	0.4%	Aeronaves TSM; Aloha Air Cargo; Asia Pacific Airlines; DHL; FedEx; Quest Diagnostics Aviation; IAero Airways; UPS
43	BQN	Rafael Hernandez	Aguadilla	Puerto Rico (PR)	N	11,930,959,286	0.4%	Air Cargo Carriers; Ameriflight; Contract Air Cargo; FedEx; Emirates Sky Cargo
44	ELP	El Paso International	El Paso	Texas (TX)	S	11,555,867,562	0.4%	Amerijet Int.; DHL; FedEx; UPS
45	MKE	General Mitchell International	Milwaukee	Wisconsin (WI)	M	11,474,073,709	0.4%	AirNet Express; Berry Aviation; DHL; FedEx; Freight Runners Express; Martinaire; Royal Air Freight; UPS
46	TPA	Tampa International	Tampa	Florida (FL)	L	11,385,249,288	0.4%	Amazon Air; FedEx; UPS
47	RDU	Raleigh-Durham International	Raleigh	North Carolina (NC)	M	10,571,858,302	0.4%	FedEx; Quest Diagnostics; UPS
48	RNO	Reno/Tahoe International	Reno	Nevada (NV)	S	9,570,619,881	0.3%	Ameriflight.; DHL; FedEx; UPS
49	RIC	Richmond International	Highland Springs	Virginia (VA)	S	9,163,140,552	0.3%	Amazon Air; DHL; FedEx; UPS

Table 2. Cont.

Rank	IATA Code	Airport Name	City	State	Category	Total Freight * (2000–2020) Major Tenants	Total % by Airport	Cargo Airlines Operations
50	LRD	Laredo International	Laredo	Texas (TX)	N	8,409,472,112	0.3%	ABX Air; Aeronaves TSM; Ameristar Air Cargo; FedEx; Martinaire; UPS
Total Freight Tons (million)						2,753,676,182,108	100%	

Source: Author's own elaboration from FAA [108,109], and IATA [101]. * The total freight includes 'landed weight', which refers to the weight of aircraft transporting only cargo in intrastate, interstate, and foreign air transportation.

Table 3. Top 25 cargo airlines worldwide from 2020 to 2014 (Scheduled Cargo Tonne Km 'CTK' terms, and International + Domestic flight), and Year-on-Year (YoY).

Rank	Up/ Down	Airline Name	2020	YoY%	2019	YoY%	2018	YoY%	2017	YoY%	2016	YoY%	2015	YoY%	2014
1	0	Federal Express 'FedEx'	19,656	12.3%	17,503	0.0%	17,499	3.8%	16,581	7.2%	15,712	−0.6%	15,799	−1.4%	16,020
2	+1	United Parcel Service 'UPS'	14,371	11.9%	12,842	3.1%	12,459	4.3%	11,940	6.0%	11,264	4.2%	10,807	−1.2%	10,936
3	−1	Qatar Airways	13,740	5.5%	13,024	2.6%	12,695	15.4%	10,999	19.3%	9221	20.4%	7660	27.7%	5997
4	0	Emirates	9569	−20.6%	12,052	−5.2%	12,713	0.0%	12,715	3.6%	12,270	4.2%	12,157	8.2%	11,240
5	0	Cathay Pacific Airways	8137	−25.6%	10,930	−3.1%	11,284	5.2%	10,722	7.8%	9947	0.1%	9935	5.0%	9464
6	0	Korean Air	8104	9.3%	7412	−5.5%	7839	−2.2%	8015	4.5%	7666	−1.2%	7761	−3.9%	8079
7	+1	Cargolux	7345	2.3%	7180	−1.9%	7322	0.1%	7317	−0.9%	6878	9.0%	6309	9.7%	5753
8	+1	Turkish Airlines	6977	−0.7%	7029	19.3%	5890	24.6%	4728	29.9%	3640	N/A	N/A	N/A	2580
9	+1	China Southern Airlines	6591	−3.4%	6825	3.5%	6597	6.9%	6174	4.0%	5939	10.9%	5355	13.1%	4736
10	0	China Airlines	6317	18.4%	5334	−8.1%	5804	1.1%	5741	8.9%	5273	−1.3%	5343	1.5%	5266
11	0	Air China	6121	−9.5%	6767	−4.0%	7051	5.2%	6701	10.0%	6089	6.5%	5718	16.5%	4910
12	+4	Atlas Air (4)	5458	20.7%	4522	−0.7%	4553	0.8%	4515	N/A	N/A	N/A	N/A	N/A	N/A
13	+10	Kalitta Air (4)	5211	45.0%	3593	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14	+10	Aerologic (2)	4870	36.0%	3581	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	−8	Lufthansa (1)	4828	−33.2%	7226	−2.3%	7394	1.0%	7322	6.4%	7384	7.2%	6888	−2.4%	7054
16	−2	AirBridgeCargo Airlines	4609	−10.8%	5168	−6.2%	5511	−0.6%	5543	12.8%	4914	20.8%	4069	25.3%	3248
17	−5	Singapore Airlines	4156	−32.4%	6146	−5.3%	6491	−1.5%	6592	3.9%	6345	4.3%	6083	1.1%	6019
18	−3	United Airlines	3950	−18.6%	4852	8.9%	4455	4.8%	4249	20.2%	3534	10.2%	3206	4.3%	3073
19	0	EVA Air	3888	N/A	N/A	N/A	3580	N/A	3609	3.7%	3480	−7.4%	3757	−6.2%	4007
20	−5	Asiana Airlines	3601	0.9%	3567	−12.3%	4067	1.5%	4008	5.1%	3813	6.1%	3595	−2.7%	3693
21	−2	Polar Air Cargo (4)	3478	−8.7%	3809	−5.7%	4038	−7.8%	4378	4.0%	4211	0.6%	4186	32.8%	3153
22	New	Ethiopian Airlines	3394	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23	−6	All Nippon Airways (1)	3172	−27.7%	4389	−4.3%	4587	−4.6%	4810	11.5%	4315	12.4%	3840	−0.2%	3847
24	−2	KLM (1)	3025	−16.2%	3609	0.1%	3604	0.0%	3603	1.1%	3564	−0.1%	3567	−0.7%	3592
25	New	Silk Way West Airlines	2876	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Annual Top 25 total			163,444	−3.3%	108,971	−1.0%	170,670	2.3%	150,262	6.8%	135,459	4.3%	126,035	5.1%	122,667

