



Volume 122

2024

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: <https://doi.org/10.20858/sjsutst.2024.122.10>



Journal homepage: <http://sjsutst.polsl.pl>

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**Article citation information:**

Macioszek, E. Cargo transport on the example of a selected mode of transport in Poland. *Scientific Journal of Silesian University of Technology. Series Transport*. 2024, **122**, 181-197. ISSN: 0209-3324. DOI: <https://doi.org/10.20858/sjsutst.2024.122.10>.

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## CARGO TRANSPORT ON THE EXAMPLE OF A SELECTED MODE OF TRANSPORT IN POLAND

**Summary.** The article presents the problem of the cargo transport with the example of a selected mode of transport in Poland. The volume of goods transported by air transport in 2010-2021 was analysed. Cargo transport in air transport is very popular. From year to year, there is an increase in the volume of transported goods. The coronavirus pandemic, and the related economic crisis did not significantly affect cargo transport, as was the case with passenger transport, the number of which decreased significantly during the pandemic.

**Keywords:** air transport, transport, traffic engineering

### 1. INTRODUCTION

Air transport is one of the fastest, most expensive, and, at the same time, the safest forms of transport. This highly effective way of moving people, cargo, and information is a key element of Poland's economic infrastructure, as well as an interpretation of the development of the economy of the entire globe [6], [13]. The economic impact of this mode of transport is both indirect and direct, and its development is a dynamic and variable process. Transport itself, by reducing transport time and costs as well as increasing the speed and volume of flows, affects the accessibility of markets, even those with an increasingly large spatial range [15], [16], [19], [32].

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The market, in turn, is defined in the scientific literature as an economic institution enabling the exchange of goods, services, and production factors [9], [20], [28]. The structure of the market is determined by the number of buyers and sellers, which is of great importance for its functioning. The more participants there are, the weaker their position on the market. The market can be considered on many economic levels. One of them is the air transport market. When explaining the concept of the air transport market, one should bear in mind the aspect of its functioning because it can be referred to as a place, process or even space [1], [27], [36].

According to the definitions [14], [29], [37], the air transport market is a place, process, space, situation, sector, mechanism or set of conditions in which the company operates and in which it defines its potential rivals as well as actual and potential buyers, sellers offering air transport services for sale, and buyers requesting specific air transport services, supported by an appropriate purchasing fund. The air transport market is also defined as an economically and organizationally coherent structure governing and regulating according to specific rules and principles. There is an exchange of value of services and information on the market; there are negotiation and competitive processes on the branch and inter-industry scale [25], [30, 31]. There are many entities on the air transport market, both internal and external, which to a greater or lesser extent affect its operational activity. The main entities present in the air transport market include [31]:

- aviation organizations (international, state, private),
- airlines,
- carriers,
- airports,
- organizations cooperating and supporting services (travel agencies, tourist agencies, etc.),
- capital groups related to air transport,
- manufacturers of aviation equipment, aircraft, infrastructure, and other equipment used in this type of activity,
- other producers providing services to carriers and airports,
- demand buyers (institutional and natural persons).

All entities operating within the market share similar features that enable the creation of a common air transport environment and allow the regulation of buyers' behavior. The aforementioned air transport environment can be divided into several smaller markets, called sub-markets. This confirms how extensive the mode of transport is air transport. The air transport market is multi-level, which provides it with a number of opportunities and gives it an advantage over other carriers or modes of transport. It is worth mentioning that despite the continuous technological and economic development over the years, the factors taken into account for the division into sub-markets do not change significantly and remain valid [13], [43].

The article presents the problem of the cargo transport on the example of a selected mode of transport in Poland. The volume of goods transported by air transport in 2010–2021 was analysed. After the introduction, the second section contains the characteristics of air transport in Poland. Then, in the third section, the principles and ways of transporting cargo by air are presented. In turn, the course of the transport process for cargo in air transport is presented in the fourth section. The fifth section contains an analysis of the cargo transport volume in Polish airports. The last, sixth section contains a summary and conclusions from the analyzes carried out in the article.

## 2. AIR TRANSPORT IN POLAND

Dynamic changes related to the development of the air services market were initiated with Poland's accession to the European Union, which forced the liberalization of regulations related to access to the Polish market by carriers from EU countries and vice versa. Since then, the air transport services market has become part of the European and global transport systems, additionally enriched by three Open Sky policy packages [10], [39].

Among the other benefits resulting from Poland's integration with the European Union, the following can be distinguished [36]:

- development of passenger service by air carriers and airports,
- high involvement of foreign air carriers,
- competitive processes in the aviation market,
- investment processes in air transport companies,
- greater involvement of regions in the development of air transport,
- development of the network of connections.

Another breakthrough moment for Polish civil aviation was 2007, when the number of passengers and goods served at airports significantly increased, as well as the number of air operations performed. Since that year, the number of entities holding concessions for air transport has been successively increasing, including the share of low-cost carriers [39]. The range of air services in Poland is quite diverse and conditioned by many factors. Currently, there are several dozen air carriers operating in Poland on all routes, both domestic, continental, and non-European. Some of them have their headquarters in Poland, and some are abroad. The former are authorized to provide their services based on a license issued by the Civil Aviation Authority (CAA), and the others on the basis of certificates of their country, bilateral agreements or an open skies agreement. Other differences between carriers' concern, among others, size, form of ownership, capital structure, and fleet of aircraft owned. Carriers on the air transport services market perform regular and charter flights or operate the so-called little air traffic. However, the largest share in the Polish market (about 80%) is held by regular transport [35]. Among the entities holding the CAA concession for conducting business in the field of air transport, the following companies can be mentioned: Enter Air, Ibex U.L., PLL LOT, Sky Taxi, AMC Aviation, Travel Service Poland, Smart Jet or Sprintair Cargo. PLL LOT remains the largest Polish carrier, which has been systematically expanding its network of connections since 2016, fearing growing competition [35].

When characterizing air transport, one should mention its infrastructure, which includes linear and point elements. The first group is the airspace, divided vertically and horizontally into air corridors, along which aircraft can move at a certain distance from each other and at a certain time interval [18]. As for the point infrastructure of air transport, it includes all airstrips and airports, without which the operation of air carriers would not be possible. Fifteen airports are currently located in Poland. These are:

- Warsaw Airport (WAW),
- Kraków-Balice Airport (KRK),
- Airport Gdansk (GDN),
- Katowice-Pyrzowice Airport (KTW),
- Wrocław-Starachowice Airport (WRO),
- Warsaw/Modlin Airport (WMI),
- Poznań-Ławica Airport (POZ),
- Rzeszów-Jasionka Airport (RZE),

- Szczecin-Goleniów Airport (SZZ),
- Lublin Airport (LUZ),
- Bydgoszcz Airport (BZG),
- Lodz-Lublinek Airport (LCJ),
- Olsztyn-Mazury Airport (SZY),
- Zielona Góra-Babimost Airport (IEG),
- Radom-Sadków Airport (RDO).

