Air transport Networks of Global Integrators in the More Liberalized Asian Air Cargo Industry

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ABSTRACT

Driven by the impressive growth of Chinese e-commerce, Asia Pacific is expected to become the world's largest regional parcel market in the near future. However, it was only after 2003-2004 that global integrated carriers gained the necessary traffic rights to establish hubs in China. This development led to a significant reshaping of the Asian air networks and has produced the current configurations. The aim of this paper is to provide an analysis of such configurations by graphical analysis and complex network metrics.

Our results show that DHL, FedEx, and UPS operate extensive multi-hub networks while the TNT network is quite limited. This finding suggests a general need for flexibility and robustness in a context of changing regulations and still-imperfect market liberalization. This need, however, has been addressed with different strategies. DHL (whose network exhibits the highest centralization and the lowest density) focuses more on the efficiency of its air network, while FedEx and UPS rely more on robustness but in different ways (i.e., in the case of FedEx, the highest transitivity combined with a lower centralization while UPS relies on the lowest centralization combined with the highest density). Moreover, airports' centrality indices confirm the central role gained by Chinese airports as a result of the change in the Chinese aviation policy. Such airports lay on a remarkable number of shortest paths that connect couples of other airports in the three networks. Finally, we provide an interpretation of our results in a policy perspective and indicate the possibility of a re-configuration of integrators' air networks toward a more efficient structure if Asian governments implement policy interventions that facilitate international trade, cooperation, and liberalization.

KEYWORDS: Asian air cargo, integrated carriers' networks, DHL, FedEx, UPS.
CLASSIFICATION: Air Cargo; airline network development.

1 Introduction

Global integrators' market has traditionally consisted of moving B2B packages through connecting major metropolitan areas as quickly as possible. Four main operators—the so-called big 4 (DHL, FedEx, TNT, and UPS)—used to compete globally in this market. However, in recent years, significant events have occurred that are reshaping the parcel express industry. First, with the boom of retail e-commerce, major operators such as Amazon, Alibaba, and eBay rely heavily on the express delivery services. This shift has moved integrators toward a more B2C-centered business model, whose deliveries exhibit quite a different profile from typical B2B models. Indeed, although consumers have lower requirements in terms of speed, they are mainly concerned with not adding too much to the cost of their online orders (Karp, 2017). Second, the competitive dynamics of the industry are changing. On the one hand, the recent acquisition of TNT by FedEx (made official in May of 2016) has reduced the number of global integrators in the market to three. On the other hand, Amazon's creation of its own branded Amazon Air fleet, which started scheduled operations in 2016, suggests that Amazon is bound to compete with the big three (although at the current time this competition seems to be limited to the U.S. internal market). Third, new technologies are expected to have a significant impact on the industry, as both Amazon and UPS have started to test drone deliveries.

Despite such a vibrant context, the academic literature—and empirical studies, in particular—on integrated carriers is very limited. Few contributions have studied the U.S. air networks of integrated carriers, while very limited evidence exists on the European carriers.[1] Furthermore, to best of our knowledge, no empirical studies have focused on the Asian integrators' air networks despite the fact that Asia Pacific is expected to become the world's largest regional parcel market by 2019 (IPC, 2015) with China at the forefront.[2]

Even more interesting, the Asian air cargo industry has been significantly reshaped by the shift toward greater openness in the Chinese air cargo policy since 2003 and 2004. Given the primary role played by China in the Asian economy in general and in e-commerce in particular, these changes have had a relevant influence on the business strategies of air cargo operators. Such influence is clearly reflected in the air network structure of global integrators. The aim of this paper is to provide an analysis of global integrators' air transport networks in Asia as the result of such policy changes adopted in China, and thus filling the abovementioned gap in the literature. We compare integrated carriers' networks in terms of hubs, spokes, and other specific network

[1] See Malighetti et al. (2018) for a more detailed discussion of the existing literature and Onghena (2011) for details on the integrators' industry.

[2] According to Boeing (2016), China's forecasted e-commerce market will be larger than the combined 2015 markets of the U.S., Britain, Japan, Germany, and France by 2020.

measures. As pointed out in Zanin and Lillo (2013), the description of the topological and metric structures of air transport networks is of interest not only for understanding the business strategies embraced by the different carriers, but also for assessing freight mobility in the presence of direct and indirect connections—an issue dear to the heart of policy makers, who are dealing with the growth of air traffic demand and a growing interest in the resilience of transport networks.

2 China’s air cargo policy as a main determinant of the current air network structures in Asia

As previously discussed, Asia is the fastest-growing large air cargo market. As such, DHL, FedEx, and UPS all have extensive intra-regional air cargo networks there. Much more limited is the presence of TNT, with a weaker penetration in the Asian markets (compared, for example, to its 12% of market share in Europe, according to Malighetti et al., 2018) and a stronger reliance on road transport.

The current air networks’ configuration has been quite recent, as it was only after 2003–2004 that the global integrated carriers received the necessary permission to establish hub airports in China—i.e., the most important Asian country in terms of the e-commerce market (Bowen, 2012). The permission was granted due to a gradual change in the Civil Aviation Administration of China (CAAC) policy. In fact, the export-oriented development strategy adopted by China since the early 1990s pushed the central and regional Chinese governments to put pressure on the CAAC to shift from a protective international aviation policy toward a more liberal regime (Lei and O’Connel, 2011). In this context, cargo legislation was prioritized (see also Zhang and Zhang, 2002) with the idea that, on the one hand, China’s growing economy and international trade would have taken significant advantages, and, on the other hand, the impact on Chinese passenger carriers would have been limited. Hence, in 2003 and 2004, a number of cargo traffic rights were offered to foreign cargo airlines on a unilateral basis thereby allowing DHL, FedEx, and UPS to establish operating bases at Chinese airports.[3] This had a relevant impact on integrators’ network configurations: FedEx and UPS moved their primary intraregional hubs from the Philippines to Southern China (in 2009), while DHL established a northeastern Asian hub in Shanghai in 2012. Further movement by the three integrators interested Chinese airports in the following years (Walcott and Fan, 2017). The entire air cargo network was also influenced by the rise of the so-called hinterland airports—airports dedicated to the transport of airfreight—newly built or converted from secondary passenger airports with the aim of meeting the need for efficient and timely delivery of goods (Yuen et al., 2016).

[3] Particularly relevant was the establishment of full liberalization between the U.S. and China for cargo operations in 2004.

As pointed out in Yuen et al. (2016), the competition between hinterland and gateway airports had an impact on the cargo carriers' location choices. In analyzing the competition between the Hong Kong (a gateway airport) and Shenzhen (a hinterland airport) airports, the authors point out some relevant differences. More specifically, the Shenzhen airport offered dedicated cargo flights an advantage in being closer to the cargo source, thus creating a positive impact at the ground-transportation cost level. However, air carriers in Hong Kong prefer to operate combination flights (passengers and cargo). This may explain why UPS decided to use the Shenzhen airport as one of its cargo hubs in Asia.

The entrance of global integrators in such a growing economy combined with the inadequate freight capacity of Chinese carriers led to a situation in which the former exploited the bigger piece of the pie while the latter received only a residual portion of the Chinese international air cargo market (Lei and O'Connel, 2011).[4] However, although starting in 2012 global integrators got the green light to provide intra-China express package services (Berman/Logistics Management, 2014), the domestic Chinese express market has mainly been controlled by state-owned and private players, with global integrators continuing their focus on the international express delivery business.[5]

The most recent developments in Chinese aviation policy are mainly linked to the so-called "One Belt One Road Initiative" (2013), a strategy initially proposed with the aim of improving maritime and rail links between China, Southeast Asia, the South Pacific, South Asia, Africa, and Europe. At a later stage (2015), aviation was brought into the picture because of its cheaper infrastructure compared to the costs of building road and rail connections, as well as its ability to speed up trade among countries. As a consequence, CAAC committed to further opening the country's airspace and allowing for more direct air links. The expected result is to have an increased air-freight capacity on the routes (Journal of Commerce, 2015). Such result may have an impact on the strategies of air cargo operators, including global integrators, in the coming years. Furthermore, with the "National Plan on New Forms of Urbanization in China," it is expected that a further gradual improvement in the level of logistics in underdeveloped regions (Deloitte, 2015) will occur, given that China is gradually establishing an efficient service system of city logistics, which is basically the last mile in the logistic chain (Xiao, 2017).

[4] For example Lei and O'Connel (2011) point out that despite the Shanghai Pudong Airport cargo traffic experiencing a 31% growth rate from 2000 to 2010, the Chinese carriers did not have the cargo capacity to capitalize from such growth. This was due mainly to (i) the limited number of freighters in the Chinese fleet, and (ii) the competitive disadvantages along the supply chain compared to the integrated carriers.

[5] The main state-owned and private players are EMS of China Post, China Rail Express, China Air Express, ZJS Express, SF Express, and STO Express (Zacks Equity Research, 2012).

In light of such recent developments in Chinese aviation policy, and the growing influence of integrators in the Asian international parcel market, an analysis of integrators' air networks in Asia not only allows us to understand their business strategies, but also to assess freight mobility in the presence of direct and/or indirect connections, an issue of interest from a policy maker perspective.