Source: Author's own elaboration from IATA [101]. Notes: (1) All operations considered as scheduled traffic; (2) US Department of Transportation (DOT); (3) IATA estimate; (4) Includes operations of Lufthansa CityLine, Lufthansa-marketed operations by Air Dolomiti, Eurowings, and Germanwings airlines; (5) Includes operations of ANA Wings and Air Japan airlines; (6) Includes operations of KLM CityHopper. (N/A) Not available. Moreover, Table 2 shows the Top 25 cargo airlines between 2020 and 2018. From 2017 to 2004, British Airways, Air France, American Airlines and Etihad Airways cargo airlines were also included.

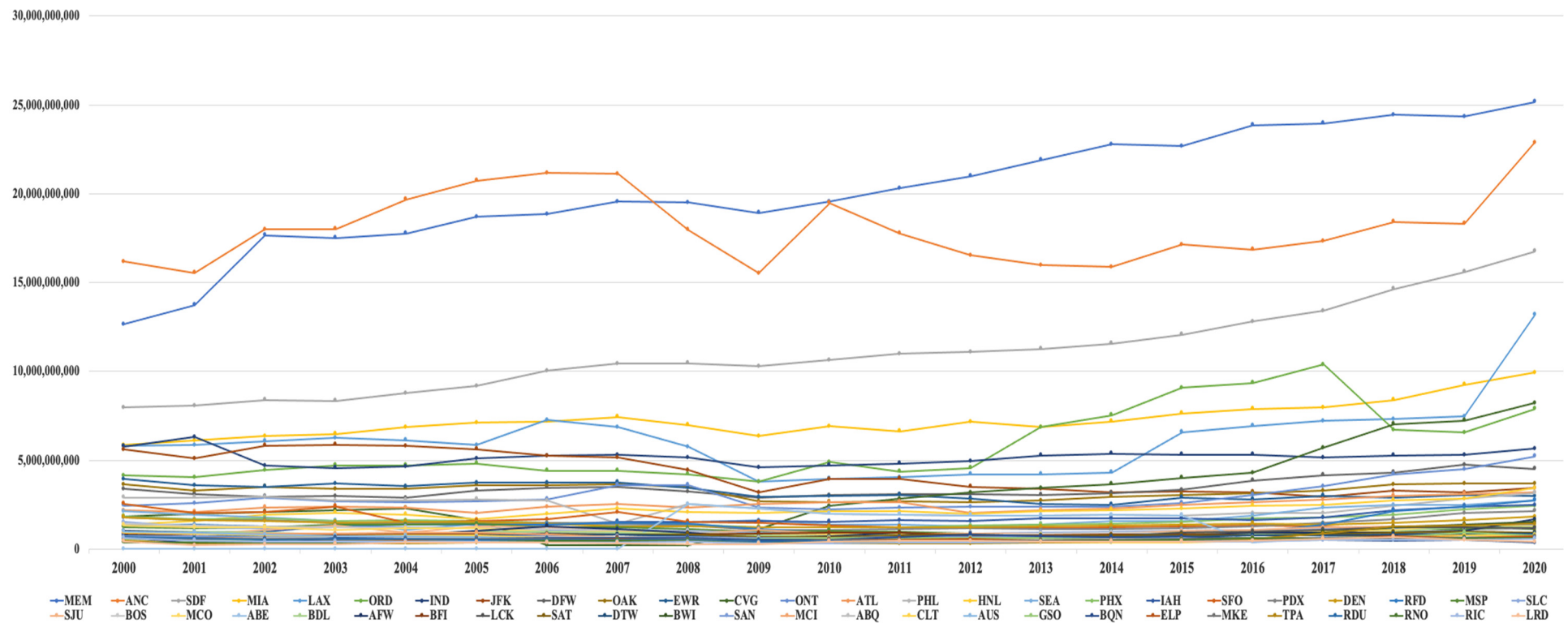


Figure 6. Freight tons carried (million) by 50 airports from 2000 to 2020. Source: Author's own elaboration from FAA [108]. Lehigh Valley International (ABE) airport, data not available from 2000 to 2007.

