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SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

BANKRUPTCY PREDICTION OF AIR CARGO CARRIERS

Ljubljana, September 2023 ALENA BERNGARDT

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LIST OF ABBREVATIONS

ABC - AirBridgeCargo

ANA - All Nippon Airways

APAC - Asia-Pacific

ATK - Available Tonne Kilometres

China - People's Republic of China

CO2 – Carbon Dioxide

COVID-19 – Coronavirus Disease of 2019

Crr. - Current

CRAF - Civil Reserve Air Fleet

DHL - Deutsche Post

EU – Europe Region

FedEx – Federal Express

FTK - Freight Tonne Kilometres

GDP - Gross domestic product

IAG - International Airlines Group

IATA- The International Air Transport Association

ICAO - The International Civil Aviation Organization

Kg - kilogram

KLM - KLM Royal Dutch Airlines

Km - kilometre

KUSD – Thousands of United States dollars

Max – maximum value

MEA – Middle East

Mean – average value

Median – middle value

Min – minimum value

Russia - Russian Federation

Russia and CIS – Russia and The Commonwealth of Independent States

Std Dev - Standard deviation

USA – United States of America

USD – United States dollar

WCO - World Customs Organization

WHO - World Health Organization

WSJ - The Wall Street Journal

INTRODUCTION

The cargo aviation industry has had many challenges over the last three years. Since the beginning of 2020, COVID-19 has been affecting the functioning of factories as well as airlines and, later, inflation has hurt consumer expenditures (Hailey, 2022). Moreover, the Russian "military operation" in Ukraine caused sanctions against Russian airlines; and non-Russian airlines are forced to choose longer routes to avoid the limited airspace (Hepher & Lampert, 2022). Plus, the price of aviation fuel is increasing (Shepardson, 2022).

These and other factors are causing a crisis in this industry with the decline of the air cargo market and consequently the bankruptcy of air cargo carriers: more than 20 international airlines announced their bankruptcy during 2020-2022 (Russell, 2022). This master's thesis aims to identify which other companies from the aviation industry (namely air cargo carriers) are facing financial distress.

In 1968, professor Altman developed a model showing a company's bankruptcy potential with 82-94 percent point probability (Altman, 2013). Indeed, in 2009, it was successfully predicted which business entities would go bankrupt due to the financial crisis of 2008 (Altman & Karlin, 2010). In 2005, professor Kroeze did additional research and adapted Altman's Z-score model for the airline industry. Kroeze's Y-score model precisely predicts selected airlines' bankruptcy (Kroeze, Zemke, & Raab, 2018). Both of these models are based on financial variables and multiple discriminant analysis. However, another specific industry model of bankruptcy prediction exists. The Pilarski Score (P-score) Model is also used to predict bankruptcy and is based on logistic regression analysis. This analysis estimates the probability of bankruptcy and is helpful in ranking firms by financial strength. The logit model was used to determine the financial stress model of airlines (Pilarski & Dinh, 1999). Also, the Department of Transportation in USA used the P-score to track financial strength (Gritta, Adrangi, Davalos, & Bright, 2008). Another model specific to the aviation industry is the fuzzy logic model (unlike the models mentioned above, this one is based on the Hybrid Financial Statement Analysis method). This model was applied to Brazilian and American airlines (Shome & Verma, 2020). Thus, these original or augmented models can be used to understand the scale of this crisis and how it affects the economy, the global supply chain, and logistics.

This qualitative grounded theory research aims to understand which selected air cargo carriers are potentially at risk of bankruptcy in the following years. Twenty-five international air-cargo carriers (combined carriers/all-cargo airlines, integrated carriers) was monitored during the proposed period between 2017-2021:

American region: Atlas Air, Federal Express, United Airlines, United Parcel Service, AirCanada, CargoJet;

Europe region: Lufthansa Group, KLM, Finnair, IAG, DHL;

Russia and CIS: AirBridgeCargo Airlines, Volga-Dnepr Airlines, Aeroflot;

APAC: ANA Group, Singapore Airlines, Cathay Pacific, AirChina, EVA Air, Korean Air, China Southern Airlines, China Airlines;

Middle East: Turkish Airlines, Emirates.

The theoretical framework for this master thesis is based on applied material. The empirical analysis is based on selected multiple discriminant analysis models, Altman's Z-score model, and Kroeze's Y-score model. In addition, a logistics regression analysis model called the Pilarski Score (P-score) Model and the HFSAT Fuzzy Logic model are also used. In contrast, all four analyses head-to-head predict bankruptcy or financial instability for selected international cargo airline providers. The quantitative data included in Chapter 3 was gathered from primary (official airlines' websites) and secondary sources (WSJ databases). The balance sheet, income statement, cash flow statement, and nonfinancial documents necessary to use the selected bankruptcy prediction models is presented using descriptive analysis.

To address the purpose of the study, the following research objectives were explored:

RO1. To define and determine the air cargo industry through time, including later years in the global supply chain,
RO2. To present and overview the most common factors influencing the air cargo industry through time, including selected international air cargo carriers globally,
RO3. To review previous empirical analyses and discuss empirical analysis expectations by selected models,
RO4. To empirically analyze influencing factors of the selected international air cargo carrier’s industry with selected models,
RO5. To compare the results of the empirical analysis and determine the possible impact on the selected international air cargo carriers for their bankruptcy probability.

This study provides insight into the current state of the air cargo industry, both at the company and global levels. Such an insight is essential for governments, industry leaders, academics, and air cargo investors because it draws attention to the industry's bottlenecks and provides a forecast for the coming years, which is primarily essential for customers when planning their supply chain in the future (Walton, 2012).

In Chapter 1, the context of the study is introduced. The background of cargo aviation also is provided, and the significance of cargo airlines in the global supply chain is defined.

In Chapter 2, the existing literature is reviewed to identify critical factors of airlines' function and nature of bankruptcy and to discuss the studies on bankruptcy prediction models. The necessary theoretical and empirical background is obtained using the qualitative theoretical-analytical review of secondary sources, such as scientific papers, and journalistic-scholarly articles.

The third chapter presents the empirical analysis based on the selected bankruptcy prediction models. The application of a quantitative research approach is justified, and the broader research design, including its limitations, is discussed.

1 DEFINITION AND SIGNIFICANCE OF CARGO AIRLINES IN THE GLOBAL SUPPLY CHAIN

As is well known, cargo aviation is a part of global logistics. This chapter shows the significance of air cargo carriers throw the history of this industry and the factors which have influenced cargo transportation.

1.1 Historical overview defining the air cargo industry

The history of air cargo transportation began in 1910, and by the end of that decade, almost all operating airlines provided a cargo service. However, the main problem with this method of cargo delivery was the airlines' low payload capacity – no more than 450 kg of cargo. In 1923, due to growing demand for heavier planes, the Boeing Company provided two aircrafts: Model 40 and Model 40A, which had about a 3 ton payload capacity that was later used by the United States Postal Service to deliver mail from San Francisco to Chicago. American Airlines was the first airline to master transcontinental routes for cargo transportation (Allaz, 2005). Although the 1919 Paris Convention and the 1925 Warsaw Convention essentially created an international regulatory framework conducive to developing air cargo, most developed countries initially used airspace primarily to build extensive airmail networks, domestically and internationally (Debbage & Debbage, 2021).

In 1942, during World War II, mass production and active use of the Douglas DC-3 aircraft began. All in all, more than 10,000 aircraft were produced. The USA mainly used it. The next generation of this aircraft (the DC-6) ushered in the era of regular air cargo (Allaz, 2005). By the 1950s, the demand for air cargo began to grow because jets with more extended range, greater capacity, and fuel efficiencies, such as the Boeing 707 and Douglas DC-8 (some of which are still used as cargo planes today), entered the market. These aircraft helped reduce the cost of flights (the new aircraft models were 75 percent points faster and had twice the payload). At the same time, new airline business models emerged to maximize the revenue generated from carrying cargo by airplane (Debbage & Debbage, 2021).

Both cargo and passenger aircrafts can transport cargo. The capacity of passenger planes allows for small volumes of cargo to be carried in the cargo sector of the plane. Therefore, it can be said that most airlines are involved in air cargo transportation. Moreover, as passenger air transportation has grown and developed, so has cargo transportation: most

aircraft were initially designed to transport passengers and then adapted for cargo transportation (Allaz, 2005).

Demand for air cargo has remained high since the 1970s, with the only significant decline resulting from the first Gulf War in the early 1990s and the September 11, 2001 terrorist attacks (Allaz, 2005). Looking at air cargo trends from 2004 to 2019 (Appendix 2), the only remarkable decline in air cargo demand occurred during the 2008-2009 global economic crisis. Air cargo growth was relatively sluggish from 2010 through early 2016, but 2017 saw near-record growth due to the worldwide replenishment cycle of high-value export commodities. Trade tensions between China and the USA increased industry competition, fuel price volatility, a shift to cheaper ocean freight, and overcapacity in the air cargo sector led to slower growth in air cargo profitability in 2018 and 2019 (Debbage & Debbage, 2021).

Such occurrences provided massive airlines' financial distress. Appendix 7 shows the number of USA airlines which declared reorganization (the company desires to continue operating and repay creditors concurrently through a court-approved plan of reorganization) or liquidation (the process of closing the business and distributing its assets among the claimants) during and after the most critical years (1990-1992, 2001-2002, 2008-2010, 2017-2019) (Airlines for America, 2022). Especially, the Gulf War 1990-1991 and the Global Economic Crisis 2008-2009 have the largest number of these cases (26 and 16 airlines, respectively). All in all, 12 airlines claimed liquidation. Therefore, it is possible to assume that wars and global crisis have a significant impact on civil aviation industry.

During the COVID-19 pandemic between 2020 and 2021, vital medical devices (such as ventilators) and masks that help people around the world fight the disease were transported by air (Appendix 3). Moreover, while transportation and tourism are the sectors most affected by the pandemic and lockdown, losses on the cargo side of aviation are debatable. Because cargo is transported by air by freight and passenger airlines, airlines stopped serving regular passenger flights, converted their planes to cargo ones, and increased the number of cargo flights to forestall disruption in the global supply chain. Thus, the number of cargo flights in the European region increased by 35 percent points compared to April 2019. Meanwhile, cargo airlines (such as Cargolux) increased flights by 6.5 percent points and 20 percent points by the end of 2020 because of increased demand for medicines and personal protective equipment. As a result of the pandemic, the economic performance of cargo airlines is up 27 percent points-33 percent points from December 2019 (Nsiri, 2021)**.**

In any case, over the past fifty years, air cargo has seen relatively steady long-term growth; and from 2019 to 2038, growth continues to be projected, and air carriers will need more than 2,800 additional cargo aircraft. Although cargo aircraft (or all-cargo aircraft) represent only 8 percent points of the total commercial aircraft fleet, they carry more than 50 percent points of all air cargo traffic. For 2019, Boeing expected global

cargo traffic to double and grow at a 4.2 percent points annual rate, mainly due to continued growth in e-commerce, with East Asia–North America, East Asia–Europe, and inland East Asia as critical markets (Debbage & Debbage, 2021).

Air cargo has experienced dark times throughout its history: whether it be war, pandemic, or financial crisis (described in more detail later in the next chapter). Nevertheless, air cargo has always been in demand because of its speed of delivery and mobility to hard-to-reach regions.

1.2 Significance of cargo aviation as part of the global supply chain

Air cargo is taking on a critical role in both the global supply chain and the global economy. From an economic perspective, air cargo enables a nation, regardless of geographic location, to have fast and reliable access to distant markets and global supply chains. It is critical for implementing international best business practices, including operational inventory management and on-demand production. Airfreight is an effective driver of economic progress in developing countries because it connects markets across continents. High-value electronic equipment and perishable goods, such as foodstuffs and flowers, are transported worldwide, preserving jobs and sustaining economic growth in regions that benefit from such trade. Air transport is crucial for Small Island Developing States (SIDS), Landlocked Developing Countries (LLDCs), and Least Developed Countries (LDCs), as it allows them to address the lack of regular shipping services and poor land transport infrastructure. In such areas, air cargo plays a critical regional life support role. Aviation speed and reliability can be vital in emergency relief operations during natural disasters, epidemics, and wars. Relief organizations primarily rely on air cargo delivery when responding to humanitarian disasters. Air cargo also plays a significant role in the fast delivery of medical supplies and organ transplants everywhere. The main economic benefits provided by an advanced air cargo network are the broad long-term economic benefits through overall productivity gains. New markets are opening up, export volumes are increasing, the domestic market is becoming more competitive, and the choice of goods produced abroad is increasing (ICAO, 2021).

Air transportation accounts for 6 trillion USD of different goods yearly, which is 35 percent points of all world trade by value. However, if counted by the volume of cargo transported, it is less than 1 percent points of global trade. This imbalance between value and volume can be explained by the fact that the air cargo transported is a high-value commodity. Moreover, in a single day, air cargo carriers around the world (IATA, 2019):

- Use more than 100,000 aircraft,
- Transported more than 20 million packages,
- Transported 18.6 billion USD worth of cargo.

Despite this, air cargo logistics is highly heterogeneous due to the wide variety of participants and transport flows. The main determinants of this supply chain are, of

course, airports and airlines. However, customs brokers, cargo handling companies, maintenance, and fuel suppliers impact the smooth operation of air cargo logistics. The absence of participants makes the whole concept of air transportation incomplete, which certainly affects the quality of cargo delivery (for example, delivery time or cargo safety). Thus, the air cargo supply chain consists of the following participants (Chu, 2014):

- Shipper - a party (a specific person or company unrelated to freight transportation) that wants to move goods (or another object) from one place to another at a specific time to a specific recipient for minimal time and money;
- Forwarder - a company that organizes the transportation of this cargo from door to door. They are intermediaries between shippers and carriers, as they typically bundle individual shippers' goods into larger shipments and then book cargo capacity with cargo airlines to provide more efficient and cost-effective transportation;
- Carrier - a company that delivers the cargo from the departure airport to the destination airport.

Depending on the chosen business model of the air cargo company, the carrier can be integrated or non-integrated. In the air cargo industry, most carriers are non-integrated and include combined carriers (for example, KLM and Qatar Airways, which handle passenger and cargo traffic) and all-cargo carriers (AirBridgeCargo and Southern Air, which handle only air cargo traffic and do not handle passengers) (Debbage & Debbage, 2021).

The integrated carriers own all the production assets throughout the chain and play an essential role in shaping the air cargo industry. According to IATA's 2021 TOP 25 ranking of the largest air carriers by ton-kilometers (CTK) (Appendix 8), the integrated carriers Federal Express (FedEx) and United Parcel Service (UPS) topped the list (Debbage & Debbage, 2021).

When developing a business model (integrated/non-integrated), one must consider factors critical to the entire air cargo chain (Appendix 4), the extensive network of service providers, the regulatory environment, the workforce, or the policies of the port authorities (Debbage & Debbage, 2021)

However, when cargo can be transported under integrated and non-integrated business models, the decision to transport cargo through a cargo carrier (i.e., in a specialized cargo aircraft), is made in consideration of cost, convenience, reliability, the commercial value of the cargo and required level of service, and variables including the market share and market power of the airline (Debbage & Debbage, 2021).

The main issue in organizing air freight is the unique geography of the route (e.g., East Asia–Western Europe). Unlike the bidirectional specification of most passenger air travel (e.g., paired flights), an outbound flight is not necessarily complemented by a return or transit flight for air cargo. Uneven demand on cargo flight routes results from the

movement of goods from their places of production (often East Asia) to their places of consumption (for example, Europe and North America) (Debbage & Debbage, 2021). Many carriers are forced to use triangular, often intercontinental routes to avoid "empty" flights or flights with a minimum load to solve the "reverse delivery" problem (flying to the place of production of the goods). While this may help increase payload, it also increases transit times and may not be appropriate for some types of perishables or time-critical (e.g., live animals) cargo (Budd & Ison, 2017).

The main rules of cargo transportation on international airlines relate to the fact that it is prohibited to transport cargo that contributes to the spread of terrorism, violence against people, and other similar things that can harm people or the environment. There are severe legal penalties for transporting such goods. The regulatory framework for the transportation of cargo by air is (ICAO, 2021):

- ICAO's regulatory framework for protecting the entire air cargo chain is currently embodied in the Standards and Recommended Practices (SARPS) of Appendix 17, Safety, of the Chicago Convention, which is supplemented by instructional material in the Aviation Security Manual (DOC 8973 - Restricted);
- Convention for the Unification of Certain Rules Relating to International Carriage by Air (Warsaw Convention), 1929, as amended in 1955 and 1961;
- Convention for the Unification of Certain Rules for International Carriage by Air (Montreal Convention), 1999;
- International Convention on the Simplification and Harmonization of Customs Procedures (Revised Kyoto Convention);
- The WCO Council Framework of Standards to Secure and Facilitate Global Trade (SAFE).

Thus, air cargo logistics is an industry that has different cost structures, operating characteristics, and supply and demand patterns.

1.3 Factors influencing the air cargo industry by different time periods

As mentioned earlier, even though air freight accounts for less than 1 percent points of global trade in terms of ton-kilometers but accounts for 35 percent points of global trade in terms of value, air freight logistics is an essential component in the global supply chain (IATA, 2019). Yes, air transport is very fast in terms of time and can deliver goods to hard-to-reach places where road/railway/sea transport would not reach. But still, this industry is susceptible to changes in the business environment, and many factors affect freight aviation.

1.3.1 Fuel prices

The air cargo industry's ever-increasing price of jet fuel is the biggest issue. According to historical data, the price per jet fuel gallon rose from 75 cents to 2.01 USD from 2001-2006, the equivalent of about 68 USD per barrel on average that year. In 2014, the price per gallon peaked at 2.68 USD, but in February 2022, it almost caught up with that figure at 2.60 USD (Shepardson, 2022).

In 2004, fuel costs accounted for about 22 percent points of airlines' direct operating costs. However, for most airlines that own wide-body aircraft, fuel accounts for a more significant percentage of total operating costs (Kupfer, Meersman, Onghena, & Van de Voorde, 2010).

The rise in fuel prices is due to several factors (Kupfer, Meersman, Onghena, & Van de Voorde, 2010):

- increased demand from India, China, and Third World countries,
- a lack of refining capacity in the Western Hemisphere,
- political instability in the world (instability in the Middle East, Russian invasion of Ukraine),
- a lack of competition among fuel suppliers.

In the case of aviation fuel, airlines are not as flexible on price. A plane cannot drive up to another pump where the price is lower than the other. Carriers usually have only one or two options for airport fuel suppliers. As fuel prices rise, airlines impose surcharges to cover fuel price increases. This surcharge can be as much as 30 percent points of the total fare, but it does not cover all fuel costs. Moreover, if there is a shortage of fuel supply (and that resource is limited in nature) or jet fuel prices rise to 3.50 USD a gallon, the cost of air travel will increase by 100 percent, and companies will move their shipments to marine vessels (Kupfer, Meersman, Onghena, & Van de Voorde, 2010).

1.3.2 Peak seasons and difficulties in filling capacity

The busiest seasons are the holiday season, which begins in September or October (mostly in the fourth quarter, preparing for pre-Christmas growth). Normally, electronic and cell phone manufacturers (for example, Apple or Samsung), release new products in the fall that need to hit the markets before the Christmas and New Year's celebrations. Another peak season comes in February, when the demand for fresh flowers on Valentine's Day causes additional demand that often cannot be covered by scheduled services (Morrell & Klein, 2019).

Such busy seasons have a significant impact on the industry. Increased demand for air transportation affects the growth of rates, especially for those carriers who do not have

long-term contracts with airlines and transport their cargo at ad-hoc rates. During the holiday season, such fares can increase threefold (Robinson, 2018). Therefore, airlines provide seasonal charter flights as a supplement to regular flights to meet increased demand during the high season, so the main airlines' business will not get hurt (Morrell & Klein, 2019).

In general, demand for such flights increases or decreases in line with overall market development: in weak years with overcapacity in markets, the number of seasonal charters remains relatively small, while in strong years the capacity of both airlines and airports can reach its limits. In the winter of 2014/15 and spring of 2015, when a labor strike at U.S. West Coast ports significantly reduced the transshipment capacity of ocean container terminals on the trans-Pacific trade lanes, demand for air cargo charters as an alternative to ground transportation increased dramatically. A similar development could be observed in the fall of 2016 after the bankruptcy of the Korean container shipping line Hanjin. And this leads to another problem, such as difficulties in filling capacity.

In 2018-2019, this problem was common among cargo airlines. At that time, finding cargo to ship to a particular destination was challenging to increase the payload. After all, during this "quiet" period, suppliers of goods mostly did not have a time frame and could use cheaper alternatives for transporting cargo–sea transport. Furthermore, perishable or any other time-sensitive cargo is not enough in the world trade to fill voyages regularly. Therefore, it is crucial to have a good relationship with freight forwarders to ensure maximum loading in the future (Robinson, 2018).

1.3.3 Security threats

On September 11, 2001, terrorists hijacked aircrafts and crashed them into the Twin Towers of the World Trade Center and the Pentagon building in the United States. On August 10, 2006, an act of terrorism on ten passenger planes was foiled in Britain–the plan was to blow up the airliners with explosives hidden in hand luggage (Elias, 2007).

Following such incidents, State Security ministers called for 100 percent screening of all cargo on passenger planes and for the cargo of container ships to be inspected before they leave for U.S. ports. They also recommended that cargo that cannot be screened using existing explosive detection methods not be allowed to be transported on passenger planes (Elias, 2007).

Shippers disagree with this tightening of air cargo screening rules. A new regulatory framework to ensure every air shipment is screened could be an unbearable burden on air commerce. The cost of a 100 percent screening regime, estimated at 650 million USD in the first year, may not justify any additional benefits such a program could provide compared to the current risk-based approach. Nevertheless, because of the prospect of

future terrorist threats, the increase in security enhancements in the industry continues to tighten (Elias, 2007).

Of course, with technological advances, cargo inspection has become more automated, but it still affects operational costs and cargo loading and unloading times. Also, because of the threat of terrorist attacks, carrying cargo in the belly of a passenger plane may be prohibited altogether. And since this method of air cargo transportation accounts for fifty percent of all air cargo traffic, fare costs rise dramatically (Elias, 2007).

1.3.4 Consolidation

Air cargo is experiencing a consolidation trend in the transportation industry, with significant transportation and logistics companies acquiring small freight forwarders. UPS and DHL are pursuing a one-stop shopping strategy for the customer–they are buying up freight forwarders in clusters to achieve economies of scale. Other large logistics service providers are following a similar strategy (Kupfer, Meersman, Onghena, & Van de Voorde, 2010):

- In early 2006, Schneider Logistics acquired American Overseas Air Freight, an international freight forwarder, and customs broker;
- In 2005, Meridian IQ, a global logistics management subsidiary of YRC Worldwide, acquired Shanghai-based GPS Logistics Group;
- In November 2005, Deutsche Bahn AG, the parent company of Schenker, acquired BAX Global, Irvine, Calif. This acquisition allows Deutsche Bahn to expand its position as an international logistics service provider in key growth markets in Asia-Pacific, China, and the United States.

The acquired companies have significant assets and strong operational capabilities. Their operations differ from the way air freight forwarders traditionally do business. Freight forwarders and global integrators operate on a time-sensitive, high-capacity basis. They use sophisticated information systems and optimization capabilities. In contrast, freight forwarders have historically operated on a "free space" basis, with more variability in services and schedules and less discipline (Kupfer, Meersman, Onghena, & Van de Voorde, 2010).

According to experts, airlines also need to adopt the consolidation strategy of freight forwarders. They need to be able to match resources and negotiate power with major freight forwarders and logistics service providers. The Air France–KLM merger, for example, is the first consolidation across geographic borders (Kupfer, Meersman, Onghena, & Van de Voorde, 2010).

Restrictions on cross-border ownership and the allocation of transportation rights to national carriers impede further global consolidation. But even if carriers do not

consolidate, there is a clear trend toward inter-firm and inter-continental cooperation (Kupfer, Meersman, Onghena, & Van de Voorde, 2010).

Amazon provides another example. As a significant parcel shipper, the online retailer has integrated its distribution by air for the domestic market of USA. Amazon began leasing its fleet of forty planes called Prime Air. Equally crucial in market structure is whether or not a given airport has an integrator and/or a home carrier already handling large volumes of air cargo. Such airports receive tonnage from the respective airline and attract additional air cargo due to the wide range of origin and destination routes served. In particular, airports with a permanent air cargo carrier usually have several still-operating global freight forwarders (Kupfer, Meersman, Onghena, & Van de Voorde, 2010).

They can offer door-to-door freight services globally to the network of such carriers and the benefits of such transport companies. Therefore, there is likely to be an increase in the spatial concentration of global general cargo services. Another reinforcing mechanism is the interaction between the location of logistic distribution centers of multinational corporations in the vicinity of significant cargo airports. It leads to an increase in air cargo shipments that benefit from solid international availability by air. Despite some strong fluctuations in air cargo, it seems likely that this market will continue to grow. It also applies to all derivative activities, such as handling, storage, and destination delivery. It is even more likely that the significant volatility of the air cargo market will continue. The question arises as to what strategic changes might occur. There is no single, unique model of air cargo transportation. The market is noticeably heterogeneous, with many players operating by their business models. One possible scenario is the business model of an average airline, which is adapted to the new cooperation. Other market players could also be involved in such an evolution (Kupfer, Meersman, Onghena, & Van de Voorde, 2010).

Airlines usually face many opportunities to cooperate with other airlines, cargo carriers, or even airport operators and authorities. Thus, another scenario is possible, in which there may be far-reaching concentration in the air cargo market, resulting in a limited number of large companies or alliances. Even the role of government should not be ignored, as its influence can range from active equity participation in an airline or airport operator to intergovernmental cooperation in the field. Operators in any industry sector are constantly searching for new niche markets. It is also true for air cargo (Merkert, Van de Voorde, & de Wit, 2017).

Moreover, as discussed earlier, unlike passenger transportation, where there is usually a round trip, air cargo is usually a one-way trip from the point of production to the center of distribution or consumption. It leads to an imbalance in cargo flows. The airline that can most successfully neutralize this imbalance will be rewarded with better capacity utilization and, therefore, a higher profit margin, ultimately leading to victory in the competitive game that characterizes the air cargo market. Since most air cargo traffic will

continue to be handled by passenger airlines, this segment of the air cargo market will also significantly impact air cargo. For example, new protectionist symptoms in parallel with further liberalization of air cargo markets (see the EU-USA dispute and the Gulf) also have implications for air cargo development. And how will new aircraft technology affect combined air carrier networks? The rapid renewal and expansion of the existing passenger fleet will impact cargo capacity in the belly and cargo aircraft conversion capabilities. The future of the A380 is uncertain, but how will this type of aircraft affect air cargo markets? Airport congestion and slot shortages will skyrocket over the next decade. Will long-haul passenger flights get priority in slot allocation? Will slots sell out, leading to the displacement of whole cargo aircraft? How will 3D printing affect air cargo demand? Will digitalization make air freight more cost-effective? How will combined carriers use modern revenue management systems to improve the profitability of passenger, cargo, and other additional revenue streams? These are just a few of the questions that will persist in the air cargo world (Merkert, Van de Voorde, & de Wit, 2017).

1.3.5 COVID-19

The first case of unusual pneumonia from unknown causes was WHO-registered on December 31, 2019, in Wuhan, China. And as early as January 7, 2020, the Chinese government determined that the disease was caused by a new coronavirus (a family of viruses that cause various ailments) and named it "2019-nCoV" (WHO, 2021).

The WHO declared a pandemic on March 11, 2020, due to a rapid increase in COVID-19 cases outside the People's Republic of China. More than 118,000 cases and 4,291 deaths had been reported in 114 countries by then. Also, by mid-March 2020, Europe was the epidemic's epicenter, with over 40 percent points of COVID-19 cases worldwide and 63 percent points of fatalities (WHO, 2021).

Countries have introduced restraints in various ways. Some of them closed places of mass gathering (shopping malls, restaurants, schools) and implemented police hours, while others only educated their citizens. WHO recommended strict limits on temporary measures to protect the health care system. Country responses ranged from strict lockdowns to public education. As of March 26, 2020, 1.7 billion people worldwide were on lockdown. By the first week of April, that number had risen to 3.9 billion people, which is more than half the world's population (Kaplan, Frias, & McFall-Johnsen, 2020).

The COVID-19 pandemic and its containment measures have created severe problems for supply chains worldwide. Numerous national blockages have significantly slowed and, in some cases, even temporarily stopped the supply of raw materials or finished products, disrupting production and the entire industry as a whole (Harapko, 2021).

But unlike most industries, cargo aviation did not suffer much. Especially if we compare passenger traffic, which sagged significantly during the lockdowns and closed borders due to quarantine measures, cargo aviation did not suffer and was even on the plus side. So, in 2020, freight forwarders and air cargo airlines made an excellent economic profit–freight forwarders at 4 percent and air cargo airlines at 9 percent. But in fact, the only five airlines that made a profit in 2020 are AirBridgeCargo, Atlas Air, Cargojet, Cargolux, and Kalitta. These companies are cargo carriers (Bouwer, Krishnan, Saxon, & Tufft, 2022).

As was said earlier, the number of cargo flights in the European region increased by 35 percent points compared to April 2019. Meanwhile, cargo airlines (such as Cargolux) increased flights by 6.5 percent points and 20 percent points by the end of 2020 because of increased demand for medicines and personal protective equipment. As a result of the pandemic, the economic performance of cargo airlines is up 27 percent points–33 percent points from December 2019 (Nsiri, 2021).

This demand for air cargo was first driven by shipments of personal protective equipment and medicines and then by problems in the shipping supply chain and the high growth of e-commerce sales. Also, during the pandemic, the number of cargo capacities offered by airlines declined as the number of decommissioned passenger planes increased, resulting in narrower aircraft capacity and higher rates (and therefore revenue) (Bouwer, Krishnan, Saxon, & Tufft, 2022).

Global air cargo yields were up 40 percent points in 2020 and another 15 percent points in 2021. Load factors also increased significantly, by 10 percent points in 2021 compared to 2019 (Bouwer, Krishnan, Saxon, & Tufft, 2022).

