The air cargo market overview

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Abstract. Measured by the value of goods, about one-third of all international trade is moved by air. It stands for a big chunk of the transport market and global GDP, playing a crucial role in moving products of high value in relation to their weight, but also the backbone of overnight shipping and enabling e-commerce growth. This places air cargo as very dependent on overall economic deviations. As the world slowly exits the global pandemic state, each part of the aviation industry should be subject to analyses that confirm or contradict previous forecasts, thus helping to make correct business decisions by the relevant entities in the aviation industry. The following article is devoted to the analysis of the air cargo market. As a starting point, the article shows a general overview of the world's economy by pointing out the main variables that impact demand for air cargo and presenting forecasts on some of those. General air cargo market overview is the next subject. This part shows the latest trends connected with the general aviation market and the cargo part, outlining the general look. An overview of forecasts for the aviation market, coming from aircraft manufacturers, is the last of the analytical parts of this article, describing each entity's market outlook. Presented analyses were later used to determine trends most likely to show in coming years. The accurate description of those allowed for creating a coherent forecast of the air cargo market, with the calculation of actual cargo tonne-kilometers for oncoming years using a simple, multivariate forecasting method based on creating a historical data-driven model. The article concludes with a summary that provides an overview of the covered subjects.

Keywords: air cargo, analysis, forecast

1. Introduction

Air cargo should be understood as the transport of goods using aircraft. It can be done in two main ways – transporting goods on dedicated cargo aircraft or passenger aircraft in the belly alongside all passengers' luggage. Each year over 52 million tonnes of cargo is transported by air, representing more than 35% of global trade by value but less than 1% by volume [9]. Daily, almost $18.6 billion worth of goods are being carried, and the entire market is valued at nearly $123 billion [18]. Thanks to its characteristics, air cargo is especially useful for such subjects as the Just-In-Time policy of supplying overnight

shipping and transporting goods quickly, making it only possible for long and medium distances transport in an emergency.

Air cargo is a vast and crucial part of the world economy, dependent on it and enabling its growth. However, a situation that was observable during the last couple of years (the COVID-19 pandemic) may have resulted in a change in air cargo and the aviation industry. Therefore, new forecasts and analyses should be carried out to enable the best possible business decisions by relevant aviation entities. The following article focuses on analyzing the air cargo market based on an overview of the global economy, a general air cargo market overview, and a brief analysis of aviation entities' forecasts. Those are later used to create a numerical model for forecasting growth in the air cargo market. Results may be used as initial data for creating new, updated business strategies.

2. Economy overview - main variables and drivers for air cargo demand

When discussing the air cargo market, it is worth starting with discussing the topic of a wider economy overview. Wider aviation makes up a considerable part of the economy, contributing $3.5 trillion to the annual global GDP (Gross Domestic Product) [2]. Global air cargo follows closely with global economic health, which should call for concern as the global economy enters 2022 in a weaker position than previously expected [13]. A healthy economy means more demand for products, which means more of them is being sold, which means more is being produced out of raw materials from the main suppliers. At each of those steps, the transport of goods plays a big part. The Omicron variant of Coronavirus led to reimposing mobility restrictions by some countries, weighing in on supply disruptions all around the globe and holding back a broader recovery.

The COVID pandemic resulted in 2020 global debt reaching 263% of global GDP, the highest in the last half a century [18]. Though the situation was direr than ever in 2020, the global economy comeback was observable in 2021, resulting in an over 6% GDP rise (compared to the previous year's over 3% decline) at purchasing power parity (PPP) of 2010, as shown in Fig. 1.

Taking into consideration the economic climate in individual countries and the world economy forecast of GDP in coming years was calculated by OECD (Organisation for Economic Co-operation and Development) using model-based analyses and experts' judgments [16]. Said forecast, shown in Fig. 2, shows a steady growth of indicator in coming years at a compound annual growth rate (CAGR) of 2,06%.

As a result of a global pandemic, inflation continued to rise throughout 2021. Different factors drove it, mainly fossil fuel prices, which have almost doubled compared to the end of 2020. It reached its highest value since September 2014 [13, 15] (Fig.3). It is assumed that when the global pandemic slows down, it will be possible to see both a fade in inflation from the current 3.9-5.9% level and moderation in an increase of fuel prices.