3.2. Data Analysis

3.2.1. Airports and E-Commerce: A Long-Term Commercial Relationship

Data analysis involved data checks and the placing of each airport in a category. These were then analysed and quantified by freight tons carried. Table 1 provides the category of the 50 US cargo airports selected in this study, that is, the top 50 cargo airports in the US. Initially, 24 hub airports were categorized in this paper, followed by 13 medium airports, six small airports, and five no-hub airports. The Fort Worth Alliance airport (AFW) in the state of Texas is not categorized by FAA organizations. An airport may be both a commercial service and a cargo service airport.

Concerning the top 50 US cargo airports selected in this study, Table 2 and Figure 6 display how Memphis International airport (IATA code: MEM) is the most important US airport in terms of tons of cargo handled, with 424 million tons, and this increased by 3.4% in comparison with 2019, followed by Ted Stevens Anchorage airport (ANC) with 380 million tons, which increased by 25% compared with the previous year. These are followed by Louisville Muhammad Ali airport (SDF) with 232 million tons (7.4% year-on-Year), Miami International (MIA) with 152 million (7.5% YoY), Los Angeles International (LAX) with 128 million tons (76.5% YoY), Chicago O'Hare (ORD) with 121 million tons (20.4% YoY), and, in seventh place, Indianapolis International airport (IND) with 108 million tons (6.6% YoY). The rest of the hub, medium, small, and non-hub airports are below the 90 million ton level, but their localization and strategic operability are key to cargo airlines, online companies, and the synchronization and optimization of cargo traffic flows.

In 2020, according to the FAA [108,109], Guam International (GUM) airport had the highest growth in air cargo by percentage, with 407.2%. It is localized in Oceania, and it is on the largest island of the Mariana Islands and Micronesia. It is an organized, unincorporated territory of the US. In March 2020, United operated more than 4000 cargo-only flights, moving more than 130 m pounds of cargo. United Cargo helped to move 190,000 pounds of fresh produce to Guam for the US Department of Agriculture's Coronavirus Farm Assistance Program. The airline worked with food-logistics specialist Commodity Forwarders Inc. to transport the produce from Los Angeles (LAX) to Guam (GUM) on United's new cargo-only flight, a route added to meet cargo demand during the COVID-19 crisis [110]. The air cargo industry plays a significant role in creating a framework of bilateral agreement between regions' or countries' economies, and it contributes significantly to better productivity in the economy and the well-being of the population. In addition, as we saw earlier, Los Angeles International (LAX) airport ranked second with an increase of 76.5% on the previous year, followed by Ellington (EFD) airport with 64.82%, the Fort Worth Alliance (AFW) airport with 63.8%, and in fourth place was the Theodore Francis Green State (PVD) airport with 59.5%.

In the light of Table 2, it is clear that the interoperability between airports and cargo airlines operators enabled by the existence of a national and international network is essential for strategic and commercial positioning of cargo airlines and their main competitors. FedEx, UPS, DHL, or Amazon air cargo airlines are geographically and commercially well positioned in these 50 airports, and according to the strong potential in the industrial, commercial, and services sectors around airports, these sectors provide daily inputs, outputs, and specific services to cargo airlines and online companies. For instance, Amazon, UPS, and FedEx have their own fleets because these companies are focused on the end customer, thus eliminating the intermediation of other cargo companies.

Nevertheless, airports face numerous difficulties in capital planning because of instability and unpredictable demand. Some trends such as excess bellyhold capacity have depressed demand for dedicated cargo flights, whereas others, like the growth in e-commerce, are stimulating demand unevenly among airports [111]. Suwanwong et al. [79] indicate that the current problems and bottlenecks block the ability to perform well in air connectivity in Thailand, which has e-freight, ground handlers, and airline bottlenecks. The occurrence of short-shipped cargo causes delays in delivering cargo and increases waiting times that would reduce connectivity [112]. Moreover, we should add that warehousing jobs pay

poorly, and many of them are temporary and unstable. Studies find that about 60% of warehouse workers employed at facilities in Southern California worked temporarily in a very tough working environment, often with no health benefits or guarantee of hours [113].

Indeed, each airport faces different challenges, owing to the heterogeneity of the cargo business such as international or national cargo, new business models, and airports focused on e-commerce and warehouse logistics. For example, the Lehigh Valley International 'ABE' airport is the Amazon Air operational base and is focused on the air cargo activity of this company. Moreover, Memphis International airport registered over 4 million metric tons in 2013, in this airport over 90% is air cargo domestic [114]. This pronounced emphasis of air cargo domestic is related to the geography of the American continent [115]. Therefore, Memphis will be affected differently by changes in the market environment from Hong Kong airport, which is highly dependent on international air cargo [116]. This might be one of the main reasons why Memphis International airport, with 15.4%, is the most important cargo airport in the US (see Table 2), followed by Ted Stevens Anchorage airport (ANC) with 13.8%, where the location strategic and operations are unique in this State, and it has an operational advantage over international air carriers as a supplement to its well-established geographical advantage [117]. In third place is Louisville Muhammad Ali airport (SDF) with 8.5%. We must remember that the main hubs of FedEx and UPS are localized in Memphis and Louisville respectively, because these cities provide geographically good access to the rest of the US, that is, these airports are mainly focused on domestic air cargo.