In accordance with the classification provided by the European Union guidelines, airports have been divided into central, regional and local airports. There is also a second division that distinguishes four categories of airports: A, B, C and D, depending on the number of passenger flights per year. Regardless of the size of the airports, each of them is assigned a three-letter alphanumeric IATA (International Air Transport Association) code. The largest airport in Poland is the Chopin Airport in Warsaw. It is a central airport that handled over 18.8 million passengers in 2019. In second place in terms of the number of passengers served is Kraków-Balice Airport, with 8.4 million passengers. Subsequently, good results were achieved by the following ports: Gdańsk (5.36 million), Katowice-Pyrzowice (4.84 million), Wrocław-Starachowice (3.49 million), Warszawa-Modlin (3.1 million), and Poznań-Ławica (2.37 million) [40]. Other regional airports in Poland usually do not exceed 1 million passengers per year.

The air transport market is, on the one hand, an area of advanced cooperation and, on the other hand, an arena of strong competition. The competition present in every sector of the economy consists of the competition of independently operating entrepreneurs aiming at achieving similar economic goals. This competition is between two (or more) parties called competitors. These are entrepreneurs who currently or potentially introduce or purchase goods on the relevant market at the same time [34]. In the air transport market, competitors can be all entities operating within it, which, generally speaking, will compete for customers and benefits resulting from specific relationships. However, the main group of competitors in the air transport market are carriers and airports. They compete in order to maintain or, more often, to increase their position in the market. Carriers providing air transport services compete for buyers, ticket prices, the market position of entities on the supply side, and the quality of services provided. In turn, the subject of competition of airports may be, for example, carriers, buyers of air services, fly connections or funds for development. Sometimes competition takes on an unfair character because it is motivated, for example, by the desire to achieve a monopoly and exclude others, especially smaller players. Therefore, air carriers enter into various types of agreements and alliances that favor internal coordination of activities and, more importantly, help to use labor resources more efficiently and protect market interests [31]. An example of such integration may be strategic alliances, which are popular among carriers, i.e., relationships between enterprises aimed at achieving a common goal [32].

Airports also take all measures to strengthen their market and competitive position. These entities mainly conclude agreements with carriers, but also, for example, with airport security services or border guards. The functioning of all these entities on the market depends on many political, social, and economic factors. When talking about both intra-industry and inter-industry competition, one should also remember about formal restrictions on access to the air transport market, i.e., the so-called market entry barriers, which include restrictions of [31]:

- formal and legal,
- technical and technological,
- operational,

- economic (mainly capital),
- qualitative in the process of educating services,
- resulting from the image of the airline.

Air transport is undoubtedly a pillar of the global economy on which the activities of many other industries depend. It is not without reason that for years there has been a close relationship between the rate of growth of air passenger transport and the rate of economic growth of the world's major economies [38]. The development of the air transport industry is inevitable. It is expected that in the coming years the air transport market will undergo many changes regarding, for example, its shape or functioning. Further development of air transport will be shaped by endogenous (working environment), and exogenous (contextual environment) factors. Endogenous factors include [32]:

- technological development,
- organization of the market,
- microeconomic relations,
- legal regulations.

On the other hand, exogenous factors include [32]:

- demographics,
- globalization,
- economy,
- random factors.

The development of the air transport market should therefore be considered from a global perspective, as the changes that follow it affect various aspects of everyday life, including the natural environment. In order to reduce the negative impact of air transport development on individual areas of economic, environmental, and social policy, the Renewed Sustainable Development Strategy of the European Union was adopted [32]. Development forecasts until 2030 indicate that the Polish air services market has quite a large development potential. The task of the relevant services, institutions and state authorities is to care for balanced and sustainable development, taking into account safety standards and pro-ecological activities for the natural environment.

### **3. CARGO TRANSPORT BY AIR**

The strong position of air transport as the main element of the infrastructure of the modern world economy results not only from the migration needs of society, but also from the choice of this type of transport as a method of delivering goods. Cargo air transport is a noticeable part of the supply chain and takes part in its individual processes, ensuring consistency and flexibility of operation. This air transport link in the supply chain participates in the creation of its value and, more importantly, has the ability to adapt to the constantly changing environment [42].

In fact, transporting goods by air looks a bit less promising. In terms of the transported cargo weight, air transport, compared to other modes of transport, has a slightly smaller share in servicing the international exchange of goods. It is not yet the most popular form of distribution among exporters and importers, which is mainly due to the costs, which often exceed the value of the transported products. The transport of goods by air transport is not door-to-door (d2d).

For this reason, in addition to the basic costs directly related to the flight itself, the air transport process generates a number of other indirect costs in the form of supplementary activities, such as the delivery of goods to and from the airport. In addition to the high cost of the service, this type of transport of goods is associated with other limitations, including the capacity of aircraft, which limits the size and weight of the cargo, and high dependence on weather conditions [18].

Comparing all modes of transport, there is no doubt that air transport is by far the fastest form of transport. It is the time of operation that is the greatest and strongest advantage of air transport. Thanks to the high-speed and collision-free conditions of movement, it allows cargo or the service to quickly reach the designated destination, which in some cases becomes crucial due to the specificity of the transported cargo or the service itself. In addition, air transport has other significant features, such as safety, regularity of deliveries or geographical coverage. It is considered the safest means of transport, for which distance is not a barrier. All these fundamental advantages that distinguish air transport ultimately determine the choice of this form of flow of goods and, at the same time, contribute to the further development of global logistics [42].

Cargo air transport plays a very important role in the international exchange of goods. In the 21st century, where time is of the essence, this type of delivery of goods allows for meeting the challenges posed by even the most demanding customers. Under the term cargo, there is a practically unlimited assortment of cargo that can be shipped to any point on the globe [17].

Various types of goods are transported by air transport, ranging from ordinary luggage with everyday items, through mail and courier parcels to animals or even cars. Quite a large group of loads are postal items, which account for about 15% of the total freight. Definitely, however, due to the very strong time-space compression, and a high degree of safety, air transport is often used to transport products with a short shelf life and fragile, delicate products that are highly sensitive to shocks [23].

The objects of transport in the air transport are most often [33], [42]:

- perishable goods,
- goods of increased value,
- goods that expire quickly,
- goods sensitive to transport, e.g. electrical and electronic equipment,
- components and semi-finished products for production,
- oversized loads, e.g. machines, cars, metal articles, automotive equipment and its spare parts,
- groceries, e.g. vegetables and fruits,
- plants, e.g. cut flowers,
- pets,
- clothes,
- goods of small weight and volume,
- post and express mail.