A forecast of crude oil prices provided by the US Energy Information Administration (Fig. 4), shown as a part of a Knoema study from 2021, reports that the growth of said prices will be visible in the coming years [14]. The forecast states steady growth with a CAGR of 4.2% in the coming 20 years. Although percentage growth will be lower than in 2021, when a great price increase compared to the worst year of the pandemic (2020) was observable. At the end of the forecast, it is believed that crude oil prices will rise up to $214 per barrel.
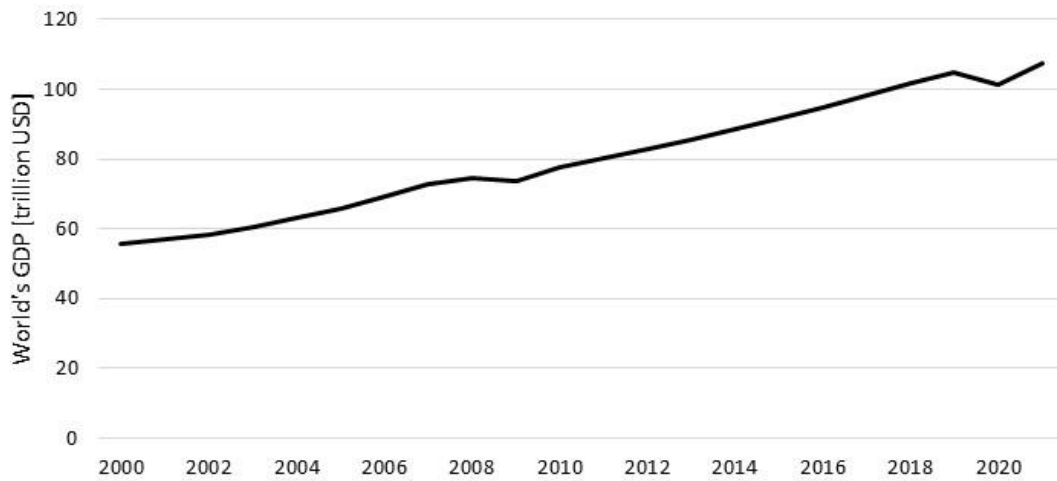
Fig. 1. World's GDP in trillions of USD
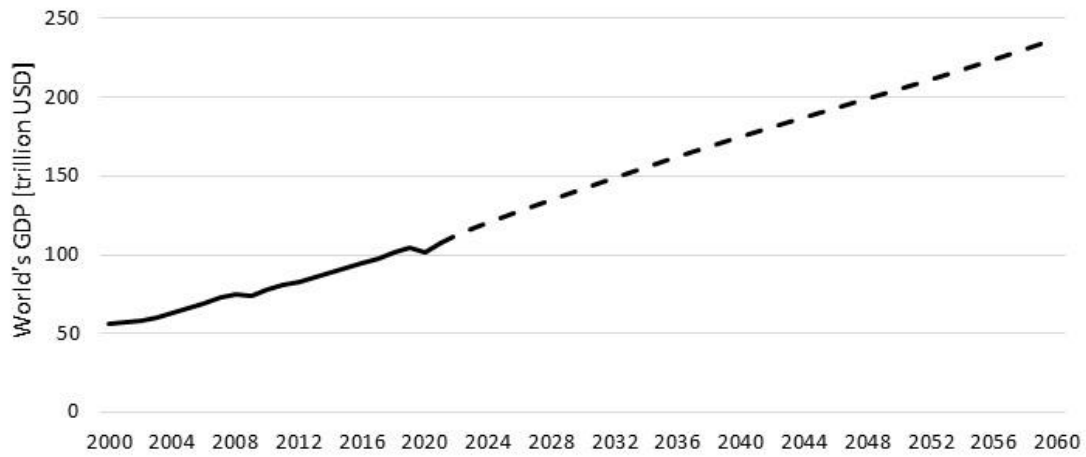Source: own study based on [16]

Fig. 2. World's GDP forecast in trillions of USD
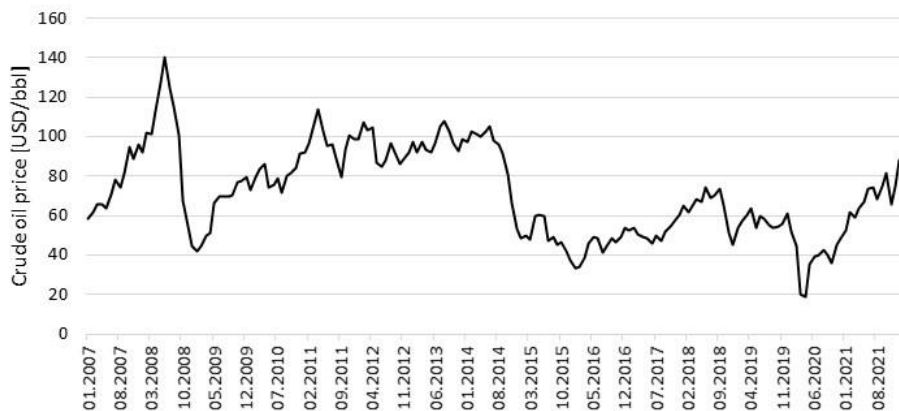Source: own study based on [16]