3 The role of integrators in the Asian cargo industry

Several airline business models have been developed for the provision of air cargo services (Halpern and Graham, 2018). As explained in Lakew (2014), integrated carriers provide comprehensive door-to-door freight services that are different from services provided by other dedicated air cargo (or passenger cargo) carriers (i.e., airport-to-airport freight services for third parties). This explains why integrated carriers, often called also express carriers, play a dominant role in the express freight market, where the key to success is the provision of value-added, door-to-door freight services guaranteed for delivery by a specific time (Oxford Economic Forecasting, 2005).[6]

According to Boeing (2016), international express traffic continued to grow faster than the average world air cargo growth rate, expanding to 17.6% of the total cargo traffic in 2015. Concerning regional markets, express traffic dominates the U.S. domestic air cargo market (about 60% in revenue ton-kilometers) and the intra-Europe air cargo market (more than 50% in revenue ton-kilometers). Of course, Asia is also involved in relevant growth, as the express market share doubled to 30% of the total Asia to North America cargo traffic between 2006 and 2015 (Airbus, 2017).

Concerning the Asia-Pacific market, if we look at estimated express delivery market shares for international shipments, DHL is at 44%, FedEx at 20%, UPS at 11%, and TNT at 4% (*The Wall Street Journal*, 2016).[7] All the other companies account for 21%. However, as discussed in the previous section, the weight of integrated carriers is definitely lower if we look at domestic markets. For example, looking at China, despite integrators accounting for 80% of the Chinese international express market, they have only less than 1% of the domestic express sector (where SF Express is the main player), which is mainly due to regulatory complexity and cost disadvantages (U.S.-China Economic and Security Review Commission, 2017). Similarly, in the Japanese post and parcel market, the three major providers—Yamato Transport with 45.4%, Sagawa Express with 33.5%, and Japan Post with 13.6%—cover 92.5% of the market (Uni Global Union, 2016).

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[6] The goods covered by express transportation are usually mail, parcels, and items characterized by a significant value-to-weight ratio and/or a time-critical delivery (Lafaye, 2007).

[7] Data refers to year 2014.

It is evident that integrated carriers are much more oriented toward international air cargo traffic rather than domestic traffic. Of course, this is also due to difficulties that weaken their penetration in some domestic markets. Furthermore, a context characterized by changing regulatory environments has also contributed in moderating economic cooperation (compared to the European Union and the U.S.) and may have exerted an influence on integrators' strategies reflected by the structure of their air networks. We expect that the network analysis in the following sections confirms such evidence.

4 Data

It is widely acknowledged that gaining access to data on integrators is very challenging (Lakew, 2014; Malighetti et al., 2018). This has traditionally led to a limited knowledge of the industry.

In this paper, we follow the approach adopted in Malighetti et al. (2018) and use data from Flightradar24 consisting of one week of scheduled flights "departing from" and/or "arriving at" one of the airports located in Asia.[8] Flightradar24, a flight tracking service, provides information on thousands of aircraft around the world. Here we focus on flights "departing from" and/or "arriving at" one of the airports located in Asia according to the OAG classification of airport regions. More specifically, we include airports belonging to Central Asia, NorthEast Asia, South Asia, SouthEast Asia, and the Middle East. Our final data set covers 1,461 flights operated by DHL, FedEx, TNT, UPS, and other carriers with a big 4 relationship—namely airlines (i) owned by, (ii) flying "on behalf" or (iii) operating "under the brand" of one of these four major carriers. The inclusion of other operators—again using the approach proposed in Malighetti et al. (2018)—is done in order not to underestimate their air networks. Indeed, integrators use additional aircraft as well as their own fleet (Doganis, 2009). Appendix A shows the list of the carriers with an association to one (or more) of the big 4. Notice, however, that the large majority of the flights (80.5%) in our data set is directly ascribable to one of the big 4 keeping the degree of uncertainty reasonably low as related to the associations made in Appendix A.

The information from Flightradar24 is matched with that from other sources as follows: (1) the payload of each aircraft model is mainly from the airlines' websites and Morrell (2011); and (2) the departing/arrival cities, countries, and regions come from the OAG database.

[8] Collected flights were scheduled from about 12 a.m. of November 28th to about 12 a.m. of December 5th 2015. On the Flightradar24 website, the section Data/Aircraft associates airlines with their respective fleets. The weekly schedule of each single aircraft is available. Freely accessible information is limited to one week. More specifically, the information collected include (a) flight date and time, (b) operating airline, (c) origin and destination, and (d) aircraft model. Note that FedEx and TNT are considered separately because the period of analysis precedes the TNT acquisition by FedEx.

The final data set is therefore unique and combines information from different sources. We recognize that it also has the disadvantage of being limited in time. Hence, our analysis provides a representation of the integrators' networks at a specific time with no opportunity to investigate their stability/instability. However, after the movements described in Section 2, no further comparable structural changes have occurred in Asia. The main hubs of the three carriers have remained the same (see *Nikkei Asian Review*, 2018, for a comparison to our analysis results).

Note that there is no available data on integrators' road transport networks. Hence, it is not possible to provide empirical evidence on the importance of air transport in the multimodal network strategy of each integrator. However, it is known that an important difference exists among them. Indeed, FedEx and UPS (which have large ground shipping networks in North America) concentrate, like DHL, on express delivery by air in Asia (Reuters, 2007). Different from its competitors, TNT tried to export its European strategy of transporting as many packages as possible by road to Asia. This strategy was demonstrated by the acquisition of Hoau Group, a China's private freight and parcel delivery firm, in 2007. Such a deal brought important road coverage to TNT in China based on 1,100 depots, 3,000 vehicles, and 56 hubs (Reuters, 2007).

5 The geography of integrated carriers' networks in Asia

5.1 DHL

Figure 1 represents the Asian network of DHL, based on 586 flights departing from and/or arriving at 48 different airports. [9] The airports listed in Table 1—i.e., the top 10 Asian DHL airports in terms of available cargo traffic—are labeled with their IATA codes. Figure 1 shows a dense network of connections, with Hong Kong Chek Lap Kok International Airport (HKG) enjoying a noticeably central position. Indeed, HKG, also called the "Central Asia Super-Hub," is the center of DHL's regional network. As confirmed, more than one-third of DHL's flights in the data set come through HKG. The red airports in Figure 1 are the top three airports in terms of available freight tons (AFT)—that is, the first three airports listed in bold in Table 1.

[9] Figures 1–8 have been created through the two R packages *maps* and *geosphere*.

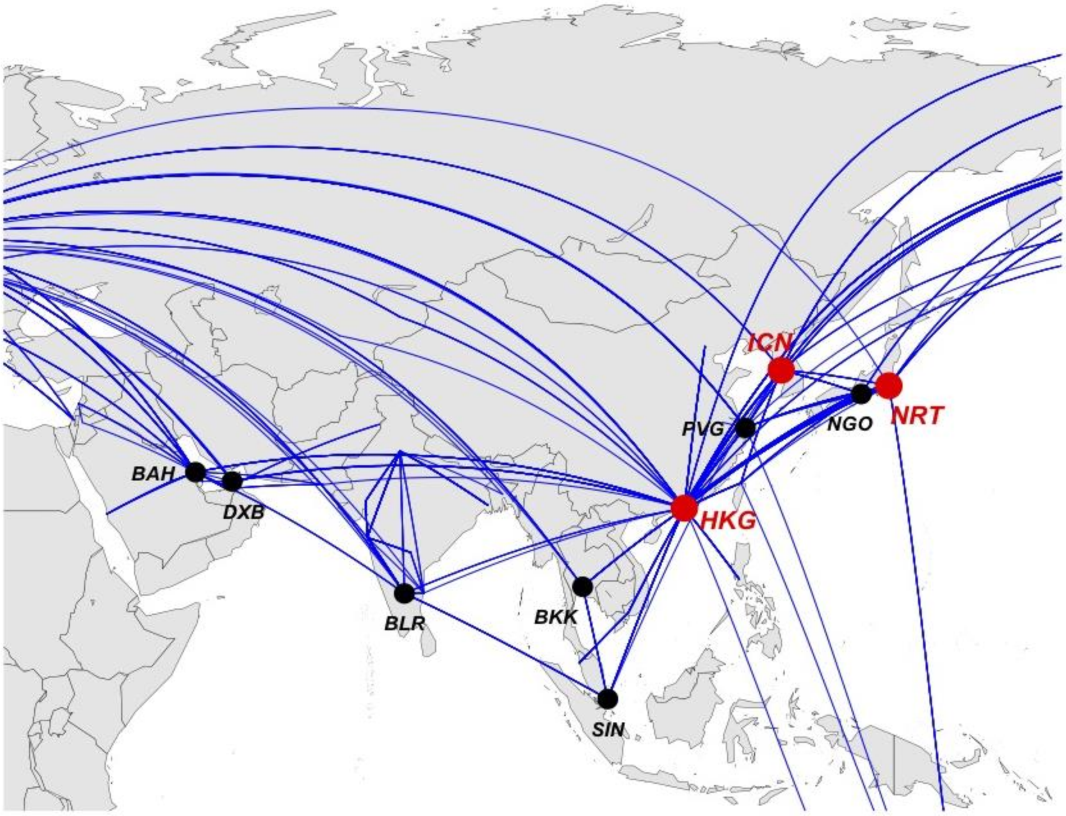

Figure 1. The DHL Asian airport network (top three airports in terms of AFT in red).