As concerns most of air cargo operations in Florida state, Miami International airport (MIA) with 5.5% is the air cargo hub for many major air cargo carriers and has a distinguished position in the nation as an air cargo import and export gateway [44], while Orlando International airport (MCO) with 0.8% is the second airport in domestic air cargo traffic in Florida. Los Angeles airport (LAX) with 4.7% is the hub cargo par excellence in California, which serves as a metro hub for FedEx Express. This is among three other important cargo airports: Hollywood Burbank (BUR), Long Beach (LGB) and John Wayne (SNA) in California state [118]. The rest of the airports contribute to improving the global air cargo transport network in the US, and where all actors are considered as a key piece of the stability of the domestic and international air transport systems. Conversely, Bombelli et al. [43] argue that assessing the relevance of an airport in the air cargo transport network must be conducted using overall cargo capacity.

Air cargo is employed for the mid- to long-distance transportation of urgent goods. Its selling position is speed and reliability. The air cargo market is served by three types of providers: all-cargo airlines, combination carriers, and integrators. The latter focus on the express market and provide door-to-door service including not only air transport but also truck deliveries [115]. Cargo airlines provide freight forwarders and shippers with services, including consultation, capacity booking, pickup, receiving, packaging, sorting, loading, transportation, dispatching, and cargo tracking and tracing. Air cargo service is classified into different levels according to the priority level, such as speed and reliability, required by the shipper [119]. With the aim of having a better global vision of main cargo carriers, Table 3 provides the top 25 freight carriers in the world from 2020 to 2014, which is dominated by FedEx with 12.3% in 2020. FedEx and UPS with 11.9% are the dominant companies in domestic air freight [120], followed by Qatar Airways with 5.5%. This company connects businesses to more than 60 dedicated cargo destinations from Doha [121], and the Gulf location is a pivotal point on the global aviation map, while its natural resources provide the necessary means to support the growth of air transportation [122].

Emirates SkyCargo with −20.6% in air cargo shows how the pandemic crisis impacted considerably on this company, owing to the high connection with international cargo around the world. This carrier provides the air accessibility network for Dubai (United Arab Emirates). Emirates began operations at Dallas/Fort Worth, Seattle, and Washington, D.C., and has a total of seven trade lanes in the US, which also include Houston, Los Angeles, New York, and San Francisco [123]. Cathay Pacific takes fifth place with −20.6%

in the top 25 freight carriers, and the same consideration may be made for this company: it is the flag carrier of Hong Kong and provides the main air accessibility network for this destination. Again, we must point out that the remaining freight carriers are part of the air cargo networks of US airports, in which they provide good air connectivity in essential goods and services transactions through the e-commerce industry.

Moreover, as we can see in Table 3, DHL is one of the world's leading logistics companies and it specializes in international freight [124], but is not in the top 25 freight carriers. However, DHL operates in around 220 countries and its main market is Asia. DHL acquired Air Express International in 2000, to enter the US market. Today, this alliance has helped it to gain a foothold in the US market [125].

The pandemic crisis has provoked a demand imbalance which occurred owing to changes in domestic and international cargo demand and in cargo capacity. According to Shaban et al. [126], the airline faces the problem whereby its fixed capacity from one route cannot cover the sum of freight forwarders' orders, named hot-selling routes, while the freight forwarders' total orders from the substituting route are much less than its capacity, named underutilized routes.

3.2.2. Initial Impact of the Pandemic on Air Cargo and Airports

The importance of accessibility is dependent on activity category and situation, especially in air cargo airlines owing to the pandemic crisis and their dependence on the international market. According to the IATA [101], at the end of 2020, industry-wide cargo ton-kilometres (CTKs) had returned close to pre-crisis values. Nevertheless, the yearly decline in CTKs was still the largest since the global financial crisis in 2009, at a sizeable 9.1% year on year increased in 2020 (see Panel A of Figure 7). In 2020, the lack of cargo capacity compared with the resilient demand for goods, and the congestion at airports and other parts of the supply chains, combined with the need for rapid e-commerce shipments and transport of personal protective equipment (PPE), put significant pressures on air freight rates. Based on previously published research and the empirical research reported in this paper, it was found that there is a direct correlation between the use of e-commerce and improved customer service.

