LOGI – Scientific Journal on Transport and Logistics
Vol. 15 No. 1 2024 DOI: 10.2478/logi-2024-0017

The Multi-Year Period Analysis of the Air Freight Industry Pre-and Post-COVID-19

Tuzun Tolga Inan[1*]

[1]*Bahcesehir University, Department of Pilotage, 34353, Besiktas, Istanbul, Turkey; Email: tuzuntolga.inan@bau.edu.tr*

***Corresponding Author:** Tuzun Tolga Inan

Received: 3 June 2024; Revised: 20 October 2024; Accepted: 14 November 2024; Published: 20 December 2024

Abstract: The paper aims to analyze air metric tons, gross logistics revenues, and cargo tonne kilometers (CTK) to benchmark pre-COVID (2014-2019) and post-COVID (2020-2022) periods using statistical methods, including mean values, standard deviation, variance, covariance, correlation, and T-tests. The findings reveal substantial decreases in all three variables in the post-COVID period, highlighting the significant impact of the pandemic on the air-freight industry. Specifically, the mean air metric tons decreased from 3,276,888 pre-COVID to 1,021,272 post-COVID; gross logistics revenues dropped from $6,155.37 million to $2,114.91 million, and CTK declined from 7,984.25 to 2,687.36. The reduced standard deviation and variance indicate less variability in the post-COVID period. Additionally, strong positive correlations between pre-COVID and post-COVID variables indicate consistent trends across the two periods. The paper's originality lies in its findings which emphasize the need for the air freight industry to adapt and develop strategies mitigating the effects of future disruptions, underscoring the pandemic's profound impact on air freight operations and financial performance.

Keywords: Air freight industry, integrated express carriers, combination aircraft carriers, pre-COVID period, post-COVID period

1. Introduction

Air transportation is the primary and most preferable mode of transportation for advancing economic growth and improving societal welfare. Air transport development contributes significantly to the countries' revenues by providing high-demand services. In history, various crises have negatively affected air transportation, but after relatively short recovery periods, demand has risen again [1]. Air freight is a transportation type that can have distinct advantages over marine, rail, road, and underground [2]. It is particularly suited for transporting urgent and perishable goods

over medium to long distances. Due to its emphasis on safety and speed, air freight provides international and intercontinental transportation utilizing wide-body aircraft [3]. Air freight transportation services involve transportation of products between shippers, road carriers, airlines (also known as carriers), and consignees [4]. Although air freight accounts only for 1% of the world's freight by volume, its high-value cargo represents approximately 35% of the global freight value [5]. Before the COVID-19 pandemic, the value of goods transported via air freight reached 6.2 trillion dollars, which equals 7.4% of the global gross domestic product. The air freight supply network is important in the shipment and distribution of commercial goods. It is indispensable for transporting perishable commodities across the globe. Sectors that rely heavily on freight include pharmaceuticals, high-tech hardware including next-generation software, and e-commerce industries encompassing food, fashion, electronics, media, furniture, etc. [6]. Academic literature highlights the complexity of analyzing air freight and air passenger transportation. This complexity is due to the involvement of all-cargo carriers, integrated express carriers, combination aircraft carriers, and passenger airlines [7].

The air freight industry covers the commercial product transportation of goods using cargo aircraft. When these goods are transported globally, the process is classified as commercial air transportation [8]. The development trend of air transportation has positively influenced the income and populations of countries, particularly those with strong industrial bases [9]. The demand for air freight transportation has led to the creation of new documentation processes, including the coordination between the receiver, carrier, and sender, suitable for the global nature of the industry [10]. Air freight has a sophisticated system related to socio-technical issues, encompassing diverse concepts in terms of diversified specifications. Integrated express carriers utilize two strategies within the supply chain services: one associated with unified integrator companies, which manage express high-volume cargo, small-volume cargo, and mail with multiple modes of transport, and the other with combination airlines, handling both passenger and cargo transportation [11]. Combination aircraft carriers operate their aircraft with a “combi” strategy, by removing seats to accommodate cargo [12]. In contrast, integrated express carriers have the advantage of carrying cargo using at least one transportation module in addition to air. Combination aircraft carriers use only air transportation for moving both freight and passengers. Integrated companies primarily employ a door-to-door strategy, which incorporates airport-to-airport service, while combination companies focus solely on the airport-to-airport strategy [13]. Safety, speed, and reliability are the key factors driving the effectiveness of air freight transportation. The types of cargo include hazardous goods, live animals, valuable goods, and perishable items [14]. A standard operation starts when freight forwarders deliver to the origin airport′s terminal, utilizing containers and pallets. The cargo is loaded, unloaded, and sorted for transport to the destination airport. The

process includes preparing documentation that specifies the weight, size, category and number of items being shipped [15].