Following Hong Kong, we find Seoul Incheon International Airport (ICN) and Tokyo Narita International Airport (NRT). Table 1 suggests that Chinese, Japanese, and Korean markets are important for the DHL network. Hong Kong (HKG), which significantly outpaces other airports in terms of cargo volumes, is strategically positioned in the Chinese market thanks to its central location at the Pearl River Delta Region—a major international center of production and trade in the region. Seoul (ICN) airport also benefits from key positioning that makes it an international gateway to Seoul and South Korea in general. Tokyo (NRT) has traditionally been the main Asian destination for air cargo traffic from/to the U.S.

Note that other important airports can be identified in the DHL network. The Chinese airports of Shanghai (PVG) and Bahrain (BAH), which connect the West Asian market, exhibit cargo volume very close to that of Tokyo. In addition, Nagoya (NGO), Singapore (SIN) and Bangalore also play a substantial role in terms of cargo traffic.

Table 1. Top 10 DHL Asian Airports in Terms of AFT

Airport (IATA code)	Country	Dep. AFT	Arr. AFT	Total AFT
Hong Kong (HKG)	**Hong Kong**	**9,195**	**9,516**	**18,710**
Seoul (ICN)	**South Korea**	**4,560**	**4,247**	**8,807**

Tokyo (NRT)	**Japan**	**2,777**	**2,777**	**5,554**
Shanghai (PVG)	China	2,730	2,503	5,233
Bahrain (BAH)	Bahrain	2,510	2,626	5,136
Nagoya (NGO)	Japan	1,419	1,796	3,215
Singapore (SIN)	Singapore	1,388	1,388	2,776
Bangalore (BLR)	India	1,197	1,224	2,421
Bangkok (BKK)	Thailand	951	904	1,855
Dubai (DXB)	United Arab Emirates	872	975	1,846

Focusing on the intra-Asia air traffic, Table 2 lists the ten busiest routes ordered in terms of AFT. The importance of Hong Kong as the main hub is confirmed by the fact that nine out of the ten "internal" routes have HKG as their origin or destination. Besides Honk Kong, six other airports (all included in Table 1) are involved. The busiest intra-Asia route is Seoul-Hong Kong with 1,833 tons of available freight tons.

Table 2. Top 10 DHL Intra-Asia Routes

Departure	Arrival	AFT
Seoul (ICN)	**Hong Kong (HKG)**	1,833
Bahrain (BAH)	**Hong Kong (HKG)**	878
Hong Kong (HKG)	Seoul (ICN)	867
Singapore (SIN)	**Hong Kong (HKG)**	770
Seoul (ICN)	Nagoya (NGO)	738
Hong Kong (HKG)	Tokyo (NRT)	660
Hong Kong (HKG)	Shanghai (PVG)	660
Hong Kong (HKG)	Singapore (SIN)	660
Tokyo (NRT)	**Hong Kong (HKG)**	660
Shanghai (PVG)	**Hong Kong (HKG)**	660

Table 3 shows the non-Asian airports included in the DHL Asian network. These airports are 9 out of 48.

Table 3. Main DHL Non-Asian Airports connected to the DHL Asian Network

Airport (IATA code)	Country	Total AFT
Leipzig (LEJ)	**Germany**	**6,346**
Anchorage (ANC)	**USA**	**5,776**
Cincinnati (CVG)	**USA**	**3,412**

Frankfurt (FRA)	Germany	927
Los Angeles (LAX)	USA	796
Milan (BGY)	Italy	455
Sydney (SYD)	Australia	324
Milan (MXP)	Italy	206
Melbourne (MEL)	Australia	103

Not surprisingly, the list in Table 3 includes Leipzig, the main DHL hub in Europe, and Cincinnati (CVG) in Ohio, which is the main U.S. hub of DHL. Anchorage (ANC) is a regional hub located in Alaska. It benefits from a strategic position as a transit airport for freight flying between the U.S. and Asia. Figure 2 confirms this finding. Leipzig, Cincinnati, and Anchorage appear as an origin or destination in all the top ten DHL intercontinental routes.

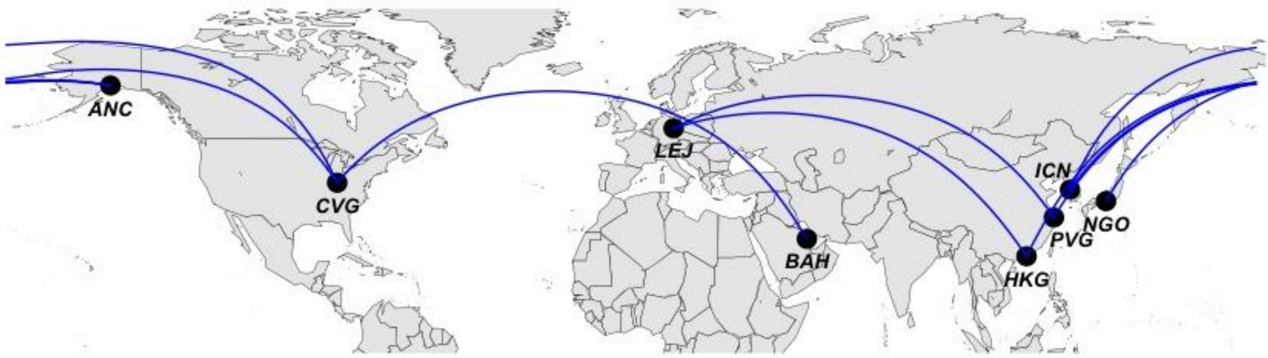

Figure 2. The DHL top extra-Asia routes (in terms of AFT).

5.2 FedEx

Figure 3 shows the Asian network of FedEx, which is based on 36 airports. Table 4 shows the top ten FedEx Asian airports.

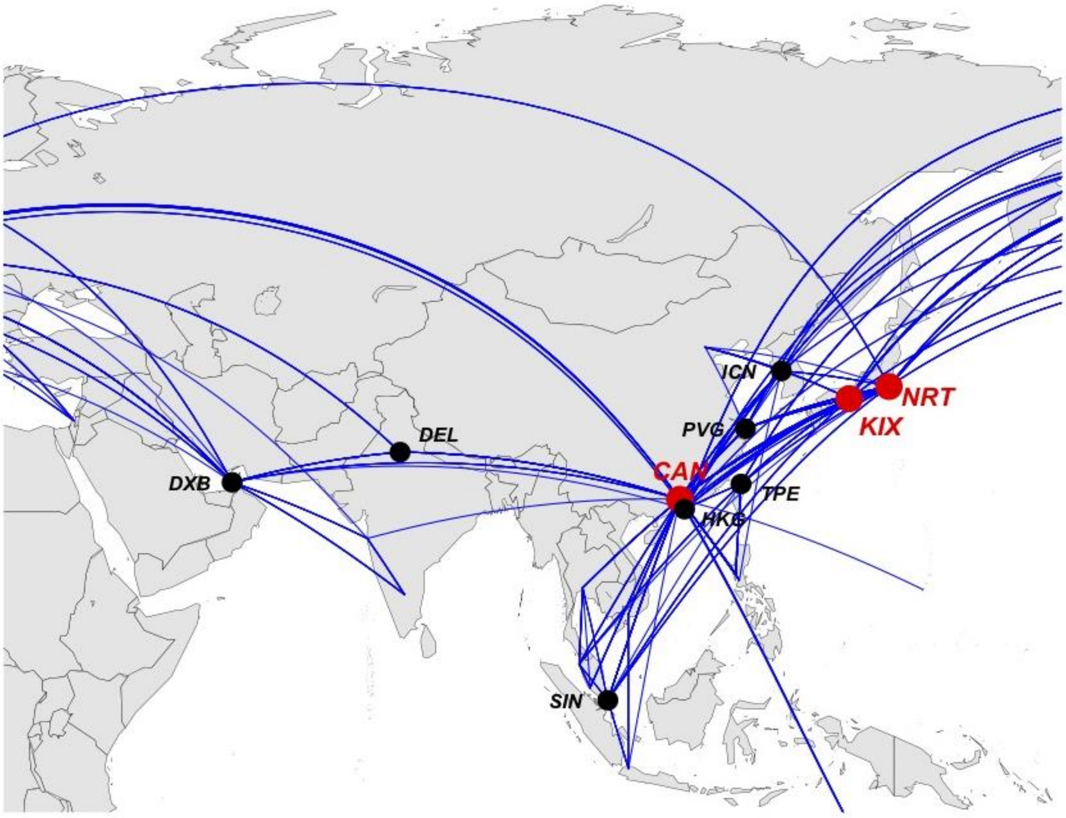

Figure 3. The FedEx Asian airport network (top three airports in terms of AFT in red).