As in any mode of transport, in air transport there is also the transport of hazardous materials. It is with regard to these types of goods that the requirements of air transport become the most restrictive, as the hazardous materials present on board the aircraft may pose a real threat to passengers and/or crew [26]. The transport of hazardous materials is subject to numerous, restrictive national and international requirements, including the provisions of the IATA DGR, which must be met in order for such a flight to take place at all. In addition, in order to carry out such an operation, it is necessary to obtain the consent of the countries that will participate in it. Such a transfer is usually carried out by cargo planes, and safety in this area is constantly monitored by the International Civil Aviation Organization (ICAO), and IATA [33], [42].

Cargo loads in Poland are divided into two groups (possibly three, if post will also be included). These are: cargo road feeder service (RFS), cargo on board, and possibly a third group, i.e., cargo mail. Cargo RFS are loads transported using the RFS technology, in which the intermediation of hubs is key. According to the assumptions of this method, the freight is transported on trucks, then cleared at the airport, and finally placed on the plane. Such a transport technique is classified as unconventional transport. On the other hand, cargo on board is cargo transported in the cargo space of aircraft [33], [42].

Air cargo transport is carried out using aircraft. Aircraft are classified on the basis of certain criteria, i.e., purpose, construction, or size. Due to the purpose of the aircraft, the aircraft can be divided into [18]:

- passenger planes,
- cargo planes,
- civil aircraft,
- private planes,
- military aircraft.

Due to the construction, aircrafts can be divided into [18]:

- narrow-body aircraft,
- wide-body aircraft.

Specialized cargo planes, typically intended for the transport of cargo, were created in response to various needs that create demand. These planes are called freighters or cargo planes and are characterized by a special design and systems supporting the processes of loading and unloading goods, making them suitable for handling a variety of non-standard goods. Many of them are former passenger planes, which, due to certain aspects of economics, have been rebuilt and configured as cargo planes. Cargo planes are most often used in the transport of oversized shipments because they have a load capacity of up to 250 tons. Cargo planes are also used to transport general cargo [13].

Examples of the possibilities of a single-load transport for individual cargo planes are as follows [33]:

- Airbus A 300 cargo - loading capacity 45 tons,
- Boeing 767 cargo - loading capacity 60 tons,
- McDonnell MD 11 - loading capacity 80 tons,
- Antonov An-124 - loading capacity 110 tons,
- Boeing 747 cargo - loading capacity 11 tons,
- Antonov An-225 - loading capacity 250 tons.

Choosing the right type of transport aircraft for a specific cargo transport, apart from the loading capacity, it is worth paying attention to other equally important auxiliary parameters, which include [42]:

- the size of the cargo hold,
- transport speed,
- range,
- systems supporting loading and unloading,
- type of engines,
- impact on the natural environment.

Antonov aircraft manufactured in Russia and Ukraine have very good transport parameters and very good economic indicators. These are the most popular and, at the same time, the most recognizable cargo planes, designed to transport the most demanding freight. The largest, currently used and heaviest aircraft in history is the Antonov An-225 Mrija [42]. However, taking into account the regularity of flights, the largest cargo plane in Poland is the plane of the American carrier UPS - McDonnell Douglas MD-11F. This plane, with the power of three engines, is able to take on board 36 containers, the loading of which usually takes only 50 minutes [33].

Carriers of PLL LOT, Lufthansa, Emirates, and Qatar Airways are leaders in the transport of cargo in Poland. According to statistics, the popular and reliable carrier Lufthansa Cargo specializes in RFS flights. Lufthansa Cargo in Europe serves over 75,000 loads per year.

For the transport of goods, not only specialized cargo planes are used, but also the lower baggage hatches of passenger planes. Currently, with a not very large overall supply of cargo, over 50% of the load weight of cargo transport is transported in this way, both by regular and charter traffic. This is one example of a sustainable development strategy that prevents underutilization of aircraft cargo space, reduces the number of flights, and thus reduces costs. Passenger planes can take on board from 2 to 12 tons of cargo [13].

In order to carry out the process of transporting goods by air transport, not only various types of aircraft are used, but also various types of devices, systems, and facilities operating on land. The key role is played by the technical facilities and services provided by airports. While there should be no problems with cargo handling by passenger planes, certain limitations may arise in the case of larger planes. Not all airports are adapted to handle large transport aircraft, and do not have the required infrastructure, such as, for example, a runway of appropriate length. Airports authorized to handle cargo aircraft should have the following characteristics [33]:

- availability of specialized equipment used for loading and unloading oversized shipments,
- optimal location,
- facilitating the customs procedure in the transit of goods within the EU countries,
- attractive rates of airport charges,
- good cooperation on the part of the airport manager or handling agent,
- the ability to handle aircraft, and perform air operations around the clock.

A characteristic element of the point infrastructure of each airport is the airport terminal, i.e. a building or a complex of buildings intended for ground handling and organizational activities related to air transport. Airports that want to participate in the exchange of goods by air must additionally have a cargo terminal, called a cargo terminal. A cargo terminal is a warehouse facility usually located in front of the apron of transport aircraft, which, thanks to the use of modern systems and technological solutions, helps in the efficient and effective handling of goods, enables their loading, unloading, and temporary storage. During the implementation of these processes, devices and technical means of internal transport are used, such as, for example, transport trolleys, cranes, conveyors, lifts, palletizers or depalletizers. In such a terminal there are also other specialized vehicles used to move pallets and containers from the airport apron, such as cargo transporters, the carrying capacity of which is up to 7 tons [18].

At airports, apart from terminal buildings, air traffic control towers, car parks, and other technical buildings, there are also other necessary elements of airport infrastructure, such as runways with the required parameters, aprons, exit/access roads, equipped with horizontal and vertical signs, radar, signaling devices or aircraft lighting and guidance systems [44]. The Polish leaders in handling cargo traffic are currently two airports: International Airport F. Chopin in Warsaw and International Airport Katowice-Pyrzowice, which has the most modern cargo



terminal. Together, these airports are responsible for over 90% of all operations of this type performed in Poland [40].

#### 4. THE COURSE OF THE CARGO TRANSPORT PROCESS IN AIR TRANSPORT

The implementation of the cargo transport by air transport is preceded by a number of necessary activities performed on land. Most of them take place in the cargo terminal, whose main task is the forwarding and storage of goods. The functioning of the air cargo terminal is based on the division into two service zones: the generally accessible land side zone, where the delivery and collection of goods takes place, and the internal air side zone, where transport from the apron takes place [21]. The organizational activities preparing the goods for the flight include customs, forwarding, and logistic services.