2. Literature Review

In 2022, aviation recovery rates for both passenger and freight numbers significantly outpaced those of 2020, even though the number of COVID-19 cases was higher in 2022. This shows that, unlike air passenger traffic, air freight transportation demonstrated steady growth since the onset of the COVID-19 pandemic [16]. Before COVID-19, air transport trend for both passenger and freight had globally outpaced the rate of the world population growth over the previous decade [17]. Historically, air transportation has been positively and/or negatively influenced by domestic and international factors, including political uncertainty, terrorism, and economic crises [18]. Despite these previous crises and pandemics that negatively affected the development of air transportation for a specific period, the COVID-19 pandemic had an unseen-of detrimental effect on air transport. Crises such as the Asian Financial Crisis, the Gulf War, 9/11, the SARS and MERS Pandemics, and the 2008-2009 global financial crisis affected the sector to varying degrees, but none of them caused the dramatic global decline in volume and revenues seen during the COVID-19 pandemic [19,20].

Especially the first and second peaks of the pandemic (23 January 2020 and 1 June 2020) had a profound negative impact on airlines, affecting both passenger movement and freight transportation [21]. However, air freight showed greater resilience due to its limited reliance on human interaction. This led to the implementation of sophisticated strategies unique to freight transport, distinguishing it from passenger services [22-24]. This study highlights the need for continuous monitoring of the air freight industry to identify emerging trends and potential risks, such as the transportation of dangerous goods requiring specialized packaging to reduce radioactivity. By maintaining a proactive approach to handling special freight that needs additional precautions, the industry can better anticipate and respond to future challenges [25,26]. In addition to crises and pandemics, the Eyjafjallajökull volcanic eruption in the spring of 2010 affected some of the world's busiest airspace, and air transportation was limited by the resulting ash cloud that covered much of European airspace [27]. Before the volcanic eruption, the 9/11 attacks in the United States had a profound impact on global aviation. These attacks involved the hijacking of four commercial passenger aircraft by 19 Al Qaeda terrorists. Two aircraft were flown into the World Trade Center's Twin Towers in New York City, causing their collapse. A third aircraft struck the Pentagon nea Washington, DC, while the fourth aircraft, believed to be targeting the White House, crashed in rural Pennsylvania after crew and passengers intervened to prevent the terrorists from completing their plan [28].

Due to its volume capacity and loading principles of product classification, air freight transportation involves greater uncertainty than passenger transportation. In addition to challenges in air freight transport, reservation cancellations for transit passengers can pose serious problems in air passenger transportation. Therefore, passengers who do not complete the boarding process cannot board the aircraft. In contrast, the planning strategy of air freight forwarders is different from passenger transportation, designating cargo capacity volumes six to twelve months before scheduling specific flights [25]. The schedule plan of passenger airlines, however, is based on reservations, which can vary significantly due to capacity management. Unlike passenger airlines, air freight forwarders are exempt from having to disclose the cost associated with unserviceable shipments [26]. Predicting the capacity of air freight is more challenging than forecasting passenger capacity, which is determined by the number of seats on an airplane determines, whereas freight capacity depends on the types and quantities of unit load devices (ULDs) [29], such as containers and pallets. These ULDs are classified based on factors like pivot weight, volume, type, and center of gravity [25]. For instance, there is a direct relationship between volume and capacity. Unlike passenger transport, weight is not a critical factor in air freight planning because air freight includes more complex scenarios in capacity planning. Instead, the volume and design of products are closely tied to the origin-destination (OD) pair of a flight. Additionally, air passenger transportation faces unique challenges, such as inadmissible and deported passengers who are prohibited from boarding. In air freight transportation, however, shipments can still move from origin to destination via several midpoint airports, unlike passenger transportation [26], which require a fixed itinerary including origin, stopover (transit), and destination airports. Network capacity planning is a critical factor in air passenger transportation, but air freight transportation is more complex. This complexity arises from the need for more conceptual and empirical modeling [13].

3. Data and Methodology

In this study, the major 25 integrated express carriers and combination aircraft carriers were analyzed based on their air metric tons, gross logistics revenues, and cargo tonne kilometers (CTK) to demonstrate the development trends in air freight transport before and after the COVID-19 pandemic. The period from 2014 to 2019 was used as a benchmark to compare with the years 2020 – 2022, highlighting changes in air metric tons, gross logistics revenues, and CTK in the air freight industry pre- and post-pandemic. Air metric tons and CTK were used to assess operational development, while gross logistics revenues served as an indicator of financial development. The year 2014 was selected as the starting point because it showed the highest development trend compared to the previous year. Available data was collected to analyze the 9-year pre- and post-

COVID-19 air freight trends related to the air cargo news data hub [30] using phyton programming statistical functions [31].