Like DHL, FedEx seems to operate a dense network of connections, with a concentration in the eastern part of Asia, mainly in China and Japan. Looking at the three main FedEx Asian airports highlighted in red (Figure 3), the central role of the Chinese hub of Guangzhou (CAN) is notable, as it the airport with the largest AFT volume. Guangzhou accounts for about 30% of collected FedEx movements. Similar to the DHL main hub of Honk Kong, Guangzhou (CAN) benefits from a strategic position in the heart of Guangzhou's Pearl River Delta. In second and third place are Osaka (KIX) and Tokyo (NRT), two Japanese airports, which enable FedEx to consolidate its prominent role in shipments between Japan and the U.S.

Table 4. Top 10 FedEx Asian Airports in Terms of AFT

Airport (IATA code)	Country	Dep. AFT	Arr. AFT	Total AFT
Guangzhou (CAN)	**China**	**5,413**	**5,559**	**10,971**
Osaka (KIX)	**Japan**	**5,003**	**4,959**	**9,962**
Tokyo (NRT)	**Japan**	**4,333**	**4,320**	**8,652**
Seoul (ICN)	South Korea	2,203	2,499	4,701
Shanghai (PVG)	China	2,188	2,098	4,286
Dubai (DXB)	United Arab Emirates	2,059	2,149	4,208

Hong Kong (HKG)	Hong Kong	1,905	1,712	3,617
Taipei (TPE)	Taiwan	1,759	1,705	3,464
Singapore (SIN)	Singapore	1,189	1,099	2,288
Delhi (DEL)	India	1,120	1,120	2,240

Note that the top three airports in Table 4 are close in terms of available freight tons, which means that the FedEx Guangzhou hub does not show up in terms of AFT transit as the Hong Kong hub does in the DHL network. Table 5 confirms the relevance of the Japanese market, which has the main intra-Asian routes in the FedEx air network. In fact, while Guangzhou's main hub appears only three times in Table 5 (highlighted in bold), one of the two Japanese airports (Osaka or Tokyo) acts as origin or destination in nine out of ten top connections. As further confirmation of the relevance of the Japanese market in FedEx network, notice that the domestic connection of the two Japanese cities, Osaka and Tokyo, is the most important connection. In general, Table 5 combined with Figure 3 seems to suggest a less-concentrated network for FedEx compared to that of DHL.

Table 5. Top 10 FedEx Intra-Asia Routes

Departure	Arrival	AFT
Osaka (KIX)	Tokyo (NRT)	878
Guangzhou (CAN)	Tokyo (NRT)	865
Tokyo (NRT)	Shanghai (PVG)	811
Guangzhou (CAN)	Osaka (KIX)	730
Osaka (KIX)	Shanghai (PVG)	721
Tokyo (NRT)	Osaka (KIX)	706
Tokyo (NRT)	**Guangzhou (CAN)**	646
Delhi (DEL)	Dubai (DXB)	605
Shanghai (PVG)	Tokyo (NRT)	592
Taipei (TPE)	Osaka (KIX)	576

As far as FedEx's extra-Asian connections are concerned, Table 6 lists the FedEx non-Asian airports with connections to the FedEx Asian airports.

Table 6. Main FedEx non-Asian Airports Connected to the FedEx Asian Network

Airport (IATA code)	Country	Total AFT
Anchorage (ANC)	**USA**	**4,250**

Memphis (MEM)	**USA**	**3,901**
Paris (CDG)	**France**	**2,756**
Oakland (OAK)	USA	811
Cologne (CGN)	Germany	650
Sydney (SYD)	Australia	540
Leipzig (LEJ)	Germany	412
Milan (MXP)	Italy	412
Indianapolis (IND)	USA	412
Los Angeles (LAX)	USA	386
Athens (ATH)	Greece	198
Guam (GUM)	USA	90

As in the DHL network, there are three main extra-Asian airports exhibiting freight volumes (in terms of AFT) close to those listed in Table 4. Not surprisingly, two of them are the main U.S. hubs of FedEx—Anchorage (ANC) and Memphis (MEM)—while the third is the Charles de Gaulle airport (CDG) in Paris, the FedEx European hub. These airports also appear as origins or destinations in many important extra-Asian routes (Figure 4) of the FedEx network, with Osaka-Memphis (1017 AFT) and Anchorage-Tokyo (901 AFT) exhibiting higher cargo traffic than the most important internal route, Osaka-Tokyo. Figure 4 also highlights the significant role of Paris (CDG) in connecting Western Asian airports to Europe.

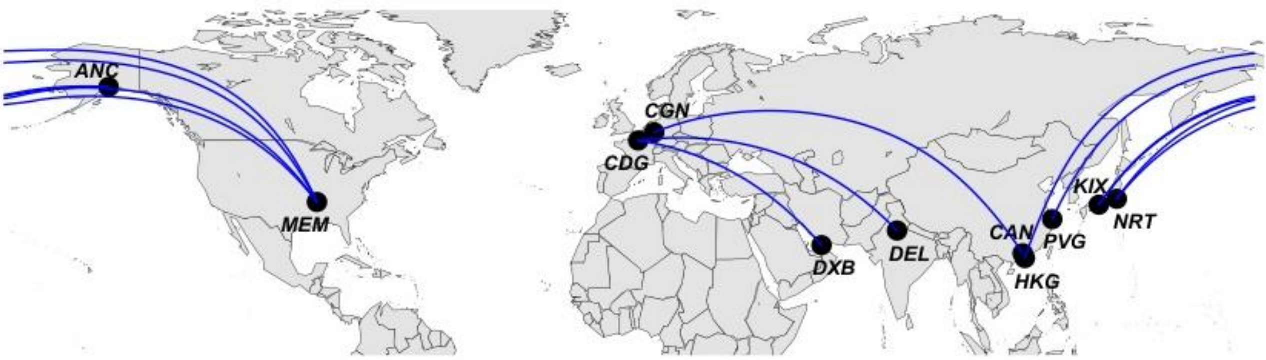

Figure 4 FedEx top extra-Asia routes (in terms of AFT).

5.3 UPS

Figure 5 represents the Asian network of UPS, which is based on 346 flights departing from and/or arriving at 24 different airports.

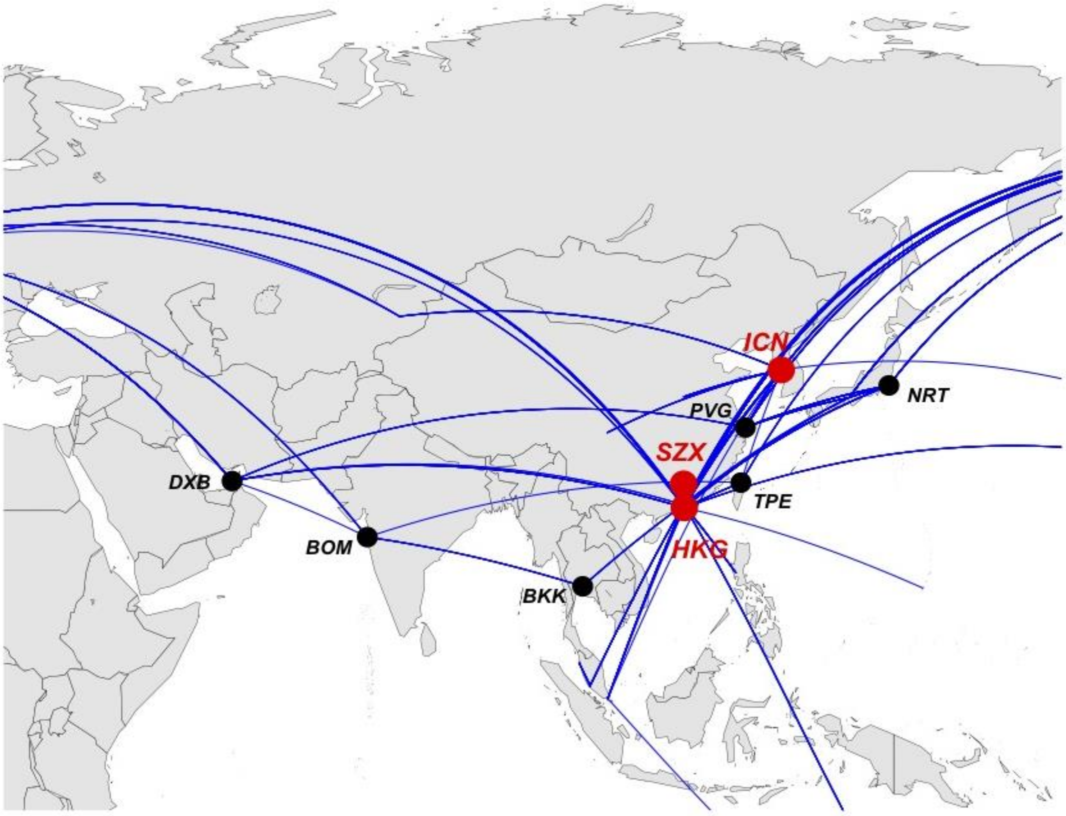

Figure 5. The UPS Asian airport network (top three airports in terms of AFT in red).

UPS operates flights on a smaller amount of connections than FedEx and DHL due to the smaller size of its intra-Asia network. Table 7 lists the ten busiest UPS airports in Asia. Similar to the DHL and FedEx networks, most of these airports are concentrated in the central part of East Asia. Hong Kong seems to play a prominent role in the network even if the centrality analysis will see Shenzen catching up significantly. Looking at the distribution of AFT among the three main airports, the UPS network seems to be more similar to that of FedEx rather than to DHL given the lower level of traffic centralization in the main hub.

