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The Impact of COVID 19 on the Aviation Fuel Supply Chain in the Face of Changes in Air Traffic Service: Case Study of one of the Polish Airports

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Abstract

Purpose: *Establishing the relationship between the decrease in air traffic and the volume of aviation fuel supplies in the context of Covid-19pandemic.*
Design/Methodology/Approach: *To establish the relationship between the number of flight operations and the volume of fuel delivered to an airport, the best method is to determine the Pearson coefficient. The use of this coefficient is the most appropriate choice, as the correlation (interdependence of features) concerns the mutual relations between the number of air operations and the volume of aviation fuel deliveries to the airport [l]. Moreover, by analyzing the relationship between these variables by the correlation method, we obtain data in relation to the direction (trend) and the strength of the linear relationship, the impact of air traffic on fuel supplies to aircraft performing air operations.*
Findings: *The analysis of the data presented in the paper shows an increase in the strength of the relationship between the number of air operations performed and the volume of fuel deliveries in the pandemic period, compared to the period before the pandemic.*
Practical Implications: *The presented solutions may contribute to the optimization of fuel supply chain management in the aviation sector.*
Originality/Value: *The originality of the text is related to the innovative application of correlation analysis to optimize the management of fuel supply chains.*

Keywords: *Supply chain, fuel logistics, air transport market.*

JEL classification: *O18.*

Paper Type: *Research article.*

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1. Introduction

The first two decades of the 21st century were a period of the air transport boom. Every year, air traffic increased, and at the same time there was a more efficient use of means of transport. The main factors influencing such a dynamic increase in the dynamics of air transport were, among others: the development of the world economy measured by GDP growth and the reduction of air travel prices, higher income available to consumers, changing lifestyles, urbanization processes, as well as a higher level of people's qualifications (Groβ and Schröder, 2007).

With the appearance of the first SARS-CoV-2 virus infections and restrictions on the mobility of the population (including air transport) introduced in Poland in mid-March 2020, restrictions in the tourism sector, gastronomy, entertainment, shops and services, changes behavior among consumers were forced. The prevailing pandemic in Poland and in the world has also caused a number of changes in the demand and supply of both products and services.

The phenomenon of the pandemic has shown that disruptions in supply chains pose a threat to the functioning of not only end consumers but also thousands of enterprises in the supply chains (Marzantowicz, Nowicka, and Jedliński, 2020). The crisis has affected all market segments, including in particular tourist, occasional and, above all, business transport. The effects of the pandemic crisis led to total grounding and dysfunction of air transport (Wasowska, Wincewicz-Bosy, and Dymyt, 2021). Consequently, the operational activity of carriers and airports around the world was limited.

It should be especially emphasized that the year 2020 was marked by negative consequences for the entire air transport industry. The pandemic restrictions had a significant impact on economic aspects, including financial ones. In addition, operational data on the number of passengers transported during this period fell to 189 billion compared to 607 billion in 2019. At the same time, fuel consumption decreased from 359 billion liters in 2019 to 200 billion liters in 2020.

Aggregate revenues of commercial airlines decreased in the year 2020 by 55.5% compared to 2019. The operating loss of airline operators in 2020 amounted to USD -110.8 billion compared to the operating profit of USD 43.2 billion, and the ROIC ratio was -19.3% in 2020 compared to 5.8% for 2019 (IATA 2021). As a consequence, as a result of the pandemic crisis, the development of the whole was halted. Until now, it has been one of the fastest growing sectors of the global economy with an average growth rate of 5% per year (Merdivenci, Erturgut, and Coşkun, 2021).

In view of such drastic changes in the key indicators influencing the value of the aviation industry companies, the efficiency of both the resources used and the optimization of supply chains, including the most important one- aviation fuel, which is the subject of consideration in this paper. Supply chain management requires comprehensive accounting for all stages that demand coordination and synchronization of their operations at the same time (Leończuk, 2021). What is more, in the face of the progressive digitization of activities, enterprises on the one hand place emphasis on modern information systems, and on the other, on sustainable development, which leads to the integration of the supply chain, network globalization, but may also mean the need to undertake restructuring activities (Bal and Pawlicka, 2021).

The consequences of the actions of operators supplying aviation fuels is an appropriate response to changes in the market environment. Apart from the issues related to the emerging symptoms of the need to use sustainable fuels, the efficiency of the equipment and devices related to the supply of aviation fuels is of great importance in the logistics management processes. Airlines based at an airport depend to the greatest extent on the reliability of supplies and the price of fuel supplies, while other operators can more flexibly manage their operational planning. Some carriers use the so-called tankering (flying with a reserve of fuel that allows you to return without refueling at an "expensive" airport).