Table 1 Air freight industry descriptive statistics. Source: [30,31]

Variable	Mean Pre-Covid	Std. Dev. Pre-Covid	Variance Pre-Covid	Mean and	Std. Dev. Post-Covid
Air Metric Tons	3,277,888	6,854,796	47,000,000	1,021,272	2,228,647
Gross Logistics Revenues	6,155,370	9,174,650	84,200,000	2,114,910	3,209,240
CTK	7,984250	12,401,820	154,000,000	2,687,360	3,579,640
	Variance Post-Covid	Covariance	Correlation	T-test p-value	
Air Metric Tons	4,970,000	5,500,000	0.88	0.003	
Gross Logistics Revenues	10,300,000	16,200,000	0.75	0.012	
CTK	12,800,000	24,500,000	0.80	0.008	

As seen in Table 1, the mean air metric tons decreased significantly in the post-COVID period compared to the pre-COVID period. The standard deviation and variance show a decrease as well, indicating reduced variability in the post-COVID period. The correlation coefficient is high (0.88), suggesting a strong linear relationship between pre-COVID and post-COVID air metric tons. The T-test p-value is 0.003, indicating a statistically significant difference between the two periods. The mean gross logistics revenues decreased post-COVID compared to pre-COVID levels. The standard deviation and variance are lower in the post-COVID period, reflecting reduced variability. The correlation coefficient is 0.75, indicating a moderate linear relationship. The T-test p-value of 0.012 confirms a statistically significant difference between the two periods. The mean CTK values also show a decrease in the post-COVID period. The standard deviation and variance are considerably lower post-COVID. The correlation coefficient is 0.80, indicating a strong linear relationship. The T-test p-value of 0.008 further confirms a statistically significant difference between the pre-COVID and post-COVID periods.