The service of air transport of goods or people, like any other transport service, is carried out according to certain accepted rules and requires the preparation of appropriate documentation. In the case of air transport, these rules are established, among others, on the basis of the Transport Law of November 15, 1984, and the Regulation of the Minister of Transport of June 21, 1985 [24]. However, the most important legal act in force in air transport is the Act of 03.07.2002 - Aviation Law. This act covers all key issues concerning Polish civil aviation and even, to some extent, foreign civil aviation [8].

The provisions of international law resulting, inter alia, from the Warsaw Convention, which was supplemented in The Hague Protocol, as well as from the Chicago Convention, are also of great importance. The Chicago Convention contains the Dangerous Goods Regulations, i.e., a set of regulations regulating the manner of transporting dangerous goods by air, applicable in all IATA member countries [8].

The basis of each flight is the contract that the carrier concludes with the customer. In the case of the transport of goods, such a contract is a bill of lading. The group of transport documents in the international air transport of goods consists of such forms as:

- air way bill (AWB),
- cargo manifest,
- cargo transfer manifesto,
- loading sheet.

Air way bills are standard and necessary documents completed in connection with the carrier's commitment to deliver specific goods to the place specified by the principal. In order to facilitate the procedures related to the entire transport process, forwarders use two types of letters: Master Air Way Bill (MAWB), and House Air Way Bill (HAWB). The first one allows sending a consolidated shipment, determines its value, and is listed as the sender. On the other hand, the forwarder's House Air Way Bill is prepared for the MAWB letter and contains detailed information about individual goods integrated into a collective shipment [21].

Commonly used documents are also cargo manifests, which present the number of consignments planned directly for a given flight in international traffic, together with numbers and all information enabling their identification. On the other hand, the security issues introduced the so-called load sheets for "on-deck" load distribution to control proper airplane trim. According to IATA recommendations, carriers often use additional documents, such as lists of shipments, boardings, documents related to special transport, or even NOTOC notes informing the captain of the aircraft about loaded goods [21].

Most of the documentation is issued and saved in electronic form, using the E-freight platform. In 2010, this system already covered 2/3 of all possible documentation, including the e-AWB air waybill. Handling cargo transport via the Internet mainly means lower costs and significant time savings. Thanks to one-time data entry, E-freight increases the accuracy and reliability of operations and speeds up service [22].

In the transport of goods by air, as in other modes of transport, the so-called Incoterms are used. Developed by the International Chamber of Commerce (ICC), a set of established international rules shows the rights and obligations of all parties to a sales contract. The provisions concern, among others, packaging, transport, insurance, customs documentation, fees, and risk transfer. Incoterms 2010 consists of 13 trade formulas, marked with a three-letter abbreviation, divided into four groups (E, F, C and D) and two categories:

- for all means and modes of transport,
- for sea and inland waterway transport.

These formulas significantly affect the relations between shippers and carriers, although they do not directly regulate them [7].

## 5. ANALYSIS OF THE CARGO TRANSPORT VOLUME IN POLISH AIRPORTS

On the Fig. 1 the volume of cargo on board handled at Polish airports in domestic and international traffic in 2010-2021 have been presented. On the basis of the presented data, it can be concluded that in the subsequent years of the analysis, the size of the cargo on board systematically increases with two exceptions. The first covers the period 2013-2015, while the second covers the period of the beginning of the covid-19 pandemic, i.e. 2020 year. The negative impact of the pandemic on the air transport sector has already been confirmed in many scientific works [2-5], [11].

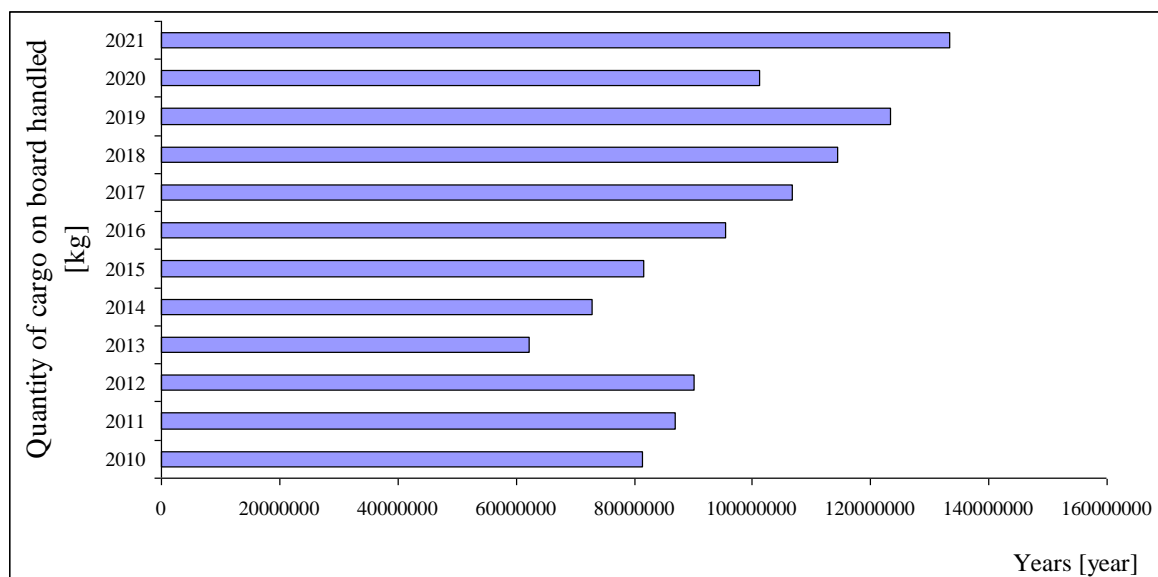
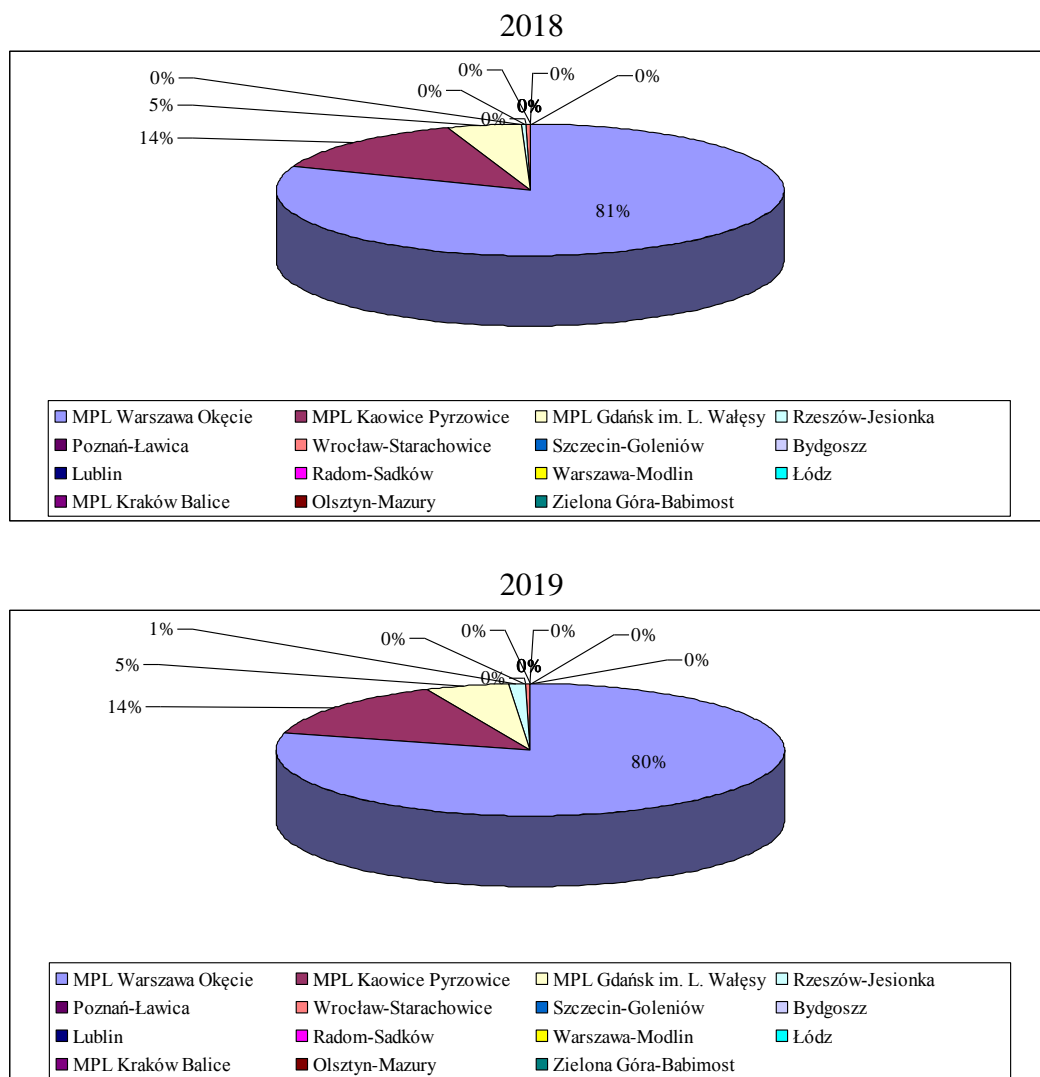