However, the use of tankering is an additional operational complication and affects the cost-effectiveness of the connections made. Tankering burns more fuel than necessary, thereby generating more emissions and distorting fair competition in the EU's air transport market. This practice not only runs counter to the European Union's efforts to decarbonise aviation, but also undermines healthy competition between aviation market players (European Commisson, 2021).

In this situation, the airport manager that wants to increase the attractiveness of his airport for all the customers (airlines, handling agents, fuel suppliers) should play an intermediary role between these parties. Due to the fact that the managing body does not usually participate in fuel trade, in most cases the impact on the fuel system operation model at the airport will be exercised by appropriate management of the fuel infrastructure critical for the operation of this system. It should be noted that there is no single, dominant model of supplying airports with fuel.

Specific solutions at a given airport depend on a number of factors, both internal, such as the size of the airport, its nature, ownership structure, and external - the structure of the fuel market and others. Nevertheless, in practice, some general, exemplary solutions have emerged that may constitute a significant inspiration for the Polish airport fuel supply market.

As for the delivery of fuel to the airport itself, most European airports have two alternative delivery routes. The most commonly used are pipelines and rail or road tankers. The fuel supply system is the result of cost-benefit calculations. While airports serving a smaller number of aircraft can function well using road tankers, it is uneconomical for larger airports. In the case of fuel storage and delivery, the operating model depends on the ownership and management structure of this infrastructure. If the airport's entire fuel infrastructure is owned, this gives it the broadest impact on that infrastructure and leads to the separation of infrastructure management and fuel trading functions. Regardless of the ownership structure, however, the fuel infrastructure should be managed in such a way as to, firstly, allow the supply of fuel from different manufacturers and that the aircraft refueling service (fuel delivery to the wing) can be carried out on a fair competition basis by more than one ground handling agent.

Public institutions, airlines and their associations have for years supported the development of competition in the field of aviation fuel supplies. B. Baca and his team state that the opening of the fuel market will not reduce the prices of the raw material and the logistic costs (Baca, Łyszyk, and Gościniarek, 2012). Such argumentation should be accepted, because effective management of the supply chain in the aviation sector may prove difficult to reconcile with the EU guidelines on the European Green Deal (European Commission, 2019).

2. Research Method

To establish the relationship between the number of flight operations and the volume of fuel delivered to an airport, the best method is to determine the Pearson coefficient. The use of this coefficient is the most appropriate choice, because the correlation (interdependence of features) concerns the mutual relations between the number of air operations and the volume of aviation fuel deliveries to the airport [l]. In addition, by analyzing the relationship between these variables by the correlation method, we obtain data in relation to the direction (trend) and the strength of the linear relationship (Lawner-Weinberg and Knapp-Abramowitz 2008) - the impact of air traffic on fuel supplies to aircraft performing air operations.

Knattar defines correlation as a statistical tool examining the relationships between two variables (Knattar, 2008). In numerical terms, the correlation analysis shows the Pearson's linear correlation coefficient (r or R), which is in the range [-1 to 1].

$$R=\frac{\sum(x-x\acute{s}r)(y-y\acute{s}r)}{\sqrt{(\sum(x-x\acute{s}r)^{2}\sum(y-y\acute{s}r)^{2})}} \quad (1)$$

where:
R > 0 - positive correlation (from 0 to 0.5 - weakly, from 0.5 to 1.0 - strong)
R < 0 - negative correlation (from 0 to 0.5 - weakly, from 0.5 to 1.0 - strong)

While the correlation shows the strength of the relationship between the variables, the linear regression shows the shape of such a relationship, it is used to predict unknown values of one variable based on the knowledge of others. ANOVA is used to study the effect of independent variable factors on the dependent variable (Darlington and Hayes, 2017).

In research on the relationship between aviation fuel supplies and aviation operations, the methods indicated are the most appropriate, as the relationships can be compared for two periods: before the Covid -19 pandemic (January 2015-February 2020) and during the pandemic (March 2020- November 2021).

The collected data on the supply of aviation fuel by one of the airports was analyzed on a monthly basis for two periods. On the other hand, data on air traffic, i.e., air operations, were made available by the Civil Aviation Authority for Poland (Civil Aviation Authority in Poland 2021). Due to the specific nature of the industry and the sensitive nature of the data - the information provider did not consent to the disclosure of the name of the airport.