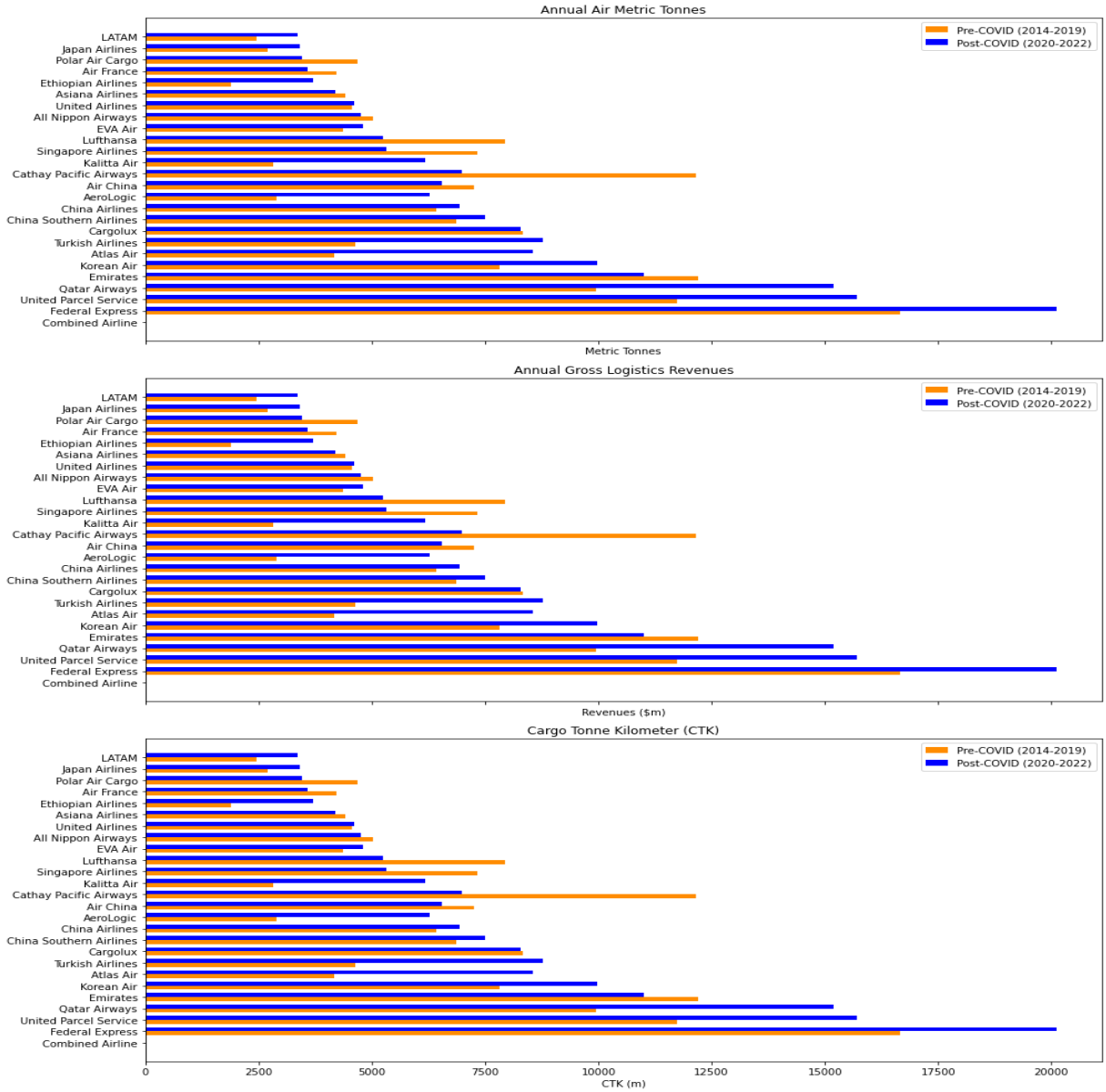

Fig. 1 The comparison of annual air metric tons, annual gross logistics and annual cargo tonne kilometers. Source: [30,31]

As seen in Figure 1, three bar charts compare the pre-COVID (2014–2019) and post-COVID (2020–2022) variables for the 25 leading integrated express carriers and combination aircraft carriers. Each chart represents a specific variable: air metric tons, gross logistics revenues, and cargo tonne kilometers (CTK). The orange bars represent the pre-COVID period, while the blue bars represent the post-COVID period. The Air Metric Tons chart compares the average annual air metric tons transported by each company in the pre-COVID and post-COVID periods. Similarly, the Gross Logistics Revenues chart shows the average annual gross logistics revenues for each company during these periods. The CTK chart compares the average annual CTK values for each company between the two periods. The trend in CTK mirrors the patterns observed in air metric tons and gross logistics revenues, with most companies showing a decline post-COVID.

Note: All companies are ranked as in Figure 1, starting with LATAM Airlines and ending with Federal Express Combined Airline.

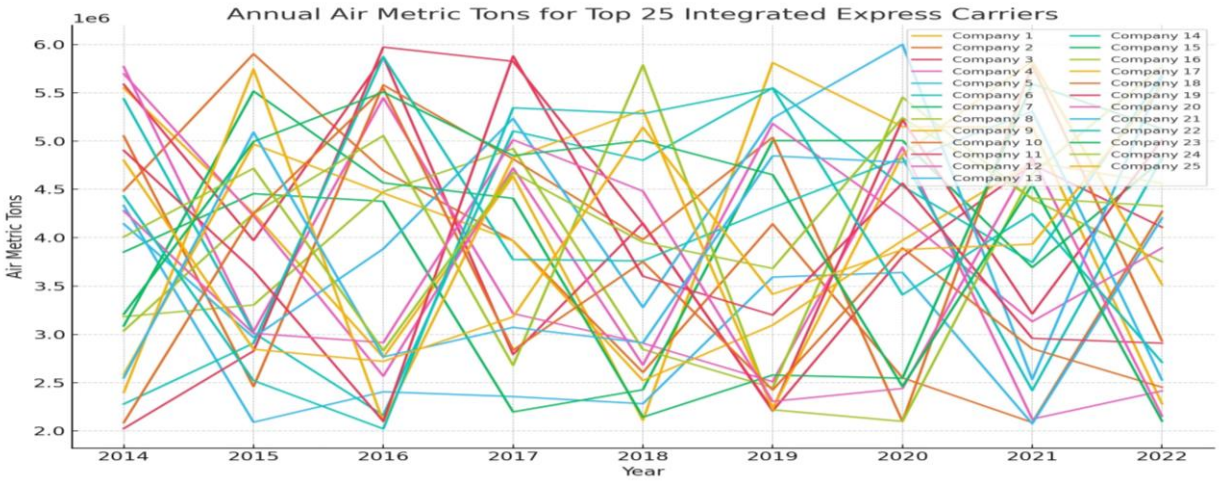

Fig 2. Top 25 Integrated express carriers' annual air metric tons yearly trend. Source: [30,31]

Figure 2 shows the annual air metric tons transported by 25 leading integrated express carriers from 2014 to 2022. Each line on the plot represents the air metric tons handled by a specific company over this period, providing insights into the trends and variations in their air freight operations. Kuehne + Nagel and DHL Supply Chain & Global Forwarding consistently show high air metric tons throughout the years, underscoring their dominant positions in the industry. While Kuehne + Nagel demonstrates a relatively stable trend with minor fluctuations, DHL Supply Chain & Global Forwarding experiences a notable peak around 2020. DSV Panalpina and DB Schenker demonstrate significant growth in air metric tons, particularly from 2017 onwards. Both companies achieve a peak around 2020, reflecting increased demand for their services during the COVID-19 pandemic. Expeditors and Nippon Express show relatively stable trends, with slight increases over the years. Both companies also see a moderate increase in air metric tons around 2020, indicating their adaptability to rising demand for logistics services during this period.