Fig. 3. Price of a crude oil barrel
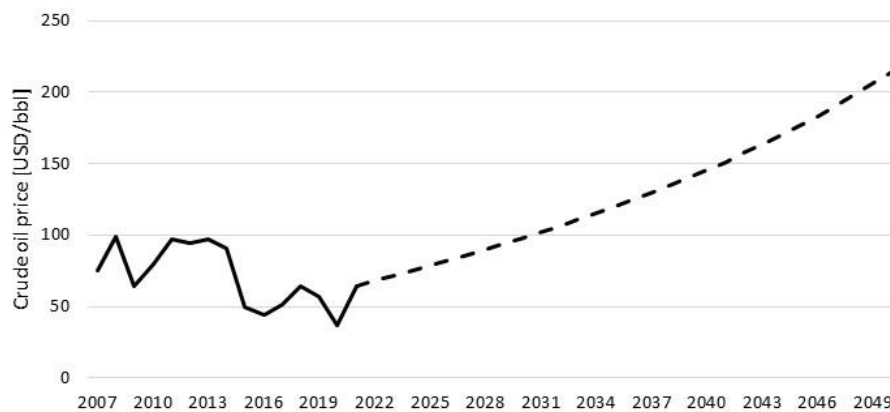Source: own study based on [15]

Fig. 4. Yearly price of crude oil barrel forecast
Source: own study based on [14]

Another factor that is said to have an impact on the demand for air cargo services is E-commerce with overnight shipping, which saw one of the greatest growths during the pandemic. The global e-commerce market size was valued at USD 9.09 trillion in 2019 and is expected to grow at a CAGR of 14.7% from 2020 to 2027 [8]. As this part of the services market grows, so air cargo has to follow, creating additional demand for available CTKs (Cargo Tonne-Kilometre – an indicator used to determine the volume of carried goods and the general size of the cargo market, one tonne of revenue freight carried one kilometer).

3. General air cargo market overview

Whenever we talk about the air cargo market, we should really take into consideration three main sources of carrying capacity, which is space available in holds of passenger aircraft, all-cargo aircraft operated by main passenger-carrying airlines, and all-cargo aircraft operated by specialist air cargo companies [7]. The short time in which the cargo is moved by air makes it suitable for products of high value in relation to their weight, like valuable livestock, precious metals, and fragile goods, but also for moving specialized medical and rescue equipment, which may be too rarely used to be stored where it is needed at the moment. Air cargo also found demands carrying such goods as car/motorcycle parts, pharmaceuticals, textiles, and electronics.

Since rather a large part of all air cargo is usually carried by passenger planes, alongside baggage, a discussion should be started with an actual discussion of the passenger market, which was always developing quite dynamically. Regardless of the geopolitical situation around the world aviation market has always recovered after crises, and the observed short-time growth after these declines was usually even greater. When analyzing the graph showing Revenues per Passenger-Kilometre (RPK), one can observe periods in which the aviation market suffered due to the situation around it, as shown in Fig. 5. For example, at the beginning of the 1980s, a significant slowdown in development due to the oil crisis can be observed. This situation was repeated in the early 90s in connection with the First Gulf War. The situation was much more serious at the turn of the century when the market was negatively affected by the combination of factors in the form of the Asian Crisis, the terrorist attacks of September 2001, and the development of the SARS epidemic. The serious situation for the aviation market repeated itself in 2008 as a result of the global financial