In addition, air cargo shipments were mainly in two categories: medical supplies and food essentials. During the pandemic, there was an acute shortage of medical supplies, protective supplies for medical personnel, and distribution of Covid-19 tests, as well as food supplies, the disruption of which was due to closed borders for all modes of transport except air. Therefore, in many cases, the only goods transported fit into one of these two categories (Bouwer, Krishnan, Saxon, & Tufft, 2022).

Another exciting thing that happened during the pandemic and had an impact on cargo aviation was the addition of new destinations. For example, during COVID-19, the Latin American airline Avianca opened a new route as part of its cargo destination for the first time since 1956–flights to Shanghai, China. The airline transports medical supplies to Latin America using its fleet of Dreamliner B787s, which were previously used to carry passengers but are now 100 percent points dedicated to cargo (Bouwer, Krishnan, Saxon, & Tufft, 2022).

1.3.6 War and geopolitical issues

The first example of how war has affected cargo aviation is the 1991 Persian War. During the U.S.–Iraq war, the risk of a crisis in the aviation industry was higher than ever. Subsequent changes in airline operations included canceled flights or rerouting, reduced service to the Middle East, and canceled nighttime flights in that region. Also, airlines transferred their aircraft to the U.S. Department of Defense (CRAF program), causing forwarders to report service disruptions and air charter brokers to reduce aircraft supply. By the second week of August, airlines had already begun raising fares and imposing additional fees, and there were predictions of a bad fiscal year for airlines due to the Gulf crisis. The main reasons for the fare hikes were rising jet fuel prices (from 0.85 USD to 1.25 USD in three months, each cent costing airlines 150 million USD) and increased insurance rates, especially military risks. The main reason for the fare hikes was the dramatic increase in cost. Delta Airlines of America, for example, reported an operating loss in its first fiscal quarter, the first for the company since 1982 (Thomchick, 1993).

Another example of the impact of war is the geopolitical conflict between Russia and Ukraine in 2022. On February 24, 2022, the Russian Federation launched a "military operation" in Ukraine (Jeffrey, 2022a). This invasion has entailed sanctions, airspace closures, military action, and geopolitical tensions that have had a significant impact on freight aviation and the global supply chain as a whole.

The most significant impact on cargo aviation here is the closure of airspace. Russian airspace covers 26 million square kilometers, with air corridors spanning North America, parts of Europe, and Asia in between. Without access to Russia's airspace, international cargo airlines will have to reroute flights south, avoiding areas of tension in the Middle East. It will result in high costs when airlines are still experiencing a pandemic (Hepher & Lampert, 2022). According to a Flexport study, average flight times on key trade routes from APAC to Northern Europe have increased by an average of 3.4 percent point (Brett, 2022a). For example, Japan Airlines and ANA have canceled some flights due to the unprofitability of rerouting (Jeffrey, 2022b).

The transportation of humanitarian cargo also affects freight aviation. The main advantage of air cargo is its responsiveness to changing situations, with delivery time much shorter than other means of cargo transportation. Therefore, nowadays, cargo airlines, if possible, are engaged in transporting humanitarian cargo and helping Ukrainian victims. Thus, CMA CGM Air Cargo has transported 55 tons of humanitarian aid from France to Poland to support the Ukrainian refugees (Jeffrey , 2022a). Also, Virgin Atlantic has already transported 27 tons of humanitarian cargo for free (Clarkson, 2022). Such support affects efficiency since the aircraft is not used for other air cargo shipments over a long time: a freighter may need to make a humanitarian flight today, while someone else may also want to transport their cargo. Consequently, this may result in lesser global international airline cargo capacity (Jeffrey, 2022b).

1.3.7 Macroeconomic determinants

Based on the study, macroeconomic variables at the global and regional levels influence the demand for air cargo transportation. Interest rates affect borrowing rates and investment. High-interest rates reduce the availability of credit and therefore reduce investment, which affects air cargo. Also, increasing GDP growth rates and the resulting increase in GDP per capita provide a favorable environment for business growth, which in turn stimulates economic growth, exports, imports, and overall demand for air cargo (Kiboi, 2017).

Global economic trends are a very significant predictor of changes in the reduction of demand for air cargo transportation, as such order depends on the financial performance of the country of origin and destination countries (increasing export and import volumes) (Kiboi, 2017).

Thus, national or global economic growth leads to an overall demand increase for cargo transportation. In contrast, the economic downturn leads to decreased demand for airfreight logistics (Appendix 5) (Kiboi, 2017).

Of course, there is nothing constant in the air cargo business. The factors listed are far from all the things that affect air cargo, which makes this industry very unstable, and the choice of this type of transport is often inefficient for some types of cargo. Nevertheless, nothing can beat airspeed.

2 LITERATURE REVIEW

The theoretical literature is dominated by the use of multiple discriminant analysis (MDA) and logistic regression analysis (logit model) to predict the financial problems of companies belonging to different industries (Abdullah, Halim, Ahmad, & Rus, 2008). Nevertheless, there are few models for predicting air cargo carriers' bankruptcy. Gritta, Adrangi, Davalos, and Bright (2008) have compiled all the models that apply only to airlines. They identified a total of eight possible models based on discriminant analysis (MDA), logistic regression analysis (logit model), and neural networks (NN), which were developed between 1985 and 2005. However, in this paper, Gritta, Adrangi, Davalos, & Bright (2008) did not include the Kroeze Y-score model, which I will use in my writing, as the Kroeze modified airline bankruptcy prediction model later (Kroeze, 2005). Also, Gritta, Adrangi, Davalos, and Bright (2008) included two Altman models in their work: the Z-score model (the original version of the model) and the Z"-score model (a modified version of the model). In the master's thesis, I will use the second variant, which considers the first variant's inaccuracies. Next, I chose two more models from the collection of Gritta, Adrangi, Davalos, and Bright (2008): Pilarski Score Model and the Fuzzy Logic Model. These models are used in my research because they were initially developed for the airline industry. Also, the Pilarski Score model was described in another paper Gritta

co-authored with other researchers (Gritta & Adams, 2016). It is also important to note that the Fuzzy Logic Model was developed for the airline industry and was based on Hybrid Financial Statement Analysis (HFSAT) (Silva, Santo, & Portugal, 2005). Also, the original studies of these models (Pilarski & Dinh, 1999; Altman, 2013; Kroeze C., 2005; Silva, Santo, & Portugal, 2005) will be examined in the study and application of the above models.

The following themes organize this literature review. The first part discusses the specifics of the air cargo industry, precisely the significant points that affect the financial stability and profitability of an air carrier (Abdelghany, 2020; Chao & Li, 2015; Chu, 2014; Debbage & Debbage, 2021; Graver, 2022; Morrell & Klein, 2019; Reiman, Main, & Anderson, 2013). The second part of the literature review describes the nature of bankruptcy and details some of the financial models found in the literature, which is necessary to understand how the models work (Abdullah, Halim, Ahmad, & Rus, 2008; Kroeze, Zemke, & Raab, 2018; Altman & Karlin, 2010; Lessambo, 2018).

The master's thesis considers previous research to analyze bankruptcy prediction models for cargo airlines. Walton (2012) described the effects of non-statistical factors on financial models and also analyzed the Kroeze Y-score models. In the study case of Bhattacharya (2021), he applied the Kroeze Y-score models and Altman Z-score models to predict bankruptcy for Indigo Airlines. Also, Shome and Verma (2020) used four models (Z-score, Y-score, Pilarski, and Fuzzy logit models) in their research of financial distress in the Indian Aviation Industry.

2.1 Air-cargo industry

For most combined cargo airlines, mainly passenger carriers, cargo is no longer a by-product but a method to increase their competitiveness among other airlines or carriers of alternative industries. Even the efficiency of a particular route is now also measured by the amount of tonnage carried (Debbage & Debbage, 2021).

However, such transportation growth dynamics are not typical for all airlines. For example, European airlines show lower results than their American competitors, while Asian airlines have tripled in the last 20 years (Debbage & Debbage, 2021).

Also, there has been an increase in the market share of all-cargo flights versus combined flights. It is because on some routes and for some types of cargo, passenger aircraft capacity has become insufficient to meet the growing demand for air cargo. Also, passenger and cargo flows do not always coincide. Moreover, some types of cargo have strict safety/security requirements, so they cannot be transported by passenger aircraft (Debbage & Debbage, 2021).

When looking at future trends in the aviation industry, there is a trend toward alliances. Furthermore, there is a noticeable difference in the passenger industry, where almost all

major airlines work through such global cooperation (STAR, SkyTeam, Oneworld). Things are much worse for the air cargo market. SkyTeam Cargo (formed around Air France - KLM Cargo, Alitalia Cargo, and Korean Air Cargo) is the only air cargo alliance. Because, here in air cargo, bilateral alliances, such as Lufthansa and Singapore Airlines or Cathay Pacific and Air China, work much better (Debbage & Debbage, 2021).

Also, the trend of consolidation among freight shippers continues unabated. To gain potential economies of scale, freight forwarders and shippers prefer that air cargo be grouped in a single hub whenever possible. It allows them to transport and consolidate cargo in as many quantities as possible, as well as varying volume/weight/value-added opportunities and using the most efficient means, either as in-flight cargo planes or as part of full-freight aircraft. This consolidation trend also leads to a permanent change in the value chain (Debbage & Debbage, 2021):

- Integrators handle the forwarding;
- Forwarders operate the aircraft for their account;
- Airlines/agencies bypass forwarders by making direct structured deals with major shippers.

2.2 Payload and fuel effectiveness

Fuel and payload efficiency are closely related since more cargo tonnage consumes more fuel. Nevertheless, fuel efficiency increases with an adequately corrected payload ratio, affecting the airline's revenue from the flight performed (Graver, 2022). In this chapter, these two metrics will also be discussed in more detail to understand how they affect airlines.

2.2.1 Payload efficiency

An airline's payload efficiency measures how productively it has filled a flight with passengers and/or cargo. It is sufficient to increase the seating density and adjust the passenger load factors for increasing the payload on a passenger flight (Graver, 2022). But in the case of cargo aviation, it is not that simple.

Air cargo is carried at a specific rate, and it is based on gross weight or volume weight, with the bigger of the two being used as the paying unit. Moreover, the greater the chargeable weight of the cargo, the lower the price per unit. When calculating the cost of air freight, the weight and volume of the cargo are taken into account. It is vital to understand the relationship between these two measurements to determine the efficiency of the payload. If the airplane is loaded with only heavy cargo, it will result in unused space. It will occur because the aircraft will reach its maximum load even though it is underutilized (payload inefficiency) (Chao & Li, 2015).

Conversely, if only light or very voluminous cargo is loaded, the entire cargo space will be filled, but payload capacity will not be achieved. It can still be loaded by weight, but there is no more space for it (payload inefficiency). Therefore, the airline needs to achieve this balance between weight and space because it provides more payload weight and increases company revenues (Chao & Li, 2015).

2.2.2 Fuel efficiency

Fuel costs are an airline's main expense item (after labor costs). Therefore, improving fuel efficiency is the most effective way to reduce company costs. However, such improvements are not only substantial from a financial point of view. Fuel efficiency also affects the reduction of CO2 emissions, which is a global climate change issue. Thus, a rare increase in fuel efficiency of 1.5 percent points per year was seen from 2009 to 2020 (IATA, 2020).

The main problem comes from payload efficiency (as discussed earlier): the vertical space of the cargo compartment is filled inefficiently. Fewer sorties would be required if the cargo bay were loaded more efficiently. Moving the same cargo volume with fewer aircraft significantly reduces the fuel required (Reiman, Main, & Anderson, 2013). Furthermore, as mentioned in Chapter 1, payloads are affected by seasonality or cargo consolidation.

2.3 Fleet and route management

This section describes the main points of fleet and route management, which are the essential components of the operational activities of any airline.

2.3.1 Fleet management

Fleet management is the process of fleet planning to determine the type and composition of aircraft to be used by an airline for commercial transportation. Fleet management is an essential component in the efficient operation of an airline, as well as the company's long-term planning and financial sustainability (Walton, 2012).

Aircraft, by themselves, are an expensive asset due to high replacement cost (as mentioned above, this is due to retraining flight crews, maintenance personnel, ground equipment, and spare parts inventory). If an airline wants to introduce a new fleet, it must be a strategic management decision that will take time. Once the fleet composition is determined, rigorous airline revenue management processes are necessary (Walton, 2012).

For economic reasons, airlines prefer to use a limited number of aircraft types. For example, AirBridgeCargo Airlines uses only Boeing-747F and Boeing-777F aircrafts with various modifications, while Atran Airlines uses the Boeing-737F aircraft. Thus, airlines reduce the cost of maintenance or training of employees and crew. Typically, airlines operate aircraft for 10 to 20 years. Therefore, the advantage of using a standard fleet is greater operational flexibility, as it is easier to find replacement aircraft or flight personnel in case of irregular operations (Walton, 2012).

2.3.2 Route management

Route management refers to identifying and evaluating the effectiveness of new and existing routes for a given airline's airport. The success rate of new routes is an indicator of efficiency, defined as previously developed routes that remain in operation one or two years after opening. If an airline has increased this measure of route performance over this period, it indicates that the airline's forecasting of route profitability is correct (Abdelghany, 2020).

Nevertheless, unfortunately, even with internal and external consulting resources, airlines cannot always predict a high rate of new route performance. In the USA, for example, low-cost airlines have a high rate only 50-70 percent of the time, which means that 30 percent of new routes are unsuccessful. Considering how much carriers have spent on developing and implementing a new route, it is not profitable for airlines to have so many failures in the route planning process (in this case, even 30 percent failures are a significant loss to the company). Of course, it is beneficial to company management to keep this business growing. However, the main mistake in developing a new route is that they rely more on wishful thinking than on market reality, which leads to a tendency to be overly optimistic when developing route plans. Also, when planning routes, one must consider (Abdelghany, 2020):

- The geography of the route,
- The demand for that distance,
- The volume of each source of demand generation,
- Competitors that already fly this route,
- Airline’s fleet,
- The necessary resources to develop this route.

After this analysis of the new distance, the company can begin to introduce the new route (Abdelghany, 2020).

2.4 Air-cargo revenue management

This section describes the main points of what the air carrier's revenue is made of and what costs airlines incur in the course of their work.

2.4.1 Revenue management

Air cargo revenue management (ACRM) is more complex than passenger airline revenue. However, both aim to optimize revenues and loads to maximize profits through price and capacity (inventory) management. Revenue optimization does not always equal profitability, as many optimization models estimate individual shipments throughout contribution margins, taking only the variable costs of transportation and cargo handling, while indirect and fixed costs (transportation or products) are challenging to determine as they are accounted for through standard cost rates (Morrell & Klein, 2019).

American Airlines was the first to implement ACRM in its operations, and it did so in 1991. However, at that time, Cargo RM was only used for load forecasting, which is now one element of the RM system. The first departure–destination ACRM system was developed by Sabre for Cathay Pacific Airways and was used to determine long-term capacity allocation at the airline's online stations. The first structured ACRM approach, including processes and technology solutions, was implemented at Lufthansa Cargo around 1998 (Morrell & Klein, 2019).

Moreover, in freight transportation, one must consider the three-dimensional problem of capacity: weight, container arrangement, and volume. For example, cargo fits in terms of volume, but in terms of weight, it is not suitable for transportation, and vice versa. Nevertheless, unlike air passenger transportation, cargo transportation is less sensitive to routes. For example, if there is insufficient capacity on one route, the cargo can be rerouted to another. Also, other uncertainties exist in air freight (Morrell & Klein, 2019):

- Traffic density on the route and at the origin/destination airport,
- Weather conditions,
- Passenger traffic, especially on connecting flights,
- Number and weight of checked baggage,
- The problem of delivering cargo to shippers at the departure airport that differs significantly in weight and volume from what is declared, which can affect the route or delivery time of such cargo.

Therefore, capacity forecasting must begin with analyzing available load, considering weather conditions, fuel on board, and passenger load to destination. From this, the payload per passenger (airlines consider the weight of a passenger with hand luggage as 70-80 kg, depending on gender), the weight of passenger baggage, and the weight of

priority mail are subtracted. Also, for wide-body aircraft, the same procedure is followed for the number of standard containers and pallet seats (Morrell & Klein, 2019).

To secure a flight's base load, contracts called "allotments" are usually entered into. These guaranteed space contracts are concluded between airlines and freight forwarders. A cargo airline, "Lufthansa Cargo," part of the Lufthansa Group, distinguishes between two types of contracts (Morrell & Klein, 2019):

- Guaranteed Capacity Agreement (GCA) - Such an agreement guarantees the allocation of cargo capacity for various flights for six months at a pre-agreed rate. Under this contract, the freight forwarder has the right to cancel the capacity 72 hours before departure. Otherwise, the forwarder is liable to pay a penalty of 25-100 percent points of the agreed rate;
- Capacity Purchase Agreement (CPA) - the forwarder buys a fixed capacity for certain flights for one year or more. In this contract, unlike GCA, the freight forwarder cannot return the unused capacity, due to which a lower rate for cargo transportation is provided.

The second option of the contract, of course, looks more profitable for forwarders. However, due to the oversupply of available capacity from 2013-2015, some freight forwarders began to contract for less capacity. However, companies reconsidered their approach to booking capacity on the flight due to a strong peak season and a booming market in 2016-2017. For example, seasonal fluctuations contribute to airlines' commitments to provide capacity during peak periods and fill allocated volume during low season. As a result, long-term, CPA-type firm packages are essentially a bet between airlines and freight forwarders. The remaining capacity is allocated to various market segments for which demand was predicted in advance based on the income of each (Morrell & Klein, 2019).

Closer to the flight date, Lufthansa will analyze the planned load of the aircraft, and if capacity is available, the airline will optimize such a flight. For example, suppose the booked cargo is approaching the maximum load volume, and the physical payload is still available. In that case, the airline will sell containers for small, heavy, and high-density cargo. Furthermore, if the opposite is accurate, and volume is available on the flight. However, the payload limit is almost reached, and the airline promotes more oversized but relatively light low-density cargo. Such capacities are sold by the airline at more favorable rates, but one must consider the difference between low-cost fill-in cargo and expensive rush cargo (Appendix 6) (Morrell & Klein, 2019).

The first step in the capacity estimation process begins with a schedule (if the company is not a charter company, a regular schedule is made for the winter and summer seasons), which is loaded into the reservation system. The initial load will be weighted by passengers, luggage (if the flight is to be on a passenger plane), and mail. Next, capacity

will be allocated to GCA, CPA, and free-selling customers (generally higher rates but less obligation to the airlines). Capacity rates should increase based on projected load factors and flight revenues. However, if loading is projected to be significantly lower than previously projected, rates can be lowered to attract additional cargo. It is also important to retain enough capacity for rush orders, which are often urgent and therefore paid for at a higher rate (Morrell & Klein, 2019).

The second step in estimating capacity is the level of overbooking. It reduces the loss of revenue when a flight is canceled, leaving some available capacity unsold. Freight tends to be uneven, and these flight cancellations have a more significant impact on load factor than passengers because more extensive flights are booked, and fewer customers are involved. Therefore, the loss of revenue from a single freight cancellation significantly impacts a company's bottom line more than the loss of two passengers from a booking. Consequences of overbooking are the following (Morrell & Klein, 2019):

- The cost of refunds or claims,
- Additional handling costs,
- Additional storage costs,
- Loss of business reputation.

The latter can be reduced to a sham if the airline has other flights on which this cargo can be transferred and delivered to the destination airport at the negotiated time. Also, it would result in a reduction in reimbursement amounts (Morrell & Klein, 2019).

The ACRM system's demand is related to the pricing and rates at which orders are accepted from the beginning of the booking and by the departure time. Accepting too many early bookings or distributing remaining capacity at low rates can result in insufficient capacity for urgent cargo with high rates closer to the departure time. Also, accepting too many reservations on one section of a flight with many connections may result in rejecting expensive shipments using that and other flight sections. Therefore, ACRM aims to achieve the best combination of fares and traffic density to maximize revenue on each flight (or, better yet, the entire network), whether it is a passenger or freight flight. It requires careful forecasting of demand at various rates based on historical data (Morrell & Klein, 2019).

2.4.2 The main expenses of air cargo carriers

This subsection will look at the high costs of air cargo carriers by group: flight operational costs, fuel costs, and capital costs. Moreover, when analysing companies' costs, the air transportation integrators produced with their aircraft is not always easy to separate from ground costs. Therefore, many commercial cargo airlines do not provide all of their operational data, especially data such as costs (Morrell & Klein, 2019).

2.4.2.1 Flight operational costs

Flight crew expenses. Such expenses include crew members' wages and salaries, pensions, allowances, insurance, and other similar expenses (e.g., uniforms). But payments to flight attendants and other passenger service personnel are not included in this account but are included in the corresponding sub-item (Morrell & Klein, 2019).

Flight equipment insurance. Such expenses include insurance against accidental damage to equipment in flight or on the ground, and liability insurance arising from the operation of the aircraft (Morrell & Klein, 2019).

Rental of flight equipment. These expenses include the lease of aircraft and crews from other air carriers as part of the leasing agreement (Morrell & Klein, 2019).

Other expenses. Here costs that relate to the operation of aircraft in flight and the corresponding waiting time are included (Morrell & Klein, 2019).

Flight equipment maintenance and overhaul. This item includes the cost of maintenance of aircraft, engines, and other components to keep them in good working order and the cost of overhauls performed by mandatory government requirements. Moreover, it also includes the salaries of maintenance staff (the aircraft and flight equipment) and the cost of repair and maintenance services by third-party contractors and manufacturers (Morrell & Klein, 2019).

Depreciation and amortisation (total) include (Morrell & Klein, 2019):

- Depreciation – flight equipment,
- Amortisation of capital leases – flight equipment,
- Depreciation and amortisation – ground property and equipment,
- Other (Amortization expense of capitalized development and preoperational costs and other intangible assets related to the performance of air transportation is included in the balance sheet).

User charges (total) include (Morrell & Klein, 2019):

- Landing and associated airport charges. All air traffic-related fees levied on the air carrier for services provided at the airport (landing charges, passenger and cargo charges, security charges, maintenance charges, parking, and hangar charges) are included. The airport charges fuel fees to the fuel supplier for access to the apron. Fuel fees are usually passed on to the airline. The airport charges boarding fees per passenger to cover passenger terminal costs, and for air cargo, cargo terminal costs are recovered through cargo handling charges. It is because, unlike a passenger terminal, a cargo terminal is usually built and operated by one or more airlines or a third party. Some African and European airports also have cargo terminal capacity charges.

- Air navigation charges. These costs include fees charged to the air carrier for providing facilities and services within the route, including approach and aerodrome management fees.

Station expenses. It includes salaries, allowances, and expenses of all station personnel; station accommodation costs; maintenance and insurance of airport facilities; representation fees and traffic handling charges; and maintenance costs of station stores (Morrell & Klein, 2019).

Ticketing, sales and promotion (total) include (Morrell & Klein, 2019):

- Commission expenses. Commission on sales of transportation and carrier services.
- Other expenses. Payments to employees who handle reservations and carrier sales, advertising fees, media publications, and agency fees.

General and administrative. Expenses incurred in the performance of general and administrative functions of an air carrier, as well as expenses related to matters of a general corporate nature (Morrell & Klein, 2019).

Other operating expenses (total) include (Morrell & Klein, 2019):

- Incidental transport-related expenses.
- Miscellaneous operating expenses.

2.4.2.2 Fuel costs

The second highest cost for many freighter operators is fuel (Morrell & Klein, 2019).

Table 1: Fuel efficiency and cost for large wide-body freighters

PVG-ANC 7,097 km	**B747-8F**	**B747-400ERF**	**B747-400F**	**B747-400BDSF**	**B747-400BCF**
Maximum payload tonnes	136	119	119	115	113
Block time (hours)	8,2	8,2	8,2	8,1	8,1
Block Fuel (US gallons)	31,795	30,520	30,489	31,302	31,301
Fuel burn per ATK (US gallons)	0,0329	0,0362	0,0362	0,0384	0,0389
Fuel cost per ATK (USD)	0,109	0,119	0,119	0,127	0,128
Fuel cost US gallon (USD)	3,30				
Fuel cost per ATK (USD)	0,055	0,060	0,060	0,064	0,065
Fuel cost per US gallon (USD)	1,67				

Source: Morrell & Klein (2019).

Fuel has a critical impact on airline profitability, as little can be done in the short term to improve fuel efficiency when fuel prices are rising rapidly. Also, fuel costs have become critical to airlines because of the increased focus on the environment and the emissions that arise from fuel combustion. Fuel costs can be divided into price and efficiency of use. The fuel price is not only the market price of crude oil but also the costs of transportation and delivery to the aircraft and possible fees that the airport can charge. The efficiency of fuel use can be achieved by, for example, airlines that have already given up using older Boing 747 models. Table 1 shows the comparative characteristics of this aircraft's new and old modifications. Thus, the new Boeing 747-8F has a larger payload and lower consumption, which shows that the Boeing 747-8F has higher fuel efficiency and, therefore, lower economic costs (Morrell & Klein, 2019).

2.4.2.3 Capital costs

Capital expenditures include depreciation and leasing. Leases or rentals include interest on loans (non-operating costs), which are also part of capital costs. Aircraft are acquired through operating leases and outright purchases, so financing is also a capital cost. Also, capital costs combine the price of capital with the efficiency of its use. The price of most currently in use is shown in Table 2 (Current Market Value is defined as the appraiser's opinion of the most likely trading price). Manufacturers also publish prices for their aircraft that are in production. Thus, Boeing offered the following prices (millions of U.S. dollars) in 2017: B747-8F is listed at 387,5, B777F at 325,7, and B767-300F at 203,7. Large orders and start-up customers get a discount of up to 40 percent points, and few airlines will pay these list prices. However, they are used as the basis for the cost increase formula that applies between the purchase contract and the final settlement on delivery (Morrell & Klein, 2019).

Table 2: Freighter values (USD million), May 2015

	Minimum	**Maximum**
A330-200F	66,84	95,44
B737-300F	5,74	8,63
B737-400F	6,43	9,72
B737-400F	15,75	39,12
B737-8F	124,62	185,88
B767-300F	17,07	62,70
B757-200PF	7,53	21,25
B777F	99,55	165,23
MD-11F	8,01	13,64

Source: Morrell & Klein (2019).

Depreciation is the most significant part of an airline's total depreciation. The operation of new cargo aircraft involves a long depreciation period, significantly if the load is not projected to be high yearly. Nevertheless, more often than not, airlines purchase aircraft that have already been converted (from passenger to cargo), with an average life of 20

years or more. Such planes have another 10-15 years of service life. Moreover, the longer the depreciation period and the higher the residual value of the fleet, the lower the depreciation cost of the aircraft will be (and vice versa). Short-haul narrow-body aircraft depreciate more over a shorter term than wide-body aircraft because they are expected to have more wear and tear due to the higher number of landings per year. Aircraft engines are also depreciated separately (Morrell & Klein, 2019).

2.5 Nature of Bankruptcy

A company's bankruptcy occurs on the application of the organization itself in court when its liabilities exceed the value of its total assets. Thus, the company's net worth becomes negative, resulting in a reorganization or liquidation of assets. Generally speaking, company bankruptcy can harm the economy economically and socially (Walton, 2012).

The most common causes of company bankruptcy are reduced cash flow and poor management. But the aviation industry is different from other industries and has more reasons for financial distress. Airlines can face overcapacity, artificial price controls, and government regulation. That causes companies to be chronically financial unstable (Altman, 2013). For example, after the well-known events of September 11, 2001, and the economic downturn, the aviation industry was forced to cut capacity at the expense of passenger service and cargo capacity availability (Walton, 2012). Also, high leveraging and high fixed and labor costs are other reasons for the bankruptcy of companies in the aviation industry (Altman, 2013).

Nevertheless, the reasons for the bankruptcy of companies may vary, but the goal, under today's law, is the same–to rehabilitate the company. In bankruptcy, the firm gets to reorganize itself (under court protection), remain viable, retain employment opportunities, and retain its reputation. However, usually, this is characteristic of those firms whose economic value exceeds their liquidation value. The rest must be liquidated (Walton, 2012).

2.6 Review of empirical studies on the bankruptcy prediction models

This section describes four company bankruptcy prediction models that apply to the air cargo industry. Also, these models will be used in this master's thesis to calculate the financial distress and bankruptcy prediction of twenty-five international air cargo carriers.

Such financial models, which are mentioned earlier, help predict the company's future financial condition. However, at this point, either scientifically or financially, it is impossible to say which model makes a better prediction. Also, the model results and forecast accuracy are influenced by the industry in which the company is being analyzed. The best-known and most popular model is Altman's Z-score, developed by Altman in

his doctoral thesis in 1967 and published in the Journal of Finance in 1968. Over the next 50 years, he and his co-authors tested this model on numerous companies (Walton, 2012).

Companies usually do not just fall into bankruptcy status, but rather go through various degrees of financial crisis that change daily. Also, bankruptcy can be different with different degrees of severity, but many of the existing financial models give only black-or-white results, meaning that answering the question "will a company go bankrupt?" will only give a definite "yes" or "no" answer (Walton, 2012).

Also, the use of such models is criticized by some authors because, in some cases, quantitative models can classify a company as being in financial distress. However, the firm may never go bankrupt because of good management actions or other factors (external or internal) that financial models cannot detect (Walton, 2012).

Nevertheless, these models can still alert management to the company's condition and give a guide as to which way to go. If the model predicts that the company will go bankrupt, then it is understandable that the company at least has financial difficulties that should be corrected soon.

2.6.1 Terminology and definitions

The models for predicting company bankruptcy discussed in this research paper are based on financial indicators: assets, liabilities, shareholders' equity, revenue and expenses. They can be found in companies' main financial statements: balance sheet, income statement, and cash flow statement (Kroeze, 2005). All of these reports should be located in the public domain.

Table 3: Summary Comparison

	Income Statement	**Balance Sheet**	**Cash Flow**
Time	Period of time	A point in time	Period of time
Purpose	Profitability	Financial position	Cash Movements
Measures	Revenue, expenses, profitability	Assets, liabilities, shareholders' equity	Increases and decreases in cash
Starting Point	Revenue	Cash Balance	Net Income
Ending Point	Net Income	Retained earnings	Cash balance

Source: own work.