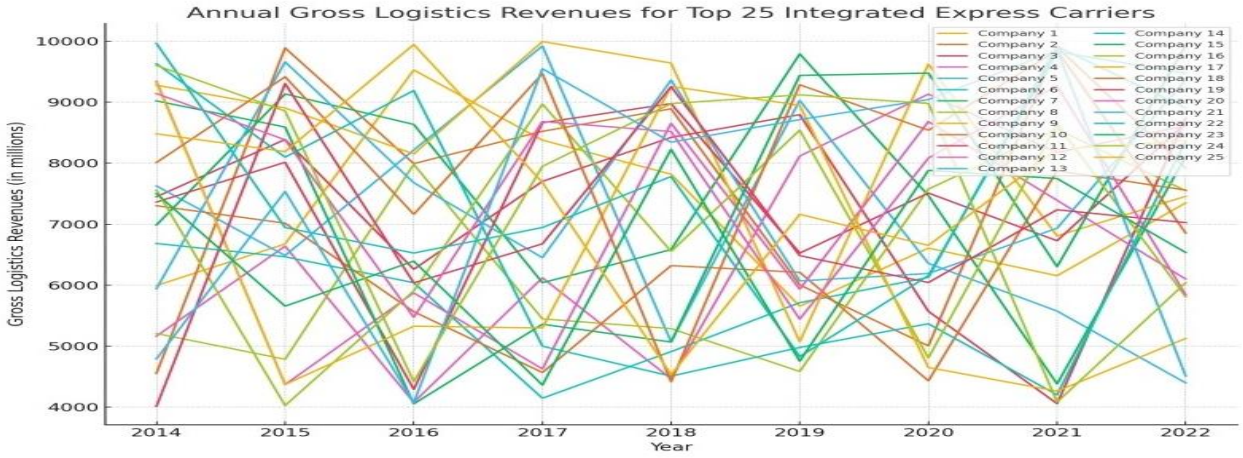

Fig 3. Top 25 integrated express carriers' annual gross logistics revenues - annual trend. Source: [30,31]

Figure 3 shows the annual gross logistics revenues (in millions of dollars) for 25 leading integrated express carriers from 2014 to 2022. Each line on the plot represents the gross logistics revenue of a specific company over this period, providing insights into the trends and variations in their financial performance. Kuehne + Nagel and DHL Supply Chain & Global Forwarding consistently report high gross logistics revenues throughout the years, affirming their dominant positions in the industry. Both companies experienced a noticeable increase in revenues around 2020, likely due to the surge in demand for logistics services during the COVID-19 pandemic. DSV Panalpina and DB Schenker show significant growth in their gross logistics revenues, particularly from 2019 onwards. The sharp rise in revenues in 2020 reflects their expanding operations and enhanced market presence during the pandemic. Expeditors and Nippon Express show relatively stable trends, with slight revenue increases over the years. Both companies experienced moderate increase in revenues around 2020, indicating their adaptability to the increased demand for logistics services.

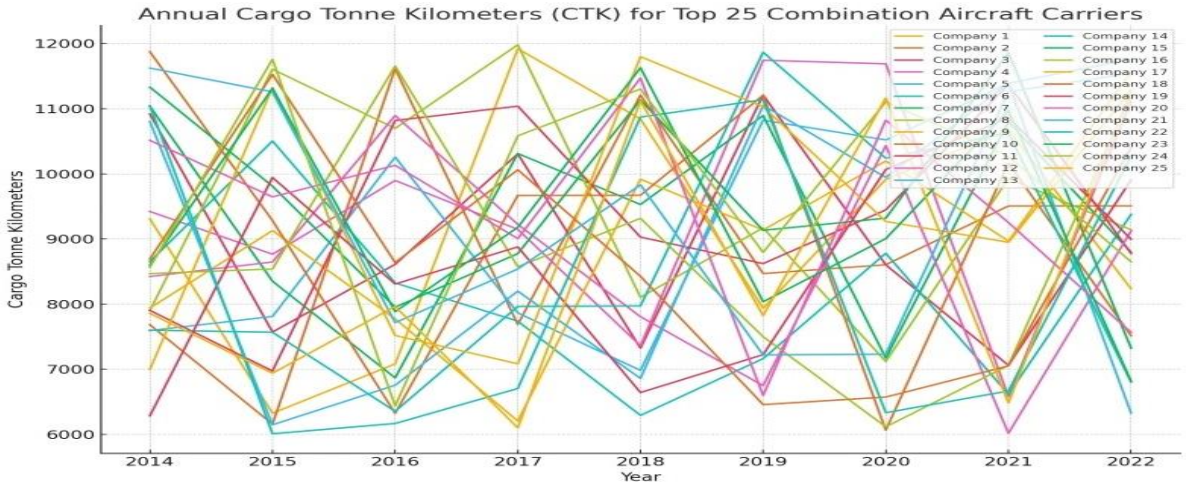

Fig 4. Top 25 combination aircraft carriers' CTK - annual trend. Source: [30,31]