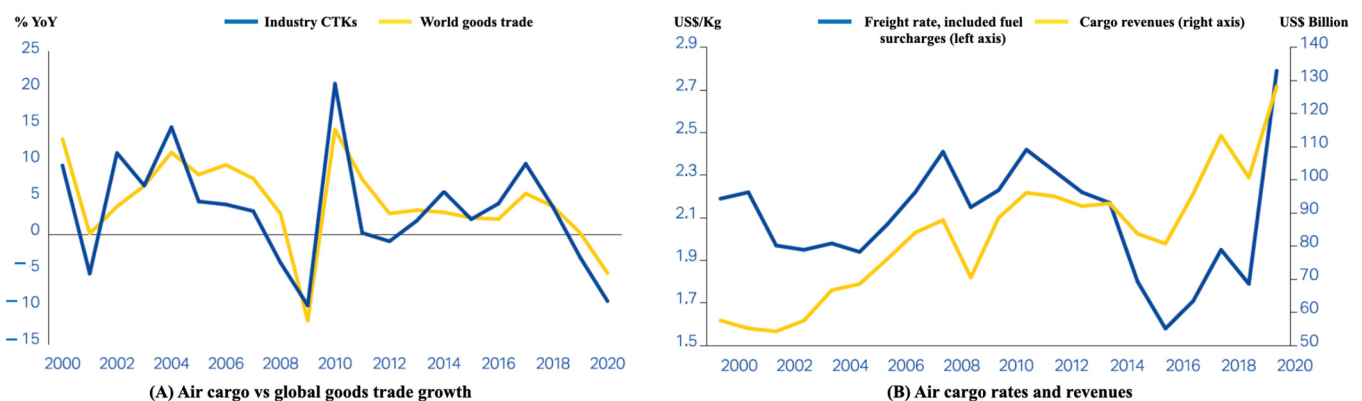


Figure 7. The initial impact of the pandemic on air cargo, rates, and revenues from 2000 to 2020. Source: Author's own elaboration from IATA [101].

Panel B of Figure 7 shows that the air freight rates increased dramatically during the peak of the supply chain disruption from March to May 2020 and moderated somewhat during the middle of the year, before climbing again during the peak cargo season in Q4. As a result, air freight rates were 55.9% higher overall in 2020 compared with 2019, at 2.79 \$/kg. Combined with the relatively resilient outcome in air cargo volumes (down 9.1% year-on-year in 2020), this means revenues from transporting goods by air rose by 27.2% in 2020. At \$128.2 bn, this is a new all-time high. We cannot forget that the cost of freight transportation is determined by two major factors: the distance inputs and outputs travel,

and the cost per mile of transport [127]. Operators of airports, airlines, and organizations must adapt to new circumstances, be efficient, and plan the use of their resources according to demand. Airports facing insolvency are mainly regional airports, which serve and are integral to local communities. Many airlines have decided to close bases or relocate them, close and reduce routes, and lay off employees to adjust costs to current demand [128].

4. Discussion

Global Vision of Results Data on US Cargo Airports, Carriers, and E-Commerce Sales

This paper seeks to analyse the role of the top 50 US cargo airports and air cargo airlines in the logistics of e-commerce companies in one of the world's largest economies, the US. The global financial crisis had a significant impact on consumer spending and as a result, on demand in air cargo markets. International trade with the US remains a significant concern for many foreign trading partners [13]. Surprisingly, air cargo in US airports has continued to grow, despite the 9/11 terrorist attacks, the financial crisis of 2007, and the great US recession in 2011 (see Figure 8). Although the World Health Organization (WHO) declared the coronavirus a global pandemic on 11 March 2020, the air cargo sector is recovering step by step towards the air freight levels seen before the pandemic. This continued growth is closely linked to the growth of retail e-commerce industry in the past 10 years (see Figures 9 and 10), thanks to new advances in technological devices, which facilitate the purchase of products and services by users in e-commerce companies.

However, the US Department of Commerce [129] reported that total retail sales for the third quarter of 2021 were estimated at \$1,5 billion, a decrease of 1.1% ($\pm 0.2\%$) from the second quarter of 2021. The e-commerce estimate for the third quarter of 2021 increased by 6.6% ($\pm 0.9\%$) over the third quarter of 2020, while total retail sales increased 13.1% ($\pm 0.7\%$) in the same period. E-commerce sales in the third quarter of 2021 accounted for 13% of total sales in the US. An interesting study carried out by Florido-Benítez [130] demonstrated that air freight in the largest airports in the British Isles endured well during the pandemic and the Brexit crisis, especially Heathrow and East Midlands airports.

As stated by Islam et al. [131], during the COVID-19 pandemic, perceived arousal has a significant positive relationship with impulsive and obsessive buying. The risks of going outside, COVID-19 outbreaks among employees of local retail stores, and health professionals' recommendations to stay at home led to impulsive buying behavior [132]. Hylton and Ross [111] suggest that that e-retail may reconfigure distribution networks and boost cargo volume at some airports, opening up opportunities to gain market share for airports that are new to e-retail.