Table 7. Top 10 UPS Asian Airports in Terms of AFT

Airport (IATA code)	Country	Dep. AFT	Arr. AFT	Total AFT
Hong Kong (HKG)	**Hong Kong**	**3,842**	**3,862**	**7,704**
Seoul (ICN)	**South Korea**	**2,742**	**2,672**	**5,414**
Shenzhen (SZX)	**China**	**2,577**	**2,577**	**5,154**
Shanghai (PVG)	China	1,794	1,614	3,408

Osaka (KIX)	Japan	1,730	1,640	3,370
Dubai (DXB)	United Arab Emirates	1,374	1,444	2,818
Tokyo (NRT)	Japan	1,242	1,296	2,538
Taipei (TPE)	Taiwan	714	694	1,408
Mumbai (BOM)	India	604	604	1,208
Bangkok (BKK)	Thailand	550	550	1,100

Table 8 confirms the relevance of the Honk Kong hub and shows the top ten intra-Asia routes. These routes involve 11 different airports and exhibit a smaller amount of traffic compared to the top "internal" routes of DHL and FedEx.

Table 8. Top 10 UPS Intra-Asia Routes

Departure	Arrival	AFT
Hong Kong (HKG)	Taipei (TPE)	640
Hong Kong (HKG)	Osaka (KIX)	630
Bangkok (BKK)	Mumbai (BOM)	550
Shenzhen (SZX)	Bangkok (BKK)	550
Hong Kong (HKG)	Dubai (DXB)	540
Seoul (ICN)	Almaty (ALA)	540
Shanghai (PVG)	Seoul (ICN)	450
Seoul (ICN)	**Hong Kong (HKG)**	438
Osaka (KIX)	Shanghai (PVG)	380
Shanghai (PVG)	Tokyo (NRT)	378

Different from its intra-Asian network, the UPS network seems comparable to that of DHL and FedEx on extra-Asian routes (see Table 9 and Figure 6).

Table 9. Main UPS Non-Asian Airports Connected to the UPS Asian Network

Airport (IATA code)	Country	Total AFT
Anchorage (ANC)	**USA**	**8,774**
Cologne (CGN)	**Germany**	**4,134**
Honolulu (HNL)	**USA**	**640**

Sydney (SYD)	Australia	630
Warsaw (WAW)	Poland	450
Guam (GUM)	USA	110

Not surprisingly, we again find a relevant role for Anchorage, which confirms its strategic role in connecting the U.S. and Asia as well as the UPS European hub of Cologne. Figure 6 presents the top UPS extra-Asia routes.

Figure 6. The UPS top extra-Asia routes (in terms of AFT).

5.4 TNT

As explained in previous Sections, the TNT Asian air network is much more limited than its competitors.

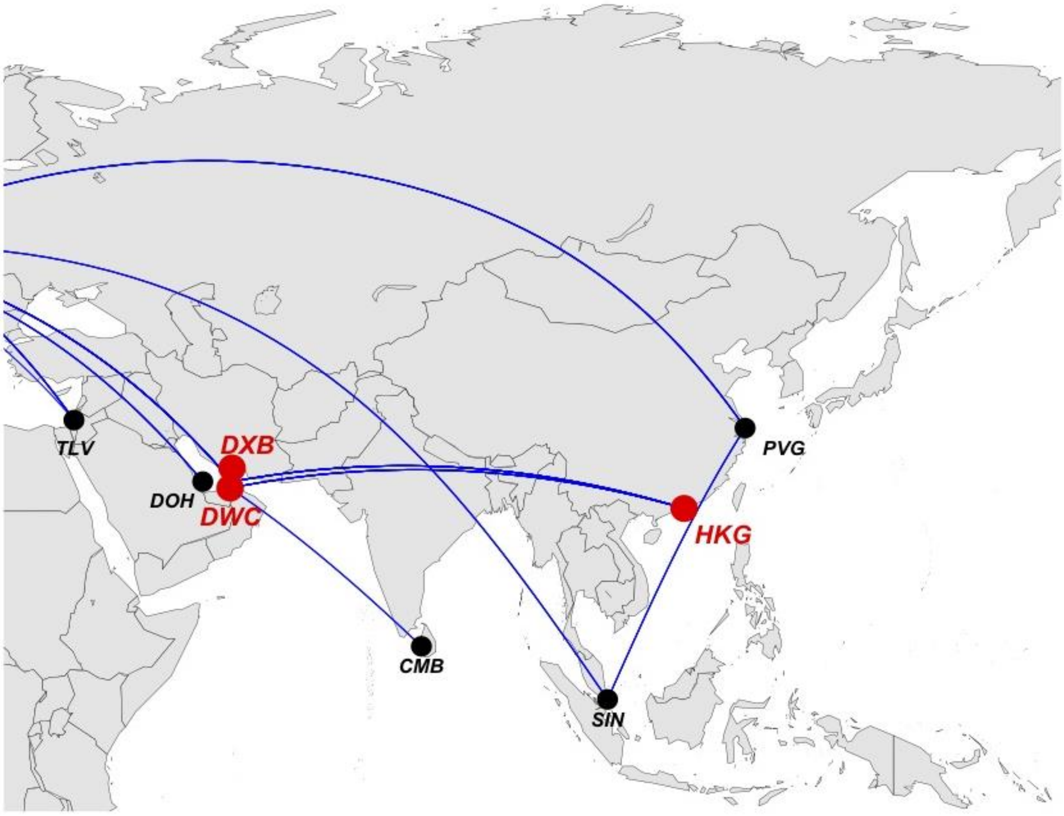

Figure 7. The TNT Asian airport network (top three AFT airports in red).

Figure 7 and Tables 10–11 show that most of the flights operated by TNT are connections to the European market, specifically to the Belgian airport of Liege, which is the main TNT hub. Among Asian airports, note the relevance of Dubai (DXB), Hong Kong and Dubai (DWC). As far as routes, TNT's busiest routes are (equally important) Dubai-Liegi and Hong Kong-Dubai (DXB). However, it is clear that according to our data set, a focus on the TNT intra-Asia network would not make much sense, and therefore TNT will not be considered in the course of the present analysis.

Table 10. Top 10 TNT Airports in the Asian Air Network

Airport (IATA Code)	Country	Dep. AFT	Arr. AFT	Total AFT
Liege (LGG)	Belgium	1,180	1,283	2,463
Dubai (DXB)	**United Arab Emirates**	**1,133**	**1,152**	**2,285**
Hong Kong (HKG)	**Hong Kong**	**1,058**	**955**	**2,013**
Dubai (DWC)	**United Arab Emirates**	**550**	**550**	**1,100**
Shanghai (PVG)	China	440	440	880
Singapore (SIN)	Singapore	330	330	660
Doha (DOH)	Qatar	206	206	412
Colombo (CMB)	Sri Lanka	110	110	220
Tel Aviv (TLV)	Israel	57	76	133
Vienna (VIE)	Austria	76	38	114

Table 11. Top 10 TNT Routes in the Asian Network

Departure	Arrival	AFT
Dubai (DXB)	**Liege (LGG)**	618
Hong Kong (HKG)	Dubai (DXB)	618
Liege (LGG)	Dubai (DXB)	534
Dubai (DXB)	Hong Kong (HKG)	515
Shanghai (PVG)	**Liege (LGG)**	440
Dubai (DWC)	Hong Kong (HKG)	440
Hong Kong (HKG)	Dubai (DWC)	440
Liege (LGG)	Singapore (SIN)	330
Singapore (SIN)	Shanghai (PVG)	330
Doha (DOH)	**Liege (LGG)**	206

5.5 Global integrators' common choices

Global integrators' (DHL, FedEx and UPS) hub-positioning strategies have an important common denominator (as previously discussed by Bowen (2012))—that is, their choice to locate hubs in the Pearl River Delta (PRD). This area, where the Pearl River flows into the South China Sea, has incredible strategic importance and hence this choice is not surprising. Indeed, the PRD is one of the most densely urbanized regions (about 120 million inhabitants) in the world and one of the main centers of China economic growth. The World Bank recently named the PRD as the biggest urban area in the world in terms of population and geographical size (*The Guardian*, 2016). The PRD comprises more than eight metropolises and includes Guangzhou, Shenzhen, and the Hong Kong Special Administrative Region. It is not a coincidence that, as highlighted in Walcott and Fan (2017), east coast Chinese cities were the first to embrace the global economy in the 1980s. Since the 1990s, these cities have experienced significant economic growth, which in turn has led to a greater demand for air cargo services. Thus, along with the previously discussed 2003–2004 changes in China air cargo policy, an important step toward the expansion of global integrators in China was made (Bowen, 2012 and Walcott and Fan, 2017). In the following years, UPS and FedEx moved from the Philippines and established hubs respectively in Shenzhen (2008) and Guangzhou (2009), while some years later, DHL established a Northeast Asian hub in Shanghai. Further movements by the three integrators involved Chinese airports in the following years. Different Chinese airports (i.e., Shenzhen, Guangzhou, and Shanghai) proved to be among the most important hubs of the three carriers. As a result, the influence of China's more liberal air cargo aviation policy of the last 10 to 15 years has been confirmed. In the next section, we perform an empirical network analysis to corroborate this insight.