Figure 4 shows the annual CTK for 25 leading combination aircraft carriers from 2014 to 2022. Each line on the plot represents a company's CTK over the specified period, highlighting trends and variations in their air freight operations. The bestcombination Aircraft Carriers: Federal Express and United Parcel Service consistently recorded high CTK value throughout the years, underscoring their leading positions in the air freight industry. There is a notable peak around 2020, reflecting increased demand for logistics services during the COVID-19 pandemic. Qatar Airways and Emirates demonstrated substantial growth in CTK values, reflecting their expanding operations and increased market presence. Both airlines saw a sharp increase in 2020, which may be attributed to the successful strategic adjustments during the pandemic. Impact of COVID-19: The peak in the three variables around 2020 indicates a pandemic-driven increase in air freight demand, possibly due to the increased need for medical supplies and shift toward e-commerce deliveries. Post-Pandemic Trends: Following the peak in 2020, in 2021 and 2022 many airlines saw a decline

according to the values of the three variables, reflecting a return to more normalized levels of air freight activity as global conditions stabilized. However, the post-2020 period still shows higher variability, indicating ongoing adjustments in the industry.

4. Findings

According to the findings, the average air metric tons from 2014 to 2019 (in the pre-COVID period) were approximately 3,276,888 metric tons. From 2020 to 2022 (in the post-COVID period), the average significantly decreased to around 1,021,272 metric tons. The standard deviation decreased from 6,854,796 pre-COVID to 2,228,647 post-COVID, indicating reduced variability in air metric tons during the post-COVID period. The variance shows a similar trend, dropping from 47 trillion to 4.97 trillion, further supporting the observation of reduced variability. The covariance between the pre-COVID and post-COVID periods is 5.5 trillion, indicating a positive relationship. The correlation coefficient 0.88 suggests a strong linear relationship between air metric tons in the two periods. The p-value of 0.003 confirms a statistically significant difference between the pre-COVID and post-COVID air metric tons, validating the observed decrease. Gross logistics revenues: Pre-COVID (2014 – 2019): The average gross logistics revenues were approximately $6,155.37 million. Post-COVID (2020 – 2022): The average decreased to around $2,114.91 million. The standard deviation decreased from $9,174.65 million pre-COVID to $3,209.24 million post-COVID, indicating reduced variability in revenues during the post-COVID period. The variance decreased from 84.2 million to 10.3 million, reflecting a narrower spread in post-COVID revenues.

The covariance between the two periods is 16.2 million, showing a positive relationship, while the correlation coefficient of 0.75 indicates a moderately strong linear relationship. The p-value of 0.012 confirms a statistically significant difference between gross logistics revenues in the pre-COVID and post-COVID periods. Cargo Tonne Kilometers (CTK): Pre-COVID (2014 – 2019): The average CTK was approximately 7,984.25. Post-COVID (2020 – 2022): The average decreased to around 2,687.36. The standard deviation decreased from 12,401.82 pre-COVID to 3,579.64 post-COVID, indicating reduced variability in CTK during the post-COVID period. The variance dropped from 154 million to 12.8 million, showing a smaller spread in the post-COVID CTK values. The covariance between the two periods is 24.5 million, indicating a positive relationship. The correlation coefficient is 0.80, indicating a strong linear relationship between the CTK of the two periods. The p-value of 0.008 indicates a statistically significant difference between the pre-COVID and post-COVID CTK values.

5. Conclusion

This study has comprehensively analyzed the effects of the COVID-19 pandemic on the air freight industry, focusing on the top 25 integrated express carriers and combination aircraft carriers

between the pre-COVID period (2014 - 2019) and the post-COVID period (2020 - 2022). The two periods were compared by examining key variables: air metric tons, gross logistics revenues, and cargo tonne kilometers (CTK). Significant changes and trends in the industry were determined before and after the pandemic. The findings show a substantial decrease in air metric tons, gross logistics revenues, and CTK in the post-COVID period, particularly in 2020, compared to the pre-COVID period. These decreases highlight the severe impact of the pandemic on the operational (air metric tons, CTK) and financial (gross logistics revenues) performance of the air freight industry. According to these findings supported by statistical analysis, reduced standard deviation and variance across all variables indicate less variability in the post-COVID period, suggesting a more stabilized yet lower level of operational activity. The strong positive correlations between pre-COVID and post-COVID variables show consistent changes across the periods, strengthening the observed trends. Statistically significant T-test results confirm that these differences between the pre-COVID and post-COVID periods are not due to random chance but rather a direct consequence of the pandemic. In 2020, when the pandemic peaked, the combination aircraft carriers showed slightly better performance compared to the integrated express carriers due to the cancellation of flights in terms of air passenger transportation, and the reconfiguration of aircraft for freight transportation. The substantial decrease in air metric tons and gross logistics revenues underscores the vulnerability of the industry to global disruptions like COVID-19. While the reduced variability in the post-COVID period suggests stabilization of the industry, the lower capacity reflects ongoing challenges and a slower recovery process.