crisis. However, it should be remembered that after each of the crises, the market rose and developed quite dynamically. It should therefore be assumed that despite the current pandemic situation, which resulted in a decrease in traffic on an unprecedented scale, the aviation market should return to the observed record levels from 2019.
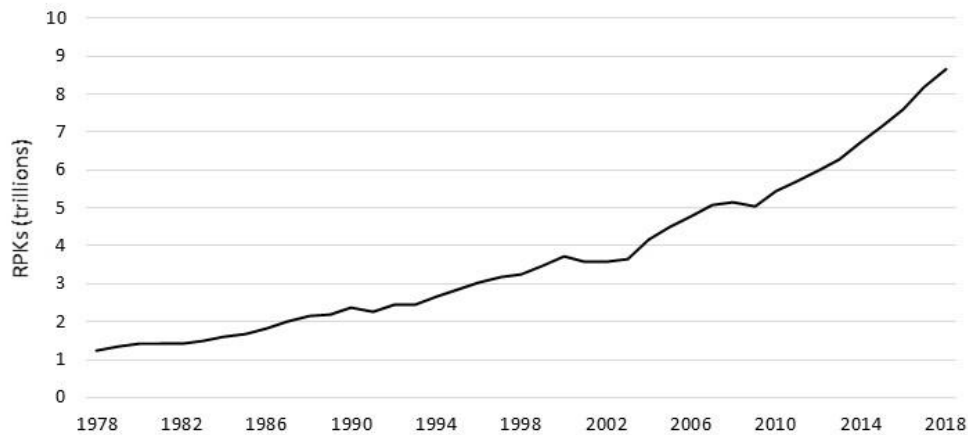

Fig. 5. Annual RPKs forecast
Source: own study based on [1]

Forecasts from one of the top aircraft manufacturers – Airbus – suggests that in the coming years, come back of passenger air traffic will be observable, as shown in Fig. 6.
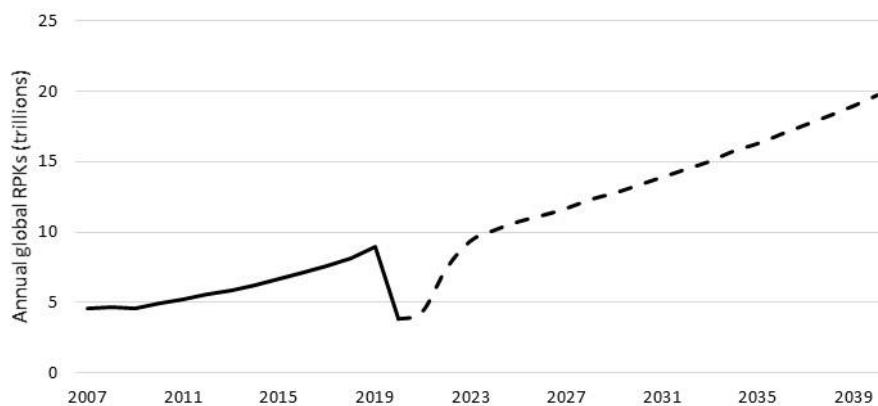

Fig. 6. Annual RPKs forecast
Source: own study based on [2]

For the last decade, we have seen almost steady growth in carrying goods by air. CTKs grew from 206 billion in 2010 to almost 264 billion in 2019 (Fig. 7). It was also observed that more recently, in October of 2021, CTKs grew by 9.4% in comparison to the same month in pre-pandemic 2019 [10].

The global COVID-19 pandemic was the biggest challenge the air cargo market faced in recent years. Until 2019, 45% of cargo worldwide (up to 60% between Europe and the US) was carried by passenger aircraft alongside passengers' baggage. Almost 90% are carried by Wide-body aircraft on long-haul flights [3]. This carrying capacity was cut down at the beginning of 2020 with the pandemic's start. With scaling down their operations, airlines cut

down available cargo capacity by 25% in January-September 2020. The beginning of the pandemic marked the worst period – in April 2020, 38% less of overall cargo capacity was available, even though freighter aircraft increased their capacity by more than 14%. It was all due to the lowering of passenger aircraft capacity by more than 73% [10]. Described can be observed as a change in Actual Cargo-Tonne Kilometres (ACTK) in Fig.8.
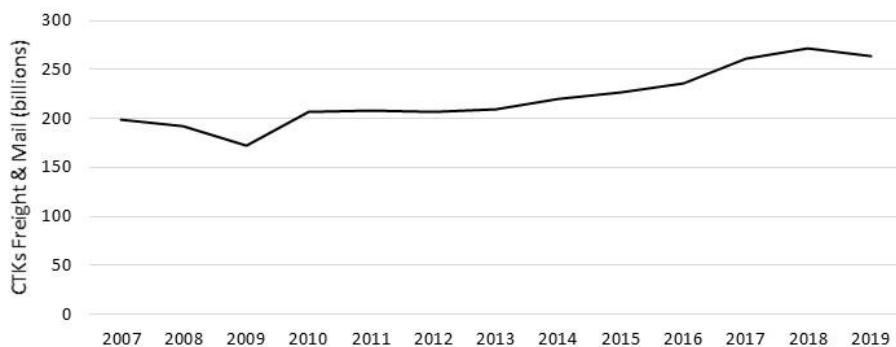