The Table 3 shows summary of financial statements. The balance sheet is the leading financial report, which reflects the financial position of the company (assets, liabilities, and equity) and is prepared at the end of each reporting period (quarter, year). For this study, the relevant period is one year. The profit and loss statement reflects the firm's success (the sum of the firm's revenues and expenses) over time. In this study, one year was also chosen as the period. The cash flow statement shows the cash impact of the company's operating, investing, and financing activities over time and explains the

change in cash from the beginning to the end of the year. In this study, one year was also chosen as the period (Kroeze, 2005).

The following company performance indicators were used to create financial models (Lessambo, 2018):

- Current (fixed) assets - the value of assets that are used (spent or exchanged) during 12 months or during one operating cycle;
- Total assets - the total value of all assets of the organization;
- Current liabilities - liabilities to be repaid within the next year;
- Total liabilities - total value of long-term and short-term liabilities;
- Book value of equity - the amount of cash remaining after the sale of the company's activities;
- Retaining earnings - the company's net profit not distributed among the shareholders but allocated to reserves or reinvested in the business;
- Earnings before interest and taxes (EBIT) - net income before income tax and interest expenses;
- Interest expenses - the cost incurred by the organization for borrowed funds;
- Operating revenues - revenues generated by an airline's general operations, including scheduled and non-scheduled flights, as well as revenues from passengers, cargo, excess baggage, and some other income related to transportation;
- Total debt obligations - the total amount of the company's debt to all creditors, including both long-term and short-term debts;
- The accounting maturities of total debt obligations - the accounting part of total debt with an expiration date.

These financial performance indicators define, follow and forecast companies' economic stability. They are an essential tool for corporate insiders (management) or for outsiders (investors) to analyze companies' current situation and probable features, especially regarding competitors or weaknesses/strengths (HBS, 2021).

2.6.2 Bankruptcy Prediction Models

Models for predicting bankruptcy are used to anticipate a company's future financial stability. There are many different financial modeling methodologies, but neither the academic community nor the financial sector can agree on the ideal model. The majority of models need to be calibrated to particular industry groupings, since some models really seem to operate better than others in some sectors (Walton, 2012). The initial attempt in the direction of bankruptcy prediction model development was made by Beaver (1966). He was the first researcher who investigated the predictive power of financial ratios. Beaver (1966) used a statistical technique known as "t-tests" to forecast bankruptcy for a pair-matched sample of enterprises. Using each accounting ratio individually, he used this

approach to assess the significance of each of a number of accounting ratios using univariate analysis (i.e., analysis with the description of a single variable). He compared the ratios of solvent firms to a sample of 79 unsuccessful businesses that had filed for bankruptcy five years earlier. He took into account both insolvent and financially troubled businesses. Three financial factors were relevant in forecasting a company's collapse, according to his analysis of 30 financial parameters, namely net income/total assets, cash flow/total debt, and total assets/total debt; although, the first two ratios were the biggest predictors of failure. Various of bankruptcy prediction models were created because of Beaver's groundbreaking study in 1966 (Gerritsen, 2015).

The first bankruptcy model based on the Multiple Discriminant Analysis (MDA) Model was created by Altman (1968), sometimes known as the Z-score model. It was a general explanation of how manufacturing enterprises with publicly listed stock may go insolvent. Later, Altman, Haldeman, and Narayanan (1977) replaced the Z-score model with the ZETA model. In 1993, the popular Altman Z- score model underwent another revision, this time to a four variable model from the original five variable model. The concept is said to work better for companies that don't manufacture anything. In his PhD dissertation, Hanson (2003) employed the improved Altman Z-score model, which produced quite accurate findings by categorizing insolvent service organizations with an accuracy of 92 percent points in the first year, 69 percent points in the second year, and 54 percent points in the third year. Altman and Gritta (1984) evaluated the US aircraft industry using the Altman ZETA model.

After Beaver's and Altman's papers, studies on bankruptcy attracted a lot of interest. Numerous attempts to validate, enhance, and develop new models have been made from time to time by diverse writers. Ohlson (1980) predicted bankruptcy using logistic regression. A logit model created by Zavgreen (1985) was able to forecast bankruptcy up to five years in advance. Jones and Hensher (2004) employed the mixed logit technique. To develop a model for predicting bankruptcy, Gepp and Kumar (2008) used discriminant and logit analysis.

Two discriminant analyses were carried out in the 1980s, particularly for the aviation sector (Altman & Gritta, 1984). For a while, it was believed that as opposed to generic models, industry-specific models may likely provide better or more accurate findings. Using data from airlines, Chow, Gritta and Leung (1991) created the AIRSCORE model. For air travel, Pilarski and Dinh (1999) created the P-Score model. Neural network models for large US airlines were created by Davalos, Gritta, and Chow (1999), while a model for minor carrier financial difficulties was created by Gritta, Wang, Davalos and Chow (2000). Although these models successfully predicted bankruptcy for samples up to one year, there was no significant improvement in their predictive power over MDA or logistic regression (Shome & Verma, 2020).

2.6.2.1 Altman's Z-score model

Altman, in the year 1983, suggested a modified version of the old Z-score model for the non-manufacturing industries. The original model looked like this (Altman, 2013):

$$Z = 0{,}012X_1 + 0{,}014X_2 + 0{,}033X_3 + 0{,}006X_4 + 0{,}999X_5 \quad (1)$$

In this case, X_5 is the use of operating leases, which are not reflected on the airlines' balance sheets, but the income derived from such leases is reflected in the carriers' income statement (Gritta, Adrangi, Davalos, & Bright, 2008).

The modified model has the following form (Altman, 2013):

$$Z = 6{,}56X_1 + 3{,}26X_2 + 6{,}72X_3 + 1{,}05X_4 \quad (2)$$

Where,

X_1 = net working capital to total assets (a liquidity ratio)

= [(Current assets − Current liabilities) / Total assets]

X_2 = retained earnings to total assets (a profitability ratio)

= [Retained earnings / Total assets]

X_3 = operating profit to total assets (a profitability ratio)

= [Earnings before interest and taxes / Total assets]

X_4 = market value of equity to book value of debt (a leverage ratio)

= [Book value of equity / Total liabilities]

Table 4 shows possible one of the model's results.

Table 4: Z-score classification

Z-score	Zone	Indicator
> 2,6	Safe	Degree of financial distress is low
1,1<Z<2,6	Grey	Due to statistical insignificance, difficult to assess
<1,1	Distress	Degree of financial distress is high

Source: Altman (2013).

The U.S. Bureau of Transportation Statistics uses this particular variation of the model to track the financial health of airlines because there is no factor in this version that can skew the results (Gritta, Adrangi, Davalos, & Bright, 2008).

2.6.2.2 Kroeze's Y-score mode

Prof. Carla Kroeze developed and applied a model for bankruptcy analysis of the airline industry, a modified model of the original Altman's Z-score model (1). In this model, Kroeze used only the financial ratios of companies, so there is no profitability ratio (X_3),

which is present in Altman's model. The model is called the Y-score and has the following form (Kroeze, 2005):

$$Y = 0{,}268X_1 + 0{,}838X_2 + 0{,}111X_3 + e \quad (3)$$

Where,

Y = Y-score index

X_1 = net working capital to total assets (a liquidity ratio)

= [(Current assets − Current liabilities) / Total assets]

X_2 = retained earnings to total assets (a profitability ratio)

= [Retained earnings / Total assets]

X_3 = market value of equity to book value of debt (a leverage ratio)

= [Book value of equity / Total liabilities]

e = Error term Multiple discriminant analysis is applied in this model.

Based on the calculated value of Y, firms can be classified into two types (Table 5):

Table 5: Y-score classification

Y-score	**Indicator**
Positive (+)	Non-bankruptcy
Negative (-)	Bankruptcy

Source: Kroeze (2005).

That is, unlike with the Z-score, Kroeze divides the state of airlines into only two zones, not three. It gives a more contiguous answer.

2.6.2.3 Fuzzy Logic Model (An International Model)

This model is not based on the MDA approach but fuzzy logic. The Fuzzy Logic Model is based on a multivariate technique known as Hybrid Financial Statement Analysis (HFSAT). HFSAT is a combination of a multivariate discriminant analysis model and the application of fuzzy logic to a firm's financial data. The Fuzzy Logic Model has been tested on several American and Brazilian airlines and has revealed their financial position. The model is presented as follows (Silva, Santo, & Portugal, 2005):

$$Z = 2{,}637 - 0{,}879X_1 + 0{,}466X_2 + 0{,}268X_3 + 0{,}28X_4 \quad (4)$$

Where:

X_1 = Shareholder Funds by Total Assets

= Equity / Total Asset

X_2 = Liquidity

= (Current Liabilities + Long Term Liabilities) / Total Asset

X_3 = Net Operating Revenue by Total Assets

= Net Operating Revenue / Total Asset

X_4= Fixed Assets by Total Assets

= Fixed Assets / Total Asset

As a result, the result Z places the company in one of the groups, which are shown in Table 6 (Silva, Santo, & Portugal, 2005):

Table 6: Fuzzy Logic classification

Classification	**Limit of Z**
Healthy	Z ≤ 1,862
Low Risk	1,862 ≤ Z ≤ 2,2
Moderate Risk	2,2 ≤ Z ≤ 2,515
High Risk	2,515 ≤ Z ≤ 2,73
Insolvent	Z ≥ 2,73

Source: Silva, Santo, & Portugal (2005).

Thus, the company is determined to be "bankrupt/not bankrupt" and receives a more realistic categorization of what risk group it is in (Silva, Santo, & Portugal, 2005).

2.6.2.4 Pilarski Score Model

The Pilarski Score Model estimates the probability of bankruptcy and is acceptable for ranking companies by financial stability; and is also used to predict the financial stress of airlines. The model is called the P-score and has the following form (Gritta, Adrangi, Davalos, & Bright, 2008):

$$W = -1{,}98X_1 - 4{,}95X_2 - 1{,}96X_3 - 0{,}14X_4 - 2{,}38X_5 \quad (5)$$

Where,

X_1 = operating revenues/total assets

X_2 = retained earnings/total assets

X_3 = equity/total debt obligations

X_4 = liquid assets/current maturities of total debt obligations

X_5 = earnings before interest and taxes/operating revenues

The number P is determined by: $P = \frac{1}{[1+e^{-w}]}$ (6)

In this model, the results are not compared with the scale, as in previous models, but show the probability (P) of bankruptcy. The higher the result P, the greater the probability of an airline's financial collapse (Gritta, Adrangi, Davalos, & Bright, 2008).

2.6.3 Financial ratios and bankruptcy prediction

There is literature on predicting these models, but less attention is paid to the choice of variables on which transactions depend. Financial variables fall into two categories– accounting-based variables and market-based variables. When building a model, data is collected several years before bankruptcy to find which variables have the most significant bankruptcy indicators. Also, liquidity, leverage, and profitability variables have been found to be some of the most significant variables for predicting bankruptcy. However, there are also industry/firm specific variables that can be taken into account when building the model. Moreover, the inclusion of data at least four years prior to bankruptcy increases the predictive power of the study. Also, the choice of financial variables is influenced by the empirical availability of the necessary data (Zubanovic & Ahmeti, 2020).

Since Kroeze's model is based on Altman's, the financial variables, which were used in the models, are the same (the difference was discussed above). Also, other models used some of the same ratios. Therefore, these variables are reviewed at the same time.

The models that are reviewed in this thesis include dependent and independent variables. A dependent variable is a variable that is impacted by an independent variable. In this research, the dependent variable is financial distress (Z, Y, W) (Darmawan & Supriyanto, 2018). The following independent factors have an impact on these variables:

- Current ratio (a liquidity ratio)

In order to determine whether a corporation can repay creditors from the total amount of cash on hand, creditors (and occasionally debtors) employ liquidity ratios. The better the liquidity ratio is for that firm, the more liquid their assets are and the more ready they'll be to pay off short-term loans.

The current ratio is the liquidity ratio that is most frequently utilized. The current ratio gives an indication of the company's ability to pay off current debts using the entirety of the assets the company has available.

- Net working capital to total assets (a liquidity ratio)

The gap between a company's current assets and current liabilities is known as working capital. A company's short-term financial stability is determined by the size of its working capital. A corporation may satisfy its short-term financial obligations and yet have money left over to develop and expand if its working capital is positive (Darmawan & Supriyanto, 2018).

Negative working capital, on the other hand, denotes a company's inability to satisfy its short-term financial commitments due to insufficient current assets (Darmawan & Supriyanto, 2018).

- Retained earnings to total assets (a profitability ratio)

The quantity of retained profits or losses in a corporation is shown by the retained earnings/total assets ratio. A low retained earnings to total assets ratio indicates that a corporation is borrowing money to pay for its expenses rather than using money from its retained earnings. It makes a company's chance of bankruptcy higher (Darmawan & Supriyanto, 2018).

A high ratio of retained profits to total assets, on the other hand, indicates that a business uses its retained earnings to pay for capital expenditures. It demonstrates that the firm attained profitability throughout the years, and it does not need to rely on borrowings (Darmawan & Supriyanto, 2018).

- Operating profit to total assets (a profitability ratio)

EBIT, a term used to gauge a firm's profitability, indicates the ability of a corporation to generate profits solely from its operations. The EBIT/Total Assets ratio shows how much income a firm can generate in order to remain profitable, pay for ongoing operations, and pay off debt (Darmawan & Supriyanto, 2018).

- Market value of equity to book value of debt (a leverage ratio)

The market value of a company's equity is sometimes referred to as its market capitalization. It is calculated by dividing the number of outstanding shares by the stock's current price (CFI, 2023).

The market value of equity/total liabilities ratio demonstrates how much a firm would lose in market value if it filed for bankruptcy before the value of its obligations exceeded

the value of its assets. Investor trust in the company's financial stability can be indicated by a high market value of equity to total liabilities ratio (CFI, 2023).

- Shareholder equity ratio

The entire shareholders' equity is divided by the company's total assets to arrive at the shareholder equity ratio, which is given as a percentage. The outcome shows how much of the assets shareholders still have a claim on. The corporate balance sheet contains the numbers that were utilized to determine the ratio (CFI, 2023).

- Asset turnover ratio

The assets turnover ratio demonstrates how well management generates revenue from assets in comparison to the industry. A high assets turnover ratio indicates that the management only needs to make a minimal investment to create sales, which raises the company's overall profitability (CFI, 2023).

A low or declining assets turnover ratio, on the other hand, indicates that management will need to use more resources to produce adequate sales, which will lower the company's profitability (CFI, 2023).

- Operating profit ratio

It is a ratio that depicts how much profit a business is making for each dollar worth of sales it is making. Operating profit ratio does not account for tax or interest in the numbers it deals with (CFI, 2023).

2.6.4 Model comparison and their performances

As it was mentioned before, the Altman and Kroeze models are based on multiple discriminant analysis (MDA), the Pilarski model is based on logistic regression analysis, and the Fuzzy Logic Model is based on a Hybrid Financial Statement Analysis (HFSAT), a combination of a multivariate discriminant analysis model and the application of fuzzy logic. Both discriminant and logistic regression analysis use the direct stepwise method. This procedure introduces predictor variables based on their contribution to the likelihood ratio statistics, and variables without significant contribution are not considered. The main reason for the need for the stepwise procedure is the lack of a theoretical basis for selecting independent variables (Abdullah, Halim, Ahmad, & Rus, 2008).

When considering the accuracy of predicting bankruptcy of companies, the results of the most common model, the MDA Z-score by Altman (1986), was accurate in 94 percent points of cases. However, when using this model in the prediction of bankruptcy of airlines from 1998-2003, the model was unsatisfactory, and the overall accuracy was only 57.5 percent points. The Altman model has been subjected to many studies and

modifications for different industries. One of them was conducted by Kroeze in 2005. For example, Kroeze simplified the Altman model, while improving the model's predictive ability specifically for the aviation industry. Using 1998-2003 sample data, the prediction accuracy was 80.9 percent points. This result significantly improved over the 57.5 percent points of the Z-score model. It means that the Kroeze model can do a decent job of predicting future bankruptcy and can be a helpful management tool (Kroeze, Zemke, & Raab, 2018).

Further, the Fuzzy Logic and Pilarski P-score models were developed using the financial statements which are critical for airlines' operational work. The Fuzzy Logic model tested the financial situation of a few American and Brazilian airlines (Shome & Verma, 2020). The U.S. Department of Transportation uses the Pilarski P-score model to track financial strength. In developing this model, the authors found that the model correlates with the Altman Z-score (Gritta, Adrangi, Davalos, & Bright, 2008).

However, regardless of what bankruptcy prediction model is used and how accurate it is, there are some limitations that these statistical methods cannot account for. For example, accounting reports (from which data can be obtained to calculate the model), especially those of small or new firms, may not represent the company's financial situation. Moreover, there may be problems in selecting independent variables because there is generally no theory for selecting independent variables in accounting, and purely empirical variable selection can lead to overfitting and, thus, an unstable model with little overall applicability. Also, the financial crisis of companies can be influenced by factors such as deteriorating industry conditions, high debt burden, corporate fraud, and disasters such as natural disasters or terrorism (Walton, 2012).

2.7 Literature discussion

An analysis of the theoretical literature revealed the uniqueness of the air cargo industry. Revenue management is influenced by factors unique to this industry, such as fleet, fuel, route selection, and payload efficiency. All of these directly impact the company's financial stability because it is not enough for an airline to sell a unit of cargo capacity simply. It must also consider the above factors when planning a cargo flight.

Because of this complex and unique mechanism of an air cargo carrier, generalized models for predicting bankruptcy and financial instability, such as the Altman Z-score model, are not always appropriate. Therefore, several researchers, such as Kroeze, Gritta and Pilarski have modified existing models or even created new ones for the airline industry to obtain more accurate results. It is also important to note that this literature does not indicate if these models have been tested on air cargo companies.

While existing studies have used the Z-score model (and the modified Z-score model) and the Kroeze Y-score model in the context of the Indian (Bhattacharya, 2021; Shome

& Verma, 2020) or USA (Walton, 2012) Aviation Sector, none of the previous studies to the best of our understanding have considered the Altman modified Z-score, Kroeze Y-score, Pilarski P-Score, and Fuzzy Logic models all together for a combined analysis, especially for the air cargo industry.

The present study is an extension of previous research in the aviation industry. The main purpose of this investigation is to assess the suitability of major bankruptcy prediction models by applying them to different air cargo carriers from different locations and business models. The objectives of this study are: (a) to analyse the financial situation of air cargo carriers using various models (generic and industry specific); and (b) to examine the existence of financial distress in the global air cargo industry.

The Altman Z-score, Kroeze Y-score, Fuzzy Logic, and Pilarski models are used in a subsequent empirical analysis of bankruptcy and financial instability for 25 air cargo carriers using data from 2017 to 2021. Of course, there are significant operational and economic differences between passenger and cargo airlines that may affect the financial stability of the two industries differently (for example, demand, traffic patterns), and these differences, along with other qualitative factors, are considered in this thesis (Walton, 2012).

3 EMPIRICAL ANALYSIS

This chapter discusses the methods used in this master's thesis. The purpose of this chapter is to present how the data was collected and analyzed to get the result, to answer the main research question, and to explore the research objectives.

3.1 Definition of the research problem

The goal of this master’s thesis is to answer the following main research question: Which selected air cargo carriers are potentially at risk of bankruptcy in the following years?

The purpose of this master's thesis is to explore the following research objectives:

The first research objective of this master's thesis is to define and determine the air cargo industry through time, including later years in the global supply chain. This understanding is vital because, in this way, it is possible to evaluate how much the bankruptcy of an air cargo carrier would affect not only a particular industry but the entire global supply chain in general.

The second research objective is to present and overview the most common factors influencing the air cargo industry through time, including globally selected international air cargo carriers. Thus, it is possible to understand which factors most affect the state of the industry and financial and operational performance. Also, it is possible to draw a

conclusion about the current state of the industry and how (un)favorable conditions for the development of the air cargo business are at the moment.

Moreover, the third research objective is to review previous empirical analyses and discuss empirical analysis expectations by selected models. Such an analysis helps in this study's airline bankruptcy forecasting, as it provides the necessary knowledge and experience to calculate the selected models.

The fourth research objective is to empirically analyze the influencing factors of the selected international air cargo carrier industry with selected models. This analysis helps verify the validity of the bankruptcy prediction models and helps give the correct answer to the main research question.

The fifth research objective is to compare the results of the empirical analysis and determine the possible impact on the selected international air cargo carriers in reference to their bankruptcy probability.

3.2 Research methodology

This master's thesis is devoted to analyzing the bankruptcy of air cargo carriers and covers 25 currently operating companies in this industry. The IATA ranking of the best air cargo carriers for 2021 was used to determine the companies in the sample. A purposive sampling method was used to collect the data. The primary data sources are the companies' published annual reports on their official websites and the website wsj.com. All relevant data collected for this study is from 2017 to 2021. Relevant calculations were performed in Microsoft Excel, 2010.

The literature review in Chapter 2 shows that the most accurate bankruptcy prediction models for the cargo aviation industry are Kroeze Y-score, Fuzzy Logic, and Pilarski models. In contrast, the Altman Z-score model is generic and specified using a broad sample of firms in various industries. However, the Z-score model is used in this study because most of the existing financial models are based on Z-score, and it is also good to check the Z-score model's results for the aviation industry.

Table 7: Pilarski P-score classification

0,0 … 0,01	Non-bankrupt
0,02…0,09	Grey zone
> 0,1	Bankrupt

Source: own work.

Moreover, the Pilarski model does not have a classification by group risk as other mentioned models. The basic rule when calculating this model is that the lower the score,

the lower the risk (Pilarski & Dinh, 1999). Therefore, in the process of this research work, three groups were identified (Table 7).

Also, calculations of the Fuzzy Logic model are enough for three years (Silva, Santo, & Portugal, 2005), but in this master's thesis, for a more accurate result, as with the other models, is considered for five years.

These models are calculated separately for each year during the five years (2017-2021). Then, when the results for each year are obtained, the arithmetic average is calculated, which shows whether the company is in the zone of bankruptcy and/or financial distress or the zone of financial stability. Usually, according to previous research papers (Walton, 2012; Shome & Verma, 2020; Bhattacharya, 2021), one does not count the arithmetic average to identify the overall bankruptcy but concludes for each year separately. However, I believe that concluding a company's bankruptcy based on the arithmetic mean is effective. So, for example, if a company had positive results before the coronavirus and the situation worsened after the pandemic, it does not mean that the company will be bankrupt.

The methodology for investigating the potential risk of bankruptcy and financial instability of the selected air cargo carriers consists of calculating the four financial models mentioned above. After obtaining the results (the model and bankruptcy indicators themselves are given in Chapter 2), the risk analysis proceeds as follows:

- If the company is not bankrupt according to the results of all four models, such a company is classified as "Healthy;"
- If the company is not bankrupt according to the results of three out of four models, it is classified as "Low risk;"
- If a company is bankrupt according to the results of two out of four models, such a company gets the "Moderate Risk" classification;
- If a company is bankrupt according to the results of three out of four models, such a company gets the "High Risk" classification;
- If a company is bankrupt according to the results of all four models, such a company gets the "Bankrupt" classification.

The Fuzzy Logic model (an international model) considers a different group of financial distress (Silva, Santo, & Portugal, 2005). For this master's thesis, "Healthy" and "Low Risk" groups are classified as "Non-bankrupt," "High Risk" and "Insolvent" groups are classified as "Bankrupt." Also, some models give "Grey Zone" or "Moderate Risk" results. In this master's thesis, those are also classified as "Bankrupt." After analyzing the results, the main conclusions and recommendations are given.

3.3 Sample Selection and Data

Collected data from 2017 through 2021 is presented in Appendix 9. The companies are divided into groups: the Americas region, the Europe region, the Russia and CIS region, the APAC region, and the Middle East region. The tables include all financial metrics needed to calculate the bankruptcy prediction models. Descriptive analysis is presented in two ways: by regions (Americas, Europe, Russia and CIS, APAC, Middle East) in Appendix 10-14 and by measures (Mean, Max, Min, Median, Std Dev) in Appendix 15-24.

All data are shown in thousands of American dollars. Also, where it was impossible to find any indicator, instead of a number, stands "-". When calculating, the absence of one or another indicator was counted as 0.

It is important to note that the financial performance of the companies, regardless of the region, was strongly influenced by the main event of 2020 and 2021, namely the coronavirus pandemic. Interestingly, the combined airlines (which are also involved in passenger transportation) showed financial growth until 2019. In 2020 their results went down (for example, the EBIT of United Airlines was -7062 million USD in 2020). The opposite is true for integrators and cargo airlines. Before COVID-19, the companies showed poor results and were on the decline, but during the pandemic, they closed the reporting period with the highest recorded profits (for example, the EBIT of Atlas Air was 507 million USD in 2020). Passenger demand dropped dramatically due to closed borders and domestic lockdowns (the result of bans during the pandemic).

In contrast, demand for medical equipment, personal protective equipment, and e-commerce (when physical stores could not operate, everyone went online) jumped. Therefore, cargo airlines and integrators gained more revenue than combined carriers. The exception is companies in the APAC region, where all show declines since 2020.

The tables in Appendix 15-24 show the results for the five measurements: Mean, Max, Min, Median, Std Dev. Based on the graphs, it can be concluded that APAC region has the highest values for Mean, Max, Median, Std Dev, but at the same time the lowest value of Min. On the other hand, the Russian and CIS region carriers have the lowest values. This contrast is explained by the following:

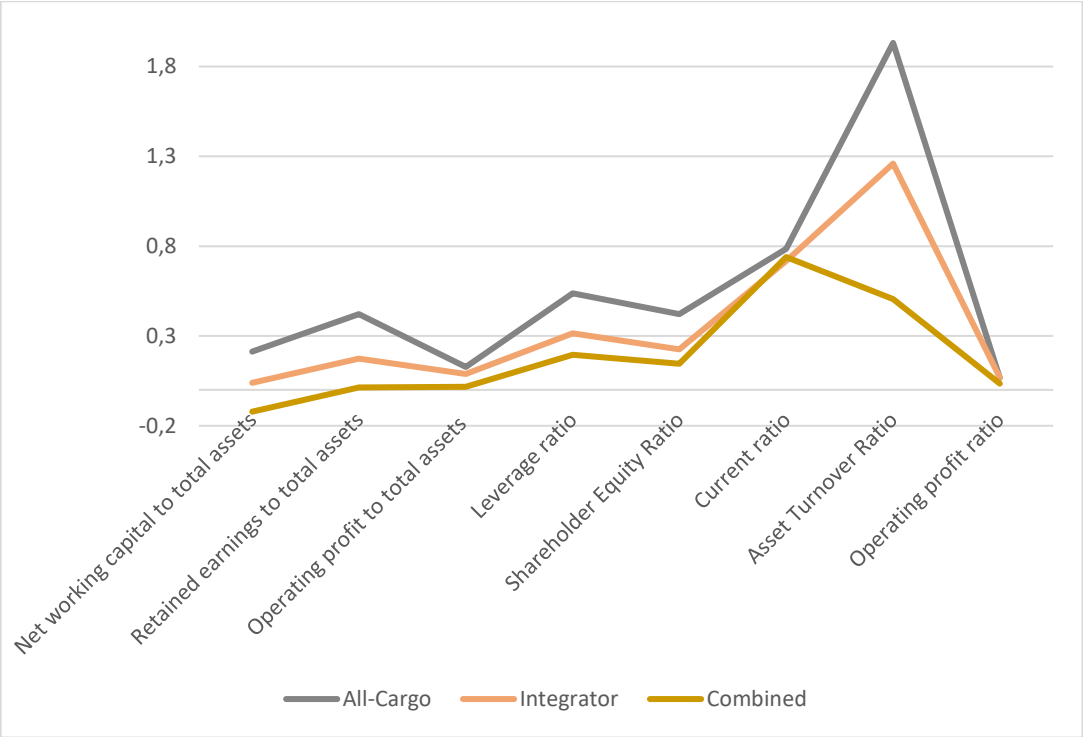
1) Air carriers from the APAC region carry more cargo and therefore have higher operational efficiency, due to the proximity of factories and global companies, since China is still a worldwide manufacturing center (Tae-won Chung, Woo-chul Ahn, Su-min Jeon, & Vinh Van THAI, 2015) and Hong Kong is a tariff-free customs zone for importing and exporting goods (Customs and Excise Department, 2022). Consequently, the APAC region has the highest freight traffic.
2) Another reason is the data sampling. For example, for this master's thesis, 9 air cargo carriers from the APAC region, 3 from the Russia region, 6 from the Americas region,

5 from the Europe region, and 2 from MEA were selected. Therefore, when calculating Mean, Max, Min, Median, Std Dev by region, the results may not show the real situation in the air cargo market.

Also, for a more in-depth analysis of the data, the financial ratios discussed above were calculated by the type of business of the companies: combined, integrated, and all-cargo. Figure 1 graphically shows the medians of financial ratios.

Thus, in general, the median is higher for all-cargo companies, and the combined companies have the lowest median. The exception is the operating profitability ratio, where all three medians are on the same level. Also, the point of asset turnover shows the greatest difference between medians. In addition, all-cargo and integrators have the highest median at this point, and about the same result at liquidity ratio point.

Figure 1: The medians of financial ratios



Source: own work.

This difference between the results may be because when selecting companies for the analysis, the number of representatives of each business group was not taken into account (for example, 4 all-cargo airlines and 18 combined airlines are considered in this dissertation). However, this is not a sampling error but a lack of such companies. On the other hand, the results may also be affected by the two years of the coronavirus pandemic, in which people needed more e-commerce and medication delivery than travel.

Nevertheless, the results of descriptive analysis do not affect further calculation of air cargo carrier bankruptcy prediction models.

