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The Main Trends and Challenges in The Development of the Different Industries During The COVID-19 Pandemic

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Abstract. The purpose of the research in this article is to investigate the main trends in the development of the different industries during the COVID-19 pandemic, to identify the main problems facing the different industries in the context of the global crisis, as well as to form the basic concepts necessary for a real recovery of the global industry. The authors identify the main problems facing the aviation industry in the developing world crisis and possible ways to solve them. As a working hypothesis, it is proposed to form the basic concepts necessary for preparing and implementing operational measures to restore passenger and cargo aviation. Considering the main threats facing the aviation industry during COVID-19, the article proposes the organizational and economic mechanisms to restore the industry. Furthermore, several recovery scenarios are considered, considering the relevant factors that have a particular impact. Next, a novel mathematical model for pharmaceutical products, which are the most important in COVID-19 pandemics, is proposed. Moreover, the model considers the uncertainty, and a robust optimization approach is applied. The study is based on a comprehensive analysis of documentary data provided by government agencies in several European countries. An analysis of global and Russian passenger traffic for Q1-Q4 (quartile) of 2020 and a development forecast for Q1-Q2 of 2021 is provided. The scenario problems facing the aviation industry in the context of the COVID-19 crisis are identified. There are key concepts necessary to prepare and implement effective measures to restore the aviation industry.

Keywords: Aviation industry, COVID-19, development trends, robust optimization, pharmaceutical industry.

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1. Introduction

Some industries like aviation and pharmaceutical, in comparison with others, is experiencing the most severe consequences from the outbreak of the new coronavirus infection COVID-19, since its raison d'être is to transport people and deliver goods around the world for various purposes, such as business travel and travel, travel around the world, tourist cruises, interregional business and international trade. The sharp decline in demand for air travel, compounded by various travel restrictions, has had very large negative results [1-3].

The financial and economic indicators of virtually all parties involved have worsened significantly: aircraft manufacturing plants; large, medium and small companies; international and regional airports, various navigation services [5,6]. Since the end of 2019, when the first data on a new large-scale disease appeared, the entire industry in the world has been in a "very deep depression." International experts, medical professionals, qualified forecasting specialists cannot yet, with a sufficient degree of probability, determine the nearest visibility of the horizon with a bright future. Unlike previous outbreaks of pandemics, such as those caused by the SARS or MERS viruses, which took about six months to recover, with an acute V-shaped scenario, the recovery period from COVID-19 will probably be much longer, which is in no small part due to the developing global economic recession [7-10].

Taking into account the main threats facing the global aviation, helping in the fight against the COVID-19 pandemic, the authors of the article recommend effective organizational and economic mechanisms for the recovery of the industry (short, medium and long-term recovery scenarios), taking into account the relevant influencing factors, and the perceived problems to be dealt with [11-13]. In this respect, every state in the world should play a primary role in the restoration of its national air transport through the joint actions of all states of the world [14,15].

The current study mainly attempts to analyze the chief trends and obstacles in the various industries throughout the COVID-19 pandemic, to recognize the major issues encountering the various sectors in the context of the global crisis, and finally to form the fundamental concepts vital for a real recovery of the worldwide industry.

2. Literature Review

The global transport and logistics system has turned out to be a sensitive area of the economy most affected by the worldwide COVID-19 pandemic. The negative consequences are based on various factors: closure of state borders between countries, imposition of restrictions on the movement of people and goods, rupture of supply chains, and decrease in demand and purchasing power [1,2]. The combination of these factors had a significant impact on all types of transport: from the use of personal and public transport in cities to the implementation of passenger and freight transport within countries and between them. The scale of the existing negative consequences depends, as a rule, on the type of transport and the state's integration into the world transport and logistics system. During the pandemic, 90% of flights were canceled in the countries of the European Union (EU), there was a decrease in the volume of passenger traffic by cars by 60-90% and by public transport by 50% [3-5]. Under the leadership of the United Nations, international organizations and international Unions, and Air Carrier Associations, taking into account the emergency situation in the world, took a joint decision to develop effective recovery mechanisms and an anti-crisis action plan for emergency stabilization and accelerated recovery of the industry, after the emerging economic difficulties. It is expected that by the end of 2020, the global volume of freight

traffic will decrease by 36%, and the losses of Russian transport companies will amount to 230 billion rubles [6-8].