Fig. 7. CTKs from Freight & Mail
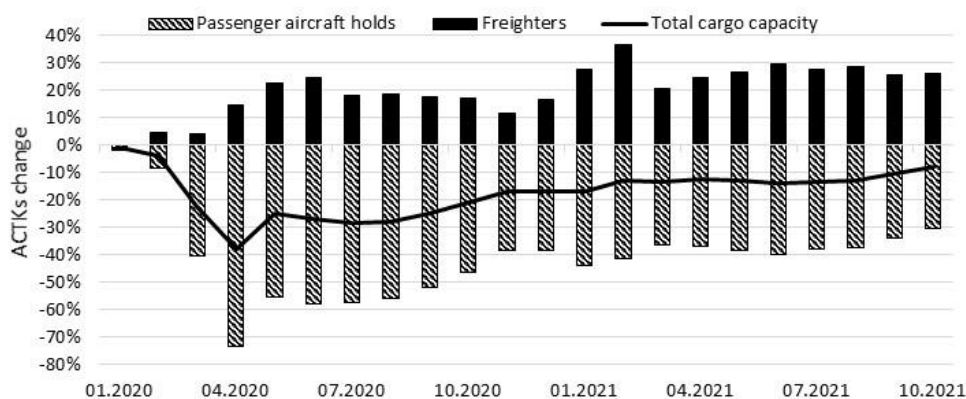Source: own study based on [3, 4]

Fig. 8. ACTKs change versus the same month in 2019
Source: own study based on [10]

On the other hand, the increasing need for carrying medical supplies at the beginning pandemic with a significant surge in e-commerce meant that actual demand for air cargo dropped by not more than 15%. This supply and demand mismatch caused a 50% increase in air freight rates, with airlines starting to fly their passenger aircraft only with cargo and also fasten with seatbelts on actual seats. Overall, the short-term issue connected with the global pandemic is that too much demand cannot be appeased. Long term issue is that this demand will not last as passenger traffic grows back with the possibility of carrying cargo in bellies.

4. Market entities' forecasts

Following article analyses forecasts developed and published by aircraft manufacturers. Though the main point of those documents was to determine possible demand for new

aircraft in coming years, the thoroughness of the undertaken research is usable during the analysis of specific market trends.

One of those forecasts has been provided by Boeing in World Air Cargo Forecast for the years 2020-2039, which provided a comprehensive overview of the air cargo industry [3, 5]. As the document was prepared by one of the key manufacturers, its methodology is based on using multiple approaches and a variety of used data. The forecast created as a part of the document is based on econometric modeling, which helped determine the overall importance of economic factors and judgemental evaluation, such as estimating the effect of air service agreements, restrictions, and changes in airlines' strategic plans and trend analysis, which was used to evaluate changes in the marketplace. Data, which was described as a historical one, was gathered by Boeing from multiple sources from all around the world.

The main anchor point for the document prepared by Boeing is the disruption of the market by the COVID-19 pandemic. Even though the year 2020 was characterized by the quick spread of COVID and the loss of a major part of cargo capacity being carried by passenger aircraft, it is thought that the market will grow, also thanks to a great rise in the e-commerce market. In terms of CTKs, the market, within a base case, is said to double from 264 billion in 2019 to 578 billion in 2039, at 4% yearly growth, as shown in Fig. 9.
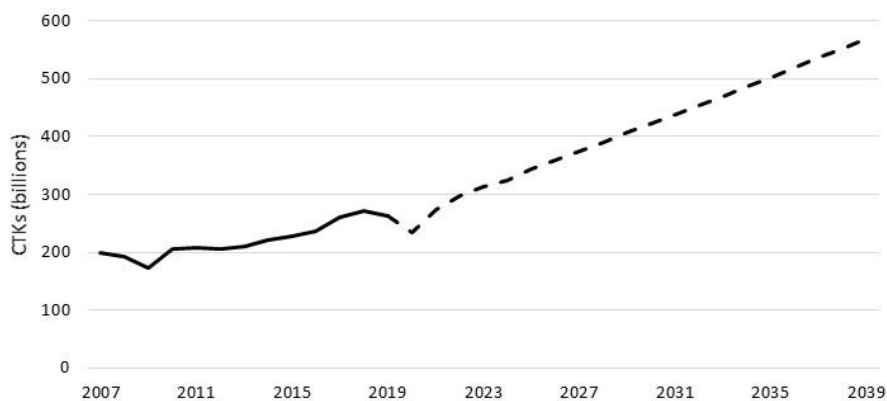

Fig. 9. Boeing's CTKs long-term forecast
Source: own study based on [3, 4, 5]

Airbus Global Market Forecast [2] was prepared during a more severe time of the COVID-19 pandemic and, as such, assumes lower growth of the air cargo market. The forecast of the global air cargo market is said to be driven by strong growth of e-commerce and expected steady growth in world international trade, which will be forecasted at +2.7% CAGR. This will most probably result in the growth of both groups taken into account by Airbus. The first is general cargo growing at CAGR 2.7% in the years 2019-2040, and the second is Express Cargo, growing at CAGR 4.7%.