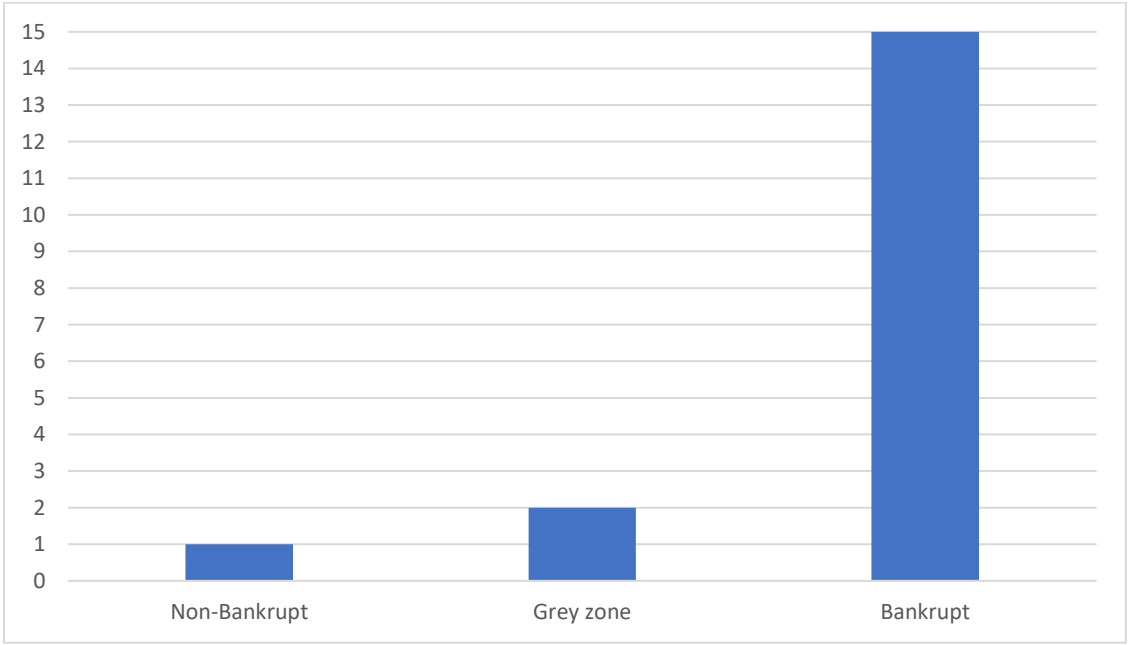
3.3.1 Combined carriers' results

This chapter presents the results of models based exclusively on combined air cargo carriers' data. Appendices 25-28 show a summary of results by the models. A total of 18 combined airlines are represented in this master's thesis. This number includes: Aeroflot, AirCanada, AirChina, ANA, Cathay Pacific, China Southern, Emirates, EVA, Finnair, IAG, China Airlines, KLM, Korean Air, Lufthansa, Qatans, Singapore, Turkish Airways, United Airlines.

3.3.1.1 Altman's Z-score model

This subsection shows the results of Altman's Z-score model calculations for 18 air carriers over five years from 2017 to 2021 (Appendix 25).

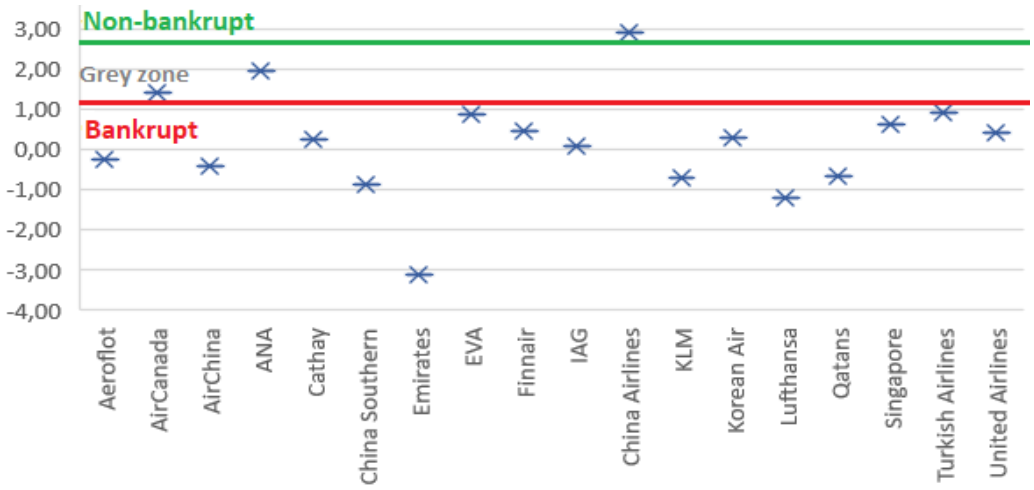
Figure 2: Altman's Z-score model results for combined airlines by groups



Source: own work.

According to the results of the calculations (Figure 2), 15 companies (United Airlines, Turkish Airlines, Singapore, Qantas, Lufthansa, Korean Air, KLM, IAG, Finnair, Emirates, EVA, China Southern, Cathay Pacific, AirChina, Aeroflot) received the result "bankrupt" on the average, 2 companies (ANA, AirCanada) are in the grey zone, and 1 air carrier (China Airlines) is not bankrupt.

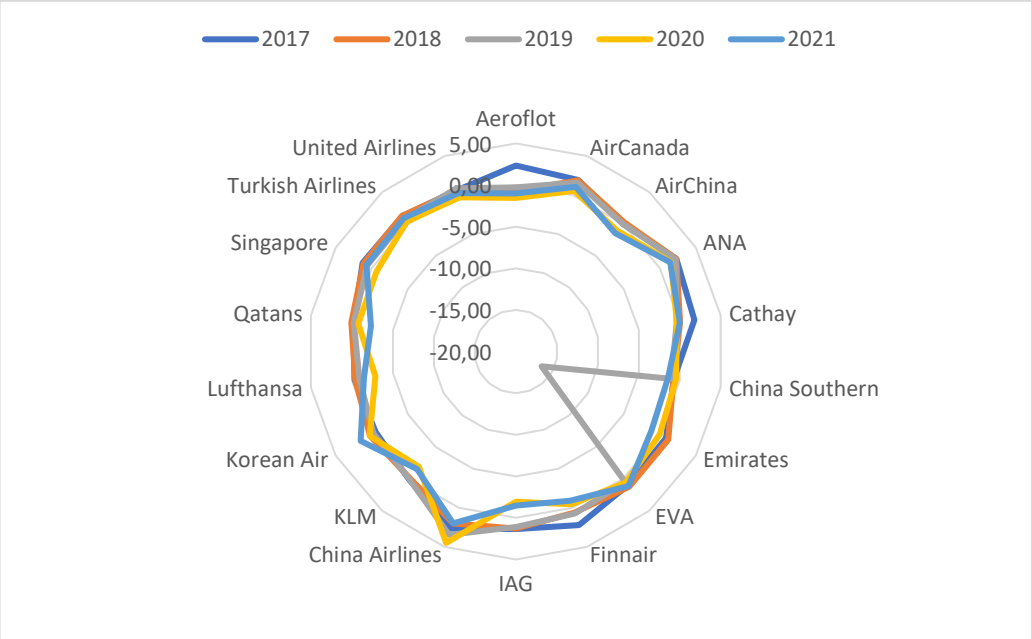
Figure 3: Altman's Z-score model results for combined airlines by zones



Source: own work.

Figure 3 graphically shows the location of companies in the bankruptcy, grey area, and non-bankruptcy zones.

Figure 4: Altman's Z-score model results for combined airlines by years



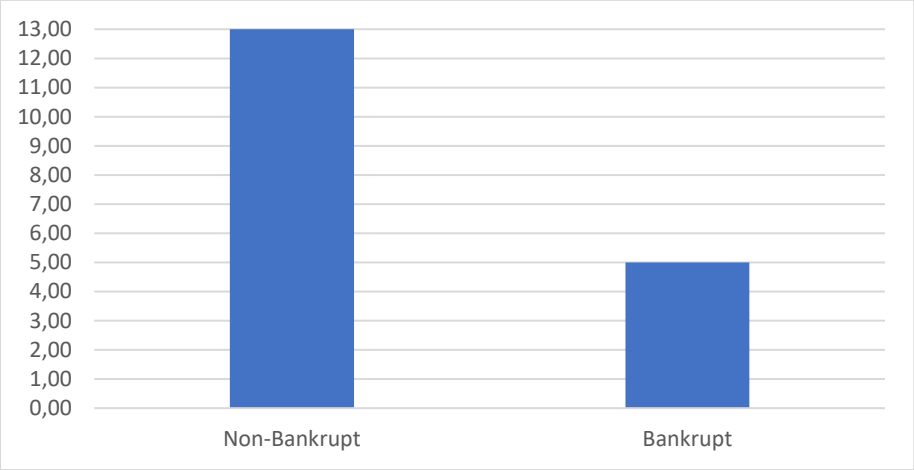
Source: own work.

Figure 4 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place (for example, 2019 for Emirates).

3.3.1.2 Kroeze's Y-score model

This subsection shows the results of Kroeze's Y-score model calculations for 18 air carriers over five years from 2017 to 2021 (Appendix 26).

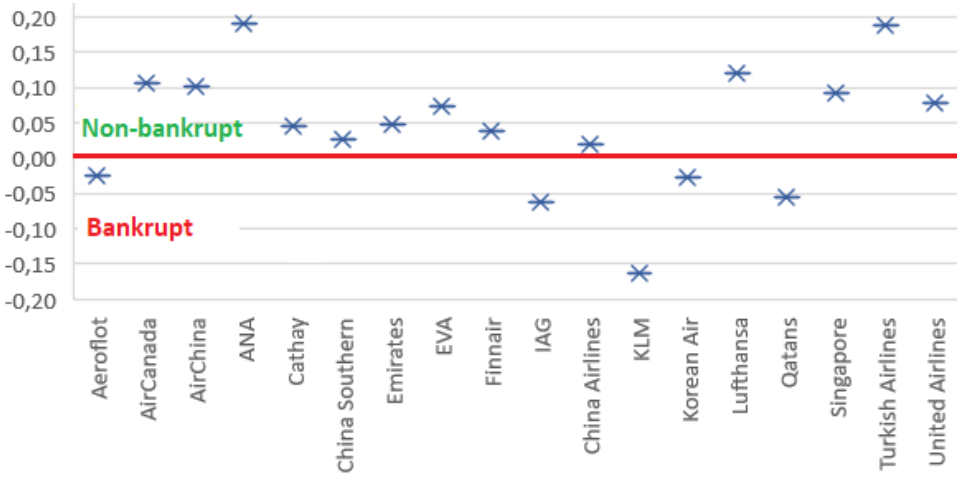
Figure 5: Kroeze's Y-score model results for combined airlines by groups



Source: own work.

In contrast to the results of Altman's Z-score model, Kroeze's Y-score model showed that only 13 of the 18 represented air carriers are bankrupt (Figure 5). This positive result may also be influenced by the fact that Kroeze's Y-score does not provide for grey areas. In addition, this model was explicitly designed for airlines, so the constant variables used in this model give a completely different result.

Figure 6: Kroeze's Y-score model results for combined airlines by zones

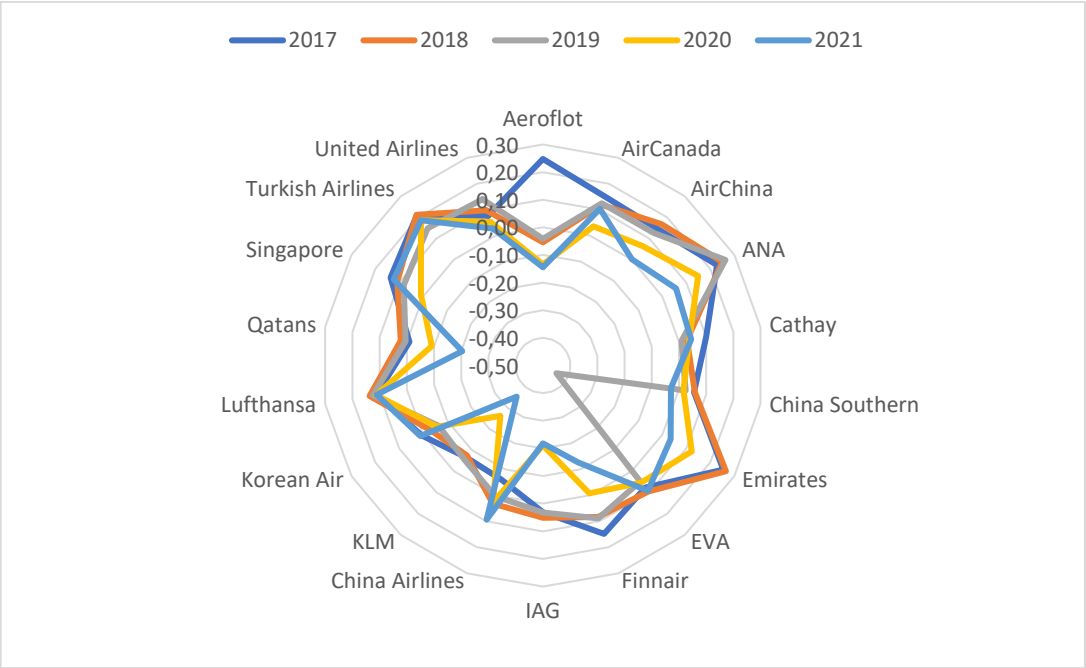


Source: own work.

Figure 6 graphically shows the location of companies in the bankruptcy and non-bankruptcy zones. So, according to the arithmetic average results, the main bankrupts are

KLM, IAG, Aeroflot, KoreanAir, and Qantas. In general, we can draw the same conclusion as the results of Altman's Z-score, namely coronavirus's effect on companies' financial results.

Figure 7: Kroeze's Y-score model results for combined airlines by years



Source: own work.

Figure 7 graphically shows the changes in company results by years. As you can see, the trend of this graph is different from Altman's Z-score and varies much more from year to year.

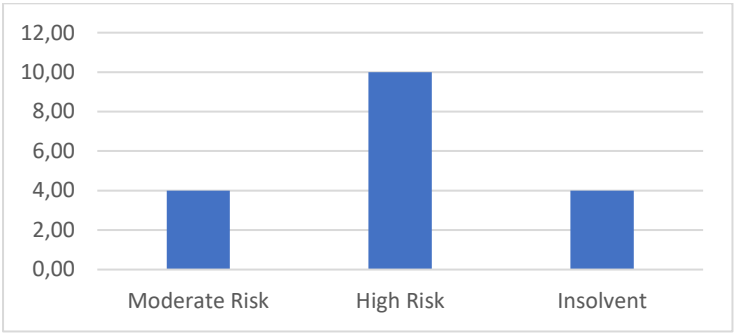
3.3.1.3 Fuzzy Logic Model

This subsection shows the results of Fuzzy Logic model calculations for 18 air carriers over five years from 2017 to 2021 (Appendix 27).

As discussed in the literature review, this model does not qualify companies for bankrupt/non-bankrupt, but rather for risk. Thus, going back to the results of this model (Figure 8), there were no healthy or low risk air carriers. Further, only four air carriers fell into the Moderate Risk group, 10 companies have High-risk status, and four are Insolvent.

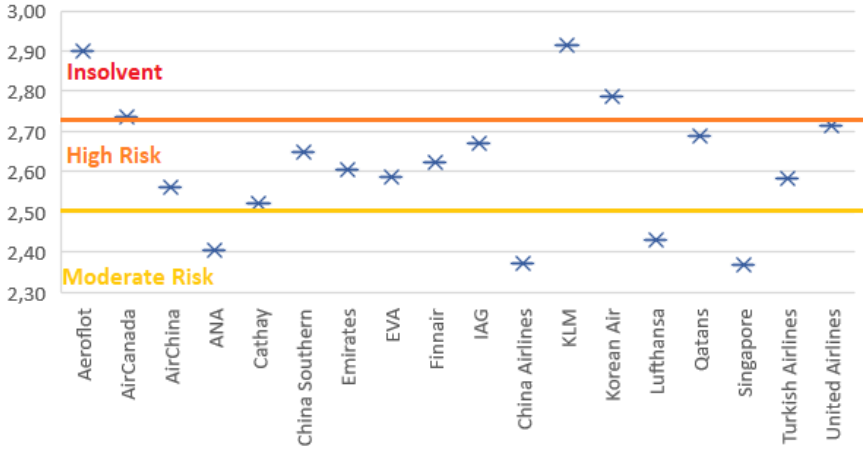
Figure 9 graphically shows the location of companies with Insolvent, High Risk and Moderate Risk designations. According to the model results, companies such as ANA, China Airlines, Lufthansa, and Singapore, are at moderate risk. Such companies as KLM, Aeroflot, Korean Air and AirCanada have Insolvent status.

Figure 8: Fuzzy Logic model results for combined airlines by groups



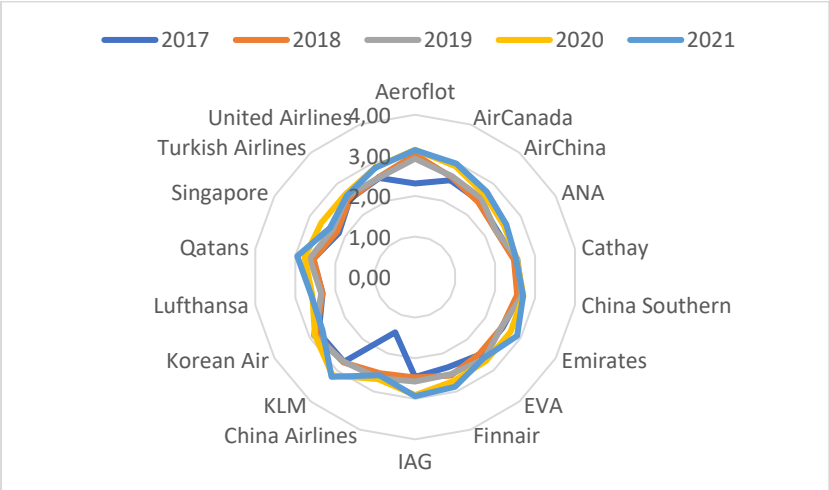
Source: own work.

Figure 9: Fuzzy Logic model results for combined airlines by zones



Source: own work.

Figure 10: Fuzzy Logic model results for combined airlines by years



Source: own work.

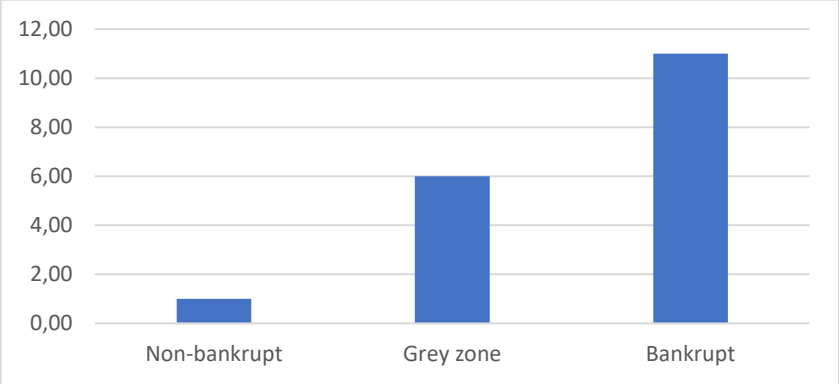
Figure 10 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place (for example, 2017 for China Airlines).

In the end, it can be said that the Fuzzy Logic model gives almost opposite results compared to the Kroeze and Altman models. Nevertheless, KLM, Aeroflot, and Korean Air are showing negative results for the third time.

3.3.1.4 Pilarski P-score model

This subsection shows the results of Pilarski P-score model calculations for 18 air carriers over five years from 2017 to 2021 (Appendix 28).

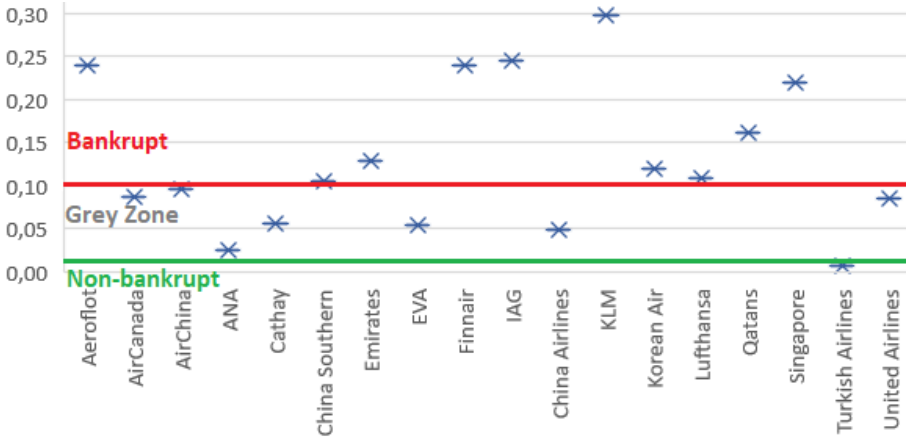
Figure 11: Pilarski P-score model results for combined airlines by groups



Source: own work.

Thus, according to the results of this Pilarski P-score model (Figure 11), only one company is not bankrupt, 6 companies are in the grey zone, and 11 carriers are bankrupt.

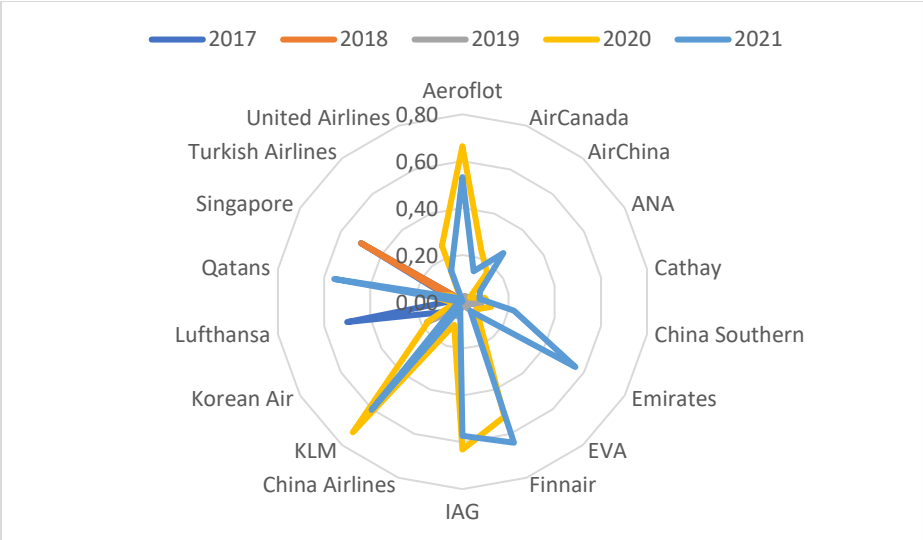
Figure 12: Pilarski P-score model results for combined airlines by zones



Source: own work.

Figure 12 graphically shows the location of companies in the bankruptcy, grey, and non-bankruptcy zones. The single non-bankrupt company is Turkish Airlines. The bankrupt carriers included KLM, Korean Air, Lufthansa, Qantas, Singapore, Finnair, Emirates, China Southern, AirChina, IAG, and Aeroflot.

Figure 13: Pilarski P-score model results for combined airlines by years



Source: own work.

Figure 13 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place. For example, the coronavirus pandemic (2020-2021) gave the most severe changes for many air cargo carriers.

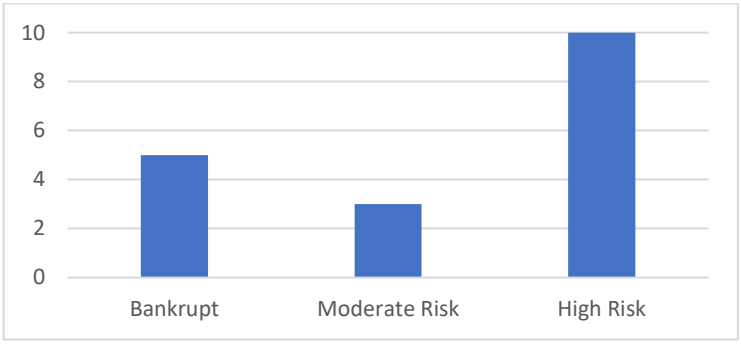
Thus, the results are not very different from those of Altman's and Kroeze's models. However, one more company was added in the non-bankrupt list, which with the Z-score and Fuzzy Logic models was bankrupt–Turkish Airways.

3.3.1.5 General results of models

This chapter presents the results of all four models for combined air cargo carriers. Appendix 37 shows a summary of results of all fours models.

As Figure 14 shows, five airlines receive "Bankrupt" status. This list includes such carriers as KLM, Korean Air, IAG, Qatans and Aeroflot. Also, ten companies are among the highest risk, namely United Airlines, Singapore, Lufthansa, China Airlines, Finnair, EVA, Emirates, China Southern, Cathay Pacific, and AirChina. Next, Turkish Airlines, AirCanada, and ANA are in the Moderate Risk group. It is also worth noting that none of the companies received a "Healthy" or "Low risk" status, as all carriers, at least according to the results of one of the models, had the status of bankrupt, high/medium risk, or were in the grey zone.

Figure 14: Results of all models for combined airlines by groups



Source: own work.

The results for the four models showed that the combined companies are in a highly fragile position at the moment. A more detailed discussion of the model results is given in the next chapter.

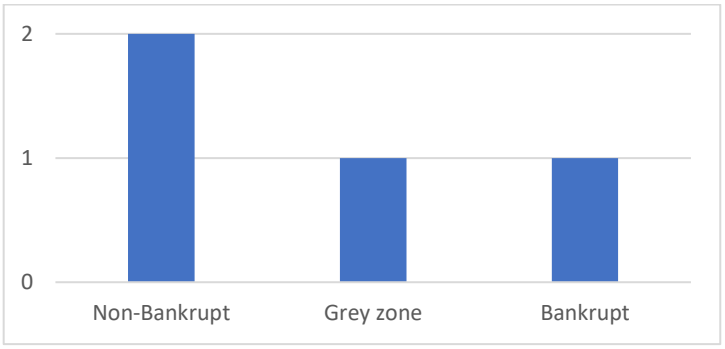
3.3.2 All-cargo carriers' results

This section presents the results of models based exclusively on all-cargo air cargo carriers' data. Appendices 29-32 show summaries of the results of the models. A total of 4 all-cargo airlines are represented in this master's thesis. This number includes: AirBridgeCargo, Cargojet, Atlas Air, Volga-Dnepr.

3.3.2.1 Altman's Z-score model

This subsection shows the results of Altman's Z-score model calculations for 4 air carriers over five years from 2017 to 2021 (Appendix 29).

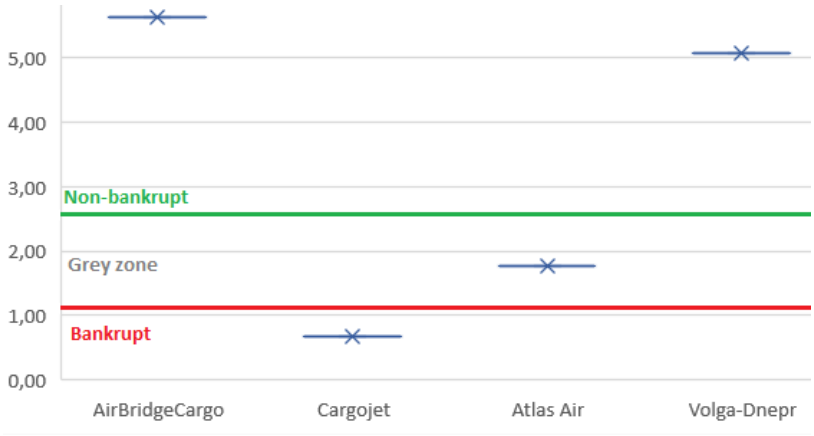
Figure 15: Altman's Z-score model results for all cargo airlines by groups



Source: own work.

According to the results of the calculations (Figure 15), 1 company (Cargojet) received the result "bankrupt" on the average, 1 company (Atlas Air) is in the grey zone, and 2 air carriers (Volga-Dnepr, AirBridgeCargo) are not bankrupt.

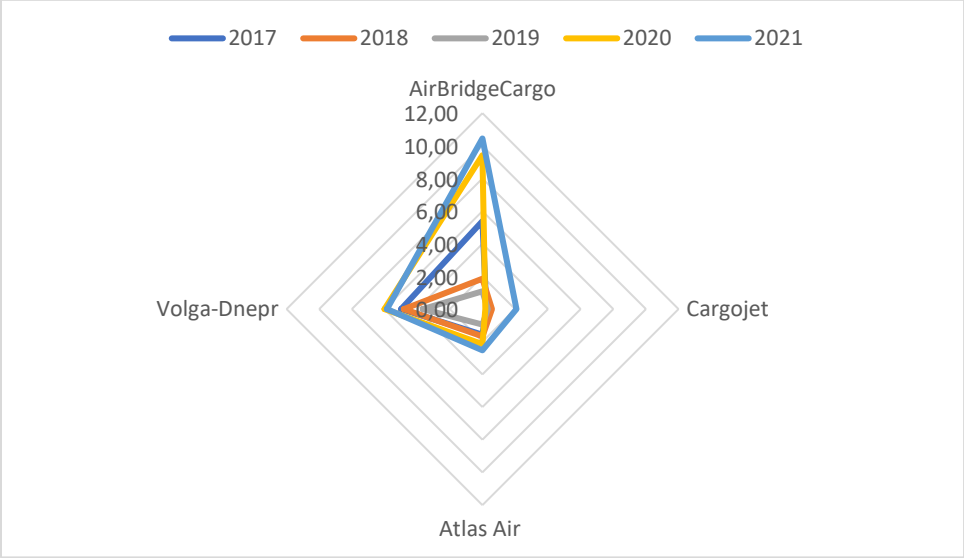
Figure 16: Altman's Z-score model results for all-cargo airlines by zones



Source: own work.

Figure 16 graphically shows the location of companies in the bankruptcy, grey area, and non-bankruptcy zones.

Figure 17: Altman's Z-score model results for all-cargo airlines by years



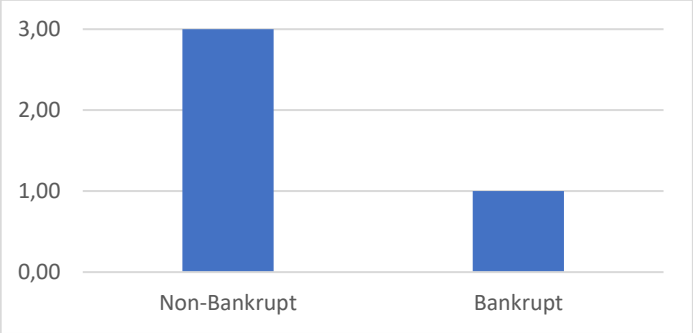
Source: own work.