Looking at extra-Asian airports, the role of the Anchorage airport in both the FedEx and UPS networks is apparent, and both companies have made huge investments in their logistics centers there. The main advantage of the ANC airport (located in Alaska) location is that 90% of the industrialized northern hemisphere can be reached within less than 10 hours, meaning more cargo to transport and less fuel to consume.[10]

Generally, most of the routes are international, which may confirm that integrated carriers are much more oriented toward international air cargo traffic than domestic cargo traffic. As previously discussed, this orientation may also be due to difficulties that are weakening their penetration in some domestic markets (e.g., the Chinese one).

6 The structure of the networks

While Figures 1–7 show the geographical layout of integrators' networks, the focus in this section is on network topology. Indeed, carriers' strategies strongly define their network structure with network topology affecting both efficiency and robustness. More specifically, an efficient network provides economic advantages to the airlines in terms of economies of scale, density, and scope, while a robust network can improve the flexibility, stability, and security of airline operations (Lordan et al., 2016). Hence, both efficiency and robustness exert an impact on profitability, and in this sense, carriers' strategic choices can be seen as a trade-off between these two main characteristics. At the two extremes we find hub-and-spoke (H&S) and point-to-point configurations (PP). An H&S system with a single hub can be considered the most efficient configuration. It serves network destinations with the fewest routes (and number of aircraft) of any alternative structure (Button, 2002). Furthermore, as customer density and network size increase, the economic advantages of consolidating spoke-city traffic increases (Cook and Goodwin, 2008). Concerning specifically the integrated carriers, an H&S system allows the process of handling and sorting parcels to be centralized (Lim and Shiode, 2011). However, given the essential role of the central hub, H&S networks are less robust than the more spatially dispersed PP networks (Sun and Wandelt, 2018). Finally, multi-hub networks are H&S networks with more than one hub. As explained in the literature, a carrier may find it efficient to operate multiple hubs when (i) economies of density disappear at high hubbing levels, or (ii) there is excess of demand compared

[10] O'Grady (2010) explains exactly that these are the reasons why, for example, ordered iPad tracked on the Apple order status page, exhibit a travel from China to Anchorage and not to UPS main hub of Louisville (Kentucky).

to airline capacity at the airport (Düdden, 2016). Furthermore, multiple hubbing may be due to a convenient location of the hubs, with each one serving different and distant geographical areas. However, multi-hub systems can be adopted even when none of the abovementioned conditions arise. Indeed, a carrier may decide to sacrifice a measure of efficiency in order to achieve a more flexible and robust network, especially when the context in which it operates is unstable (e.g., changing regulations or residual obstacles to free trade among countries).

Integrators' pure network structures are depicted in Figures 9–12.[11] Each configuration is represented as a set of nodes also called vertices (i.e., airports) and directed edges (i.e., connections with directions between two vertices *i* and *j*) called arcs. The grey arrows depicted in Figures 9–12 indicate the direction of the connection. Remember that only flights having origins and/or destinations in Asia are considered in this analysis, which means that the central position of an airport, whether Asian or not, is determined almost exclusively on the basis of the number of connections with Asian airports.

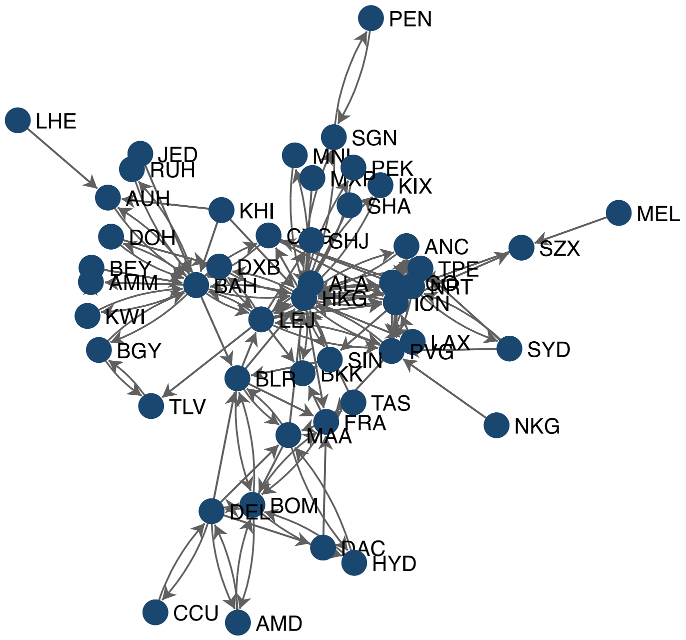

Figure 9. The DHL network structure.

Figures 9–12 confirm the predominance of a hub-and-spoke topology given the presence of few hubs with a very high number of connections. DHL, FedEx, and UPS all clearly rely on a set of "secondary" hub airports from which it is possible to reach several destinations. Hence, they operate

[11] Figures 9–12 were created through the STATA package *nwcommands*.

multi-hub networks with more than one central airport. Furthermore, many airports that are linked to their main hub act also as stopovers to reach one or more further airports in the network. Hence, despite the potential high degree of centralization, the presence of such stopovers and feeders implies that the air networks cannot be classified as pure H&S networks. DHL seems to exhibit a more centralized structure with a main edge—namely, the Hong Kong super-hub—and Seoul, Tokyo, Shanghai, and Bahrain (and obviously the European hub of Leipzig). In the FedEx network, the Guangzhou super-hub and the airports of Osaka, Tokio, Seoul, Shanghai stand out. In the UPS network two main hubs are recognizable— Shenzhen and Hong Kong—and play a similar central role as well as a significant role for other airports.

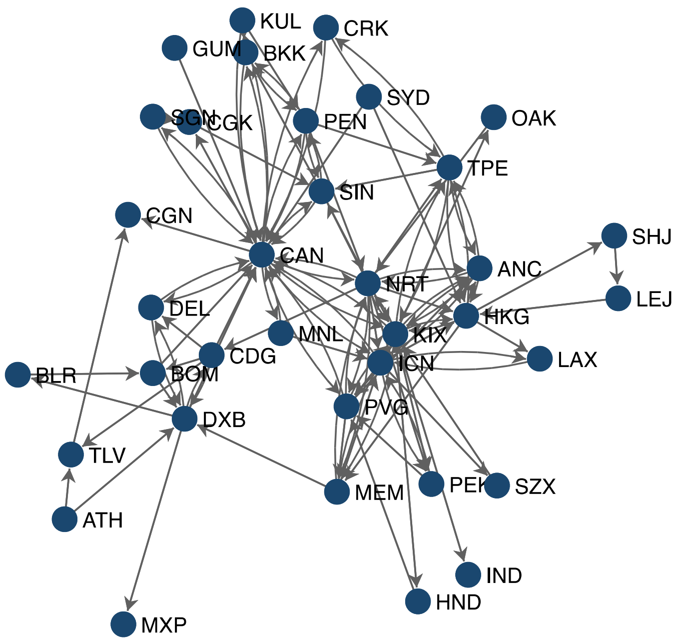

Figure10. The FedEx network structure.

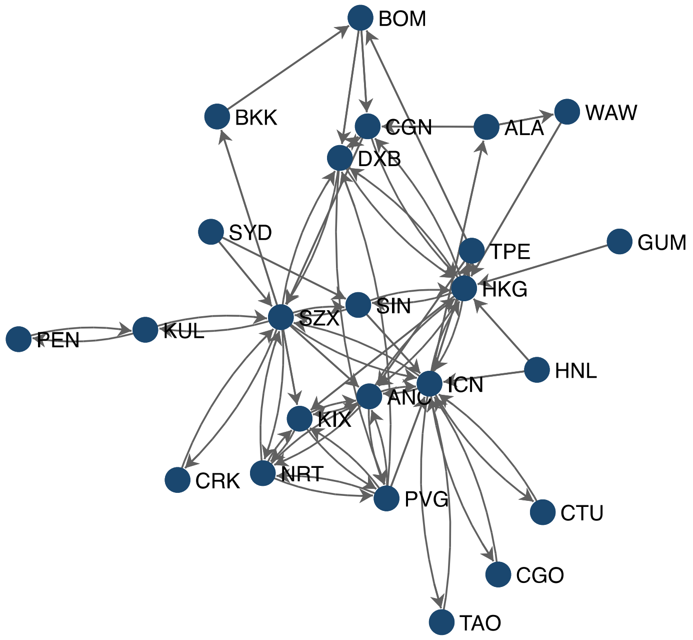

Figure 11. The UPS network structure.

More detailed information on the structures of the networks (and their links with carriers' strategies) can be obtained by analysing complex network metrics.[12] Hence, similar to Malighetti et al. (2018), our graphical network analysis is combined with analytical measures of network characteristics.