Fig. 1. The volume of handled cargo on board (in kg) at Polish airports in domestic and international traffic in 2010-2021

Source: own research based on data presented by the Civil Aviation Authority in Poland [40]

On the other hand, Fig. 2 shows the share of handled cargo on board in Polish airports in domestic and international traffic for the last four years. Based on the presented data, it can be concluded that in each of the analyzed years, International Airport Warszawa-Okęcie has the largest share in the handling of cargo transport in Poland. This share, depending on the year of analysis, ranges from 73% to 81%. Then, in terms of the volume of cargo handled, International Airport Katowice-Pyrzowice ranks. In this case, the share, depending on the year of analysis, ranges from 14% to 18%. The share of cargo transport in other Polish airports is small and varies from 5% to 9% depending on the year. Both International Airports Warszawa-Okęcie and MPL Katowice-Pyrzowice handle in total from 91% to 95% of cargo on board in Poland.



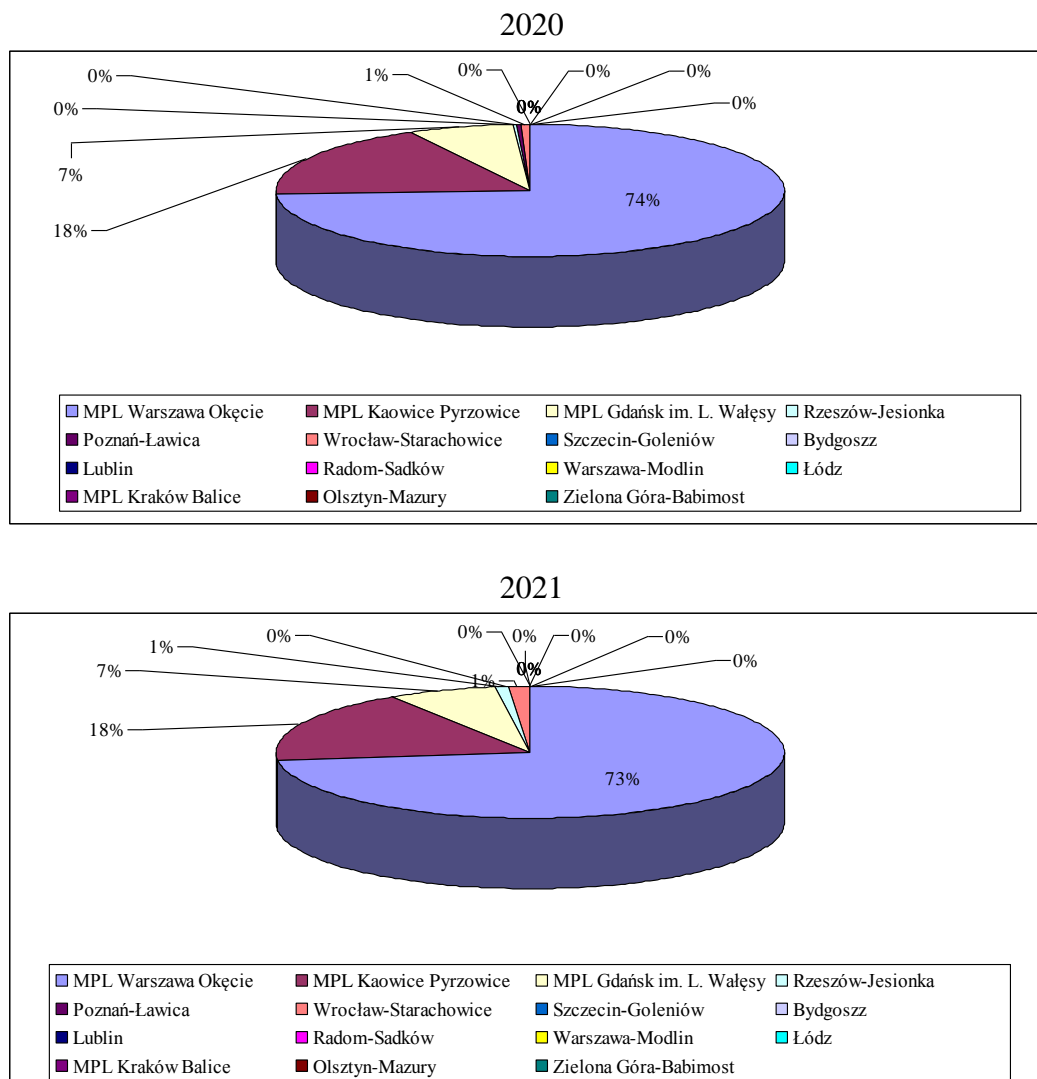


Fig. 2. Share of handled cargo on board (in kg) at Polish airports in domestic and international traffic in 2018-2021