Additionally, Airbus predicts that in the next 20 years, the global air freighter market will need over 2 400 new aircraft, with over 61% of them being intended as replacement units for retired ones and just under 64% being conversions of passenger aircraft. The bulk of new air freighters will be small cargo aircraft, with almost 41% being under 40 tonnes loading capacity.

This brief analysis of two forecasts published by aircraft manufacturers leads to the conclusion that the air cargo market will grow at a steady rate in post-pandemic times. The

amount of carried goods will rise with the return of passenger aircraft and their cargo capacity. Despite that market will have great demand for dedicated freighter aircraft.

5. Forecasting

The following chapter was devoted to the forecasting of global air cargo CTKs in the coming years and was divided into a couple of main parts. The first of them was the brief description of a chosen forecasting method, overviewing each step undertaken in forecast development and describing data on which the forecast will be based. In the second part creation of the forecasting model was explained. This section featured a simple, general mathematical representation and described the way the coefficients' values were determined. The chapter ends with the creation of a forecast.

5.1. Forecasting method & input data description

As the level of actual yearly CTKs may depend on many different variables, in the article below, it was decided to apply the multivariate forecasting method with the creation of a numerical model based on historical input data. As data chosen to be input data was showing not to be time-dependent, it was decided that the non-time-series model would be the best choice. A numerical model for forecasting purposes was created based on a set of historical input data and actual CTKs observed in the 2007-2019 period. Input data, chosen to be the base of the model, was:

– **Global GDP** – the main factor in defining the economic health of the world, the following forecast uses OECD long-term forecast,
– **Crude oil price** – as transport is still heavily dependent on fossil fuels, which is probably the truest when it comes to air transport, crude oil prices provided by US EIA were used to create a model and forecast,
– **RPKs** – in the pre-pandemic world big part of air cargo was being transported via passenger aircraft alongside passengers' baggage. Airbus data was chosen to be one of the drivers of the model.

As all three shown factors describe the air cargo market from a different side – GDP as part of the global economy, crude oil price as dependent on fossil fuel, and RPKs as being also driven by the passenger part of the aviation market – a full picture can be derived from those. Therefore no need to identify any other factors was assumed. However, it is important to note that for a higher level of detail or direction of the analysis, additional factors could be introduced.

After choosing the data, a simple general equation describing the function of actual forecasted CTKs was created. To determine the correct value of coefficients and powers for each of the variables, chosen historical data, forecasts provided by OECD [16], US EIA [14], and Airbus [2] were uploaded into the model alongside historic CTKs provided by Boeing [3, 4].

An evolutionary method of determining all searched equation coefficients was used, and the goal was to find the coefficients set which would provide minimal mean squared error (MSE) for the historical data set. An evolutionary method is based on creating multiple random sets of preliminary values for coefficients in the first step. Multiple sets are then

compared to find the lowest value of MSE. The set for which MSE was the lowest is then chosen to create its 'mutation', which means they are tweaked compared to the previously best set. This second generation created is then compared to the previous best set and to one another, choosing the new, best set. This goes on until very little change in the MSE is observable from one generation to the next resulting in staying with the best possible set of coefficients.

5.2. Creation of forecasting model

The creation of the numeric model used for forecasting started with creating a generic function, which represented each chosen input data as well as coefficients and powers for each of them. A proposed function consists of each input factor being present only once, meaning that global GDP, price of the crude oil barrel, and RPKs can have only a single coefficient and power assigned. This way compromise between the accuracy of the model and the time needed for its creation was achieved.

$$CTK(GDP, CO, RPK) = A1 \cdot GDP^{P1} + A2 \cdot CO^{P2} + A3 \cdot RPK^{P3} + C \qquad (1)$$

where:
CTK – Cargo Tonne-Kilometres calculated by the model,
GDP – Global GDP value,
CO – the price of a crude oil barrel,
RPK – Revenue Passenger-Kilometres,
$A1$ – GDP coefficient,
$P1$ – GDP power,
$A2$ – Crude oil price coefficient,
$P2$ – Crude oil price power,
$A3$ – RPKs coefficient,
$P3$ – RPKs power,
C – constant.