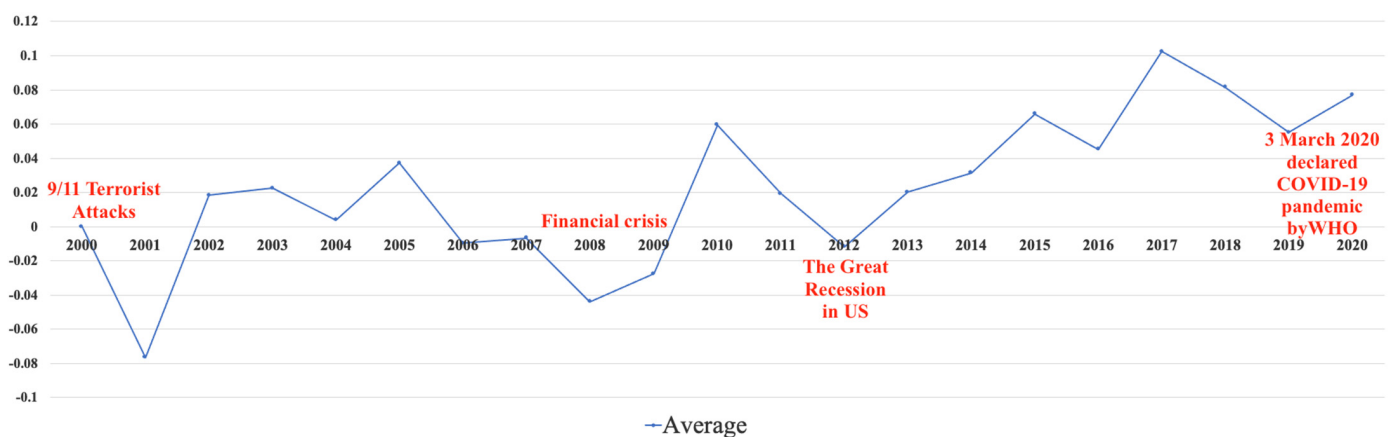


Figure 8. Average of evolution of freight tons carried in % by 50 airports (2000–2020). Source: Author's own elaboration from FAA [108]. Note: WHO declared the coronavirus a global pandemic on March 11 2020.

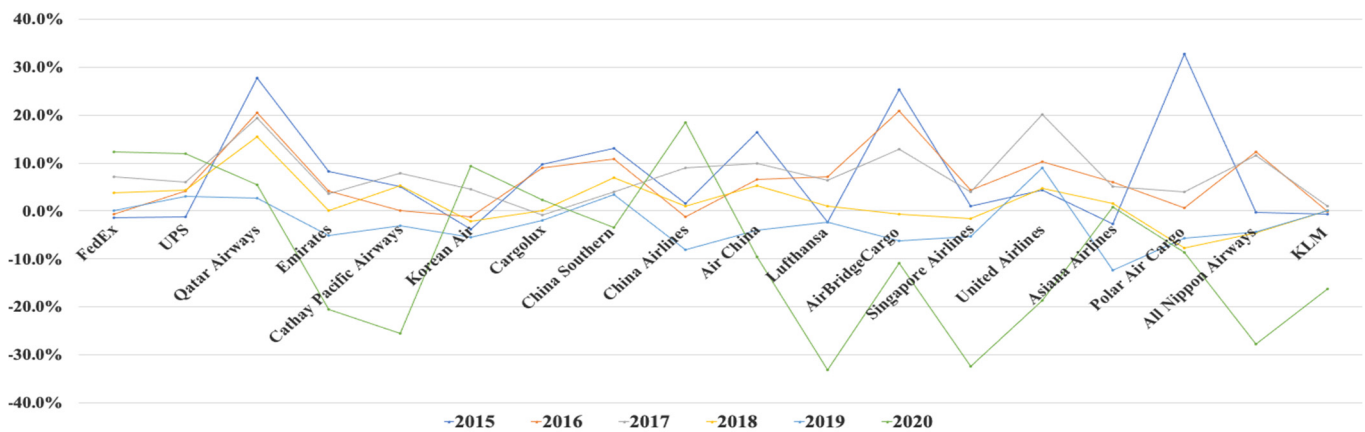


Figure 9. Evolution of total percentage freight tons carried by 16 cargo airlines (2015–2020). Source: Author's own elaboration from IATA [101]. Note: This graph shows only air cargo airlines with completed data from 2015 to 2020 (Silk Way West Airlines, Ethiopian Airlines, EVA Air, Aerologic, Kalitta Air, Atlas Air, and Turkish Airlines were excluded).

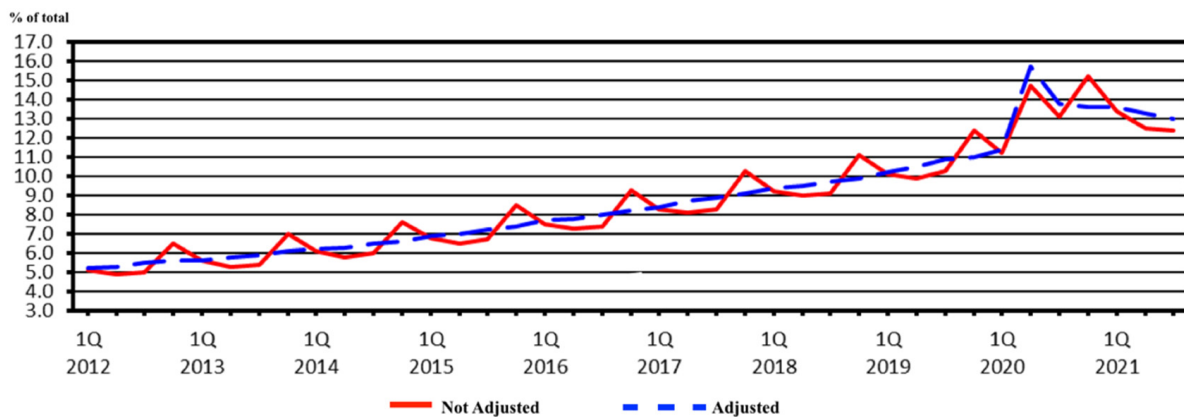


Figure 10. Quarterly retail e-commerce sales in US from 2012 to 3rd quarter 2021. Source: US Department of Commerce [129]. Note: Statement regarding COVID-19 impact: The Census Bureau continues to monitor response and data quality and has determined that estimates in this release meet publication standards.