Figure 17 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place (for example, 2020 and 2021 for AirBridgeCargo).

3.3.2.2 Kroeze's Y-score model

This subsection shows the results of Kroeze's Y-score model calculations for 4 air carriers over five years from 2017 to 2021 (Appendix 30).

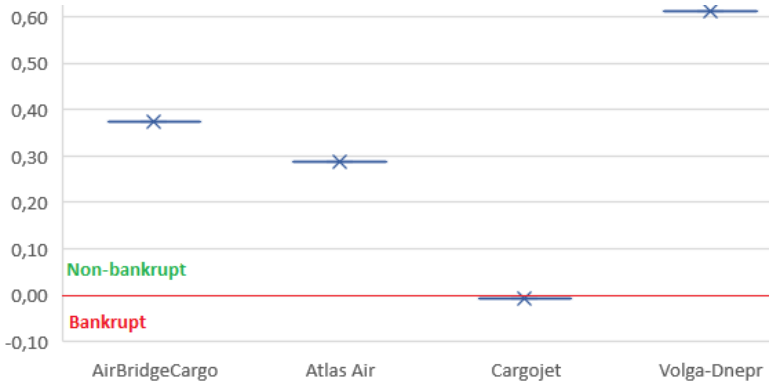
Figure 18: Kroeze's Y-score model results for all-cargo airlines by groups



Source: own work.

In contrast to the results of Altman's Z-score model, Kroeze's Y-score model showed that only 1 out of the 4 represented air carriers are bankrupt (Figure 18). This positive result may also be influenced by the fact that Kroeze's Y-score does not provide for grey areas. In addition, this model was explicitly designed for airlines, so the constant variables used in this model give a completely different result.

Figure 19: Kroeze's Y-score model results for all-cargo airlines by zones



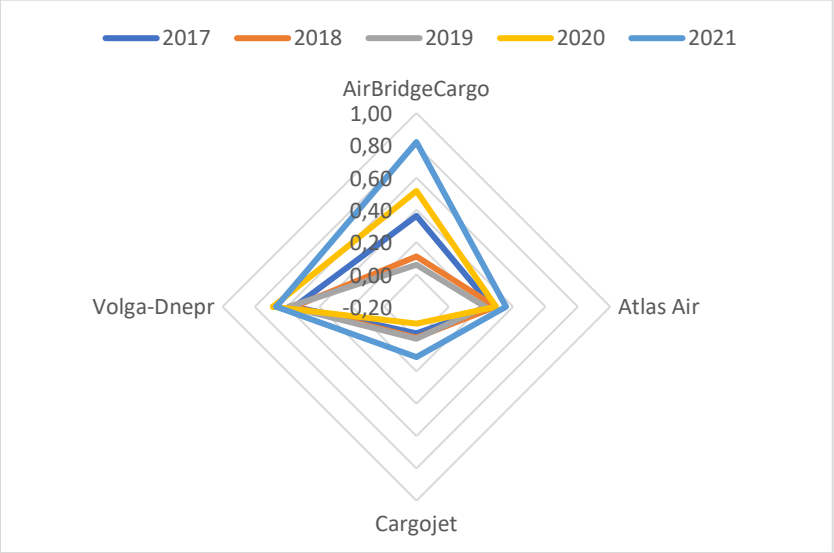
Source: own work.

Figure 19 graphically shows the location of companies in the bankruptcy and non-bankruptcy zones. So, according to the arithmetic average results, the only bankrupt is Cargojet, which is very close to 0 (non-bankrupt line).

Figure 20 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place (for example, 2021 for AirBridgeCargo and Volga-Dnepr). Unlike Altman's Z-score, where there was a trend and, in most cases, the

years were at the same level, here we get a very different figure. It can be seen very well the changes to which the companies were subjected during the five years.

Figure 20: Kroeze's Y-score model results for all-cargo airlines by years



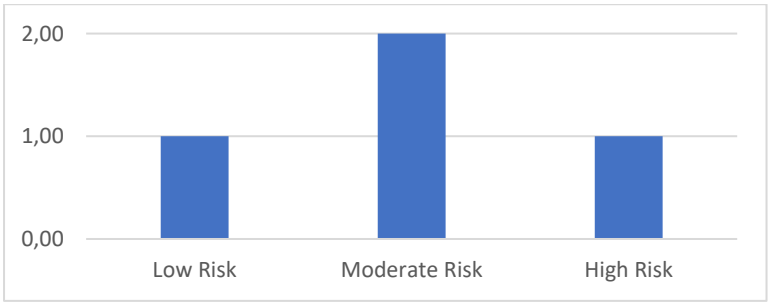
Source: own work.

Thus, the results of the Kroeze and Altman models are not different from each other. However, we can already see that 1 airline may already be at risk, namely CargoJet, which are bankrupt according to the results of the two models. Other companies are not in the risk zone.

3.3.2.3 Fuzzy Logic model (International Model)

This subsection shows the results of Fuzzy Logic model calculations for 4 air carriers over five years from 2017 to 2021 (Appendix 31).

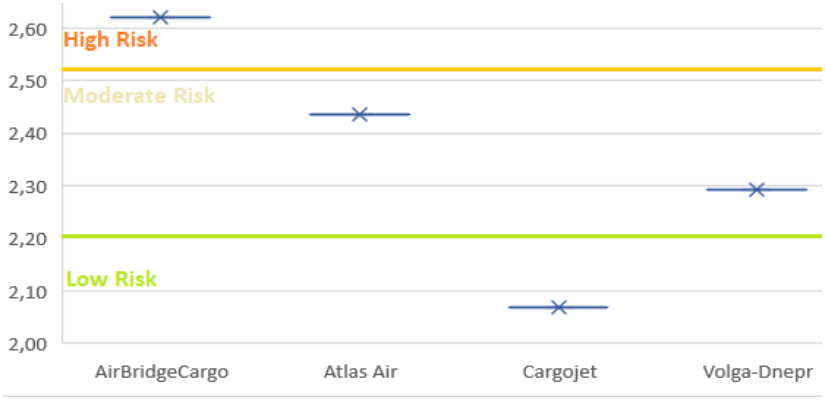
Figure 21: Fuzzy Logic model results for all-cargo airlines by groups



Source: own work.

As discussed in the literature review, this model does not qualify companies for bankrupt/non-bankrupt, but rather for risk. Thus, going back to the results of this model (Figure 21), there were no healthy or insolvent air carriers. Moreover, there is only one with low risk–CargoJet, which was bankrupt according to the results of the previous two models. Further, 2 air carriers fell into the Moderate Risk group and only one company has high-risk status.

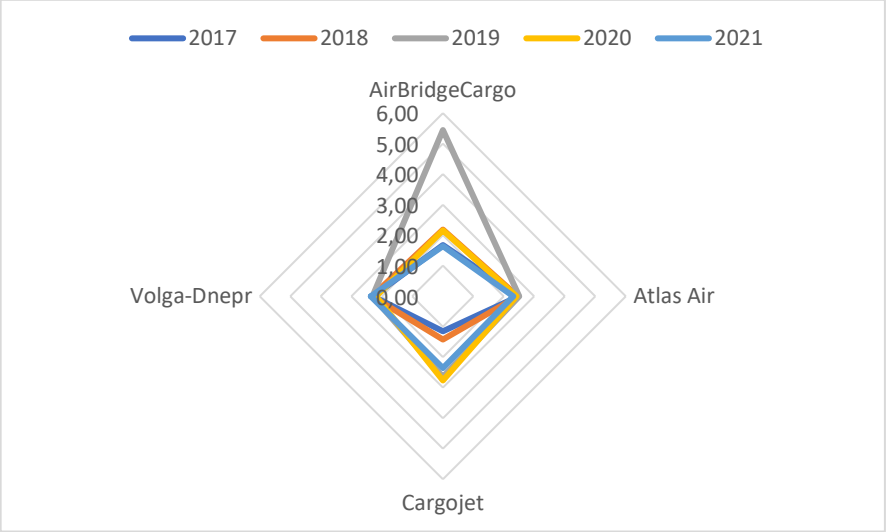
Figure 22: Fuzzy Logic model results for all-cargo airlines by zones



Source: own work.

Figure 22 graphically shows the location of companies in High Risk, Moderate Risk, and Low Risk. According to the model results, companies such as Atlas Air and Volga-Dnepr are at moderate risk. AirBridgeCargo airline, which was not a bankrupt according to the Altman and Kroeze models, are at Moderate risk.

Figure 23: Fuzzy Logic model results for all-cargo airlines by years



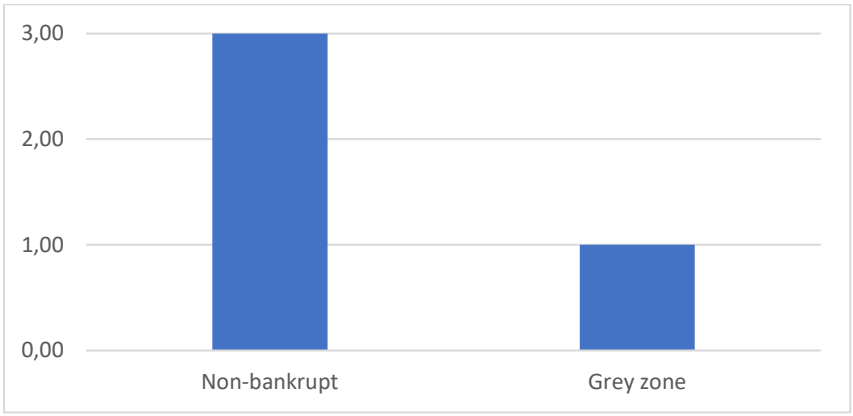
Source: own work.

Figure 23 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place (for example, 2019 for AirBridgeCargo).

3.3.2.4 Pilarski P-score model

This subsection shows the results of Pilarski P-score model calculations for 4 air carriers over five years from 2017 to 2021 (Appendix 32).

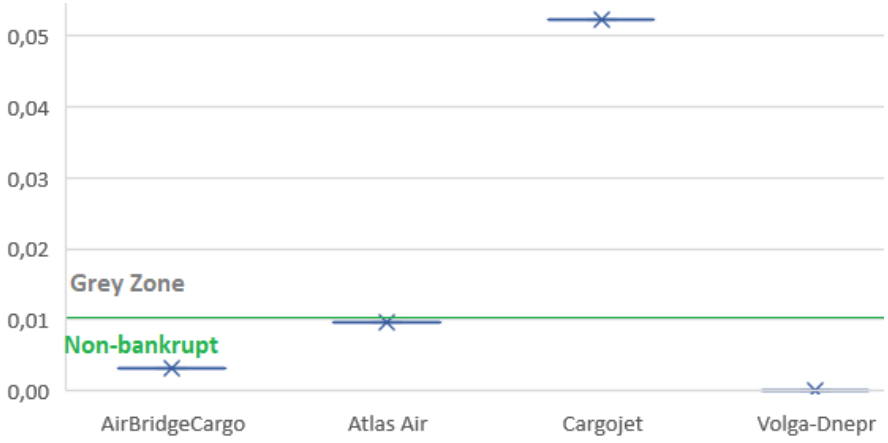
Figure 24: Pilarski P-score model results for all-cargo airlines by groups



Source: own work.

Thus, according to the results of this Pilarski P-score model (Figure 24), three companies are not bankrupt, and one company is in the grey zone. None of the all-cargo carriers are bankrupt.

Figure 25: Pilarski P-score model results for all-cargo airlines by zones

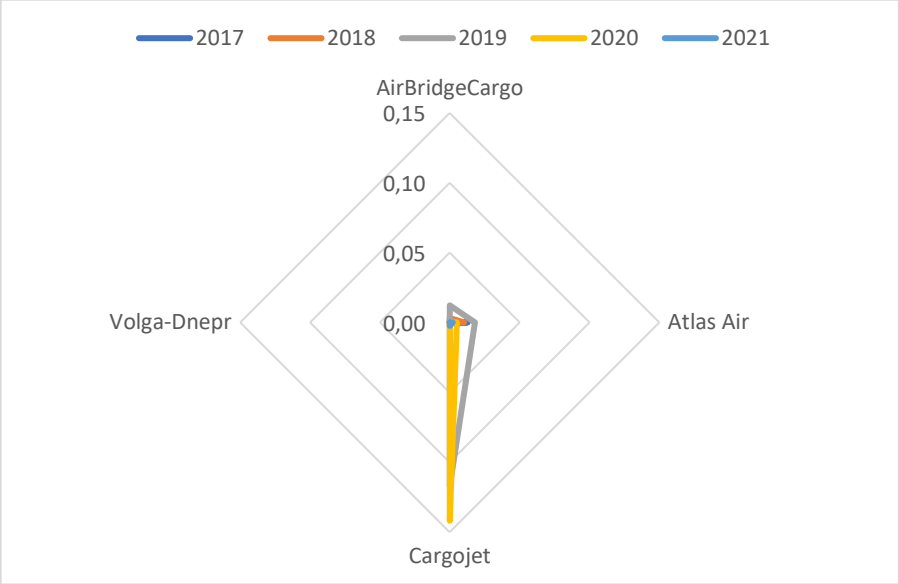


Source: own work.

Figure 25 graphically shows the location of companies in the grey zone and non-bankruptcy zones. The non-bankrupt companies are such air carriers as Volga-Dnepr,

Atlas Air, and AirBridgeCargo. Also, as in Altman's and Kroeze's models, these are mostly integrator companies and only cargo airlines. The "grey zone" carrier is Cargo jet.

Figure 26: Pilarski P-score model results for all-cargo airlines by year



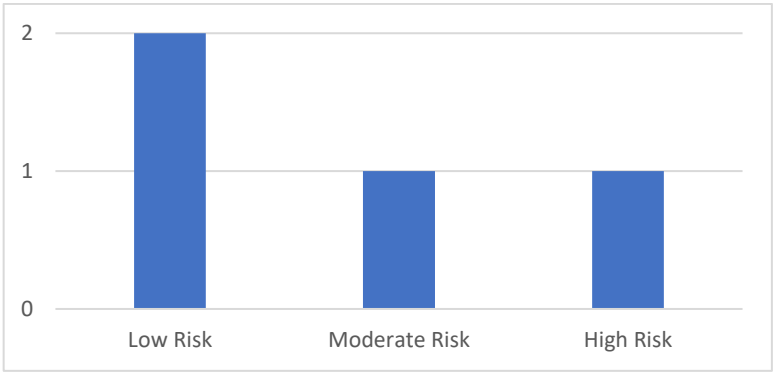
Source: own work.

Figure 26 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place. For example, 2020 and 2019 for Cargojet.

3.3.2.5 General results of models

This section presents the results of all four models for all-cargo air cargo carriers. Appendix 38 shows a summary of results of all four models.

Figure 27: Results of all models for all-cargo airlines by groups



Source: own work.

As Figure 27 shows, two airlines receive “Low risk” status. This list includes such carriers as AirBridgeCargo and Volga-Dnepr. Also, one company is in the highest risk category, namely Cargojet. Next, Atlas Air is in the Moderate Risk group. It is also worth noting that none of the companies received "Healthy" or “Bankrupt” status, as all carriers, at least according to the results of one of the models, had the status of bankrupt, high/medium risk, or were in the grey zone.

The results for the four models showed that the combined companies are in a more or less stable position at the moment. A more detailed discussion of the model results is given in the next section.

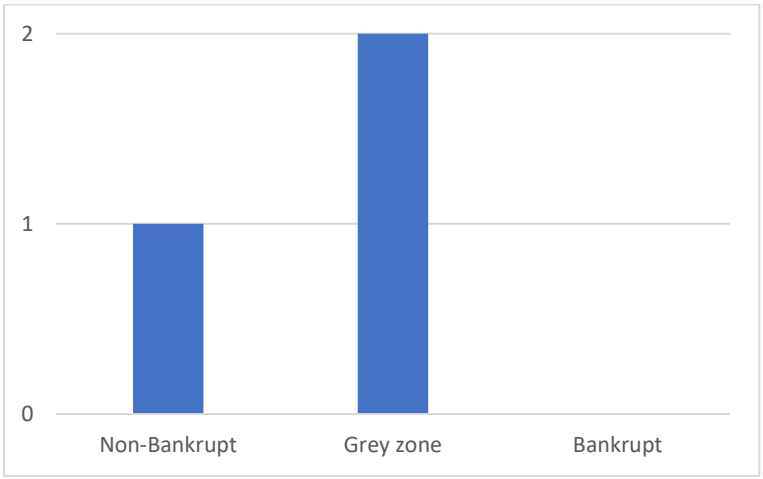
3.3.3 Integrate carriers’ results

This section presents the results of models based exclusively on integrate carriers’ data. Appendices 33-36 show summaries of the results of the models. A total of three companies-integrators are represented in this master's thesis. This number includes: DHL, FedEx and UPS.

3.3.3.1 Altman’s Z-score

This subsection shows the results of Altman's Z-score model calculations for 3 integrators over five years from 2017 to 2021 (Appendix 33).

Figure 28: Altman's Z-score model results for integrators by groups

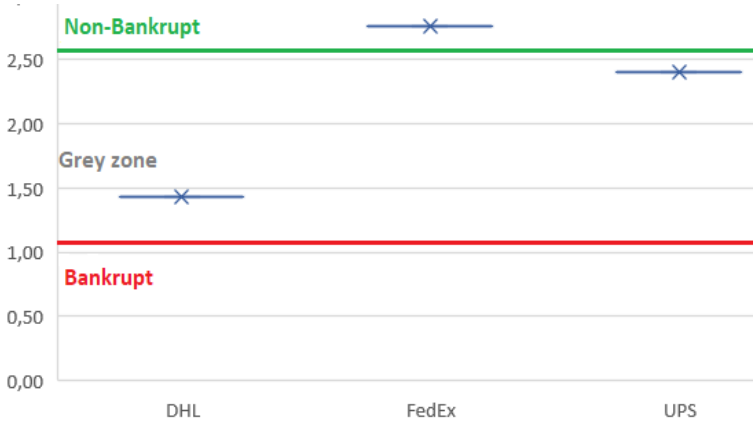


Source: own work.

According to the results of the calculations (Figure 28), 2 companies (DHL and UPS) are in the grey zone, and 1 air carrier (FedEx) is not bankrupt. Also, zero companies are bankrupt.

Figure 29 graphically shows the location of companies in the bankruptcy, grey area, and non-bankruptcy zones**.**

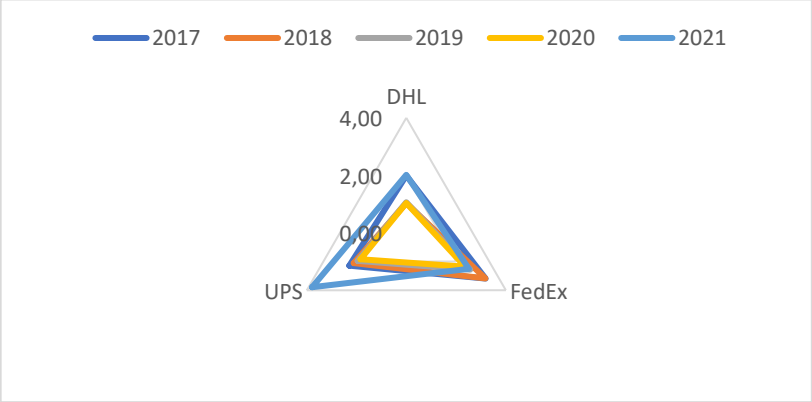
Figure 29: Altman's Z-score model results for integrators by zones



Source: own work.

Figure 30 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place (for example, 2021 for UPS).

Figure 30: Altman's Z-score model results for integrators by years



Source: own work.

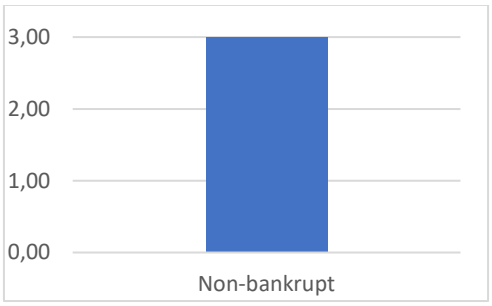
3.3.3.2 Kroeze's Y-score model

This subsection shows the results of Kroeze's Y-score model calculations for 3 integrators over five years from 2017 to 2021 (Appendix 34).

In contrast to the results of Altman's Z-score model, Kroeze's Y-score model showed that there are zero bankrupt carriers (Figure 31). This positive result may also be influenced by the fact that Kroeze's Y-score does not provide for grey areas. In addition, this model

was explicitly designed for airlines, so the constant variables used in this model give a completely different result.

Figure 31: Kroeze's Y-score model result for integrators by groups



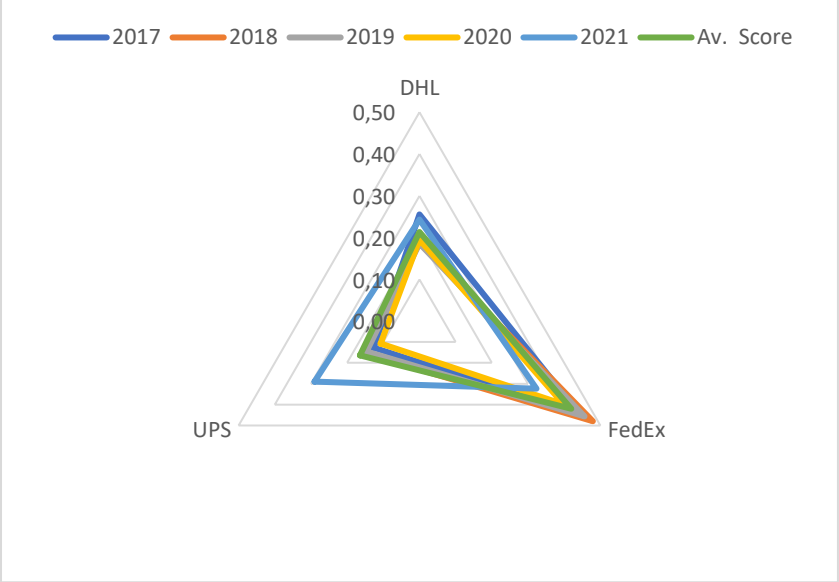
Source: own work.

Figure 32: Kroeze's Y-score model results for integrators by zones

Source: own work.

Figure 32 graphically shows the location of companies in the bankruptcy and non-bankruptcy zones.

Figure 33: Kroeze's Y-score model results for integrators by year



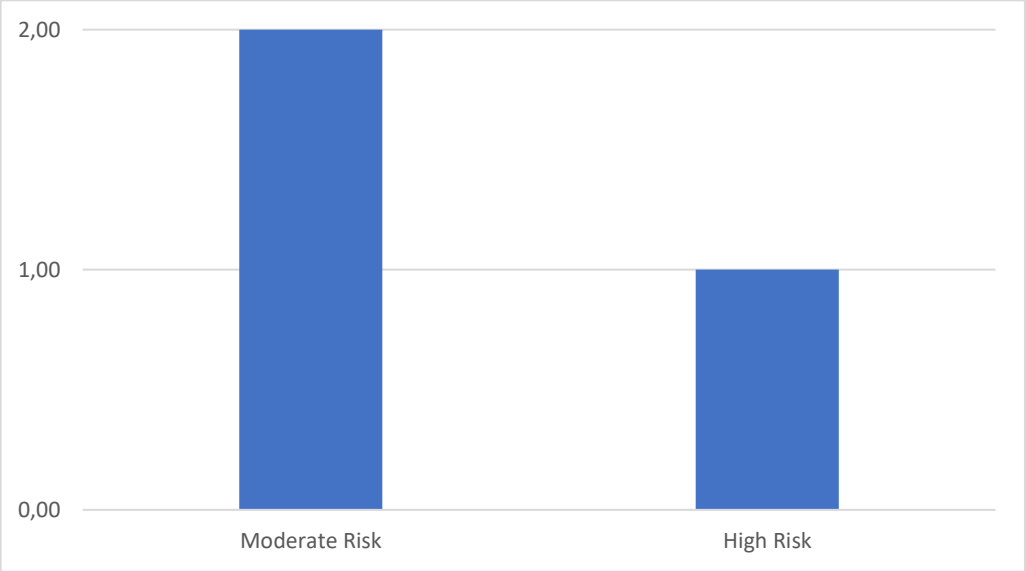
Source: own work.

Figure 33 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place (for example, 2018 for FedEx).

3.3.3.3 Fuzzy Logic model (International Model)

This subsection shows the results of Fuzzy Logic model calculations for 3 integrators over five years from 2017 to 2021 (Appendix 35).

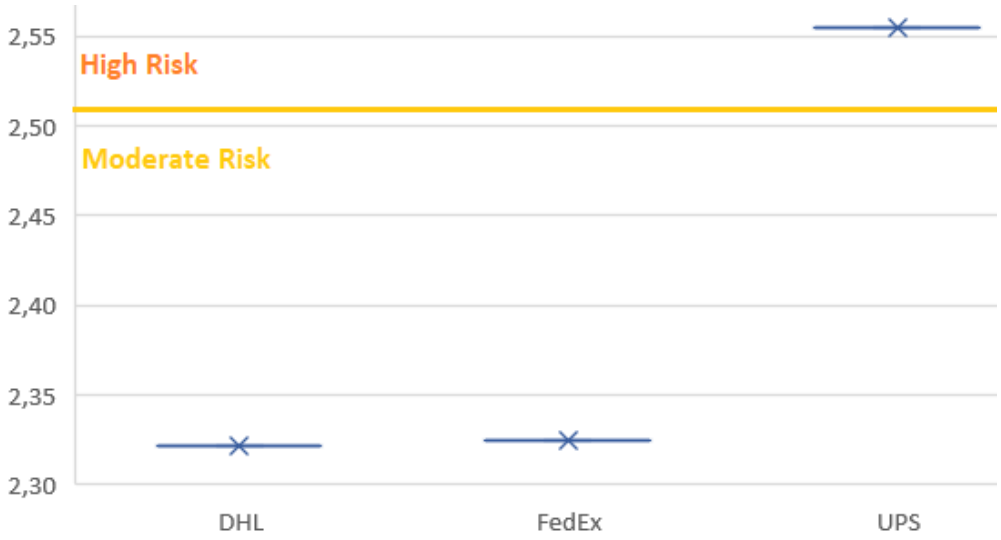
Figure 34: Fuzzy Logic model results for integrators by groups



Source: own work.

According to Figure 34, there were no “healthy”, “low risk” or “insolvent” air carriers. Therefore, two air carriers fell into the Moderate Risk group and one company has high-risk status.

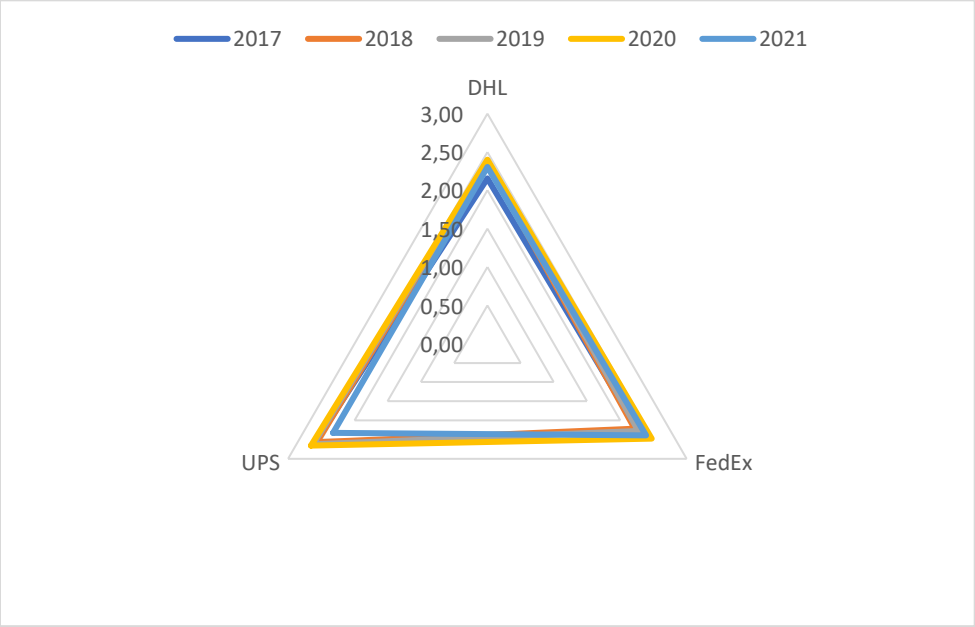
Figure 35: Fuzzy Logic model results for integrators by zones



Source: own work.

Figure 35 graphically shows the location of companies with High and Moderate Risk. According to the model results, companies such as DHL and FedEx are at moderate risk. According to Altman’s and Kroeze’s models, UPS is not in the bankruptcy zone, but is at Moderate Risk.

Figure 36: Fuzzy Logic model results for integrators by years



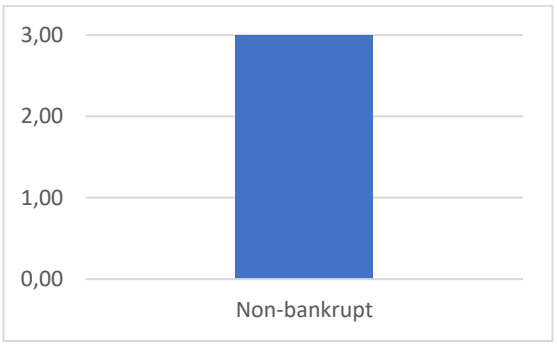
Source: own work.

Figure 36 graphically shows the changes in company results by year. All-in-all, here is no significant changes during 5 years, which show stability of integrators.