Table 15. Comparison of Integrated Carriers' Networks

	DHL	**FedEx**	**UPS**
Nodes	48	36	24
Arcs	145	119	72
Density	0.06	0.09	0.13
Reciprocity	0.44	0.37	0.53
Transitivity	0.38	0.93	0.26
Betweenness centralization	0.50	0.38	0.32
Indegree centralization	0.41	0.40	0.27
Outdegree centralization	0.35	0.31	0.27
Paths (largest comp.)	2,256	1,260	552
Diameter (largest comp.)	7	6	6
Average shortest path (largest comp.)	2.57	2.12	2.19

Table 15 shows that DHL exhibits the most developed network in terms of airports (nodes) and routes (arcs). FedEx is exactly in the middle between DHL and UPS in terms of nodes, while it is

[12] Complex network metrics were computed through the STATA package *nwcommands* (Grund, 2015).

closer to DHL in terms of arcs. Despite the sparseness of all three networks, UPS exhibits the highest density (i.e., the highest portion of potential connections that are actual connections), suggesting a structure in which the role of hubs is less dominant and freight volumes are less concentrated in few nodes compared to its competitors. Indeed, as density increases, there are a higher number of point-to-point connections, suggesting that the structure tends to deviate from the typical multi-hub configuration and is characterized by higher flexibility and robustness. Such general low level of density is also influenced by the low level of reciprocity as compared to air passenger airlines. Indeed, reciprocity refers to dyads—namely, pairs of airports—and is the fraction of dyads that are reciprocated or, in other words, the percentage of bidirectional connections. The generally significant percentage of the edges flown in only one direction is an implication of the fact that freight, different from passengers, can be transported in a more efficient manner because it is not sensitive to multiple stops and circuity (Lakew, 2014; Malighetti et al., 2018). Transitivity is instead the fraction of airport transitive triplets out of all the potentially transitive triplets in the network. In terms of network topology, the higher the transitivity, the greater the number of sets of three airports characterized by a transitive relationship (i.e., A connected to B + B connected to C => A connected to C). The FedEx network is largely the most transitive, which may suggest that in the FedEx network there is a high proportion of triangles of airports A, B, and C so that the company operates flights from A to C both directly and one-stop (i.e., with a stop in B). This high proportion combined with the low reciprocity could mean that airports that act as stopovers to reach further airports in the network (B in our example) are also important points of freight loading and unloading (otherwise the A-C link would be sufficient to transport freight between the two airports). At the same time, transitivity may imply higher robustness and flexibility in connecting nodes. Indeed, the possibility to choose whether to fly from A to C directly or through a one-stop flight A-B-C means that nodes exist in the network that can be bypassed (the higher the transitivity, the higher the number of such nodes). On the other hand, this is a structure that moves away from a typical hub-and-spoke configuration because it requires more arcs for the same number of airports connected to the network; in other words, the structure might be expected to be less efficient.

Despite a general orientation towards robustness given by the multi-hub nature of integrators' network (with respect to a single-hub configuration), these indices (i.e., density and transitivity) seem to reflect different strategies adopted by the three integrated carriers.

According to the centralization scores, DHL has the most centralized network. Network centralization indices are composed of numbers between 0 and 1, in which 0 means that all the airports have equal centrality value (as in a cycle), while 1 indicates an airport that completely dominates all other nodes (as in a star). We computed three indices of centralization at the network level. The first is the so called "betweeness centralization" and is based on betweeness centrality scores (Freeman, 1977; Brandes, 2008) of the airports belonging to a specific network. According to this measure, an airport is important when it connects other airports. Indeed, betweenness node centrality is defined as the number of shortest paths (i.e., shortest sequences of arcs) among all other nodes that pass through that node. This means that airports with high betweenness centrality act as intermediaries with a significant role in connecting other airports and function as an essential bridge point for many of the freight flows transported along the network. Formally, the betweenness centrality of a single node $C_B(v_i)$ and the betweenness centralization of a network $C_B(N)$ can be defined as follows:

$$C_B(v_i) = \frac{1}{(N-1)(N-2)} \frac{\sum_{j,k} g_{jk}(v_i)}{g_{jk}}$$

$$C_B(N) = \frac{\sum_{v_i \epsilon N} C_B^* - C_B(v_i)}{max \sum_{v_i \epsilon N} C_B^* - C_B(v_i)},$$

where g_{jk} indicates the total number of directed shortest paths from vertex *j* to *k*; $g_{jk}(v_i)$ denotes the number of directed shortest paths from vertex *j* to *k* that vertex *i* lies on; *(N-1) (N-2)* is the number of pair nodes used for normalization purpose; and C_B^* is the highest value of the selected unit-centrality measure $C_B(v_i)$. *max* in the denominator indicates that the numerator is divided by the maximum numerator that could be attained by an N-node graph. As the level of centralization increases, efficiency increases, and robustness decreases. Hence, our results on betweenness centralization suggest two main considerations: (i) the DHL network is the most centralized, confirming both the graph analysis and the indications from Tables 1,4 and 7, and (ii) scores not close to one corroborate the idea derived from the graph analysis that integrated carriers operate multi-hub structures with more than one central node in their networks.

The other two centralization indices we computed are indegree and outdegree centralization. Again, centralization indices at the network level are based on centrality scores computed at the airport level. At the airport level, indegree centrality is the number of origins that offer flights toward a specific airport, while outdegree centrality is the number of destinations to which it is possible to fly from a specific airport. At the network level, indegree $C_I(N)$ and outdegree $C_O(N)$ centralization indices (Freeman, 1978) can be computed as follows:

$$C_I(N) = \frac{\sum_{v_i \epsilon N} C_I^* - C_I(v_i)}{max \sum_{v_i \epsilon N} C_I^* - C_I(v_i)}$$

$$C_O(N) = \frac{\sum_{v_i \epsilon N} C_O^* - C_O(v_i)}{max \sum_{v_i \epsilon N} C_O^* - C_O(v_i)},$$

where $C_I(v_i)$ and $C_O(v_i)$ are respectively the indegree and outdegree centralities of a single node v_i, and $C_I{}^*$ and $C_O{}^*$ are respectively the highest values of selected unit-centrality measure $C_I(v_i)$ and $C_O(v_i)$. Note that according to the two "degree" indices, DHL and UPS are confirmed respectively as the most and least centralized networks. Hence, centrality indices corroborate the evidence on the differences between the three carriers' strategies. Despite a common multi-hub structure, DHL seems to have chosen efficiency as a key driver as demonstrated by a more central network in which the majority of freight volume is concentrated in the main hubs and density and transitivity are low. FedEx and UPS exhibit a focus mainly on robustness and flexibility, however, with different respective strategies. Indeed, FedEx combines the highest transitivity-to-medium centralization (i.e., lower than DHL, but higher than UPS) and density, while UPS combines the lowest centralization-to-highest density. In this sense, the UPS network structure seems such that it deviates more from the typical multi-hub configuration.

From a policy perspective, it is also important to know how airports are indirectly connected with each other—i.e., how it is possible to fly from airport *i* to airport *j* through a path in the network. As previously explained, a sequence of arcs is called a path from vertex *i* to vertex *j* if an aircraft can be flown from airport *i* to airport *j* via other airports (i.e., with intermediate stops). The number of ties determines the length of a path. A direct link between two vertices is also called a path with length equal to one. To determine how many flights it takes to reach all other airports from a given airport, it is possible to compute the so-called geodesic distance of one airport *i* to all the other airports in the network. It is then possible to obtain the following information at the network level:

- Paths: the total number of paths in the largest component of the network (i.e., the maximal set of nodes such that each pair of nodes is connected by a path);
- Diameter: the length of the greater geodesic distance (i.e., the length of the longest shortest path between any two nodes computed for the largest component of the network);
- Average shortest path: the average length of all the shortest paths in the largest component of the network.

These indices confirm once again that the DHL (2,256) network is more developed than those of FedEx (1,260) and UPS (552). Interestingly, FedEx and UPS, despite their different sizes, exhibit similar numbers in terms of both diameter and average shortest path. In an air transportation network, the average shortest path length is the average minimum number of flights that one needs to go from any airport to any other airport in the network. Our results suggest that, on average, it is possible to reach any destination in the UPS and FedEx networks with a two-step flight, while a three-step (2.6) flight is necessary to do the same in the DHL network. However, considering the bigger size of the DHL network, we can conclude that its network is characterized by a higher level of interconnectivity.