Today, many European countries are in a transitional stage: there is an adaptation to the updated operating conditions and gradual recovery from the crisis in the transport sector. However, there are still a number of risks. The anticipation of a second wave of the pandemic, increase in the number of COVID-19 cases in some regions of the world, partial restoration of previously removed restrictions, and other factors create further uncertainty regarding global transport and logistics systems [7,9,10]. At the same time, the uncertainty concerns the timing of a return to pre-crisis indicators and the future image of the transport sector in the post-coronavirus world as a whole. The initial exposure to COVID-19 was limited to specific countries that had an outbreak in January-February 2020. Most countries in the world, starting in March 2020, have closed their borders and imposed tighter restrictions on the movement of people as the spread of the disease continued to grow, affecting most governments as one of the measures to contain the spread of the disease. This resulted in sharp cancellations of flights by airlines and a substantial reduction in demand for air travel, creating tangible pressures on the revenue and cash flows of all stakeholders in the aviation sector [11-13]. The International Civil Aviation Organization monitors the economic impact of COVID-19 on civil aviation and adjusts its analytics as the situation evolves. New assessments of the situation, which experts made already in 2021, demonstrate the very significant devastating consequences of the COVID pandemic for the resumption of permanent air routes for passenger traffic shortly. Unfortunately, even the most pessimistic forecasts for the resumption of flights in 2020, which analysts made of aviation companies, did not come true [7,14,15]:

- The total reduction in seats offered by airlines: 37 - 48%.
- The total reduction in passengers: 411 - 535 million.
- Potential loss of airline gross operating income: approximately $ 90 - $ 118 billion.

The most significant negative impacts on the aviation industry as a whole are forecasted in the European continent and in many countries of the Asia-Pacific region. Further, they are followed by countries located in the Middle East and North and South America. For example, most airlines will lose more than $ 23 billion in financial profits from international passenger traffic to China in the same period. These estimates were based on the V-path recovery scenarios from the end of May 2020 and the U-shaped recovery scenario, which foresees a steady decline until mid-2021. The difference in the development of the situation depends, first of all, on the availability of supply and demand [16-19]:

- Real periods of time for recovery and the number of material losses of aviation companies.
- The value of passengers' confidence in air transportation is estimated by the value of the aircraft load factor.

We believe that one of the two forecasted scenarios for the development of the situation can be realized. Realistic pathways to recovery are highly dependent on a variety of factors that rapidly change over time, such as the duration and magnitude of outbreak response and containment, the availability of government assistance, consumer confidence, and economic conditions. The imbalance between supply and demand in transportation services due to the impact of the COVID-19 pandemic naturally affected not only carriers but also vehicle manufacturers. The aircraft market situation was not easy before the start of the pandemic. Boeing (USA), one of the largest aircraft manufacturers in the world, was already in crisis due to two disasters of the 737 MAX model [4,20,21]. Cancellation of orders, deterioration

of financial and economic indicators, and drop in share prices were already noted in 2019 (Figure 1).

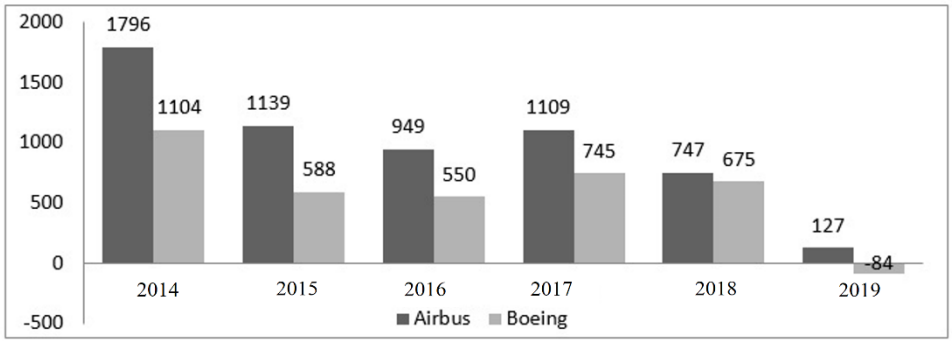


Figure 1. Decrease in global demand for aircraft products.
Source: [11]

The spread of coronavirus and falling demand for products forced Boeing's American factories to halt production and cut workplaces completely. Another major aircraft manufacturer, the European company Airbus, was also forced to adapt production to new conditions. However, given the geographical distribution of production, each specific situation was significantly influenced by a group of measures taken by the national government aimed at combating the spread of infection and supporting the economy [20,21,22].

In the face of a fall in demand for vehicles, many large companies re-equipped their production facilities for health care needs, for the production of personal protective equipment or mechanical ventilation devices, which helped in the fight against the spread and consequences of infection but did not help to compensate for lost profits. Experts say that one of the potential solutions for the aircraft industry is the possibility of reaching an agreement with governments and regulators to reduce the maximum permissible life of aircraft, which will entail an accelerated replacement by carriers of the fleet of relatively old and expensive wide-body aircraft in operation with new models. This would not only lead to an increase in orders in the aviation industry, thereby reducing the negative effects of the pandemic, but would also have a beneficial effect on the environment since new aircraft are generally more environmentally friendly [15,17,23].