Moreover, such growth between airports and e-commerce does not come of its own accord. Air cargo carriers have been fundamental in the internationalization of airports and online companies. Van Asch et al. [8] argue that e-commerce has become a real game-changer in the air cargo industry and is forecast to be the main growth driver in future years. Figure 10 shows the evolution of total freight tons carried by 16 cargo airlines in percentage terms. The omnipresent FedEx carrier had a sustained growth in the past five years, despite the pandemic crisis. FedEx took the decision in 2019 to not renew its US domestic contract with Amazon, in order to focus on serving the broader e-commerce market [133].

After FedEx, UPS is the second largest air cargo carrier in the world, followed by Qatar Airways. These three companies are crowned as the best integrated carriers in the world. The rest of the carriers have an evolution of ups and down as far as air cargo transport is concerned over the past five years. The unique selling propositions of air transport are speed and reliability [115], which includes goods such as pharmaceuticals, electronics, perishables, urgent shipments, valuables, and e-commerce [134]. Four global carriers (DHL, TNT, FedEx, and UPS) operate in this market, which is characterized by low switching barriers thereby facilitating customer defections [135]. Nevertheless, if air cargo operators want to exploit their competitive advantages against their main competitors, they need

to optimize the flow of inputs on a just-in-time basis to meet demand in time and costs terms. The efficiency of operations, loading time, and lowering costs by airport operators in air cargo loading are key factors in the cost-benefit analysis and traffic forecasting of air cargo operators.

Figure 11 shows how a good geographical location of airport, and a stable interaction zone between an airport and cargo market, provide a global input/output connectivity for goods and services, operational efficiency, and personalized operations by airports, forwarders, and integrators through air cargo airlines. As regards air cargo carriers, they provide speed and reliability of services to online companies and users in shopping and returns terms, as well as optimized synchronization of traffic flows, frequency of flights, and order settlement to online companies and users. This figure displays the role of airports and air cargo airlines in the logistics of e-commerce companies. It is a fact that recent operations through e-commerce have highlighted the interaction between demand and supply during COVID-19, and how e-commerce is one of the growth drivers of the present air cargo industry and is expected to stay an important market. The results show that e-commerce companies are highly dependent on the quality and efficiency of air cargo airlines and airports, with the aim of providing a good shipping service for their products.

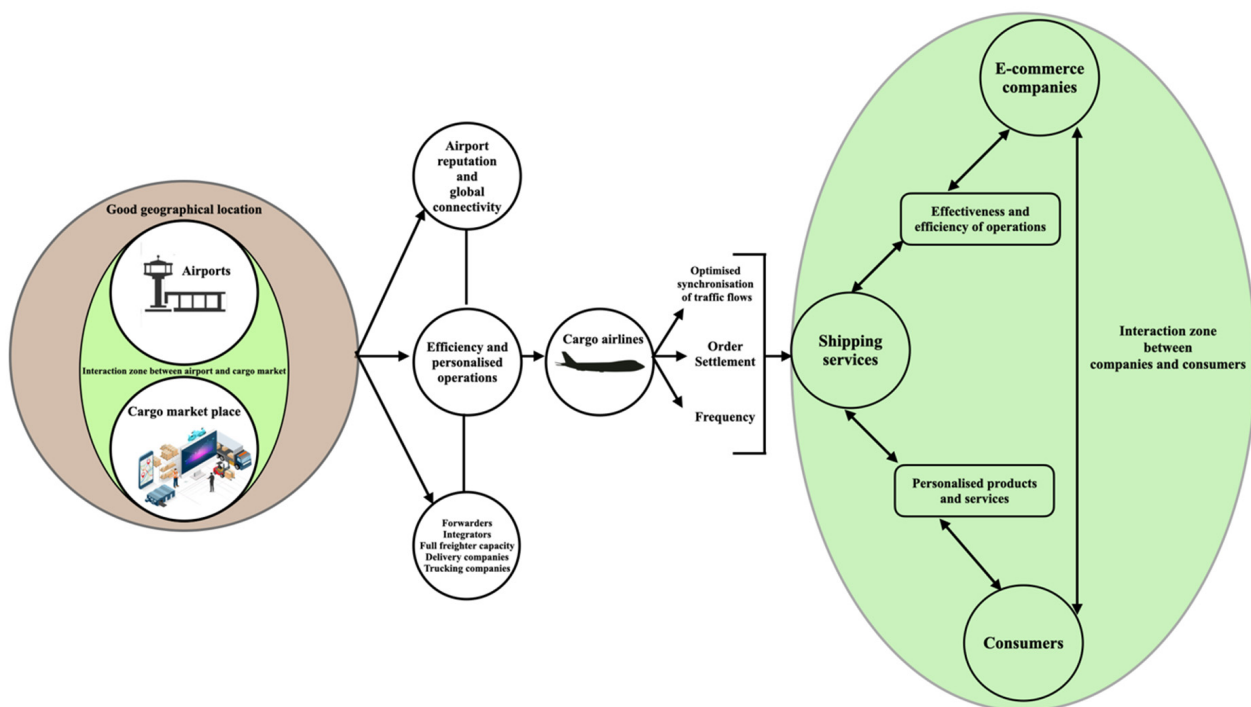


Figure 11. Overall research model. Source: Author's own elaboration. \longleftrightarrow Shopping and returns by companies or consumers.