Looking more specifically at the Chinese airports in the three networks, we analyze the betweenness-centrality scores at the airport level to obtain a further measure of the relevance gained by these airports as a result of the change in China's aviation air cargo policy that occurred in 2003–2004. Remember that it has only been since 2009 that integrators began establishing their hubs in China on the heels of such a change. Among the 48 airports in the DHL network, Shangai PVG is the fifth one in terms of betweenness. The Chinese airport resides on 78 shortest paths that connect other couples of airports in the network. Despite the fact that this value is far from 605—the value of the main DHL hub of Honk Kong HKG—the Chinese airport has certainly gained a central role in the network. In the FedEx network, Guangzhou CAN has even become the main central hub as it is on 286 shortest paths (the first score in the network passing through it). The same applies to the UPS network, where Shenzen is the most central hub with about 100-shortest paths passing through it. These results provide further confirmation of the significant influence exerted by China's air cargo policy that has completely reshaped the integrated carriers' networks, as well as the current configurations. Of course, this transition from "no Chinese hubs" to "significantly central Chinese hubs" is of great interest for air transport policy makers from both China and nearby countries.[13]

Our analysis not only highlights the impact of previous policies on integrators networks and helps to understand their strategies, but it also allows us derive some indications that may be of interest to policy makers. Figure 12 shows a comparison between the concentration of cargo traffic in the European and in the Asian networks for each integrator (information on European traffic comes from Malighetti et al., 2018). More specifically, the figure illustrates a concentration of the cargo volumes (in percentage) at the 10 main airports on each continent. It is evident that in Europe, freight volumes are more concentrated at the main hubs compared to Asia where the distribution is sparser. The explanation for this result is given by our analysis that shows the multi-hub structure of the Asian networks of the three carriers. Indeed, the FedEx and UPS networks in Europe operate a single-hub network structure (Malighetti et al., 2018) even if not pure. The difference is less evident for DHL because the German carrier operates a multi-hub structure also in Europe. However, the DHL choice in Europe may be explained in terms of traffic that is sufficiently large and diffuse to support such a configuration (Malighetti et al., 2018). It is less easy to explain what DHL, FedEx,

[13] Think, for example, of the overlapping Pearl River Delta hinterland of Hong Kong and Chinese airports such as Shenzen (Kresl, 2010). The issue of competition for cargo traffic will become increasingly relevant in the next years and will also involve national policy makers.

and UPS found it beneficial to locate in different countries several hubs that are often very close to each other (e.g., Hong Kong and Chinese airports such as Shenzen). We believe that the decisions regarding these hub locations were not based on either a cessation of density economies, demand excess, or reasons connected to spatial distances. One reason for such a robust and flexible configuration, we believe, is inherent in the nature of very heterogeneous regions of the Asian continent. More specifically, a more complex (compared to Europe) trade of goods and services among countries combined to a lack of economic cooperation and to changing regulatory environments played a role in determining the current network configurations. In a more favorable context, integrated carriers may further pursue efficiency. In other words, we believe that policy interventions facilitating trade, cooperation, and liberalization may lead also to a reconfiguration of integrators' air networks toward a more efficient structure in terms of economies of scale, density, and scope. Such a reconfiguration would be reflected in terms of lower costs, prices and, consequently, social welfare. Although we are aware that the abovementioned diversities make it difficult to define a single strategy for the region, governments should work to address these challenges and stimulate integration by implementing the correct initiatives and policies.

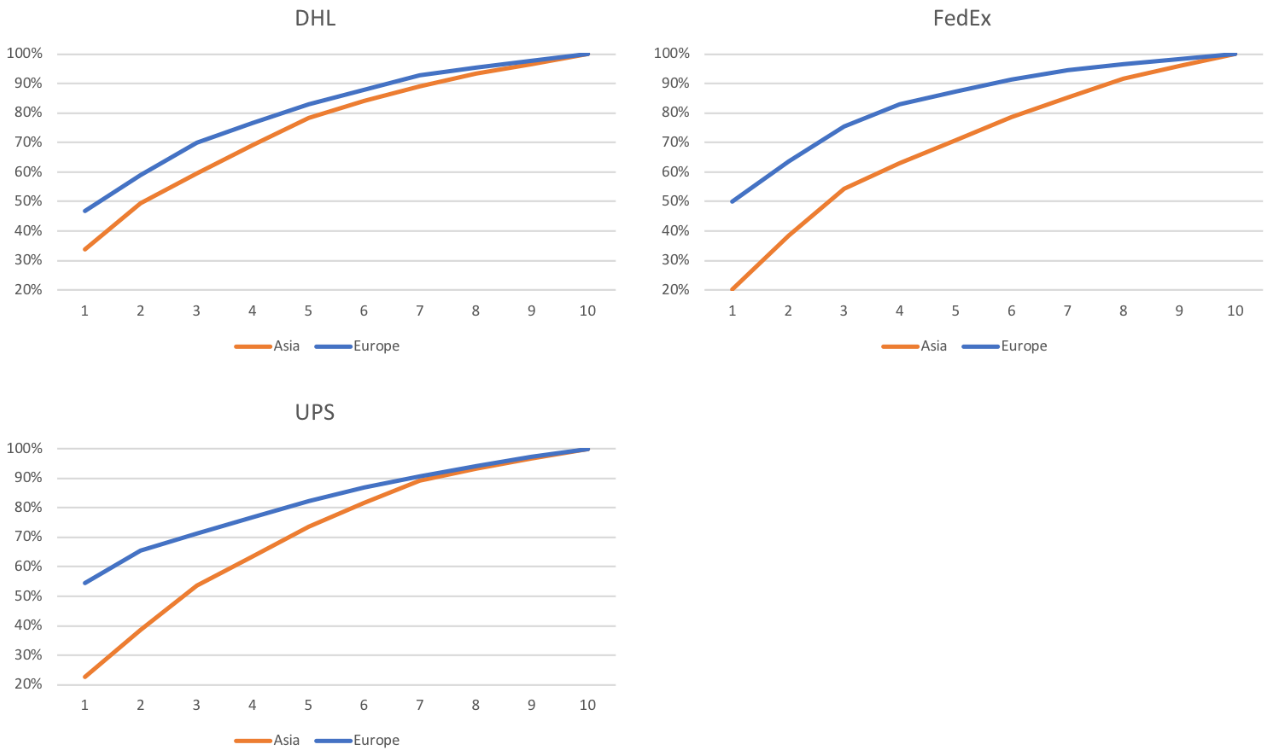

Figure 12. Integrators' concentration of freight volumes at the top 10 airports in Europe and Asia.

7 Conclusion

This paper studies the Asian air transport network of the four integrators—DHL, FedEx, TNT, and UPS. A network analysis was performed to quantitatively describe the network structures of the integrated carriers.

Our results suggest some important considerations. First, we provide empirical evidence that following the adoption of a more open air cargo aviation policy in China, integrated carriers have established very important hubs at Chinese airports (in terms of both cargo volumes and centrality in the network) that play now a central role in the Asian air cargo market.

Second, despite a general focus on Eastern Asia markets, DHL has a more developed Western Asia network and also a more developed intra-Asia network with respect to FedEx and UPS (with FedEx having in turn an "internal network" greater than that of UPS). Moreover, FedEx seems to have a prominent role in shipments between Japan and the U.S., while the TNT presence in Asia appears to be quite limited.

Third, DHL, FedEx, and UPS operate their flights through "hybrid" hub and spoke models. More specifically, they operate multi-hub networks. This strategic choice provides more robustness and flexibility to their networks (compared to a single-hub structure). However, such robustness and flexibility are the result of a trade-off with efficiency, which the three carriers achieve at different degrees. More specifically, the DHL network is the most concentrated due to the great centralization, low density, and transitivity of the structure. This suggests a focus on efficiency aimed at capturing advantages coming from the economies of scale, density, and scope typical of H&S structures. The FedEx network has the largest level of transitivity, and it is denser than the DHL network. This suggests a focus that is more oriented on robustness and flexibility. In addition, the UPS network appears flexible and robust even if such robustness is not built on transitivity, but on the lowest centralization and the greatest density among the three carriers under analysis. In this sense, the UPS network appears to be the furthest from the classical H&S configuration.

Fourth, a comparison between traffic concentration in Europe and in Asia shows that the same carriers tend to operate a more centralized network in Europe than in Asia. We believe this is due to a more complex environment in Asia (compared to Europe) and, as such, the networks' robustness and flexibility are more important. In other words, a more laborious trade of goods and services, combined to a lack of economic cooperation and to changing regulatory environments, seems to have exerted a significant influence on current network configurations. From a policy perspective, it is relevant to understand that in a more favorable context, integrated carriers may sacrifice robustness and flexibility in favor of efficiency. In other words, we believe that policy interventions facilitating liberalization, trade, and cooperation may induce a reconfiguration of the integrators' air networks with the aim of achieving more efficiency (through economies of scale, density, and scope). Cost reductions may be passed on to customers in terms of lower prices or higher quality that positively impact social welfare. Hence, we encourage policy efforts going in a direction that would stimulate integration, cooperation, and liberalization.

Our work has some limitations. First, in order not to underestimate integrators' operations partners, airlines have been incorporated in our analysis. However, our procedure is inevitably non-rigorous, as it is based on the limited information available. Second, our focus is only on air networks, while road transport—surely a relevant part of the story—is not considered due to data unavailability. Third, it is not possible to investigate a temporal evolution of the network since our data set merely provides a picture of the networks' structures in a specific period; as such, a temporal analysis is left for future research. Despite such limitations, we believe that our results are of interest given that the paper is a first step in the limited empirical literature regarding integrators' activities in the Asian region.

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APPENDIX A - Airlines included in the dataset.

Airline	**Integrator**
AeroLogic	DHL
ASL Airlines Ireland	DHL
Atlas Air	DHL
Air Hong Kong (DHL cs)	DHL
Blue Dart Aviation	DHL
DHL	**DHL**
DHL International	**DHL**
EAT Leipzig	**DHL**
FedEx	**FedEx**
LAN Cargo	FedEx
Polar Air Cargo	DHL
Southern Air	DHL
TNT Airways	**TNT**
TNT/Emirates Air cargo	TNT
UPS	**UPS**
Western Global Airlines	FedEx