In the short term, passenger demand for air transport services may remain subdued due to the high risk of contamination from vehicles. In addition, businesses are likely to move away from business travel, reduce costs, and become more commonplace during the crisis to work remotely. Recent expert assessments indicate that the potential impact of COVID-19 on global scheduled passenger traffic, compared to the baseline, will be as follows [9,11,24]:

What happened in 2020:

- overall reduction of 51% of seats offered by airlines.
- The overall decrease in the number of passengers from about 2.874 million passengers to 2.886 million.
- Approximate financial losses from $ 389 billion to $ 391 billion in passenger operating revenue of airlines.

The first half of 2021 (January – June) is projected the following:

- The general reduction in the number of seats offered by airlines from 30% to 37%.
- Overall reduction in the number of passengers from 903 thousand to 1.264 million.
- Airlines' estimated financial losses will be from $ 135 to $ 183 billion.

Actual impacts will depend on the duration and magnitude of the outbreak and containment measures, as well as consumer confidence in air travel, economic conditions, etc. (Table 1).

Table 1. Analysis of global and Russian passenger traffic for Q1-Q4 of 2020 and development forecast for Q1-Q2 of 2021

Period of time	Number of seats available for boarding (%)		
	Total	International flights	Russian flights
First quarter of 2020 (Q1)	-18%	-20%	-17%
Second quarter of 2020 (Q2)	-79%	-92%	-69%
Third quarter of 2020 (Q3)	- 56%	-75%	-42%
Fourth quarter of 2020 (Q4)	from -48% to -49%	from -72% to -75%	from -30% to -31%
Total for 2020	from 51% to -51%	from 67% to -67%	from -40% to -41%
First quarter of 2021 (Q1)	from -37% to -41%	from -63% to -73%	from -19% to -26%
Second quarter of 2021 (Q2)	from -24% to -33%	from -44% to -69%	from 9% to -24%
Period of time	Number of passengers carried (million)		
	Total	International flights	Russian flights
First quarter of 2020 (Q1)	-287	-111	-176
Second quarter of 2020 (Q2)	-1.044	-488	-556
Third quarter of 2020 (Q3)	-884	-478	-406
Fourth quarter of 2020 (Q4)	from -660 to -672	from 387 to -392	from -273 to -279
Total for 2020	from -2.874 to -2.886	from -1.464 to -1.470	from -1.410 to -1.416
First quarter of 2021 (Q1)	from -509 to -615	from 324 to -368	from -186 to -247
Second quarter of 2021 (Q2)	from -394 to -649	from -286 to -409	from -107 to -240
Period of time	Revenue from passenger transportation ($ billion)		
	Total	International flights	Russian flights
First quarter of 2020 (Q1)	-35	-20	-15
Second quarter of 2020 (Q2)	-136	-86	-50
Third quarter of 2020 (Q3)	-122	-86	-36
Fourth quarter of 2020 (Q4)	from 96 to -97	from 71 to -72	from -25 to -25

Total for 2020	from -389 to -391	from -263 to -264	from -126 to -127
First quarter of 2021 (Q1)	from 76 to -90	from -60 to -68	from 16 to -22
Second quarter of 2021 (Q2)	from -59 to -93	from 50 to -72	from -9 to -22

Source: ICAO Air Transport Reporting Form A and A-S plus ICAO estimates

According to the data shown in Table 1, international passenger traffic in 2020 experienced a 67% decrease in the number of seats offered by airlines, the total number of passengers decreased from 1.464 to 1.470 million, and the approximate loss of potential revenue by airlines, according to some experts, is from 263 up to $ 264 billion. Russian passenger traffic in 2020 decreased from 1.410 to 1.416 million passengers. The number of seats offered by airlines was reduced by 40%. Approximately the lost profit for airlines is from 126 to 127 billion dollars.