Source: own research based on data presented by the Civil Aviation Authority in Poland [40]

The dynamics of changes in handled cargo on board at Polish airports in domestic and international traffic in 2012-2021 were also analyzed. The volume of handled cargo on board is the basic characteristic of cargo transport at each airport. It is subject to constant changes, which reflect the socio-economic situation of a given area. Knowledge of the pace of changes in the volume of handled cargo on board allows for better adjustment of the activities carried out at a given airport. They may concern, among others, investments in infrastructure, modernization of resources, human resources, administration of the flow of goods, applied technologies, but also many other matters related to the functioning of a given airport. Based on the data presented in Fig. 3, it can be concluded that, except for 2020/2019, when a negative indicator was recorded, in the remaining years of the analysis, the indicator characterizing the dynamics is positive, which indicates an increase in handled cargo on board at Polish airports in domestic and international traffic in 2012-2021.

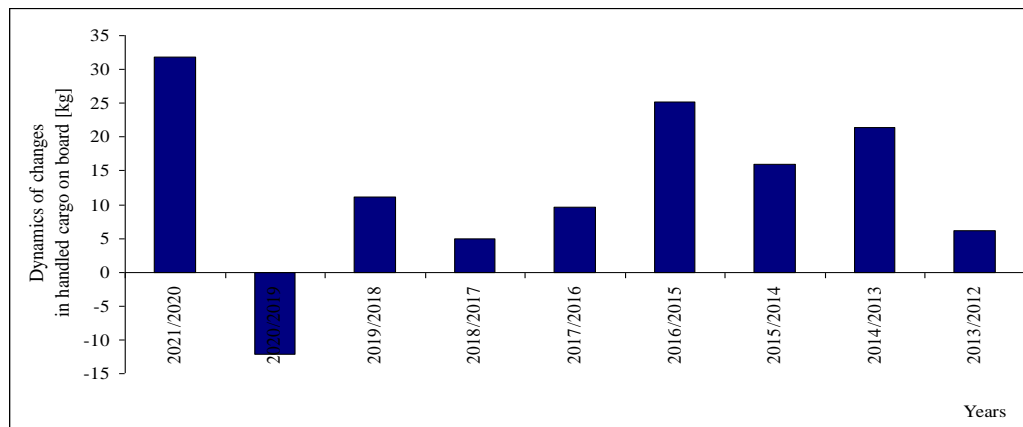


Fig. 3. Dynamics of changes in handled cargo on board (in kg) at Polish airports in domestic and international traffic in 2012-2021

Source: own research based on data presented by the Civil Aviation Authority in Poland [40]

## 6. SUMMARY AND CONCLUSIONS

The article presents the problem of the cargo transport with the example of a selected mode of transport in Poland. The volume of goods transported by air transport in 2010-2021 was analysed. Cargo in air transport is very popular, which can be seen from the statistics of the weight of the handled cargo over the years. From year to year, there is a regular increase in the volume of transported cargo. The coronavirus pandemic, and the related economic crisis did not significantly affect cargo transport, as was the case with passenger transport, the number of which decreased significantly during the pandemic. According to the statistics of the IATA organization [41], in 2021, the demand for cargo exceeded the volume from 2019 (i.e., before the Covid-19 pandemic) by 8%. The World Trade Organization forecasts an increase in global trade of 5.6% in the coming years. In addition, IATA estimates that the total losses of air carriers from 2020-2022 may exceed \$200 billion. The scale of the phenomenon is therefore huge, and its effects will probably be felt for a long time and will affect many aspects.

For the purposes of work related to planning the future of the air transport cargo industry, the IATA organization has created a special program operating under the name Future Air Cargo Executives (FACE). This program brings together approximately 60 members of the air supply chain, led by outstanding leaders in this field. Future Air Cargo Executives presented a vision of development until 2030, in which aspects of emerging new technologies and trends were discussed along with their impact on existing processes and workforce. FACES Vision 2030 predicts the most significant changes in the area of technology, which, in addition to its own transformation, will also serve as the main factor initiating other changes. Among the breakthrough technological discoveries that will contribute to the development of cargo transport in aviation, FACE indicates such tools as [12]:

- augmented reality (AR),
- artificial intelligence (AI),
- robots and robotic systems,
- molecular monitoring (Screening Devices),
- Internet of Things (IoT),
- drones and airships.