3.3.3.4 The Pilarski Score Model

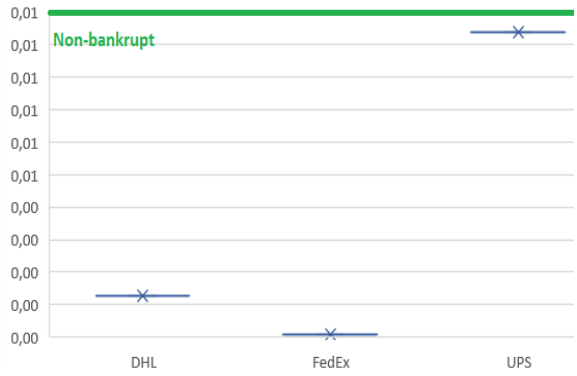
This subsection shows the results of Pilarski P-score model calculations for 3 integrators over five years from 2017 to 2021 (Appendix 36).

Figure 37: Pilarski P-score model results for integrators by groups



Source: own work.

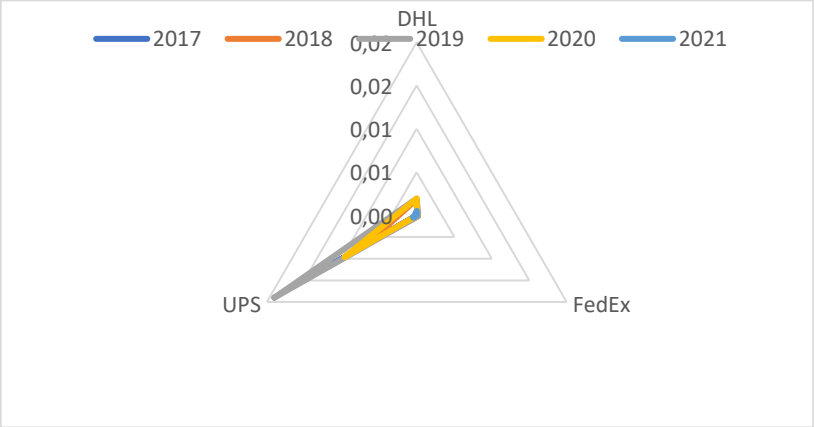
Figure 38: Pilarski P-score model results for integrators by zones



Source: own work.

According to the results of the Pilarski P-Score model (Figure 37), none of the three companies are bankrupt. Figure 38 graphically shows the location of the companies within the non-bankruptcy zones.

Figure 39: Pilarski P-score model results for integrators by year



Source: own work.

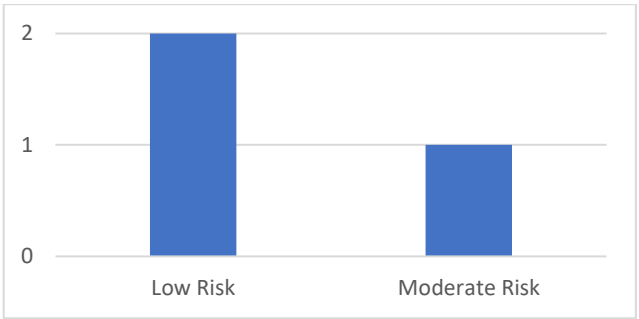
Figure 39 graphically shows the changes in company results by year. Thus, we can see in which years the main changes took place, for example, 2019 for UPS.

3.3.3.5 General results of the models

This subsection presents the results of all four models for all-cargo air cargo carriers. Appendix 38 shows a summary of results for all four models.

As Figure 40 shows, two airlines receive a “Low risk” status. This list includes such carriers as FedEx and UPS. Also, one company is in the moderate risk category, namely DHL. It is also worth noting that none of the companies received a "Healthy," “High Risk” or “Bankrupt” status.

Figure 40: Results of all models for integrators by groups



Source: own work.

The results for the four models show that the combined companies are in a more or less stable position at the moment. A more detailed discussion of the model results is given in the next section.

3.4 Discussion of results and implications for cargo airlines

This section gives an overview of the results of three business groups: combined, all cargo and integrators, as well as an analysis of the current global situation and the possibility of applying these results in practice.

3.4.1 Discussion of results

According to the results of the models, the following air cargo carriers are not bankrupt: UPS, FedEx, AirBridgeCargo and Volga-Dnepr.

UPS and FedEx are integrated companies with air cargo as one of their business segments, while AirBridgeCargo and Volga-Dnepr are all-cargo airlines. As mentioned above, this success and low risk of bankruptcy and financial instability are due to the impact of the coronavirus, namely the high demand for e-commerce during the pandemic. Since these companies do not serve passengers, and the airspace in 2020-2021 was always open for cargo aviation, these companies did not suffer damage. On the contrary, it only improved their financial performance (Nsiri, 2021). Also, because of the closed borders for passenger airlines, AirBridgeCargo and Volga-Dnepr lost their main competitor in the Russian market–Aeroflot.

KLM, Korean Air, IAG (British Airways and Iberia), Qatans and Aeroflot are combined airlines. Moreover, they are all flagship or national passenger carriers. Although they operate air cargo operations, scheduled passenger traffic is their core business. Therefore, these airlines have suffered severe losses due to the coronavirus restrictions of the last two years. In addition, the business of passenger transportation (regardless of the type of transport) in most cases is a loss-making business, as it is possible to cancel an entire flight with a load of 1 ton of cargo, and in many cases, it is impossible to cancel an entire flight with one passenger (Morrell & Klein, 2019). Therefore, most airlines did not show encouraging results even before the coronavirus.

3.4.2 Implications for cargo airlines

As stated earlier, these models for predicting the bankruptcy of companies have a reasonably high level of prediction accuracy (on average, 70 percent points accuracy), and these models are used in the management of various companies and the transport sector of public administration. However, one way or another, the global situation which prompted me to choose this topic for my master's thesis is not reflected in these models. In this chapter, I deal with some points that influence the conclusions regarding the bankrupt companies.

3.4.2.1 Russian-Ukrainian war

Here it should be noted that the list of air carriers with the lowest probability of bankruptcy includes two companies, Volga-Dnepr and AirBridgeCargo, which are part of the Volga-Dnepr Group. Both companies are based in Russia and have foreign fleets. AirBridgeCargo has only the Boeing-747F type aircraft (an American aircraft, whose operating certificates must be confirmed with the official manufacturer). At the same time, Volga-Dnepr uses An-124 type aircraft (the official manufacturer is in Ukraine) and Russian (Soviet) Il-76 aircraft. Also, AirBridgeCargo registered their aircraft in Bermuda.

These airlines survived the 2008 crisis, sanctions against Russia from 2014 to 2019 (even had to give up any military orders that brought maximum profit), and even the coronavirus pandemic had only a positive effect. Nevertheless, the Russian invasion of Ukraine on February 24, 2022, led to several events, namely the closure of airspace in the regions of Europe and America, the termination of leasing contracts, and the deprivation of registration in Bermuda (Brett, 2022b), refusal of partnership contracts from Western companies, freezing of bank accounts, refusal to provide maintenance, as well as many other sanctions that directly affect the direct operation of airlines, namely cargo delivery (Tunnicliffe, 2022).

The primary revenue of the airlines came from the APAC-RU-EU flights, so the income from this direction would cover the return EU-RU-APAC flight. Due to the closed airspace and other sanctions, flying to Europe or America is no longer possible. Moreover, outside the territory of the Russian Federation, planes are arrested (Jeffrey, 2022c).

These issues have led to the closure of hubs, AirBridgeCargo and Volga-Dnepr offices and staff reductions. Since Volga-Dnepr did not cease operations for one reason (for example, the presence of Russian aircraft in the fleet), most employees and customers from AirBridgeCargo moved to Volga-Dnepr.

Of course, Volga-Dnepr Group receives 15.5 million USD in subsidies from the government, as do several other Russian cargo airlines (Brett, 2022c), and government orders. Nevertheless, the global situation has hurt the airlines' operations.

Thus, although according to the results of 2017-2021, AirBridgeCargo and Volga-Dnepr are not bankrupt, the outcome of 2022-2023 may be quite different (or until the current geopolitical situation is resolved).

Also, another airline–Finnair, the official national carrier of Finland, which according to the results of this study, has a high risk of bankruptcy–announced possible bankruptcy. Because of the counter-sanctions that Russia imposed against the countries of Europe and North America, Finnair has to fly around the territory of Russia, which increases the cost of flights. For example, the flight time from Finland to Japan used to take 9 hours, but

now, due to overflight, the flight time is 13 hours. Moreover, since December 2021, the company's fuel costs have increased from 30 percent points to 55 percent points of total airline costs. Also, Russian tourists accounted for 20 percent points of the company's passenger traffic. Now, the company has seen a decrease in aircraft load (Rusbankrot, 2022).

3.4.3 Other reasons of higher risk of bankruptcy

The airlines I used in my research paper are not the only ones at risk of bankruptcy. As recently as winter 2022/2023, a number of weaker airlines in Europe have been facing financial problems and could become bankrupt. It is because the states where these airlines are based used to support such airlines, especially during the coronavirus (Jasper, 2022).

However, because of rising inflation, governments focus their support on other sectors. Also, carriers have faced rising jet fuel and labor costs combined with a seasonal decline in travel (Jasper, 2022).

Regardless, Air France-KLM, IAG, and Lufthansa Group are at minimal risk because they can still count on government support if needed (Jasper, 2022).

CONCLUSION

This research aimed to identify which selected air cargo carriers are potentially at risk of bankruptcy in the following years. Based on a quantitative and qualitative analysis of the freight aviation industry and bankruptcy prediction models, it can be concluded that KLM, Korean Air, IAG (British Airways and Iberia), Qatans and Aeroflot may likely face potential bankruptcy in the coming years. Based on the companies' business models, they are all combined cargo carriers.

This research paper examines the air cargo industry and its position in the world during certain developments (COVID-19, rising fuel prices, the Russian invasion of Ukraine, and high demand for freight capacity). Also, common factors influencing the industry were analyzed. Moreover, to better answer the main research question, bankruptcy prediction models were used. These models were chosen for their applicability and relevance in the literature (three of the four models were developed only for the civil aviation industry). These models use accounting information, firm characteristics, and several statistical methods (multiple discriminant analysis, logit analysis, and HFSAT).

This thesis shows that the freight aviation industry has several financial problems. The industry can be divided into two categories: before and after the coronavirus pandemic. This pandemic, which all of humanity fought for over two years, virtually destroyed passenger airlines while giving cargo airlines the opportunity for new growth. Therefore,

such companies as Federal Express, UPS, AirBridgeCargo, and Volga-Dnepr have the lowest risk of bankruptcy. As they are not connected to passenger carriage, the pandemic has only added to their work because of the record growth of e-commerce. In addition, many passenger companies, even before the pandemic, had financial difficulties because of the specifics of the business of passenger air transportation. And the profit from the cargo segment does not cover all of the companies' costs.

Through the results and discussions, this research highlighted not only future possible bankrupt companies but also that when calculating financial models, one must consider the global situation the world is facing. Thus, even if a company is not bankrupt according to the financial model results, it may still be at risk group due to external factors.

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APPENDICES

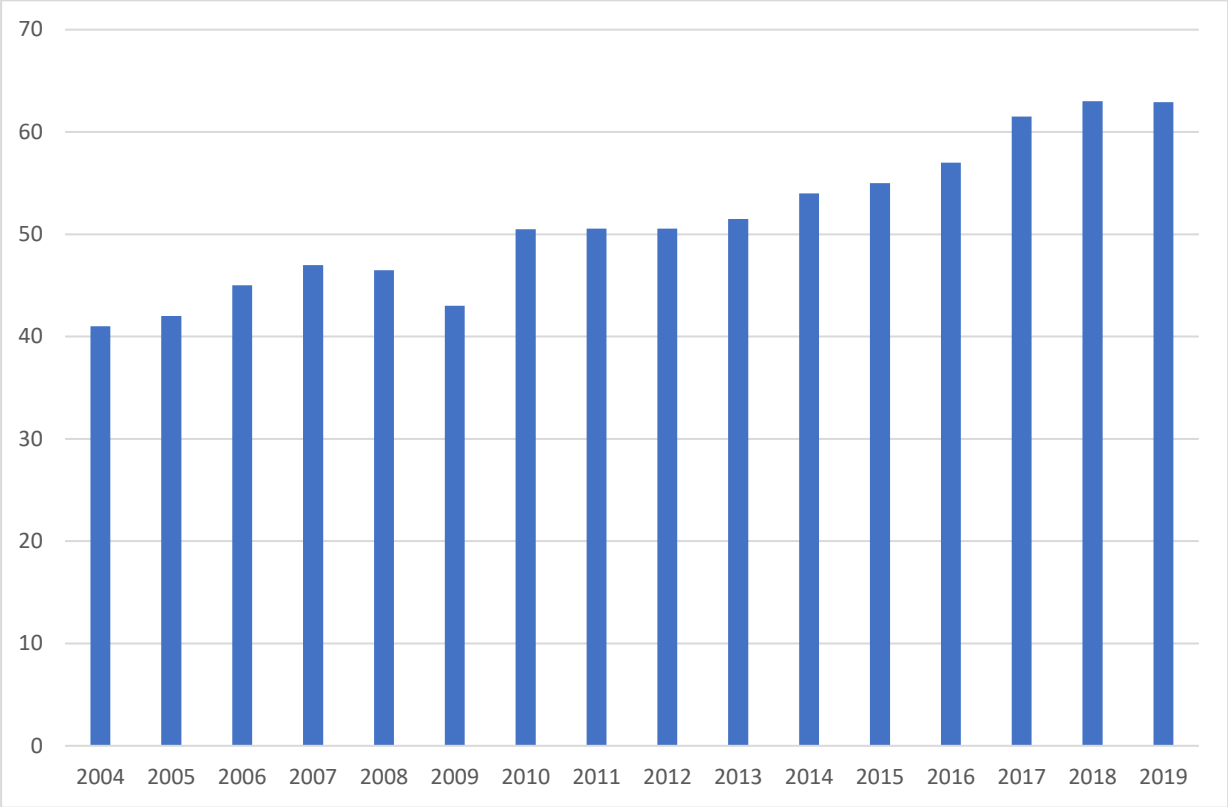
Appendix 1: Abstract in Slovenian language

Od COVID-19 in geopolitičnih vprašanj v svetu se letalska industrija sooča s težavami pri operativnem delu. Če nekaterim podjetjem te razmere prinašajo dobiček, pa za druga pomenijo začetek krize. Zato v tem magistrskem delu z rezultati modelov za napovedovanje stečajev preučujemo finančne težave letalskih prevoznikov v tovornem prometu. Analiza temelji na izbranih modelih večkratne diskriminantne analize (Altmanov model Z-score in Kroezejev model Y-score), modelu logistične regresijske analize (Pilarskijev model P-score) in modelu HFSAT Fuzzy Logic.

Rezultati izbranih modelov so pokazali, da so kombinirane letalske družbe (KLM, Korean Air, IAG in Aeroflot) v skupini tveganja, letalske družbe in integratorji, ki se ukvarjajo samo s prevozom tovora (kot so Federal Express, UPS, AirBridgeCargo in Volga-Dnepr), pa so v najbolj stabilnem položaju.

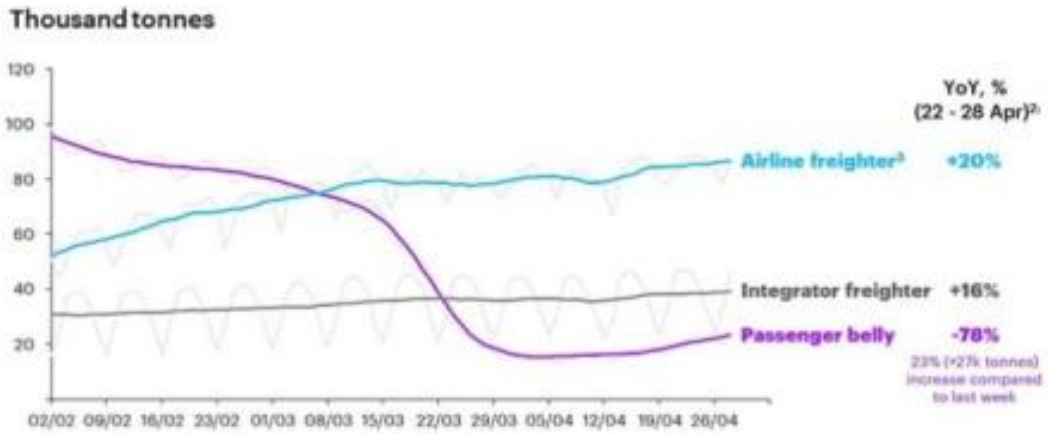
Ključne besede: logistika, upravljanje dobavne verige, tovorno letalstvo, modeli za napovedovanje stečaja, finančne težave.

Appendix 2: **Worldwide air freight traffic: 2004-2019 (Million Metric Tons)**



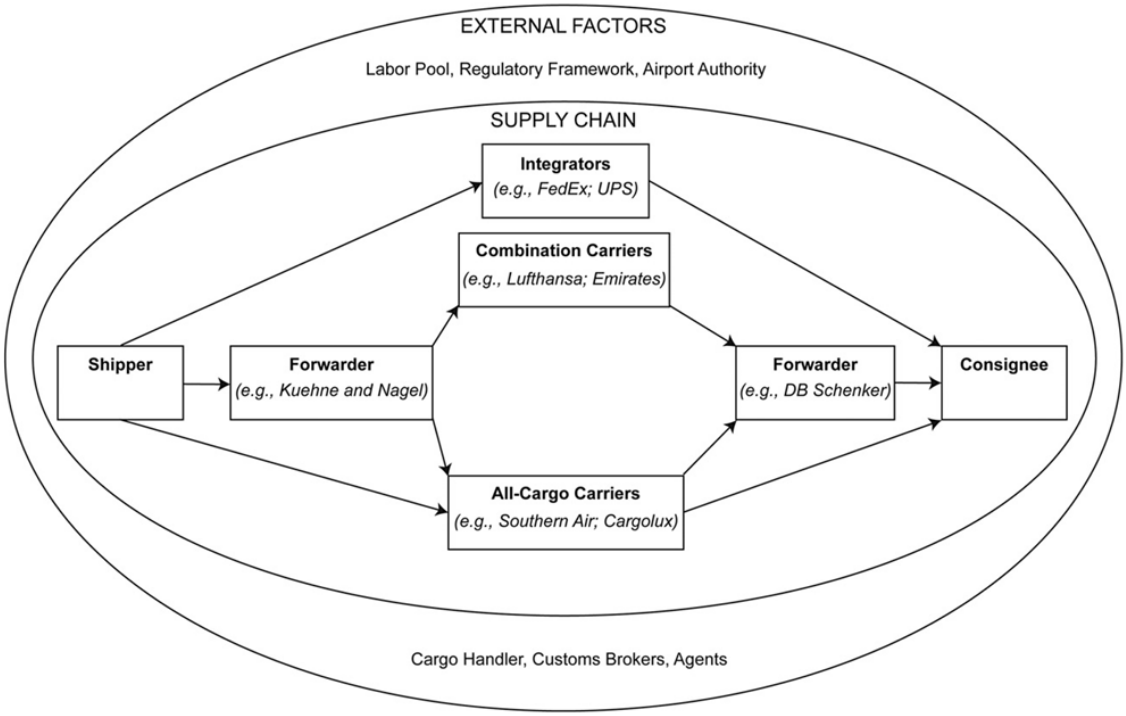
Source: Data from IATA (2019).

Appendix 3: **Daily international cargo capacity - February to April 2020**



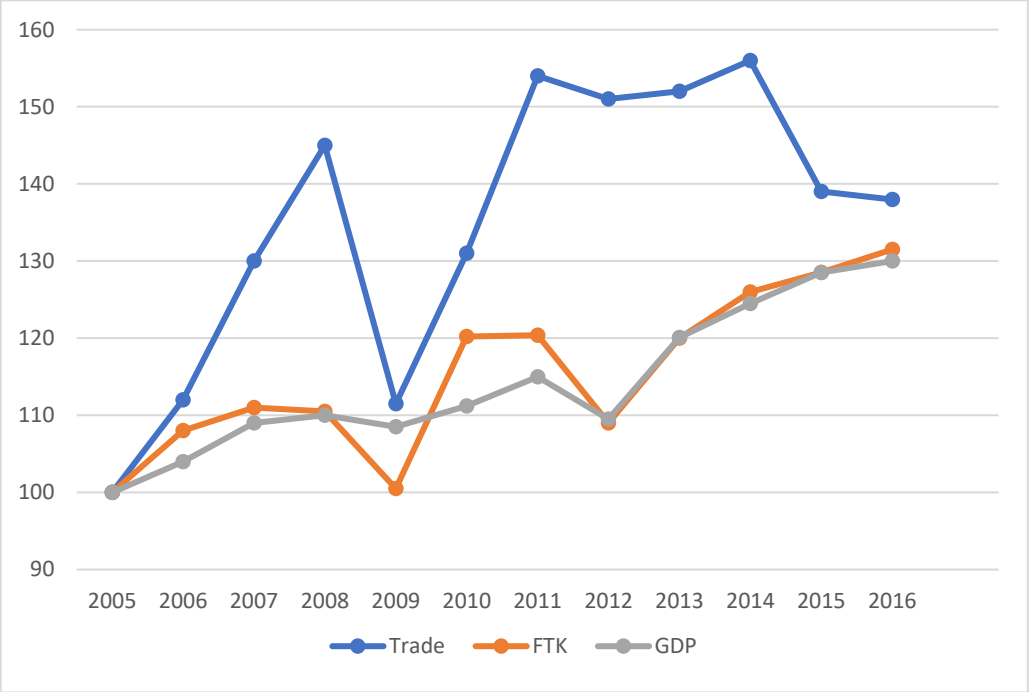
Source: IATA (2021).

Appendix 4: The business model of air freight delivery



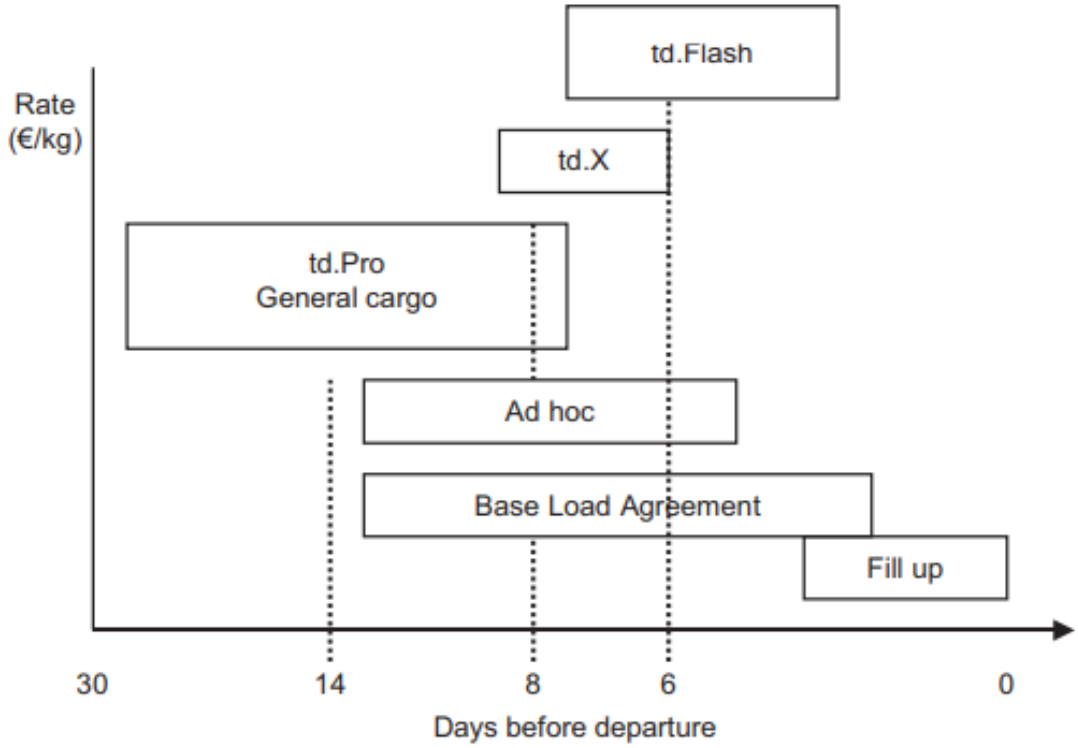
Source: Debbage & Debbage (2021).

Appendix 5: US inventory to sale ratio vs international air freight traffic



Source: Kiboi (2017).

Appendix 6: **Spot market rates by product and advance booking**



Source: Morrell & Klein, (2019).

Appendix 7: **US Airlines claimed financial distress**

Year	Airline	Status	Year	Airline	Status
1990	Continental Airlines	Reorganization	2001	Trans World Airlines	Reorganization
1990	Britt Airways	Reorganization	2002	United Airlines	Reorganization
1990	Rocky Mountain Airways	Reorganization	2002	US Airways	Reorganization
1990	CCAir	Reorganization	2002	Vanguard Airlines	Reorganization
1990	SMB Stage Lines	Reorganization	2002	Sun Country Airlines	Liquidation
1990	Pocono Airlines	Reorganization	2008	Primaris Airlines	Reorganization
1991	Flagship Express	Reorganization	2008	Sun Country	Reorganization
1991	Midway Airlines	Liquidation	2008	Gemini Air Cargo	Liquidation
1991	Mohawk Airlines	Reorganization	2008	Vintage Props & Jets	Reorganization
1991	America West Airlines	Reorganization	2008	Gemini Air Cargo	Reorganization
1991	Metro Airlines Northeast	Reorganization	2008	Air Midwest	Liquidation
1991	Jet Express	Reorganization	2008	Eos Airlines	Reorganization
1991	Metro Airlines	Reorganization	2008	Frontier Airlines	Reorganization
1991	Grand Airways	Reorganization	2008	Skybus Airlines	Reorganization
1991	Midway Airlines	Reorganization	2008	ATA Airlines	Reorganization
1991	Northcoast Executive	Liquidation	2008	Champion Air	Reorganization
1991	Virgin Island Seaplane	Reorganization	2008	Aloha Airlines	Liquidation
1991	Bar Harbor Airlines	Reorganization	2008	Big Sky	Liquidation
1991	Eastern Air Lines	Liquidation	2010	Gulfstream International Airlines	Reorganization
1991	L'Express	Reorganization	2010	Arrow Air	Reorganization
1991	Pan Am World Airways	Liquidation	2010	Mesa Air	Reorganization
1991	Pan Am Express	Liquidation	2017	Island Air	Reorganization
1992	States West Airlines	Reorganization	2017	PenAir	Reorganization
1992	Markair	Reorganization	2017	Dynamic International Airways	Reorganization
1992	Hermans/Markair Express	Reorganization	2018	OneJet	Liquidation
1992	L'Express	Liquidation	2018	Seaborne Airlines	Reorganization
1992	Trans World Airlines	Reorganization	2019	Via Airlines	Reorganization
2001	Midway Airlines	Reorganization	2019	California Pacific Airlines	Reorganization

Source: Airlines for America (2022).

Appendix 8: **Top-25 Air Cargo Carriers - Scheduled Cargo Tonne Kilometres (m)**

Rank	Airline	2020 (CTK)	2019 (CTK)
1	FedEx	19,656	17,503
2	UPS	14,371	12,842
3	Qatar Airways	13,740	13,024
4	Emirates	9,569	12,052
5	Cathay Pacific	8,137	10,930
6	Korean Air	8,104	7,412
7	Cargolux	7,345	7,180
8	Turkish Airlines	6,977	7,029
9	China Southern Airlines	6,591	6,825
10	China Airlines	6,317	5,334
11	Air China	6,121	6,767
12	Atlas Air	5,458	4,522
13	Kalitta Air	5,211	3,593
14	AeroLogic	4,870	3,581
15	Lufthansa	4,828	7,226
16	AirBridgeCargo	4,609	5,168
17	Singapore Airlines	4,156	6,146
18	United Airlines	3,950	4,852
19	EVA Air	3,888	N/A
20	Asiana Airlines	3,601	3,567
21	Polar Air Cargo	3,478	3,809
22	Ethiopian Airlines	3,394	N/A
23	All Nippon Airways	3,172	4,389
24	KLM	3,025	3,609
25	Silk Way West Airlines	2,876	N/A
	Annual Top 25 total	163,444	168,971

Source: IATA (2021).