The model, created in MS Excel, and fed by the historical data, determined the final values of the coefficients using the solver-implemented tool with the usage of the evolutionary method. The final set of coefficients and powers for each of the chosen variables resulted in a minimal MSE value of 72.122.

Table 1. Forecasting model's coefficients' values

Coefficient	Value
GDP coefficient	1.87714561
GDP power	1.079126774
Crude oil price coefficient	0.447327895
Crude oil price power	0.56592944
RPKs coefficient	0.992498154
RPKs power	1.70370037
Constant	42.75205517

Source: own study

Table 2. Forecasting model's CTKs (billions)

Year	Actual observed CTKs (billions)	Model CTKs (billions)
2007	199.229	185.8707789
2008	191.902	190.8243903
2009	172.739	187.308505
2010	206.756	196.8039206
2011	208.276	205.0088084
2012	206.306	211.1308241
2013	209.877	217.99236
2014	220.589	225.1884763
2015	226.844	231.1587279
2016	236.303	239.1394141
2017	260.580	249.9009285
2018	271.880	261.2404153
2019	263.701	272.174176

Source: own study on the basis of [3, 4]

5.3. Forecast creation

The previously created model was later used for creating CTKs forecasts. Feeding forecasting model with input data forecasts coming from different entities – global GDP forecast, crude oil price, and global RTKs – allowed to define of global CTKs, which will be carried out until 2040. The results of the forecast can be seen in the form of Fig. 10, being compared to the historical data.
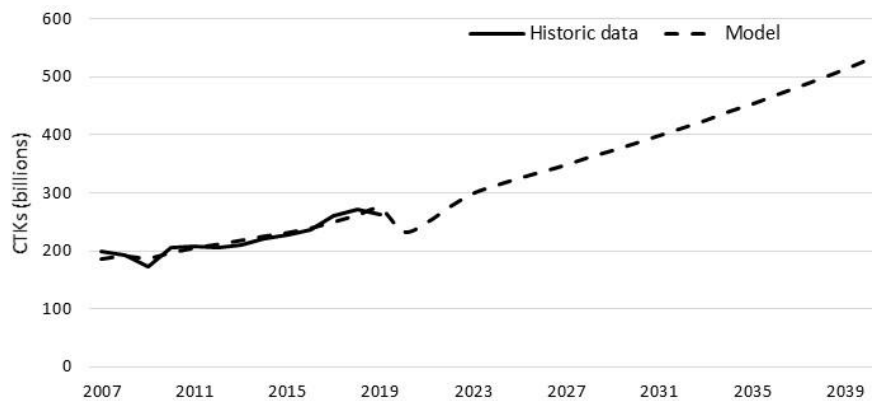

Fig. 10. CTKs forecast
Source: own study based on [3, 4]

Created forecasting model allowed defining forecast which shows steady air cargo market growth. Global CTKs are growing from below 250 billion in 2020 and 2021 to almost 530 billion in 2040, at a CAGR of 3.6% in 2022-2040. This growth in the air cargo market is a direct reflection of forecasted input data.

It is important to note that since the created model is running based on forecasted values, it is possible that showed trends might not occur. The completed forecast is based on variables whose future values were established on the currently seen market situation. As such, it would be beneficial to update it each time new, more probable data appears.

6. Summary

This article was devoted to a general overview and analysis of the air cargo market as a major part of the aviation business. It raised issues related to the general world economy, like global GDP and crude oil prices, analyzed the air cargo market in terms of general passenger aircraft and freighters movements, and observed changes in capacity (ACTKs) for the year 2021.

It was determined that in the coming years, we might see come back of the world's economy to a state of constant growth. Economic forecast determined by OECD based on their approach with model analyses and experts' judgment suggests that global GDP will be steadily rising in coming years with CAGR of 2.06%. As the air cargo market size seems to track with global GDP, yearly CTKs should also increase if forecasts are accurate. GDP growth is also dependent on countries lifting restrictions connected with the COVID-19 pandemic. As such action allows the global transport market to return to its pre-pandemic way of operating so, pre-pandemic trends should also be observable once more – one of them being an increase in crude oil price. Research suggests that from 2022 steady growth at CAGR 4.2% in crude oil prices will be observable. This could serve as a negative factor in forecasted air cargo growth seeing as air transport is the highest user of oil per tonne of transported cargo. An additional positive factor for air cargo demand will also be growth in e-commerce related to it overnight shipping. The E-commerce market was developing rapidly before the pandemic, which just sped up the growth process. Until 2027 e-commerce market is supposed to grow at CAGR 14.7%, which could result in increased demand for air cargo as the most reliable provider for overnight shipping over vast distances.