## References

1. Atallah Stephanie, Hotle Susan L., Mumbower Stacey. 2018. The evolution of low-cost Carrier operational strategies pre- and post-recession. *Journal of Air Transport Management* 73: 87-94. ISSN: 1873-2089. DOI: 10.1016/j.jairtraman.2018.08.011.
2. Alberts Sascha, Rundshagen Volker. 2020. "European airlines' strategic responses to the covid-19 pandemic (January-May, 2020)". *Journal of Air Transport Management* 87: 1-7. ISSN: 1873-2089. DOI: 10.1016/j.jairtraman.2020.101863.
3. Abate Megersa, Christidis Panayotis, Purwanto Alloysius Joko. 2020. "Government support to airlines in the aftermath of the covid-19 pandemic". *Journal of Air Transport Management* 89: 1-15. ISSN: 1873-2089. DOI: 10.1016/j.jairtraman.2020.101931.
4. Amankwah-Amoah Joseph. 2021. "Covid-19 pandemic and innovation activities in the global airline industry: A review". *Environment International* 156: 1-7. ISSN: 1873-6750. DOI: 10.1016/j.envint.2021.106719.
5. Amankwah-Amoah Joseph. 2020. "Note: Mayday, Mayday, Mayday! Responding to environmental shocks: Insights on global airlines' responses to covid-19". *Transportation Research Part E: Logistics and Transportation Review* 143: 1-9. ISSN: 1366-5545. DOI: 10.1016/j.tre.2020.102098.
6. Button Kenneth, Taylor Samantha. 2000. "International air transportation and economic development". *Journal of Air Transport Management* 6(4): 209-222. ISSN: 1873-2089. DOI: 10.1016/S0969-6997(00)00015-6.
7. Cybulska Daria, Jarosław Stolarski. 2017. *Organizowanie i monitorowanie procesów transportowych. Kwalifikacja A.31.1. Podręcznik do nauki zawodu technik logistyk*. Warsaw: WSiP. ISBN: 9788302149788. [In Polish: *Organizing and monitoring transport processes. Qualification A.31.1. Handbook for learning the profession of a logistics technician*].
8. Deja Marcin, Wojciech Matysiak, Paweł Ślizewski. 2015. *Organizowanie środków technicznych w celu realizacji procesów transportowych. Kwalifikacja A.31.2*. Warsaw: WSiP. ISBN: 9788302149795. [In Polish: *Organizing technical means to carry out transport processes. Qualification A.31.2*].
9. Di Vaio Assunta, Luisa Varriale. 2020. "Blockchain technology in supply chain management for sustainable performance: Evidence from the airport industry". *International Journal of Information Management* 52: 1-16. ISSN: 1873-4707. DOI: 10.1016/j.ijinfomgt.2019.09.010.
10. Dominguez C.C. Marta, C. Casanueva, A. Gallego. 2021. "Tourist destinations and cooperative agreements between airlines". *Journal of Destination Marketing & Management* 20: 1-10. ISSN: 2212-571X. DOI: 10.1016/j.jdmm.2021.100613.
11. Fontanet-Perez Pol, Xose H. Vazquez, Diego Carou. 2022. "The impact of the covid-19 crisis on the US airline market: Are current business models equipped for upcoming changes in the air transport sector?". *Case Studies on Transport Policy* 10(1): 647-656. ISSN: 2213-6258. DOI: 10.1016/j.cstp.2022.01.025.
12. Future Air Cargo Executives. Faces vision for air Cargo in 2030. Available at: <https://sway.office.com/s1YaCALy1w8dIQBC>.
13. Frankiewicz Kamila, Bartłomiej Dzwonnik. 2021. „Przewóz towarów cargo w transporcie lotniczym w Polsce”. *O AFL Studenckie czasopismo internetowe* 2(1): 1-16. ISSN: 2544-4662. [In Polish: "Transportation of cargo in air transport in Poland". *O AFL Student Internet Journal*].

14. Hoyos Diana Tascón, Oscar Diaz Olariaga. 2020. "Behavior of air passenger demand in a liberalized market". *Transport and Telecommunication* 21(1): 1-14, ISSN: 14076179. DOI: 10.2478/ttj-2020-0001.
15. Jacyna Marianna, Mariusz Wasiak, Konrad Lewczuk, Michał Kłodawski. 2014. "Simulation model of transport system of Poland as a tool for developing sustainable transport". *Archives of Transport* 31(3): 23-35. ISSN: 0866-9546. DOI: 10.5604/08669546.1146982.
16. Kaczorek Maciej, Marianna Jacyna. 2022. "Fuzzy logic as a decision-making support tool in planning transport development". *Archives of Transport* 61(1): 51-70. ISSN: 0866-9546. DOI: 10.5604/01.3001.0015.8154.
17. Kamosiński Sławomir. „Przewozy ładunków drogą lądową w Polsce w latach 1945-1989 i po przełomie ustrojowym 1989 r. Zarys problemu”. [In Polish: „Overland cargo transport in Poland in the years 1945-1989 and after the political breakthrough in 1989. Outline of the problem”].
18. Kaźmierczak Maciej, Jan Szymczyk. 2019. „Zarządzanie logistyczne w cywilnym transporcie lotniczym artykułów chłodzonych i głęboko mrożonych z zachowaniem zimnego łańcucha dostaw”. *Gospodarka Materialowa i Logistyka* 10: 277-300. ISSN: 1231-2037. DOI: 10.33226/1231-2037.2019.10.19. [In Polish: “Logistics management in civil air transport of refrigerated and deep-frozen products with the preservation of the cold supply chain”. *Materials Management and Logistics*].
19. Kruszyna Maciej. 2021. “Investment challenges pertaining to the achievement of the goals of the Mobility Policy based on the analysis of the results of traffic surveys in Wrocław”. *Archives of Civil Engineering* LXVII(3): 505-523. ISSN: 1230-2945. DOI: 10.24425/ACE.2021.138068.
20. Ku Edward C.S. 2022. “Developing business process agility: Evidence from inter-organizational information systems of airlines and travel agencies”. *Journal of Air Transport Management* 103: 1-10. ISSN: 1873-2089. DOI: 10.1016/j.jairtraman.2022.102247.
21. Kwasiborska Anna. 2012. „Analiza zagadnienia załadunku frachtu lotniczego”. *Logistyka-Nauka* 2: 839-844. ISSN: 1231-5478. [In Polish: “Analysis of the issue of air freight loading”. *Logistics-Science*].
22. Kwasiborska Anna. 2013. „Analiza wybranych aspektów zagadnienia przewozu frachtu lotniczego”. *Prace naukowe Politechniki Warszawskiej. Transport* 89: 45-63. ISSN: 1230-9265. [In Polish: “Analysis of selected aspects of air freight transport. *Scientific works of the Warsaw University of Technology. Transportation*].
23. Liberadzki Bogusław, Leszek Mindur. 2007. *Uwarunkowania rozwoju systemu transportowego Polski*. Warszwa-Radom: Warsaw-Radom: Institute for Sustainable Technologies. ISBN: 978-83-7204-601-7. [In Polish: *Conditions for the development of the Polish transport system*].
24. Lisińska-Kuśnierz Małgorzata, Agnieszka Cholewa. 2003. „Regulacje prawne dotyczące działalności przewozowej cargo w transporcie lotniczym”. *Zeszyty Naukowe / Akademia Ekonomiczna w Krakowie* 625: 13-21. ISSN: 0208-7944. [In Polish: “Legal regulations concerning cargo transport activity in air transport”. *Scientific Journals / Cracow University of Economics*].
25. Magdalina Ana, Martin Bouzaima. 2021. “An empirical investigation of European airline business models: Classification and hybridization”. *Journal of Air Transport Management* 93: 1-11. ISSN: 1873-2089. DOI: 10.1016/j.jairtraman.2021.102059.