3. Results

In 2015-2019, fuel supplies to aircraft operating at airports were at a stable level. Less air traffic at Polish airports in the winter months results in lower deliveries. In turn, during the summer holidays (June-September), in the analyzed period, there was an increase in air traffic, which was reflected in increased supplies of aviation fuel. Delivered of aviation fuel to one of Polish airportsin 2015-2021 is presentet in Figure 1. Figure 2 shows flight operations in Polish airports from 2015-2021.

Figure 1. *Deliveries of aviation fuel to a selected airport in 2015-2021. Source: Airport internal data*

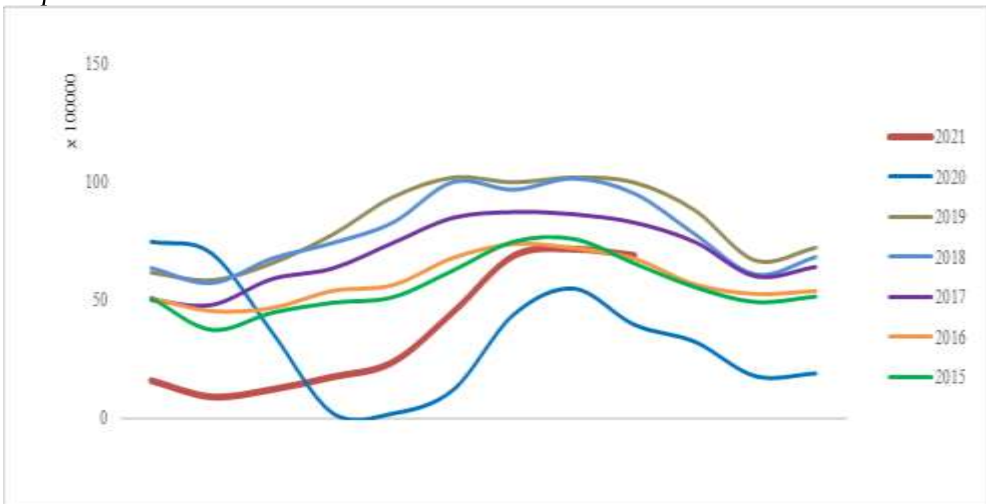
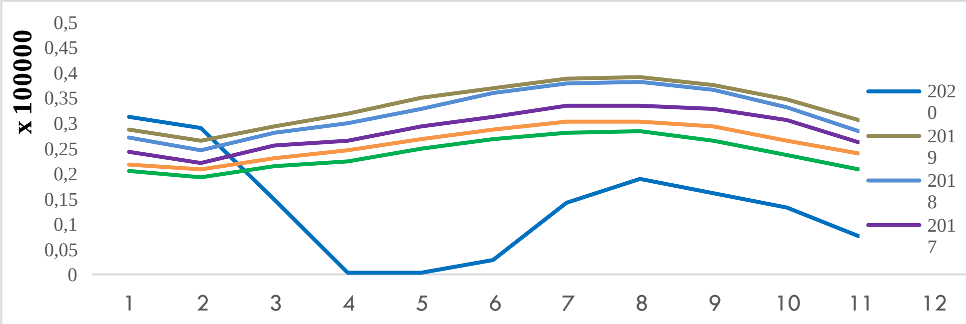
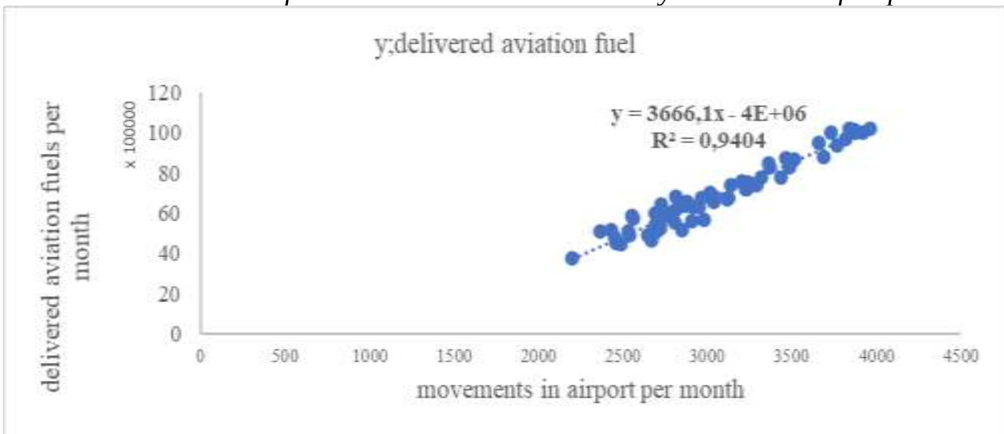


Figure 2. *Movements in Polish airport (2015-2020). Source: Airport internal data.*



On the other hand, in the years 2020-2021, during the period of the Covid -19 pandemic, there is a reduction in air traffic, which clearly affects the change in demand for aviation fuels. The relationship between air operations and the volume of deliveries before pandemic is shown in Figure 3.