Aviation and air cargo market analysis showed that despite the pandemic situation in 2020 and 2021 market will most likely take off once more – forecasts suggest that there will be a surge in passenger travel. This way, additional cargo capacity will be created to serve the growing demand. Total cargo carried is said by Boeing to grow at a rate of 4% yearly. Airbus states that there will be a difference between general cargo growing at CAGR 2.7% in years, and Express Cargo, growing at CAGR 4.7%.

Using described data mathematic model forecasting CTKs in the coming years was developed. It is based on a multivariate forecasting approach with calculating the forecasted values by using forecasts for global GDP, the price of crude oil, and RTKs as input data. The model was developed by using the same set of historical data and CTKs observed in the years 2007-2019. This approach allowed determining values of individual coefficients, with the goal being a creation of a formula that results in a minimum mean squared error. Chosen evolutionary method of determining coefficients helped to calculate model CTKs with MSE, compared to actual 2007-2019 data of 72.122. Forecast created using the developed method achieves CTKs almost at a level of 530 billion in 2040, growing at CAGR of 3.6% in the 2022-2040 period. Comparing those results to forecasts provided by Boeing and Airbus, a slight difference can be seen. Boeing's forecast seems to be the more optimistic, resulting in almost 11% higher CTKs at its end, with a slightly higher level of CAGR (Boeing's 4% versus 3.6% derived from the data analysis and forecasting model). On the other hand, the forecast provided by Airbus could be described as a slow growth case, with a CAGR of 3.12%. The forecast created as a part of this article, based on other economic and aviation indicators, appears as a rational forecast, leaning slightly towards quick air cargo market growth and the optimistic scenario presented by Boeing.

The above article provided an overview of the currently observed air cargo market with the creation of a forecast based on multiple variables that need to be taken into account when determining how the market will behave. As the results shown in the article are not far away from forecasts provided by Boeing and Airbus, as well as the accuracy of model calculations for historical data, the created forecast should be considered as accurate. Despite that, it is important to note that all results are highly dependable on input data, which is forecasted by multiple entities themselves. The accuracy of the forecast may be additionally improved by using more data that causes air cargo market deviations.

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Przegląd rynku lotniczego cargo

Streszczenie. Mierząc wartością towarów, około jedna trzecia całego handlu międzynarodowego odbywa się drogą powietrzną. Stanowi to dużą część całego rynku transportowego, jak również globalnego PKB, odgrywając kluczową rolę w przenoszeniu produktów o dużej wartości w stosunku do ich wagi, ale jest także podstawą wysyłki nocnej i jako taka umożliwia rozwój e-commerce. Plasuje to rynek transport towarów drogą lotniczą jako zależny od ogólnych odchyleń ekonomicznych. Gdy świat powoli wychodzi z globalnej pandemii, każda część branży lotniczej powinna zostać poddana analizom, które potwierdzają lub zaprzeczają wcześniejszym prognozom, pomagając w ten sposób podejmować prawidłowe decyzje biznesowe przez odpowiednie podmioty z branży lotniczej. Poniższy

artykuł poświęcony jest analizie rynku lotniczego cargo. Jako punkt wyjścia artykuł przedstawia ogólny przegląd gospodarki światowej ze wskazaniem głównych zmiennych, które mają wpływ na popyt na przewóz ładunków drogą lotniczą, a także przedstawieniem prognoz dotyczących niektórych z nich. Kolejnym punktem jest ogólny przegląd rynku lotniczego cargo. W tej części przedstawione są najnowsze trendy związane z rynkiem lotniczym, a także z częścią cargo, nakreślając ogólny wygląd. Przegląd prognoz dla rynku lotniczego, pochodzących od producentów statków powietrznych, to ostatnia z analitycznych części artykułu, opisująca perspektywy rynkowe poszczególnych podmiotów. Przedstawione analizy posłużyły później do określenia rzeczywistych trendów, które z największym prawdopodobieństwem ujawnią się w nadchodzących latach. Właściwe ich opisanie pozwoliło na stworzenie spójnej prognozy rynku ładunków lotniczych, z wyliczeniem rzeczywistych tonokilometrów cargo na nadchodzące lata za pomocą prostej metody prognozowania na podstawie wielu zmiennych opartej na stworzeniu modelu opartego na danych historycznych. Artykuł kończy się podsumowaniem, które zawiera ogólny przegląd omawianych tematów.

Słowa kluczowe: ładunek lotniczy, analiza, prognoza.