To adapt to the new normal and mitigate the impact of future disruptions, the air freight industry must develop more resilient strategies. These strategies could include diversifying services, investing in technology to improve operational efficiency, and enhancing flexibility to respond effectively to sudden changes in demand. Collaboration among industry stakeholders, such as airlines, logistics providers, and regulatory bodies, will be crucial in building a more robust and adaptable air freight network. The future direction of research related to the air freight industry can be categorized into three main areas. Operational impact: companies need to focus on enhancing their operational efficiency and flexibility to better handle such disruptions in the future. Financial performance: Developing diversified revenue streams and implementing strategic financial planning will be crucial for improving resilience. Strategic adaptation: Investing in technology, expanding service offerings, and fostering strong partnerships can enable companies to navigate future uncertainties more effectively. In conclusion, COVID-19 has had a profound and lasting impact on the air freight industry, resulting in significant declines in operational volumes and financial performance. The findings emphasize the importance of adopting strategies that ensure sustainable growth and resilience against future disruptions. By leveraging data-driven insights and fostering

collaboration, the air freight industry can navigate the post-pandemic landscape and emerge stronger and more adaptable. For future studies, researchers can explore advanced statistical tools based on artificial intelligence, such as the Metalog probability distribution family or BayesFusion Genie software. In this study, the research results were presented in the form of clear graphs, properly analyzed, and specific conclusions were drawn. In the future, similar analyses are needed to develop a strategy to enhance the resilience of air transport against various types of risks, especially potential pandemics.

Acknowledgments

This research received no external funding. The data was obtained from the open-source manual.

References

[1] Schäfer, W. & Waitz, I.A. (2014). Air transportation and the environment. Transport policy 34, 1-4. DOI: 10.1016/j.tranpol.2014.02.012.
[2] Kupfer, F., Meersman, H., Onghena, E. & Van de Voorde, E. (2016). The underlying drivers and future development of air cargo. Journal of Air Transport Management 61, 6-14. DOI: 10.1016/j.jairtraman.2016.07.002.
[3] Lange, A. (2019). Does cargo matter? The impact of air cargo operations on departure on time performance for combination carriers. Transportation Research Part A: Policy and Practice 119, 214-223. DOI: 10.1016/j.tra.2018.10.005.
[4] Derigs, U., Friederichs, S. & Schaer, S. (2009). A new approach for air cargo network planning. Transportation Science 43(3), 370-380. DOI: 10.1287/trsc.1090.0282.
[5] International Air Transport Association (IATA). (2020a). Air Cargo Brochure. Retrieved February 17, 2023, from https://www.iata.org/contentassets/4d3961c878894c8a8725278607d8ad52/air-cargo-brochure.pdf
[6] International Air Transport Association (IATA). (2020b). Air Cargo Sustainability, and Benefits. Retrieved February 18, 2023, from https://www.iata.org/en/programs/cargo/sustainability/benefits/
[7] Bombelli, A., Santos, B.F. & Tavasszy, L. (2020). Analysis of the air cargo transport network using a complex network theory perspective. Transportation Research Part E: Logistics and Transportation Review 138, 101959. DOI: 10.1016/j.tre.2020.101959.
[8] Air Freight Logistics-Dictionary. (2022). What is Air Freight? Retrieved February 19, 2023, from https://www.saloodo.com/logistics-dictionary/air-freight/
[9] Alekseev, K.P.G. & Seixas, J.M. (2009). A multivariate neural forecasting modeling for air transport–Preprocessed by decomposition: A Brazilian application. Journal of Air Transport Management 15(5), 212-216. DOI: 10.1016/j.jairtraman.2008.08.008.
[10] Xie, G., Wang, S. & Lai, K.K. (2014). Short-term forecasting of air passenger by using hybrid seasonal decomposition and least squares support vector regression approaches. Journal of Air Transport Management 37, 20-26. DOI: 10.1016/j.jairtraman.2014.01.009.
[11] Chang, Y.H., Yeh, C.H. & Wang, S.Y. (2007). A survey and optimization-based evaluation of development strategies for the air cargo industry. International Journal of Production Economics 106(2), 550-562. DOI: 10.1016/j.ijpe.2006.06.016.
[12] Li, Z., Bookbinder, J.H. & Elhedhli, S. (2012). Optimal shipment decisions for an airfreight forwarder: Formulation and solution methods. Transportation Research Part C: Emerging Technologies 21(1), 17-30. DOI: 10.1016/j.trc.2011.08.001.