Figure 3. *Relationship between the number of operations performed at an airport and the deliveries of aviation fuel before the pandemic (2015-2020). Source: own research based on data from the Civil Aviation Authority and the one of airport.*



The regression statistic and analysis of variance (01’2015-02’2020) is shown in Tables 1 and 2.

Table 1. *Regression Statistics*

Regression Statistics	
Multiples of R	0,97096986
R square	0,94278247
Matching R square	0,94181268
Standard error	410264,8
Observations	61

Source: *Calculations based on source data.*

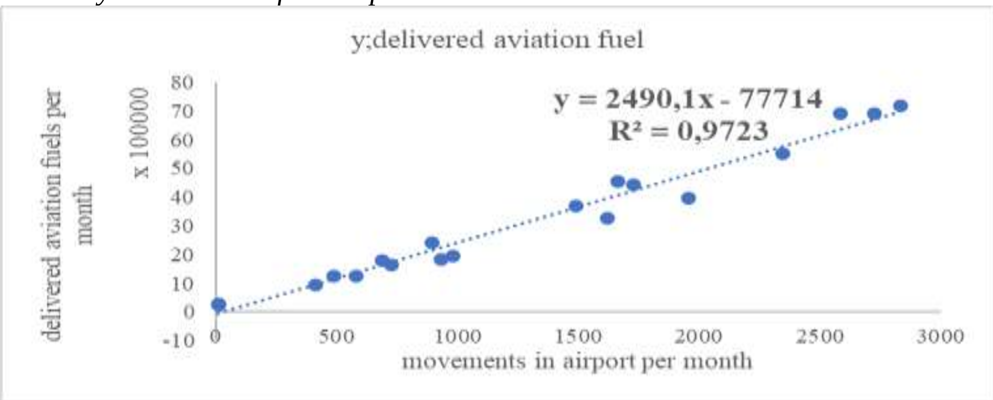
Table 2. *Analysis of variance*

	df	SS	MS	F	Relev of F			
Regression	1	1,6363E+14	1,6363E+14	972,152453	2,3667E-38			
Residual	59	9,9307E+12	1,6832E+11					
Total	60	1,7356E+14						
	Coefficients	Standard error	t Stat	Value of p	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intersection	-4473193,2	369678,362	-12,10023	1,2671E-17	-5212917,9	-3733468,5	-5212917,9	-3733468,5
x;movements	3711,19812	119,027401	31,1793594	2,3667E-38	3473,02484	3949,3714	3473,02484	3949,3714

Note: *df – degress of freedom, SS – sum of squares, MS – mean squares, F – Statistic F*
Source: *Calculations based on source data.*

The relationship between air operations and the volume of deliveries during pandemic is shown in Figure 4.

Figure 4. *The relationship between the number of operations performed at an airport and the deliveries of aviation fuel before the pandemic (March 2020-September 2021). Source: own research based on data from the Civil Aviation Authority and the one of the airport.*



The regression statistic and analysis of variance (03’2020-09’2021) is shown in Tables 3 and 4.

Table 3. *Regression Statistics.*

Regression Statistics	
Multiples of R	0,98602239
R square	0,97224014
Matching R square	0,97050515
Stndard error	398598,82
Obserwations	18

Source: *Calculations based on source data.*

Table 4. *Analysis of variance*

	df	SS	MS	F	Relevance of F			
Regression	1	8,9032E+13	8,9032E+13	560,371882	7,0123E-14			
Residual	16	2,5421E+12	1,5888E+11					
Total	17	9,1575E+13						
	Coefficients	Standard error	t Stat	Value of p	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intersection	-79318,368	164840,565	-0,4811823	0,63690134	-428764,75	270128,019	-428764,75	270128,019
x;movements	2489,47658	105,164673	23,6721753	7,0123E-14	2266,53743	2712,41573	2266,53743	2712,41573