Appendix 9: **Data collection by regions (KUSD)**

American region					
Atlas air	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	588,000	630,000	633,000	1,218,000	1,326,000
Total assets	4,955,000	5,535,000	5,386,000	6,029,000	6,443,000
Current liabilities	739,000	818,000	1,099,000	1,147,000	1,420,000
Total laibilities	3,166,000	3,467,000	3,593,000	3,768,000	3,634,000
Book value of equity	1,790,000	2,068,000	1,792,000	2,262,000	2,809,000
Retaining earnings	1,272,000	1,540,000	1,247,000	1,607,000	2,100,000
EBIT	247,000	295,000	187,000	507,000	712,000
Interest	86,289	107,941	113,769	112,634	98,453
Total debt obligations	2,226,999	2,469,840	2,387,000	2,268,459	2,117,884
Curr. maturities of total debt obligations	218,000	256,000	396,000	289,690	639,811
FedEx	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	12,628,000	13,341,000	13,086,000	16,383,000	20,580,000
Total assets	48,552,000	52,330,000	54,403,000	73,537,000	82,777,000
Current liabilities	7,918,000	9,627,000	9,013,000	10,344,000	13,660,000
Total laibilities	32,479,000	32,914,000	36,646,000	55,242,000	58,609,000
Book value of equity	16,073,000	19,416,000	17,757,000	18,295,000	24,168,000
Retaining earnings	20,833,000	24,648,000	24,823,000	29,817,000	25,216,000
EBIT	4,579,000	4,353,000	655,000	1,669,000	6,674,000
Interest	512,000	558,000	588,000	672,000	793,000
Total debt obligations	14,931,000	16,585,000	17,581,000	22,003,000	20,879,000
Curr.maturities of total debt obligations	22,000	1,342,000	964,000	51,000	146,000
United Airlines	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	7,133,000	7,094,000	8,194,000	14,800,000	21,834,000
Total assets	45,376,000	53,047,000	56,671,000	66,027,000	75,004,000
Current liabilities	12,763,000	13,839,000	14,938,000	12,725,000	18,304,000
Total laibilities	36,642,000	43,005,000	45,140,000	60,067,000	69,975,000
Book value of equity	8,734,000	10,042,000	11,531,000	5,960,000	5,029,000
Retaining earnings	4,549,000	6,715,000	9,716,000	2,626,000	625,000

(table continues)

(continued)

EBIT	5,882,000	5,840,000	6,819,000	-7,062,000	-1,904,000
Interest	671,000	729,000	731,000	1,063,000	1,657,000
Total debt obligations	13,431,000	13,636,000	14,733,000	27,301,000	33,876,000
Curr.maturities of total debt obligations	1,565,000	1,230,000	1,407,000	1,911,000	3002,000
Cargo Jet	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	41,580	55,480	52,540	71,040	158,000
Total assets	483,560	648,280	812,520	905,760	1,177,100
Current liabilities	80,850	55,480	85,100	133,940	77,420
Total laibilities	370,370	528,200	608,280	776,260	642,270
Book value of equity	113,190	120,080	204,240	129,500	510,340
Retaining earnings	-27,720	-26,600	-28,120	-103,600	6,320
EBIT	45,353	45,524	41,884	110,852	135,722
Interest	19,404	20,748	32,264	29,304	24,411
Total debt obligations	303,180	454,480	457,808	404,010	311,560
Curr.maturities of total debt obligations	47,740	19,000	43,660	76,960	17,380
UPS	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	15,718,000	16,210,000	17,103,000	20,216,000	24,934,000
Total assets	45,574,000	50,016,000	57,857,000	62,408,000	59,405,000
Current liabilities	12,886,000	14,087,000	15,413,000	17,016,000	17,569,000
Total laibilities	44,550,000	46,979,000	54,574,000	61,739,000	55,136,000
Book value of equity	994,000	3,021,000	3,267,000	657,000	14,253,000
Retaining earnings	5,852,000	8,006,000	9,105,000	6,896,000	16,179,000
EBIT	9,776,000	9,281,000	10,236,000	10,534,000	16,060,000
Interest	453,000	605,000	653,000	684,000	683,000
Total debt obligations	20,278,000	22,736,000	28,167,000	27,754,000	25,528,000
Curr.maturities of total debt obligations	4,011,000	2,805,000	28,167,000	2,623,000	2,131,000
AirCanada	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	4,155,690	4,662,740	5,637,000	5,411,571	6,116,245
Total assets	13,692,140	16,193,420	20,819,250	18,044,603	18,625,558
Current liabilities	3,927,770	4,200,240	5,831,250	4,455,450	4,212,562

(table continues)

(continued)

Total laibilities	11,057,200	13,768,440	17,519,250	16,974,272	18,620,082
Book value of equity	2,634,940	2,424,980	3,300,000	1,070,332	5,476
Retaining earnings	1,966,580	1,778,960	2,630,250	308,305	1,694,394
EBIT	2,273,040	2,792,020	3,238,500	175,996	213,548
Interest	211,750	393,680	360,000	393,807	445,349
Total debt obligations	7,874,655	10,792,275	9,891,519	11,490,046	15,511,000
Curr.maturities of total debt obligations	849,227	1,274,688	1,501,479	1,834,140	1,012,000
Europe region					
Lufthansa	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	3,537,480	2,742,240	3,071,700	4,883,100	7,571,038
Total assets	23,346,220	23,892,810	26,218,800	26,463,040	31,232,440
Current liabilities	11,330,760	11,175,150	12,974,400	14,569,760	16,882,400
Total laibilities	13,905,904	14,851,135	17,035,920	16,571,970	22,016,442
Book value of equity	6,387,800	6,822,540	7,290,000	6,253,320	6,715,244
Retaining earnings	4,177,080	5,134,740	5,580,000	5,328,360	5,835,204
EBIT	2,714,200	2,587,380	1,671,300	-6,029,460	-2,079,768
Interest	170,560	93,090	250,200	251,740	319,688
Total debt obligations	5,602,240	5,763,750	8,603,100	12,240,960	14,620,338
Current maturities of total debt obligations	-	86,130	439,200	372,280	366,384
KLM	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	7,427,560	6,785,130	7,685,100	8,113,900	9,634,642
Total assets	24,569,660	25,784,190	27,661,500	24,748,420	27,553,334
Current liabilities	9,884,280	10,737,540	11,384,100	9,657,960	10,529,948
Total laibilities	23,077,260	24,570,540	25,955,100	29,128,860	33,809,700
Book value of equity	1,482,560	1,203,210	1,692,900	-4,387,820	-6,263,550
Retaining earnings	-1,369,400	-1,180,590	-943,200	-6,734,660	-10,648,484
EBIT	2,870,820	3,733,170	3,616,200	-1,555,540	554,066
Interest	467,400	376,710	359,100	346,860	495,696
Total debt obligations	9,117,580	8,427,690	8,844,300	13,609,540	16,211,594

(table continues)

(continued)

Curr. maturities of total debt obligations	1,346,440	1,539,030	1,593,000	1,694,940	1,103,642
Finnair	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	1,168,500	1,216,260	1,124,100	788,840	1,310,182
Total assets	2,367,340	3,431,280	3,490,200	2,990,540	3,634,206
Current liabilities	912,660	1,135,350	1,099,800	488,720	1,059,640
Total laibilities	1,697,400	2,804,010	2,799,000	2,417,360	3,384,562
Book value of equity	670,760	626,400	691,200	573,180	249,644
Retaining earnings	214,020	216,630	247,500	-215,660	-669,010
EBIT	277,160	0	95,400	-510,040	-450,796
Interest	11,480	73,950	75,600	71,340	101,474
Total debt obligations	733,080	1,607,760	1,469,700	1,838,440	2,541,340
Curr.maturities of total debt obligations	18,040	108,750	126,000	111,520	158,946
IAG	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	6,083,203	7,881,330	8,638,200	5,754,760	7,143,933
Total assets	16,253,925	21,891,810	27,035,100	22,251,520	23,294,592
Current liabilities	6,046,893	8,628,660	9,721,800	8,452,560	8,989,792
Total laibilities	12,115,976	16,802,310	21,826,800	21,069,900	22,722,046
Book value of equity	3,955,057	5,242,620	5,202,900	1,177,520	568,515
Retaining earnings	-112,963	669,030	512,100	-4,895,400	-5,549,672
EBIT	2,442,829	3,507,840	4,255,200	-1,662,960	-714,474
Interest	120,360	156,600	453,600	478,060	566,902
Total debt obligations	3,820,577	5,179,980	9,464,400	9,882,640	11,567,059
Current maturities of total debt obligations	555,402	683,820	1,405,800	1,626,060	1,710,383
DHL	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	10,304,530	14,598,600	12,192,120	14,974,020	18,332,789
Total assets	26,148,291	45,631,500	44,038,080	47,237,740	53,285,564
Current liabilities	9,750,472	16,048,020	13,667,130	14,258,980	16,859,488
Total laibilities	17,472,314	33,561,990	32,380,560	35,693,780	37,561,492
Book value of equity	8,497,119	11,823,300	11,434,770	11,297,140	15,351,513

(table continues)

(continued)

Retaining earnings	6,108,082	8,556,450	8,180,190	8,761,700	12,106,543
EBIT	2,262,626	1,766,970	2,004,750	0	5,269,850
Interest	275,012	500,250	528,930	505,940	487,874
Total debt obligations	3,838,732	12,492,330	11,423,430	13,552,960	13,753,220
Curr.maturities of total debt obligations	14,793	1,829,610	1,746,360	1,493,220	1,583,777
Russia and CIS					
ABC	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	303,862	474,823	550,219	647,204	815,980
Total assets	385,055	621,366	710,934	952,528	1,441,086
Current liabilities	146,964	338,911	439,803	270,047	339,945
Total laibilities	385,055	586,877	5,434,741	485,142	520,578
Book value of equity	102,952	34,488	15,529	467	920,508
Retaining earnings	102,951	34,488	15,528	467,182	920,304
EBIT	89,399	17,207	-95	740,766	931,526
Interest	4,527	9,484	24,127	11,639	7,928
Total debt obligations	167,030	270,669	439,803	270,047	339,945
Curr.maturities of total debt obligations	152,093	175,969	326,256	132,718	189,029
Volga-Dnepr	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	209,635	209,192	206,683	204,261	302,773
Total assets	604,085	696,249	633,459	583,679	634,220
Current liabilities	35,812	76,377	79,825	13,226	56,362
Total laibilities	327,362	360,828	314,575	261,152	634,220
Book value of equity	276,723	335,421	318,884	322,527	376,358
Retaining earnings	276,713	335,412	318,875	322,520	376,351
EBIT	64,509	105,553	-33,932	65,960	70,695
Interest	20,253	15,281	16,508	13,295	9,824
Total debt obligations	30,290	56,348	34,791	16,715	56,362
Curr.maturities of total debt obligations	35,342	75,365	79,825	14,004	53753

(table continues)

(continued)

Aeroflot	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	2,978,963	2,091,524	2,319,937	2,497,396	2,579,187
Total assets	6,064,158	16,942,546	16,889,621	15,596,816	17,136,965
Current liabilities	2,503,568	3,601,021	3,750,679	3,795,507	3,693,604
Total laibilities	4,869,430	17,881,890	16,858,815	17,153,232	19,121,220
Book value of equity	1,163,412	-968,247	-26,730	-1,454,271	-1,876,707
Retaining earnings	1,446,405	-485,412	-379,953	-1,911,537	-2,381,707
EBIT	720,025	0	891,469	-1,240,130	-114,932
Interest	146,015	743,201	789,621	610,309	561,070
Total debt obligations	1,559,648	8,855,015	7,932,101	8,425,057	9,347,724
Curr.maturities of total debt obligations	1,503,178	50,473	50,932	724,747	1,555,122
APAC					
ANA	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	110,456,947	104,511,940	81,362,108	183,030,149	202,175,156
Total assets	391,215,573	401,062,985	364,694,160	478,788,507	502,880,156
Current liabilities	98,943,511	102,378,060	75,576,353	75,135,075	107,482,656
Total laibilities	238,459,542	235,493,881	212,433,476	327,695,970	377,346,563
Book value of equity	150,940,611	164,091,493	151,143,590	150,333,284	124,570,156
Retaining earnings	69,884,885	81,856,567	78,467,094	21,656,866	-17,691,875
EBIT	48,695,420	49,043,433	34,266,524	-42,732,388	-2,110,313
Interest	1,324,580	1,044,030	985,897	2,490,896	3,959,844
Total debt obligations	111,431,603	11,9163,134	120,065,812	247,082,388	392,699,375
Curr. maturities of total debt obligations	15,259,389	16,813,582	15,367,236	10,890,448	21,380,000
Singapore	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	4,253,731	3,644,853	4,073,852	3,410,563	7,272,180
Total assets	18,447,761	19,038,603	22,596,444	23,741,408	28,256,617
Current liabilities	4,692,985	4,827,721	5,465,481	7,400,775	3,926,165
Total laibilities	8,395,373	9,311,838	12,505,185	16,887,394	16,017,444

(table continues)

(continued)

Book value of equity	9,763,433	9,455,882	9,842,222	6,559,155	11,959,398
Retaining earnings	288,955	270,662	293,630	294,789	279,850
EBIT	387,015	1,171,471	643,407	-155,070	-3,727,218
Interest	67,164	85,294	163,704	188,732	294,737
Total debt obligations	2,334,328	4,892,647	8,364,444	9,750,000	11,373,684
Curr.maturities of total debt obligations	0	0	365,185	345,775	427,068
China Southern Airlines	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	2,748,912	3,505,875	2,394,246	5,964,129	5,956,024
Total assets	33,618,310	35,965,517	43,903,836	49,932,000	50,838,755
Current liabilities	10,694,366	12,188,123	13,659,207	14,637,806	17,457,889
Total laibilities	23,982,202	24,524,904	32,810,742	36,873,161	37,509,580
Book value of equity	7,675,416	9,503,959	9,169,949	10,645,419	10,672,496
Retaining earnings	3,336,492	3,486,335	3,280,307	1,848,774	-3,343
EBIT	799,616	511,494	831,202	1,825,290	-1,875,016
Interest	405,634	484,419	847,570	973,806	961,168
Total debt obligations	15,513,188	15,012,644	23,238,747	26,771,484	26,789,508
Curr.maturities of total debt obligations	3,184,635	2,283,014	1,950,639	5,833,935	6,032,789
Korean Air	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	3,237,538	3,331,588	2,935,642	3,272,358	5,902,321
Total assets	22,276,454	22,958,867	22,184,726	20,594,754	23,705,198
Current liabilities	5,999,262	6,713,565	7,208,154	6,530,602	7,505,601
Total laibilities	18,886,362	20,772,046	20,787,417	18,441,617	17,869,778
Book value of equity	3,390,092	2,186,821	1,397,309	2,153,137	5,835,419
Retaining earnings	517,626	-80,131	-542,823	-691,465	-190,380
EBIT	2,379,610	2,151,998	1,847,178	1,691,750	2,759,516
Interest	413,320	485,388	506,917	420,121	347,451
Total debt obligations	10,433,783	11,417,417	11,165,785	10,030,624	7,496,672
Curr.maturities of total debt obligations	3,891,163	5,151,108	4,960,177	4,233,678	2,871,815

(table continues)

(continued)

EVA	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	2,284,834	2,518,926	2,498,382	1,906,374	2,344,676
Total assets	7,556,523	7,994,498	11,529,191	11,232,686	11,701,942
Current liabilities	2,000,927	2,019,324	2,668,026	1,548,500	1,677,626
Total laibilities	5,443,742	5,670,335	9,000,324	8,619,905	8,367,158
Book value of equity	1,907,450	2,107,458	2,305,890	2,412,986	3,081,187
Retaining earnings	254,338	357,242	323,301	182,277	496,475
EBIT	287,914	294,630	305,599	-27,335	372,590
Interest	66,291	66,357	174,725	171,370	143,885
Total debt obligations	2,579,503	2,698,807	2,584,725	3,419,121	3,483,993
Curr.maturities of total debt obligations	2,508,212	2,656,381	2,422,880	3,264,451	3,331,763
China Airlines	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	1,564,596	1,690,496	1,710,126	2,163,770	3,090,600
Total assets	745,470	7,364,384	9,670,584	9,946,790	10,609,956
Current liabilities	1,989,537	1,950,400	2,519,616	2,192,750	1,916,604
Total laibilities	5,507,337	5,442,848	7,686,228	7,821,905	7,830,576
Book value of equity	1,876,941	1,826,624	1,866,282	2,014,565	2,665,584
Retaining earnings	48,147	36,672	-17,457	-8,085	333,144
EBIT	291,258	128,736	87,978	76,475	538,848
Interest	44,352	44,160	110,220	107,030	86,652
Total debt obligations	2,894,298	2,853,216	3,027,717	3,881,115	3,991,824
Curr.maturities of total debt obligations	834,537	665,248	874,170	1041,005	517,788
Cathay Pacific	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	4,204,225	3,782,631	3,489,003	3,557,032	3,715,700
Total assets	24,120,102	24,303,193	27,431,714	26,396,645	25,283,143
Current liabilities	5,285	6,174,330	7,271,355	6,028,903	5,546,483
Total laibilities	16,274,776	16,137,292	19,404,092	16,943,613	16,060,692
Book value of equity	7,823,431	8,165,517	8,027,238	9,452,516	9,221,808
Retaining earnings	0	9,323	33,120	59,613	32,275

(table continues)

(continued)

EBIT	542,254	585,313	411,637	-1,204,258	-408,127
Interest	222,919	294,764	384,910	286,839	319,661
Total debt obligations	8,899,616	7,688,633	9,783,632	8,887,742	8,747,589
Curr.maturities of total debt obligations	1,138,028	1,748,914	2,653,708	3,128,903	2,873,859
AirChina	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	3,190,909	3,455,428	3,549,872	3,019,355	4,781,150
Total assets	36,219,974	35,486,079	42,084,143	43,452,516	46,933,136
Current liabilities	11,087,068	10,564,623	11,153,453	12,330,323	14,411,084
Total laibilities	21,550,832	20,849,553	27,531,330	30,578,323	36,509,322
Book value of equity	13,225,992	13,567,433	13,368,542	11,862,710	9,652,822
Retaining earnings	5,888,348	6,325,670	6,029,540	4,062,323	1,556,127
EBIT	1,385,403	1,549,553	1,535,678	-2,186,710	-3,200,206
Interest	451,088	440,868	717,647	739,484	851,614
Total debt obligations	13,642,125	12,930,268	18,011,381	22,554,839	26,719,043
Curr.maturities of total debt obligations	960,051	1,042,018	1,982,737	2,074,581	2,286,100
Qatans	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	2,432,820	2,619,360	2,847,840	3,515,920	2,641,100
Total assets	13,432,380	13,425,840	13,963,800	14,218,460	13,767,600
Current liabilities	5,534,100	5,472,000	6,132,240	5,895,840	5,848,150
Total laibilities	10,671,180	10,578,240	11,914,280	13,135,000	13,370,280
Book value of equity	2,758,860	2,845,440	2,047,480	1,081,330	395,010
Retaining earnings	368,160	777,600	803,080	-963,470	-2,376,990
EBIT	1,871,220	1,978,560	1,957,720	967,020	-563,640
Interest	154,440	138,240	198,560	192,410	226,380
Total debt obligations	26,6873,100	212,561,280	498,263,200	706,778,730	806,896,090
Curr.maturities of total debt obligations	337,740	290,880	726,920	988,320	1041,040

(table continues)

(continued)

Middle East					
Turkish Airlines	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	3,631	4,505	4,770	4,178	4,938
Total assets	18,197	20,732	24,724	25,530	26,537
Current liabilities	4,297	5,184	5,964	6,454	6,773
Total laibilities	12,851	14,787	17,833	20,147	19,700
Book value of equity	5,346	5,945	5,383	6,863	6,837
Retaining earnings	3,749	4,348	3,786	5,266	5,240
EBIT	1,022	1,191	876	-255	1,414
Interest	1,078	588	247	241	318
Total debt obligations	8,083	9,338	2,962	4,208	3,166
Current maturities of total debt obligations	983	1,270	491	1,186	1,443
Emirates	**2017**	**2018**	**2019**	**2020**	**2021**
Current assets	7,584,741	9,310,627	8,423,706	7,549,046	6,237,330
Total assets	33,122,071	34,764,850	34,713,351	46,883,379	41,356,131
Current liabilities	10,458,311	11,053,406	102,849,046	13,322,071	9,728,883
Total laibilities	23,559,673	24,670,572	24,429,155	35,866,485	40,456,403
Book value of equity	9,402,725	9,932,970	10,122,343	6,261,035	5,339,782
Retaining earnings	9,222,888	9,710,627	9,920,436	7,596,185	2,068,937
EBIT	405,995	823,706	296,185	341,689	-5,531,335
Interest	40,054	39,782	123,978	500,817	398,638
Total debt obligations	13,896,458	13,923,706	14,441,417	30,027,248	29,318,801
Curr. maturities of total debt obligations	1,532,970	1,084,741	1,501,907	2,828,610	2,354,223

Source: Air Canada (2022); Atlas Air (2022); Emirates (2022); FedEx (2022); Finnair (2022); Lufthansa Group (2022); Singapore (2022); Turkish Airlines (2022); UPS (2022); WSJ (2022).

Appendix 10: **Descriptive analysis for American region (KUSD)**

Financial statement, KUSD	**Mean**	**Max**	**Min**	**Median**	**Std Dev**
Current assets	8,667,030	24,934,000	41,580	6,605,123	7,847,347
Total assets	33,424,473	82,777,000	483,560	33,097,625	27,505,473
Current liabilities	7,612,835	18,304,000	55,480	6,874,625	6370,175
Total laibilities	27,739,654	69,975,000	370,370	25,549,541	23,457,150
Book value of equity	6,014,369	24,168,000	5,476	2,721,970	7,018,267
Retaining earnings	7,052,359	29,817,000	-103,600	2,363,000	9,055,466
Earnings before interest and taxes	3,147,081	16,060,000	-7,062,000	1,190,500	4,694,568
Interest	450,060	1,657,000	19,404	449,174	370,799
Operating revenues	32,498,566	97,287,000	360,084	14,851,625	32,701,323
Total debt obligations	12,945,991	33,876,000	303,180	13,533,500	10,162,602
Current maturities of total debt obligations	1,995,093	28,167,000	17,380	988,000	5,053,058

Source: own work.

Appendix 11: **Descriptive analysis for European region (KUSD)**

Financial statement, KUSD	Mean	Max	Min	Median	Std Dev
Current assets	6,918,530	18,332,789	788,840	7,143,933	4,679,360
Total assets	24,178,084	53,285,564	2,367,340	24,748,420	13,859,135
Current liabilities	9,449,851	16,882,400	488,720	9,884,280	5,093,310
Total liabilities	19,409,293	37,561,492	1,697,400	21,069,900	11,018,449
Book value of equity	4,182,314	15,351,513	-6263,550	3,955,057	5,131,824
Retaining earnings	1,572,344	12,106,543	-10,648,484	247,500	5,382,828
Earnings before interest and taxes	1,065,069	5,269,850	-6,029,460	1,671,300	2,478,182
Interest	301,536.6	566,902	11,480	319,688	179,026
Operating revenues	21,933,302	65,921,108	679,944	18,672,810	18,859,707
Total debt obligations	8,248,270	16,211,594	733,080	8,844,300	4,714,736
Current maturities of total debt obligations	904,730,3	1,829,610	14,793	893,731	696,618

Source: own work.

Appendix 12: **Descriptive analysis for Russian and CIS region (KUSD)**

Financial statement, KUSD	**Mean**	**Max**	**Min**	**Median**	**Std Dev**
Current assets	1,092,776	2,978,963	204,261	550,219	1,054,807
Total assets	5,326,184	1,7136,965	385,055	710,934	7,203,736
Current liabilities	1,276,110	3,795,507	13,226	338,911	1,635,756
Total laibilities	5,679,675	19,121,220	261,152	586,877	7,722,921
Book value of equity	-30,579	1,163,412	-1,876,707	102,952	815,495
Retaining earnings	-36,125	1,446,405	-2,381,707	276,713	978,069
Earnings before interest and taxes	153,868	931,526	-1,240,130	65,960	531,824
Interest	198,872	789,621	4,527	16,508	303,936
Operating revenues	3,321,250	10,633,128	119,158	1,512,347	3,771,149
Total debt obligations	2,520,103	9,347,724	16,715	270,669	3,848,484
Current maturities of total debt obligations	341,254	1,555,122	14,004	132,718	513,518

Source: own work.

Appendix 13: **Descriptive analysis for APAC region (KUSD)**

Financial statement, KUSD	**Mean**	**Max**	**Min**	**Median**	**Std Dev**
Current assets	18,133,672	202,175,156	1,564,596	3,410,563	45,184,611
Total assets	68,123,808	502,880,156	745,470	23,705,198	130,402,857
Current liabilities	16,052,487	107,482,656	5,285	6,132,240	27,805,245
Total laibilities	45,775,636	377,346,563	5,442,848	16,887,394	86,248,100
Book value of equity	21,930,008	164,091,493	395,010	7,823,431	45,533,343
Retaining earnings	6,026,080	81,856,567	-1,7691,875	293,630	19,694,815
Earnings before interest and taxes	2,355,178	49,043,433	-4,2732,388	538,848	13,157,703
Interest	513,012	3,959,844	44,160	294,764	689,514
Operating revenues	34,942,752	307,210,746	2,687,324	11,559,741	75,658,184
Total debt obligations	85,459,530	806,896,090	2,334,328	11,165,785	181,446,740
Current maturities of total debt obligations	3,614,042	21,380,000	0	2,283,014	4,800,688

Source: own work.

Appendix 14: **Descriptive analysis for MEA region (KUSD)**

Financial statement, KUSD	Mean	Max	Min	Median	Std Dev
Current assets	3,912,747	9,310,627	3,631	3,912,747	3,974,562
Total assets	1,909,5550	46,883,379	18,197	19,095,550	19,423,353
Current liabilities	14,744,039	102,849,046	4,297	9,728,883	29,845,841
Total laibilities	14,906,761	40,456,403	12,851	14,906,761	15,689,138
Book value of equity	4,108,923	10,122,343	5,346	4,108,923	4,340,720
Retaining earnings	3,854,146	9,920,436	3,749	2,068,937	4,372,770
Earnings before interest and taxes	-365,951	823,706	-5,531,335	1,191	1,740,812
Interest	110,574.2	500,817	241	39,782	174,935
Operating revenues	10,695,419	26,168,937	6,734	8,237,057	11,675,390
Total debt obligations	10163539	30,027,248	2,962	10,163,539	11,505,600

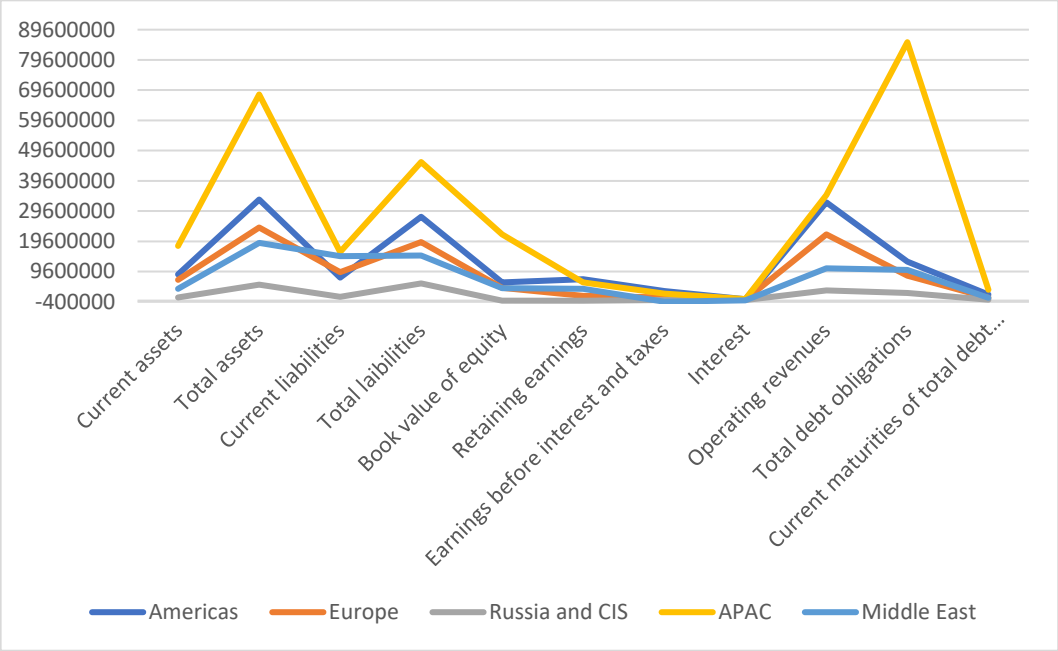
Source: own work.

Appendix 15: **Table of Descriptive analysis result by: MEAN (KUSD)**

Financial statement, KUSD	Americas	Europe	Russia and CIS	APAC	Middle East
Current assets	8,667,030	6,918,530	1,092,776	18,133,672	3,912,747
Total assets	3,344,473	24,178,084	5,326,184	68,123,808	19,095,550
Current liabilities	7,612,835	9,449,851	1,276,110	16,052,487	14,744,039
Total liabilities	27,739,654	19,409,293	5,679,675	45,775,636	14,906,761
Book value of equity	6,014,369	4,182,314	-30,579	21,930,008	4,108,923
Retaining earnings	7,052,359	1,572,344	-36,125,2	6,026,080	3,854,146
Earnings before interest and taxes	3,147,081	1,065,069	153,867.9	2,355,178	-365,951
Interest	450,060.1	301,536.6	198,872.1	513,012	110,574.2
Operating revenues	32,498,566	21,933,302	3,321,250	3,4942,752	10,695,419
Total debt obligations	12,945,991	8,248,270	2,520,103	85,459,530	10,163,539
Current maturities of total debt obligations	1,995,093	904,730.3	341,253.7	3,614,042	930,782.5

Source: own work.

Appendix 16: **Graph of Descriptive analysis result by: MEAN (KUSD)**



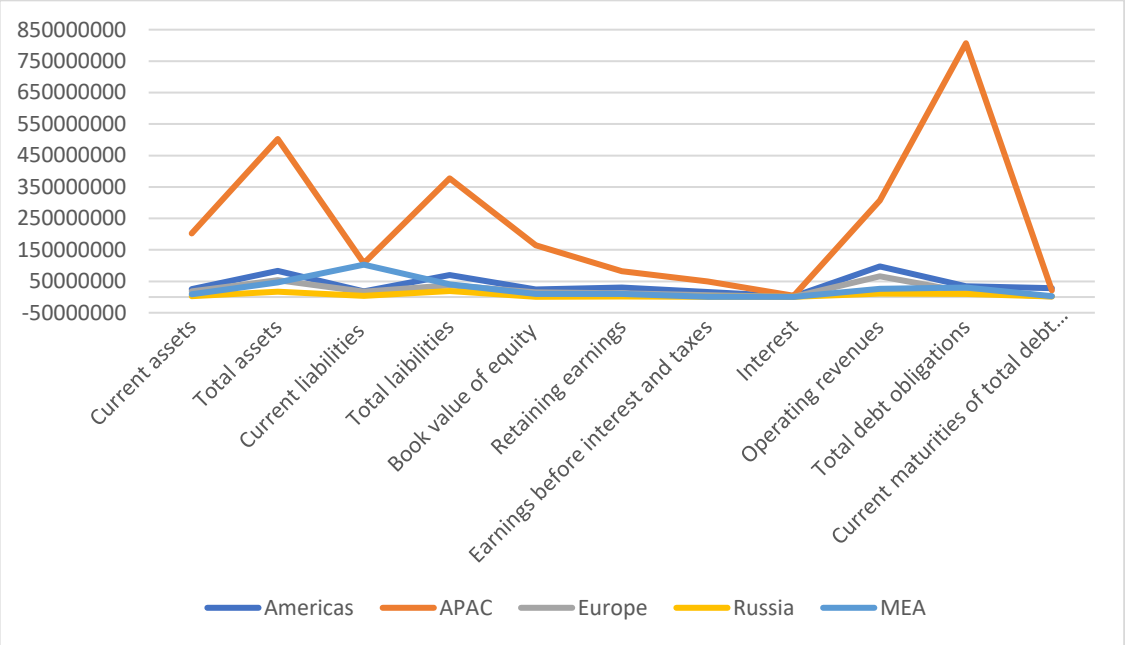
Source: own work.