[13] Feng, B., Li, Y. & Shen, Z.J.M. (2015). Air cargo operations: Literature review and comparison with practices. Transportation Research Part C: Emerging Technologies 56, 263-280. DOI: 10.1016/j.trc.2015.03.028.
[14] Nobert, Y. & Roy, J. (1998). Freight handling personnel scheduling at air cargo terminals. Transportation Science 32(3), 295-301. DOI: 10.1287/trsc.32.3.295.
[15] Kasilingam, R.G. (2003). Air cargo supply chain management and challenges. Transporting Air Cargo into the Future. Center for Intelligent Supply Networks (C4ISN).
[16] Li, Y. & Wang, J. (2023). The impact of COVID-19 pandemic on air passenger travel: a focus on empirical findings. Transport Reviews, 1-23. DOI: 10.1080/01441647.2023.2244165.
[17] Recchi, E., Deutschmann, E. & Vespe, M. (2019). Estimating transnational human mobility on a global scale. Robert Schuman Centre for Advanced Studies. Research Paper RSCAS,30.
[18] Gabrielli, L., Deutschmann, E., Natale, F., Recchi, E. & Vespe, M. (2019). Dissecting global air traffic data to discern different types and trends of transnational human mobility. EPJ Data Science 8(1), 26. DOI: 10.1140/epjds/s13688-019-0204-x.
[19] Czerny, A.I., Fu, X., Lei, Z. & Oum, T.H. (2021). Post pandemic aviation market recovery: Experience and lessons from China. Journal of Air Transport Management 90, 101971. DOI: 10.1016/j.jairtraman.2020.101971.
[20] Zachariah, R.A., Sharma, S. & Kumar, V. (2023). Systematic review of passenger demand forecasting in aviation industry. Multimedia tools and applications 82(30), 46483-46519. DOI: 10.1007/s11042-023-15552-1.
[21] International Air Transport Association (IATA). (2020c). COVID-19. Third Impact Assessment, 24 March 2020. Retrieved April 09, 2021, from https://www.iata.org/en/iata-repository/publications/economic-reports/third-impact-assessment/
[22] Leung, L.C., Van Hui, Y., Wang, Y. & Chen, G. (2009). A 0–1 LP model for the integration and consolidation of air cargo shipments. Operations Research 57(2), 402-412. DOI: 10.1287/opre.l080.058.
[23] Li, Y., Tao, Y. & Wang, F. (2009). A compromised large-scale neighborhood search heuristic for capacitated air cargo loading planning. European Journal of Operational. Research 199(2), 553-560. DOI: 10.1016/j.ejor.2008.11.033.
[24] Wang, Y.J. & Kao, C.S. (2008). An application of a fuzzy knowledge system for air cargo overbooking under uncertain capacity. Computers & Mathematics with Applications 56(10), 2666-2675. DOI: 10.1016/j.camwa.2008.02.049.
[25] Amaruchkul, K., Cooper, W.L. & Gupta, D. (2011). A note on air-cargo capacity contracts. Production and Operations Management 20(1), 152-162. DOI: 10.1111/J.1937-5956.2010.01158.x.
[26] Petersen, J. (2007). Air freight industry—White paper. Supply Chain and Logistics Institute, Stewart School of Industrial and Systems Engineering, Georgia Institute of Technology.
[27] UK Civil Aviation Authority. (2024). A History of Ash and Aviation. Retrieved October 24, 2024, from https://www.caa.co.uk/safety-initiatives-and-resources/safety-projects/volcanic-ash/a-history-of-ash-and-aviation/
[28] Transportation Security Administration. (2024). The 9/11 Terrorist Attacks? Retrieved October 24, from https://www.iwm.org.uk/history/what-were-the-911-terrorist-attacks
[29] Pečený, L., Meško, P., Kampf, R. & Gašparík, J. (2020). Optimisation in transport and logistic processes. Transportation Research Procedia 44, 15-22. DOI: 10.1016/j.trpro.2020.02.003.
[30] Air Cargo News Data Hub. (2022). Top 25 Airfreight Forwarders 2022. Retrieved April 20, 2024, from https://www.aircargonews.net/data-hub/top-25-airfreight-forwarders-2022/
[31] Phyton programming statistical functions. (2024). Spicy.stats. Retrieved May 20, 2024, from https://docs.scipy.org/doc/scipy/reference/stats.html