Note: *df – degress of freedom, SS – sum of squares, MS – mean squares, F – Statistic F*
Source: *Calculations based on source data.*

For the period before the Covid 19 pandemic, the Pearson coefficient was R = 0.971, and for the pandemic period R = 0.986, which means a very strong relationship (close to 1) between the number of air operations and the amount of aviation fuel delivered to the aircraft at the airport under study. The positive slope of the curves (Figure 2 and Figure 3) shows a positive correlation, with the increase in the number of air operations, the volume of the delivered aviation fuel increases. The coefficient of determination R^2 for the pre-pandemic period was 0.943 and for the pandemic period $R^2 = 0.972$, which proves an even better adjustment of the amount of aviation fuel delivered to the performed air operations. The corrected coefficient of determination R^2_{adj} was, respectively: 0.942 and 0.971 for the analyzed periods, which confirms a very strong relationship between the fuel supplied and airplanes traffic at the airport.

4. Discussion

As a result of the analyzes of the relationship between air traffic (air operations) and the supply of aircraft fuel, a very strong relationship should be found, however, it is not the same in the period before the Covid-19 pandemic as in the period from March 2020 to September 2021. Reduced the demand for air transport services contributed to a more efficient management of the aircraft fuel supply chain, despite changes in the price level of aviation fuel on the global market (Figure 5).

According to IATA's jet fuel analysis, in mid-July 2020, jet fuel prices were 45% lower than a year earlier. Aviation fuel is the main expense for airlines, around 15-20% of total expenditure. With such low prices of aviation fuel, carriers should receive additional bonuses for using SAF, which is more expensive than traditional fuel (EASA 2021; EASA, Eurocontrol, and European Environmental Agency 2019). Such fuels, using sustainable sources, are considered "the only viable option to achieve a significant reduction in aviation emissions by 2050" (Josephs 2021) and this must be undoubtedly agreed. Changes in the structure of aviation fuels will contribute to the purchase of more fuel-efficient aircraft, which in turn will reduce CO_2 emissions.

Figure 5. *Fuel Jet & Oil Price (USD/barrel).*

Source: *IATA, Jet Fuel Price Monitor, October 2021.*

When analyzing the data presented in the Tables, the increase in the strength of the relationship between the number of air operations performed and the volume of fuel deliveries in the pandemic period, compared to the period before the pandemic is clearly shown. Hence, it can be concluded that a significant decrease in transport (visible mainly in passenger transport) and, consequently, a decrease in airport revenues significantly contributed to the optimization of resource management, such as fuel. It is also worth mentioning that there are several entities in the supply chain of aviation operations: fuel suppliers, ground service providers, airlines, airport managers, fuel infrastructure operators, with different or even conflicting interests.

Thus, a higher degree of alignment of fuel consumption with aviation operations may also mean greater efficiency in managing a complex supply chain and the conflicting interests of entities forming the supply chain (e.g. for an airline, the attractiveness of an airport increases with a decrease in the cost of aviation fuel, but for a supplier and a ground handling agent, fuel cost increases are more significant).

A stronger dependence between the number of performed air operations and the deliveries of aviation fuel are also factors contributing to the reduction of delivery costs while at the same time providing higher service to carriers (Bartle, Lutte, and Leuenberger 2021).

5. Conclusions

As a result of the analyzes of aviation fuel supplies to airports, it was found that as a result of changes in the environment caused by the pandemic crisis, more effective management of the aviation fuel supply chain took place. Although the demand for fuel is strictly dependent on the size of air operations, during the pandemic (March

2020 - until now) the process of managing fuel supplies to the airport was more effective than in the pre-pandemic period.

It is expected that as air traffic continues to increase, the linear correlation will approach the pre-pandemic period. It will certainly be a consequence of the greater dispersion of the entire aviation fuel distribution system.

The authors state that due to the pandemic situation and its impact on the aviation fuel market, there is a need to conduct (extend) research to reassess the use of fossil fuels and carbon dioxide emissions in air transport. It turned out that in the short term, there were areas where fuel consumption and related emissions decreased. This was a direct response to the crisis and is unlikely to last long, but a commitment to planning to reduce emissions from air travel, developing sustainable aviation fuel and investing in electric propulsion could become long-term solutions that will increase environmental sustainability.

Similarly, the data from the pre-pandemic and post-crisis periods can be used to reassess the balance of passenger to cargo flights, aircraft types and sizes, number of air operations and other logistics activities.

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