26. Nicopulos M. 2016. „Transport lotniczy towarów niebezpiecznych”. *Przegląd Komunikacyjny* 3: 6-10. ISSN: 0033-2232. [In Polish: “Air transport of dangerous goods”. *Communication Review*].
27. Njoya Eric Tchouamou, Alexandros Nikitas. 2020. “The role of air transport in employment creation and inclusive growth in the Global South: The case of South Africa”. *Journal of Transport Geography* 85: 1-15. ISSN: 1873-1236. DOI: 10.1016/j.jtrangeo.2020.102738.
28. Nojszewska Ewelina. 2010. *Podstawy ekonomii*. Warsaw: WSiP. ISBN: 9788302112416. [In Polish: *Fundamentals of Economics*].
29. Oliveira Alessandro V.M., Thiago Caliani, Rodolfo R. Narcizo. 2022. “An empirical model of fleet modernization: On the relationship between market concentration and innovation adoption by airlines”. *Research in Transportation Business & Management* 43: ISSN: 2210-5395. DOI: 10.1016/j.rtbm.2021.100704.
30. Punel Aymeric, Alireza Ermagun. 2018. “Using Twitter network to detect market segments in the airline industry”. *Journal of Air Transport Management* 73: 67-76. ISSN: 1873-2089. DOI: 10.1016/j.jairtraman.2018.08.004.
31. Ruciński Andrzej, Konrad Madej. 2016. „Polski rynek transportu lotniczego w perspektywie 2030 roku”. *Studia Oeconomica Posnaniensia* 4(7): 7-38. ISSN: 2300-5254. DOI: 10.18559/SOEP.2016.7.1. [In Polish: “The Polish air transport market in the perspective of 2030”. *Study Oeconomica Posnaniensia*].
32. Rucińska Danuta, Andrzej Ruciński. 2014. „Koncepcja zrównoważonego rozwoju i gospodarowanie środowiskiem naturalnym z uwzględnieniem transportu lotniczego”. *Zeszyty Naukowe Uniwersytetu Gdańskiego. Ekonomia i Logistyka* 52: 13-30. ISSN: 0208-4821. [In Polish: “The concept of sustainable development and natural environment management, including air transport”. *Scientific Journals of the University*].
33. Rześny-Cieplińska Jagienka, M. Wach-Kłoskowska. 2016. „Obsługa procesów organizacji przewozów ładunków transportem lotniczym - ujęcie standardowe i niekonwencjonalne”. *Prace Naukowe Politechniki Warszawskiej. Transport* 111: 463-475. ISSN: 1230-9265. [In Polish: “Handling the processes of organizing cargo transport by air - standard and unconventional approach”. *Scientific works of the Warsaw University of Technology. Transportation* 111: 463-475].
34. Sendrowicz Marta, Małgorzata Sz waj. 2007. *Prawo konkurencji. Podstawowe pojęcia*. Warsaw: Office of Competition and Consumer Protection. [In Polish: *Competition law. Basic concepts*].
35. Tłoczyński Dariusz. 2017. „Podaż usług transportu lotniczego w Polsce w roku 2017”. *Research Journal of the University of Gdańsk. Transport Economics and Logistics* 75: 81-98. ISSN: 2544-3224. [In Polish: “Supply of air transport services in Poland in 2017”].
36. Tłoczyński Dariusz. 2014. „Przemiany na polskim rynku usług transportu lotniczego. Bilans 10 lat w Unii Europejskiej”. *Zeszyty naukowe Uniwersytetu Szczecińskiego* 28: 247-261. ISSN: 1640-6818. [In Polish: “Changes in the Polish market of air transport services. Balance of 10 years in the European Union”. *Scientific Journals of the University of Szczecin*].
37. Tłoczyński Dariusz. 2016. „Polski rynek usług transportu lotniczego w pozacenowym konkurencyjnym otoczeniu”. *Zeszyty Naukowe Uniwersytetu Gdańskiego. Ekonomia Transportu i Logistyka* 61: 39-64. ISSN: 0208-4821. [In Polish: “The Polish market of air transport services in a non-price competitive environment”. *Scientific Papers of the University of Gdańsk. Transport Economics and Logistics*].



38. Tłoczyński Dariusz. 2013. „Kierunki rozwoju transportu lotniczego”. *Studia Ekonomiczne/Uniwersytet Ekonomiczny w Katowicach* 143: 381-398. ISSN: 2083-8611. [In English: “Directions of air transport development”. *Economic Studies/University of Economics in Katowice*].
39. Civil Aviation Authority, Air Transport Market Department. „Analiza rynku transportu lotniczego w Polsce w latach 2004-2007”. Available at: [http://www.ulc.gov.pl/\\_download/wiadomosci/01\\_2010/analiza\\_ryнку\\_04\\_07.pdf](http://www.ulc.gov.pl/_download/wiadomosci/01_2010/analiza_ryнку_04_07.pdf). [In Polish: “Analysis of the air transport market in Poland in 2004-2007”].
40. Civil Aviation Authority. „Statystyki, analizy”. Available at: <https://www.ulc.gov.pl/pl/>. [In Polish: “Statistics, analyses”].
41. Walków Marcin. 2021. „Najgłębszy punkt kryzysu mamy już za sobą. Ale linie lotnicze nadal pod kreską z wielomiliardową stratą”. *Business Insider*. Available at: <https://businessinsider.com.pl/firmy/zarzadzanie/iata-prognozy-ruchu-lotniczego-po-pandemii-covid-19-2021-i-2022/ryzk6gv>. [In Polish: “The deepest point of the crisis is behind us. But the airlines are still in the red with a multi-billion dollar loss”].
42. Wąsowska Katarzyna. 2018. „Transport lotniczy w łańcuchu dostaw”. *Zeszyty Naukowe Politechniki Śląskiej. Seria: Organizacja i Zarządzanie* 128: 409-420. ISSN: 1641-3466. DOI: 10.29119/1641-3466.2018.128.31. [In Polish: “Air transport in the supply chain”. *Scientific Papers of the Silesian University of Technology. Series: Organization and Management*].
43. Wilfred S. Manuela, Dawna L. Rhoades, Tamilla Curtis. 2019. “Market power at the Seattle-Tacoma International Airport: The case of Alaska Airlines”. *Transport Policy* 76: 90-99. ISSN: 1879-310X. DOI: 10.1016/j.tranpol.2018.12.013.
44. Zielińska Edyta. 2019. „Struktura i działalność wybranych portów lotniczych w Polsce”. *Autobusy: Technika, Eksploatacja, Systemy Transportowe* 20(6): 359-364. ISSN: 1509-5878. DOI: 10.24136/atest.2019.177. [In Polish: “Structure and activity of selected airports in Poland”. *Buses: Technology, Operation, Transportation Systems* 20(6): 359-364. ISSN: 1509-5878. DOI: 10.24136/atest.2019.177].

Received 10.10.2023; accepted in revised form 28.12.2023



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