Appendix 17: **Table of Descriptive analysis result by: MAX (KUSD)**

Financial statement, KUSD	Americas	Europe	Russia and CIS	APAC	Middle East
Current assets	24,934,000	18,332,789	2,978,963	202,175,156	9,310,627
Total assets	82,777,000	53,285,564	1,7136,965	502,880,156	46,883,379
Current liabilities	18,304,000	16,882,400	3,795,507	107,482,656	102,849,046
Total liabilities	69,975,000	37,561,492	19,121,220	377,346,563	40,456,403
Book value of equity	24,168,000	15,351,513	1,163,412	164,091,493	10,122,343
Retaining earnings	29,817,000	12,106,543	1,446,405	81,856,567	9,920,436
Earnings before interest and taxes	16,060,000	5,269,850	931,526	49,043,433	823,706
Interest	1,657,000	566,902	789,621	3,959,844	500,817
Operating revenues	97,287,000	65,921,108	10,633,128	307,210,746	26,168,937
Total debt obligations	33,876,000	16,211,594	9,347,724	806,896,090	30,027,248
Current maturities of total debt obligations	28,167,000	1,829,610	1,555,122	21,380,000	2,828,610

Source: own work.

Appendix 18: **Graph of Descriptive analysis result by: MAX (KUSD)**



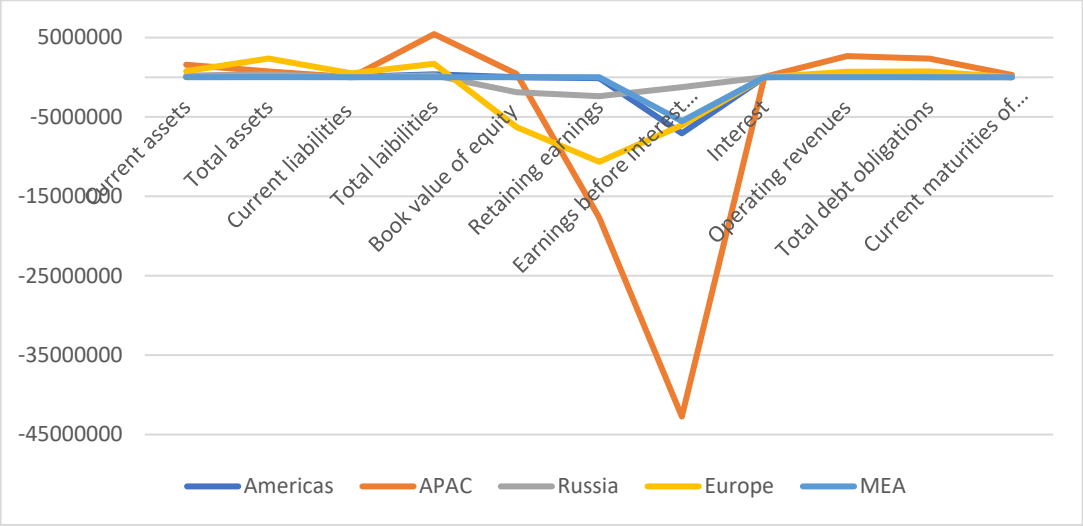
Source: own work.

Appendix 19: **Table of Descriptive analysis result by: MIN (KUSD)**

Financial statement, KUSD	Americas	Europe	Russia and CIS	APAC	Middle East
Current assets	41,580	788,840	204,261	1,564,596	3,631
Total assets	483,560	2,367,340	385,055	745,470	18,197
Current liabilities	55,480	488,720	13,226	5,285	4,297
Total liabilities	370,370	1,697,400	261,152	5,442,848	12,851
Book value of equity	5,476	-6,263,550	-1,876,707	395,010	5,346
Retaining earnings	-103,600	-10,648,484	-2,381,707	-17,691,875	3,749
Earnings before interest and taxes	-7,062,000	-6,029,460	-1,240,130	-42,732,388	-5,531,335
Interest	19,404	11,480	4,527	44,160	241
Operating revenues	360,084	679,944	119,158	2,687,324	6,734
Total debt obligations	303,180	733,080	16,715	2,334,328	2,962
Current maturities of total debt obligations	17,380	14,793	14,004	0	491

Source: own work.

Appendix 20: **Graph of descriptive analysis result by: MIN (KUSD)**



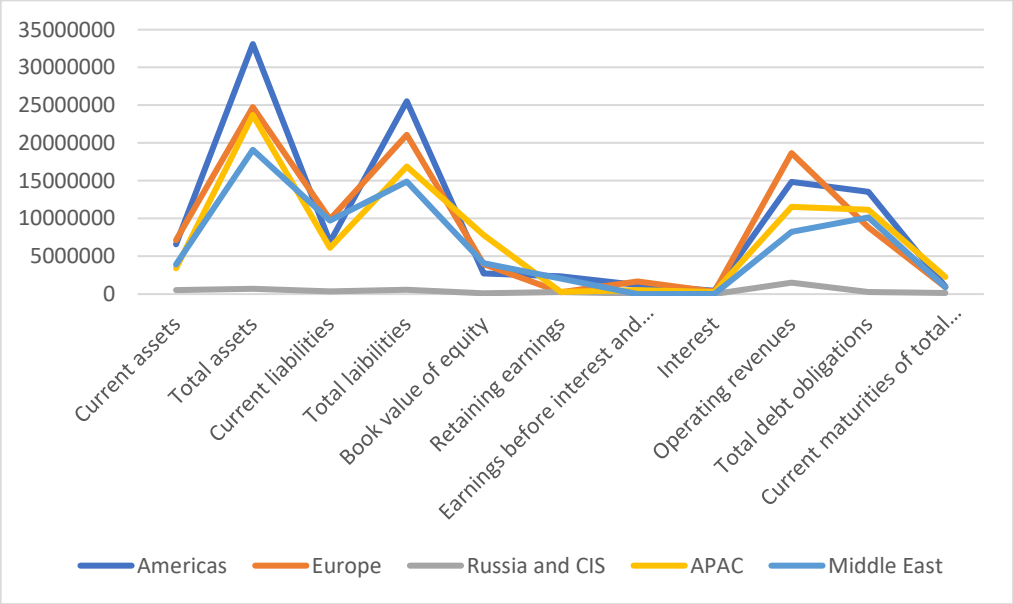
Source: own work.

Appendix 21: **Table of descriptive analysis result by: MEDIAN (KUSD)**

Financial statement, KUSD	Americas	Europe	Russia and CIS	APAC	Middle East
Current assets	6,605,123	7,143,933	550,219	3,410,563	3,912,747
Total assets	33,097,625	24,748,420	710,934	23,705,198	19,095,550
Current liabilities	6,874,625	9,884,280	338,911	6,132,240	9,728,883
Total liabilities	25,549,541	21,069,900	586,877	16,887,394	14,906,761
Book value of equity	2,721,970	3,955,057	102,952	7,823,431	4,108,923
Retaining earnings	2,363,000	247,500	276,713	293,630	2,068,937
Earnings before interest and taxes	1,190,500	1,671,300	65,960	538,848	1,191
Interest	449,174	319,688	16,508	294,764	39,782
Operating revenues	14,851,625	18,672,810	1,512,347	11,559,741	8,237,057
Total debt obligations	13,533,500	8,844,300	270,669	11,165,785	10,163,539
Current maturities of total debt obligations	988,000	893,731	132,718	2,283,014	930,783

Source: own work.

Appendix 22: **Graph of descriptive analysis result by: MEDIAN (KUSD)**



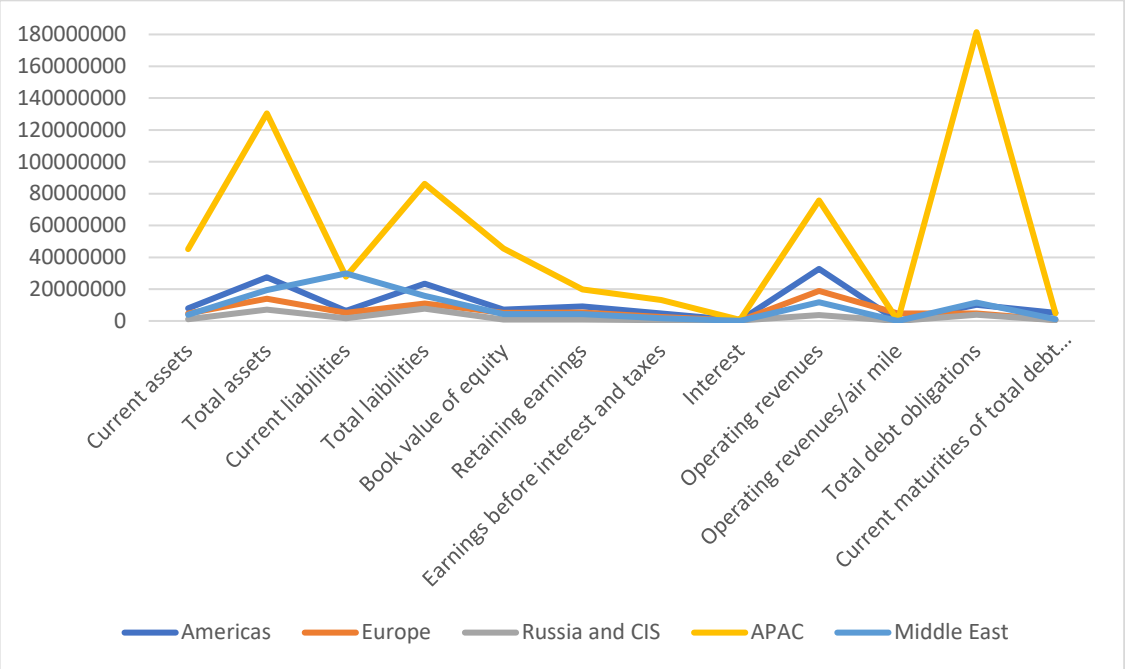
Source: own work.

Appendix 23: **Table of descriptive analysis result by: ST. DEVIATION (KUSD)**

Financial statement, KUSD	**Americas**	**Europe**	**Russia and CIS**	**APAC**	**Middle East**
Current assets	7,847,347	4,679,360	1,054,807	45,184,611	3,974,562
Total assets	27,505,473	13,859,135	7,203,736	130,402,857	19,423,353
Current liabilities	6,370,175	5,093,310	1,635,756	27,805,245	29,845,841
Total liabilities	23,457,150	11,018,449	7,722,921	86,248,100	15,689,138
Book value of equity	7,018,267	5,131,824	815,495	45,533,343	4,340,720
Retaining earnings	9,055,466	5,382,828	978,069	19,694,815	4,372,770
Earnings before interest and taxes	4,694,568	2,478,182	531,824	13,157,703	1,740,812
Interest	370,799	179,026	303,936	689,514	174,935
Operating revenues	32,701,323	18,859,707	3,771,149	75,658,184	11,675,390
Total debt obligations	10,162,602	4,714,736	3,848,484	18,1446,740	11,505,600
Current maturities of total debt obligations	5,053,058	696,618	513,518	4,800,688	1,032,581

Source: own work.

Appendix 24: **Graph of descriptive analysis result by: ST. DEVIATION (KUSD)**



Source: own work.

Appendix 25: **Altman's Z-score model results for combined air cargo carriers**

Z score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
Aeroflot	2,34	-0.73	-0.28	-1.57	-1.03	**-0.25**
	grey zone	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
AirCanada	1.94	1.89	1.59	0.54	1.04	**1.4**
	grey zone	grey zone	grey zone	bankrupt	bankrupt	**grey zone**
AirChina	0	0.24	0.04	-1.03	-1.42	**-0.43**
	bankrupt	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
ANA	2.28	2.25	2.18	1.51	1.44	**1.93**
	grey zone	grey zone	grey zone	grey zone	grey zone	**grey zone**
Cathay Pacific	1.8	0.05	-0.37	-0.33	0.02	**0.24**
	grey zone	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
China Airlines	2.66	2	3.45	4.48	1.98	**2.91**
	Non-bankrupt	grey zone	Non-bankrupt	Non-bankrupt	grey zone	**Non-bankrupt**
China Southern	-0.73	-0.77	-1.02	-0.47	-1.43	**-0.88**
	bankrupt	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
Emirates	0.84	1.16	-16.42	-0.05	-1.15	**-3.12**
	bankrupt	grey zone	bankrupt	bankrupt	bankrupt	**bankrupt**
EVA	0.98	1.19	0.44	0.54	1.11	**0.85**
	bankrupt	grey zone	bankrupt	bankrupt	bankrupt	**bankrupt**
Finnair	2.21	0.6	0.72	-0.47	-0.9	**0.43**
	grey zone	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
IAG	1.34	1.28	1.11	-1.96	-1.48	**0.06**
	grey zone	grey zone	bankrupt	bankrupt	bankrupt	**bankrupt**
KLM	0.02	-0.13	-0.04	-1.88	-1.53	**-0.71**
	bankrupt	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
Korean Air	-0.55	0.25	-0.24	0.3	1.53	**0.26**
	bankrupt	bankrupt	bankrupt	bankrupt	grey zone	**bankrupt**
Lufthansa	-0.34	-0.4	-0.91	-2.88	-1.47	**-1.2**
	bankrupt	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
Qantas	-0,22	0,07	-0,23	-0,78	-2,34	**-0,7**
	bankrupt	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**
Singapore	1,26	1.12	0.66	-0.7	0.71	**0.61**
	grey zone	grey zone	bankrupt	bankrupt	bankrupt	**bankrupt**
Turkish Airlines	1.25	1.28	0.74	0.38	0.91	**0.91**
	grey zone	grey zone	bankrupt	bankrupt	bankrupt	**bankrupt**
United Airlines	0.63	0.56	0.86	-0.28	0.24	**0.4**
	bankrupt	bankrupt	bankrupt	bankrupt	bankrupt	**bankrupt**

Source: own work.

Appendix 26: **Kroeze's Y-score model results for combined air cargo carriers**

Y score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
Aeroflot	0.25	-0.05	-0.04	-0.13	-0.14	**-0.03**
	Bankrupt	Bankrupt	Bankrupt	Bankrupt	Bankrupt	**Bankrupt**
AirCanada	0.15	0.12	0.12	0.04	0.1	**0.11**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
AirChina	0.15	0.17	0.13	0.06	0	**0.1**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
ANA	0.23	0.25	0.26	0.15	0.06	**0.19**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
Cathay	0.1	0.03	0.01	0.04	0.05	**0.04**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
China Southern	0.06	0.06	0.02	0.02	-0.03	**0.03**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Bankrupt	**Bankrupt**
Emirates	0.25	0.27	-0.44	0.12	0.03	**0.05**
	Non-bankrupt	Non-bankrupt	Bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
EVA	0.08	0.1	0.05	0.05	0.09	**0.07**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
Finnair	0.15	0.08	0.09	-0.01	-0.13	**0.04**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Bankrupt	Bankrupt	**Non-bankrupt**
IAG	0.03	0.05	0.03	-0.21	-0.22	**-0.06**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Bankrupt	Bankrupt	**Bankrupt**
China Airlines	-0.06	0.03	0	0.03	0.09	**0.02**
	bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
KLM	-0.07	-0.07	-0.06	-0.26	-0.35	**-0.16**
	Bankrupt	Bankrupt	Bankrupt	Bankrupt	Bankrupt	**Bankrupt**
Korean Air	0.01	-0.03	-0.06	-0.06	0.01	**-0.03**
	Non-bankrupt	Bankrupt	Bankrupt	Bankrupt	Non-bankrupt	**Bankrupt**
Lufthansa	0.11	0.14	0.12	0.11	0.11	**0.12**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
Qantas	-0.01	0.02	0	-0.09	-0.2	**-0.06**
	Bankrupt	Non-bankrupt	Non-bankrupt	Bankrupt	Bankrupt	**Bankrupt**
Singapore	0.14	0.11	0.08	0.01	0.12	**0.09**

(table continues)

(continued)

Y score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
Singapore	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
Turkish Airlines	0.21	0.21	0.15	0.19	0.19	**0.19**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
United Airlines	0.08	0.1	0.14	0.05	0.03	**0.08**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**

Source: own work.

Appendix 27: Fuzzy Logic model results for combined air cargo carriers

Fuzzy	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
Aeroflot	2.31	3.02	2.92	3.14	3.13	**2.9**
	Moderate Risk	Insolvent	Insolvent	Insolvent	Insolvent	**Insolvent**
AirCanada	2.53	2.62	2.65	2.91	2.97	**2.74**
	High Risk	High Risk	High Risk	Insolvent	Insolvent	**Insolvent**
AirChina	2.46	2.41	2.53	2.66	2.74	**2.56**
	Moderate Risk	Moderate Risk	High Risk	High Risk	Insolvent	**High Risk**
ANA	2.32	2.29	2.3	2.53	2.59	**2.41**
	Moderate Risk	Moderate Risk	Moderate Risk	High Risk	High Risk	**Moderate Risk**
Cathay	2.5	2.47	2.56	2.54	2.53	**2.52**
	Moderate Risk	Moderate Risk	High Risk	High Risk	High Risk	**High Risk**
China Southern	2.62	2.55	2.67	2.71	2.7	**2.65**
	High Risk	High Risk	High Risk	High Risk	High Risk	**High Risk**
Emirates	2.49	2.47	2.46	2.71	2.9	**2.61**
	Moderate Risk	Moderate Risk	Moderate Risk	High Risk	Insolvent	**High Risk**
EVA	2.49	2.47	2.65	2.71	2.62	**2.59**
	Moderate Risk	Moderate Risk	High Risk	High Risk	High Risk	**High Risk**
Finnair	2.37	2.59	2.55	2.73	2.87	**2.62**
	Moderate Risk	High Risk	High Risk	Insolvent	Insolvent	**High Risk**
IAG	2.46	2.47	2.57	2.91	2.94	**2.67**
	Moderate Risk	Moderate Risk	High Risk	Insolvent	High Risk	**High Risk**
China Airlines	1.45	2.52	2.65	2.68	2.57	**2.37**
	Healthy	High Risk	High Risk	High Risk	High Risk	**Moderate Risk**
KLM	2.73	2.75	2.73	3.17	3.21	**2.92**
	Insolvent	Insolvent	Insolvent	Insolvent	Insolvent	**Insolvent**
Korean Air	2.75	2.82	2.88	2.86	2.63	**2.79**
	Insolvent	Insolvent	Insolvent	Insolvent	High Risk	**Insolvent**
Lufthansa	2.32	2.32	2.35	2.58	2.6	**2.43**
	Moderate Risk	Moderate Risk	Moderate Risk	High Risk	High Risk	**Moderate Risk**
Qantas	2.55	2.54	2.64	2.77	2.95	**2.69**
	High Risk	High Risk	High Risk	Insolvent	Insolvent	**High Risk**
Singapore	2.17	2.23	2.34	2.68	2.42	**2.37**

(table continues)

(continued)

Fuzzy	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
Singapore	Low Risk	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	**Moderate Risk**
Turkish Airlines	2.51	2.51	2.6	2.67	2.62	**2.58**
	High Risk	High Risk	High Risk	High Risk	High Risk	**High Risk**
United Airlines	2.6	2.62	2.6	2.88	2.86	**2.71**
	High Risk	High Risk	High Risk	Insolvent	Insolvent	**High Risk**

Source: own work.

Appendix 28: **Pilarski P-score model results for combined air cargo carriers**

P-score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
Aeroflot	0	0	0	0.66	0.53	**0.24**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Bankrupt	Bankrupt	**Bankrupt**
AirCanada	0.01	0.03	0.02	0.23	0.14	**0.09**
	Non-bankrupt	Grey zone	Grey zone	Grey zone	Bankrupt	**Grey zone**
AirChina	0.01	0.01	0.03	0.16	0.27	**0.1**
	Non-bankrupt	Non-bankrupt	Grey zone	Bankrupt	Bankrupt	**Bankrupt**
ANA	0	0	0	0.04	0.09	**0.03**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Grey zone	Grey zone	**Grey zone**
Cathay	0.03	0.03	0.05	0.1	0.07	**0.06**
	Grey zone	Grey zone	Grey zone	Bankrupt	Grey zone	**Grey zone**
China Southern	0.06	0.04	0.08	0.12	0.22	**0.11**
	Grey zone	Grey zone	Grey zone	Bankrupt	Bankrupt	**Bankrupt**
Emirates	0.01	0	0.01	0.07	0.56	**0.13**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Grey zone	Bankrupt	**Bankrupt**
EVA	0.04	0.03	0.04	0.11	0.05	**0.05**
	Grey zone	Grey zone	Grey zone	Bankrupt	Grey zone	**Grey zone**
Finnair	0	0.02	0.02	0.52	0.64	**0.24**
	Non-bankrupt	Grey zone	Grey zone	Bankrupt	Bankrupt	**Bankrupt**
IAG	0	0	0.02	0.63	0.57	**0.25**
	Non-bankrupt	Non-bankrupt	Grey zone	Bankrupt	Bankrupt	**Bankrupt**
China Airlines	0	0.04	0.07	0.1	0.03	**0.05**
	Non-bankrupt	Grey zone	Grey zone	Bankrupt	Grey zone	**Grey zone**
KLM	0.06	0.06	0.05	0.73	0.6	**0.3**
	Grey zone	Grey zone	Grey zone	Bankrupt	Bankrupt	**Bankrupt**
Korean Air	0.09	0.13	0.18	0.17	0.04	**0.12**
	Grey zone	Bankrupt	Bankrupt	Bankrupt	Grey zone	**Bankrupt**
Lufthansa	0.5	0	0	0.03	0	**0.11**
	Bankrupt	Non-bankrupt	Non-bankrupt	Grey zone	Non-bankrupt	**Bankrupt**
Qantas	0.03	0.02	0.05	0.15	0.56	**0.16**
	Grey zone	Grey zone	Grey zone	Bankrupt	Bankrupt	**Bankrupt**
Singapore	0.5	0.5	0.01	0.06	0.03	**0.22**

(table continues)

(continued)

	2017	2018	2019	2020	2021	Av. Score
Singapore	Bankrupt	Bankrupt	Non-bankrupt	Grey zone	Grey zone	**Bankrupt**
Turkish Airlines	0.01	0.01	0	0.01	0	**0.01**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
United Airlines	0.01	0.01	0.01	0.26	0.14	**0.08**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Bankrupt	Bankrupt	**Grey zone**

Source: own work.

Appendix 29: **Altman's Z-score model results for all-cargo carriers**

Z score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
AirBridgeCargo	5.39	1.86	1.09	9.42	10.45	**5.64**
	Non-bankrupt	Grey zone	Bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
Atlas Air	1.57	1.67	0.94	2.14	2.52	**1.77**
	Grey zone	Grey zone	Bankrupt	Grey zone	Grey zone	**Grey zone**
Cargojet	0.23	0.58	0.32	0.17	2.08	**0.68**
	Bankrupt	Bankrupt	Bankrupt	Bankrupt	Grey zone	**Bankrupt**
Volga-Dnepr	4.99	4.82	3.66	6	5.86	**5.06**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**

Source: own work.

Appendix 30: **Kroeze's Y-score model results for all-cargo carriers**

Y score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
AirBridgeCargo	0.36	0.11	0.06	0.52	0.82	**0.37**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
Atlas Air	0.27	0.29	0.23	0.29	0.36	**0.29**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
CargoJet	-0.04	-0.01	0	-0.1	0.11	**-0.01**
	Bankrupt	Bankrupt	Non-bankrupt	Bankrupt	Non-bankrupt	**Bankrupt**
Volga-Dnepr	0.55	0.56	0.59	0.69	0.67	**0.61**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**

Source: own work.

Appendix 31: **Fuzzy Logic model results for all-cargo carriers**

Fuzzy	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
AirBridgeCargo	1.68	2.18	5.44	2.16	1.64	**2.62**
	Healthy	Low Risk	Insolvent	Low Risk	Healthy	**High Risk**
Atlas Air	2.49	2.46	2.51	2.42	2.31	**2.44**
	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	Moderate Risk	**Moderate Risk**
CargoJet	1.15	1.42	2.65	2.76	2.36	**2.07**
	Healthy	Healthy	High Risk	Insolvent	Moderate Risk	**Low Risk**
Volga-Dnepr	2.29	2.32	2.3	2.19	2.36	**2.29**
	Moderate Risk	Moderate Risk	Moderate Risk	Low Risk	Moderate Risk	**Moderate Risk**

Source: own work.

Appendix 32: **Pilarski P-score model results for all-cargo carriers**

P-score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
AirBridgeCargo	0	0	0.01	0	0	**0**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
Atlas Air	0.01	0.01	0.02	0.01	0	**0.01**
	Non-bankrupt	Non-bankrupt	Grey zone	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
CargoJet	0	0	0.12	0.14	0	**0.05**
	Non-bankrupt	Non-bankrupt	Bankrupt	Bankrupt	Non-bankrupt	**grey zone**
Volga-Dnepr	0	0	0	0	0	**0**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**

Source: own work.

Appendix 33: **Altman's Z-score model results for integrate carriers**

Z score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
UPS	2.29	2.11	1.96	1.84	3.79	**2.4**
	Grey zone	Grey zone	Grey zone	Grey zone	Non-bankrupt	**Grey zone**
FedEx	3.19	3.18	2.57	2.36	2.52	**2.76**
	Non-bankrupt	Non-bankrupt	Grey zone	Grey zone	Grey zone	**Non-bankrupt**
DHL	1.99	1.03	1.06	1.04	2.02	**1.43**
	Grey zone	Bankrupt	Bankrupt	Bankrupt	Grey zone	**Grey zone**

Source: own work.

Appendix 34: **Kroeze's Y-score model results for integrate carriers**

Y score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
DHL	0.26	0.19	0.19	0.19	0.24	**0.21**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
FedEx	0.44	0.48	0.46	0.4	0.32	**0.42**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
UPS	0.13	0.15	0.15	0.11	0.29	**0.16**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**

Source: own work.

Appendix 35: Fuzzy Logic model results for integrate carriers

Fuzzy	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
DHL	2.16	2.37	2.38	2.4	2.3	**2.32**
	Low Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	**Moderate Risk**
FedEx	2.27	2.22	2.27	2.47	2.39	**2.33**
	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	**Moderate Risk**
UPS	2.61	2.57	2.62	2.66	2.32	**2.55**
	High Risk	High Risk	High Risk	High Risk	Moderate Risk	**High Risk**

Source: own work.

Appendix 36: Pilarski P-score model results for integrate carriers

P-score	**2017**	**2018**	**2019**	**2020**	**2021**	**Av. Score**
DHL	0	0	0	0	0	**0**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
FedEx	0	0	0	0	0	**0**
	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	Non-bankrupt	**Non-bankrupt**
UPS	0.01	0.01	0.02	0.01	0	**0.01**
	Non-bankrupt	Non-bankrupt	grey zone	Non-bankrupt	Non-bankrupt	**Non-bankrupt**

Source: own work.

Appendix 37: Results for combined carriers

	Z-score	Y-score	P-score	Fuzzy	Result
Aeroflot	Bankrupt	Bankrupt	Bankrupt	Insolvent	**Bankrupt**
AirCanada	Grey zone	Non-bankrupt	Grey zone	Insolvent	**Moderate Risk**
AirChina	Bankrupt	Non-bankrupt	Bankrupt	High Risk	**High Risk**
ANA	Grey zone	Non-bankrupt	Grey zone	Moderate Risk	**Moderate Risk**
Cathay	Bankrupt	Non-bankrupt	Grey zone	High Risk	**High Risk**
China Southern	Bankrupt	Non-bankrupt	Bankrupt	High Risk	**High Risk**
Emirates	Bankrupt	Non-bankrupt	Bankrupt	High Risk	**High Risk**
EVA	Bankrupt	Non-bankrupt	Grey zone	High Risk	**High Risk**
Finnair	Bankrupt	Non-bankrupt	Bankrupt	High Risk	**High Risk**
IAG	Bankrupt	Bankrupt	Bankrupt	High Risk	**Bankrupt**
China Airlines	Bankrupt	Non-bankrupt	Grey zone	Moderate Risk	**High Risk**
KLM	Bankrupt	Bankrupt	Bankrupt	Insolvent	**Bankrupt**
Korean Air	Bankrupt	Bankrupt	Bankrupt	Insolvent	**Bankrupt**
Lufthansa	Bankrupt	Non-bankrupt	Bankrupt	Moderate Risk	**High Risk**
Qatans	Bankrupt	Bankrupt	Bankrupt	High Risk	**Bankrupt**
Singapore	Bankrupt	Non-bankrupt	Bankrupt	Moderate Risk	**High Risk**
Turkish Airlines	Bankrupt	Non-bankrupt	Non-bankrupt	High Risk	**Moderate Risk**
United Airlines	Bankrupt	Non-bankrupt	Grey zone	High Risk	**High Risk**

Source: own work.

Appendix 38: Results for all-cargo carriers

	Z-score	Y-score	P-score	Fuzzy	Result
AirBridgeCargo	Non-bankrupt	Non-bankrupt	Non-bankrupt	High Risk	**Low Risk**
Atlas Air	Grey zone	Non-bankrupt	Non-bankrupt	Moderate Risk	**Moderate Risk**
Cargojet	Bankrupt	Bankrupt	Grey zone	Low Risk	**High Risk**
Volga-Dnepr	Non-bankrupt	Non-bankrupt	Non-bankrupt	Moderate Risk	**Low Risk**

Source: own work.

Appendix 39: Results for integrate carriers

	Z-score	Y-score	P-score	Fuzzy	Result
DHL	Grey zone	Non-bankrupt	Non-bankrupt	Moderate Risk	**Moderate Risk**
FedEx	Non-bankrupt	Non-bankrupt	Non-bankrupt	Moderate Risk	Low Risk
UPS	Non-bankrupt	Non-bankrupt	Non-bankrupt	High Risk	Low Risk

Source: own work.