5. Conclusions

In this study, 50 US cargo airports, air cargo carriers, and the logistics and e-commerce sectors have been presented and analyzed from a complex theory perspective and examining the interactive context between them, from which we can obtain plenty of information on our major findings and these are critically discussed as follows.

Initially, this paper provides a consolidated airport, air cargo, and e-commerce relationship, especially in the pandemic period. Airports and air cargo carriers are identified as the most relevant partners in the e-commerce industry. This is owing to the e-commerce sector whose users demand speed and reliability in the interaction between the demand and supply of products and services. We can forget that the e-commerce industry provides large revenues to airports and carriers, and that this sector has not stopped growing in the past 10 years. After an extensive literature review, several indicators were identified as driving

factors of e-commerce at an airport. These factors were a good geographical location of the airport, a cargo market close to the airport, international connectivity, efficiency of operations, personalized services by airports and carriers, optimized synchronization of traffic flows, and frequencies of flights by air cargo carriers. Airport operators and air cargo airlines are developing new co-operative approaches to service provision in the e-commerce market. Airport operators need to diversify their business models [136,137].

The trend of e-commerce companies is outsourcing personalized services through air cargo carriers and airports worldwide to provide a better service for their customers and reducing shipping costs. Moreover, this study revealed that air cargo in US airports has continued to grow despite the COVID-19 pandemic, and the air cargo sector is recovering step by step to the air freight levels seen before the pandemic. Therefore, the findings of this research confirm previous studies on the commercial relationship between airports, air cargo carriers, and e-commerce sectors. In fact, we claim that the competitiveness of cargo airports within the air freight market depends on a wide variety of factors, as we have seen during this research. Now, in the 21st century, we combine physical media with interactive media and the objective is to attract our target customers and satisfy their wants and needs [48].

Finally, this study may be useful for airports and airline operators, online company managers, and stakeholders. The pandemic has changed the way in which organizations operate, and it is likely to create new demands for companies and the aviation and e-commerce industries. These two sectors are highly dependent on their commercial interaction relationship, because they provide products and services of primary necessity such as food, pharmaceuticals, electronics, perishables, and urgent shipments. We should be aware that recovery will not be immediate or result in an instant return to the record 2019 figures. The most logical goal would be to return to a level comparable to an average of the years leading up to the COVID-19 pandemic.

6. Theoretical and Practical Implications

In this study, we have analyzed previous studies that use diverse methodological approaches to airports, air cargo carriers, and warehouse logistics sectors. The paper contributes to the aviation and logistics literature in several areas. First, this research demonstrates a way to analyze an airport category based on air carriers, online companies' interests and location, and the air cargo market in a specific region, firmly grounded in empirical data, to lay out products and services customized by airports and carriers. Second, the study reveals that the proximity of warehouse logistics adds value to airports and air cargo carriers, which can help aviation literature reviews in future studies. Third, this study employed up-to-date studies and data, spatial analysis, and airport locations to deal with the data in the most comprehensive way. The findings of this study can help practitioners and researchers to understand new joint commercial strategies by airports, air cargo airlines, and online companies. According to the IATA [138], the Omicron variant may also encourage consumers stuck at home to buy more goods, as was the case during previous lockdowns.

Apart from the above rich theoretical contributions, this research has fruitful practical implications for aviation and e-commerce managers. Based on the results of research, this study encourages the improvement of commercial alliances between online companies and air cargo carriers, with the aim of improving the quality of shipping and personalized services, distribution channels, efficiency of distribution, logistics distribution information optimization, and the development of futures alliances in the logistics industry. Kumar and Petersen [25] revealed that internet and e-commerce allowed the complete integration of all business elements including suppliers, customer service networks, and manufacturing units. Onstein et al. [139] indicated that the design of a spatial distribution structure was of strategic importance for companies, in order to meet required customer service levels and to keep logistics costs as low as possible. Airports' products and services should be customized depending on business environments and location contexts [140]. Many

executives are developing supply-chain partnerships to reduce costs, improve service, and gain competitive advantage [141].

7. Limitations and Future Research

A major limitation of the present study is that large online companies and airports have not provided important data to help to this study, such as up-to-date data regarding air cargo operations and air cargo carriers' activities, which air cargo carriers are preferred by online companies, and the reasons for this. Moreover, another limitation of this study is that it used only the FAA database, whereas future research could focus on different countries, airports, and air cargo carriers, especially in the Asia and Pacific region where the relationship between airports and e-commerce has not reached its maximum potential. While a very few giants (e.g., FedEx, UPS, and DHL) dominate express logistics in Western countries, the burgeoning Asian express market has literally thousands of providers [142]. Therefore, we hope that future studies will note the appropriate metrics to measure and evaluate the main performance indicators of the logistics and air freight industries, to improve the quality and efficiency of air cargo airlines and airports.

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