ICAO has created a website on COVID-19 aviation safety to assist states and relevant stakeholders. All states are encouraged to inform ICAO of any current country developments in the context of COVID-19. The platform will exist until March 31, 2021, unless circumstances change its operation. The electronic resource includes a series of webinars providing updated information and relevant information in the context of the pandemic. Webinars hosted by leading international experts in their field are free. In addition to its regular COVID-19 advice to national governments, ICAO also acts as a key focal point for member states of Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA). CAPSA website contains updated recommendations from World Health Organization (WHO), complementing relevant bulletins issued by ICAO, Center for Disease Control, and other regional and international organizations. Airports Council International (ACI) has produced a brochure describing a set of standard measures implemented at major international airports. All ACI members provided the information. Key topics covered in the publication include the following issues [25-27]:

- Adapting management and planning in response to the impact of COVID-19.
- Measures to manage staff, including monitoring the health status of employees.
- Procedures for interaction with passengers, including temperature measurement and declaration of health status.
- Changes in the management of facilities, including cleaning and disinfection.
- Provision of protective equipment.
- Security measures (screening of passengers and staff).
- Requirements for information technology.

The international provider of IT solutions for airports, SITA has implemented its largest-scale biometric identification project to date, Smart Path, covering the entire air terminal complex at Beijing International Airport. This software solution, using a unique face recognition technology, allows organizing the movement of passengers from the check-in counter to boarding the plane without presenting documents. This technology reduces queuing times and eliminates physical contact between airport staff and travelers. The system takes less than 20 minutes to process the data and board 400 passengers on the plane [8,9,23]. The system is currently being installed at other international airports, such as Miami and Orlando (USA) and Doha (Qatar). In June 2020, European Commission launched “Re-open EU” web platform that promotes the safe resumption of free movement and tourism in

Europe. To help people plan their travel and vacation with confidence, the platform provides an interactive map with information on border opening, available vehicles, travel restrictions, public health and safety measures such as physical distancing or wearing masks, and other practical information for travelers. "Re-open EU" is available in 24 official EU languages [17,18,27,28].

3. Research Method

The basis of this paper is various methods of theoretical and practical research: analysis, generalization, synthesis, and abstraction. The research methodology included an economic analysis of data on air traffic in different countries. The theoretical and methodological basis of the study was the complex use of a system of methods used by Russian and foreign specialists in the field of management: methodology of structural functionalism, systems approach, structuralism, activity approach, and interactionism [4-9].

The fundamental global integration of the aviation industry, the interdependence of the world economy, and leisure/customer service culture can help rebuild the aviation industry. The recovery scenarios below are multilevel and can be adjusted (Table 2, see the appendix 1). The underlying assumption is that to determine any pathway for the recovery of the aviation industry; it is necessary to mitigate and largely address the health crisis initially. Key concepts for preparing and implementing measures to rebuild the aviation industry include the following:

3.1. Mechanisms for recovery: responsibilities of states

Every state in the world bears the primary responsibility for the development and rehabilitation of its aviation industry; role of recovery mechanisms and action plans at the national level cannot be overemphasized. All countries of the world need at the state level to adopt urgent anti-crisis plans and measures to restore the global transport system, which includes aviation, road, rail, sea, and river transport. It is necessary to go for significant economic costs in this difficult period of exacerbation of the global crisis, in the hope of obtaining, in the foreseeable future, financial profit that will compensate all costs.

3.2. Basic rules of international cooperation

It is necessary to observe real parity between the interests of the two parties: the airport service and air navigation on the one hand; airline workers and passengers, on the other hand. The International Civil Aviation Organization defends the obligation to comply with the following funding clauses: non-discrimination; a reasonable balance of income and expenses; availability of information; joint discussion with customers. It seems to us unacceptable to shift responsibility for the revenues not received by the airport management onto the shoulders of aviation companies and, directly, passengers.

3.3. State support

We believe that in the current difficult situation, all states should provide real assistance to their national aviation companies, carrying out some structural transformations and providing them with potential orders. At the same time, it is necessary to avoid ill-considered decisions so as not to upset the balance of interests in the established market by their administrative actions. The importance for all of the aviation industry can be understood by assessing the

scale of tax payments in 2018 - almost $ 140 billion. This large amount is equivalent to almost half of the gross value added of the entire industry. It would be prudent for all tax payments from the aviation industry to remain under its full control. States can offer a whole range of measures to help an air carrier:

- Maintaining a constant balance between the interests of airport services and aviation companies. Taking into account the own interests of the participants, which are so different by the nature of the property: completely state air navigation services; partly by state airports; by private airlines.
- Comprehensive government support measures, without distorting the basic structure of the market.
- Equivalence of the amounts of support provided by the state and the economic profit received in the future

3.4. New innovative solutions.

A pandemic of a dangerous disease that swept the whole world, provoked a large-scale economic crisis, which has dire consequences for the entire aviation industry. This crisis allowed us to see individual shortcomings of air transport in general. Unfortunately, it should be noted: - low operating margin of air carriers; - significant dependence on ultra-high incomes, which are brought by elite passengers of the first and business classes; - strong interdependence between all active participants in the supply chain. It is obvious that the long and difficult path to rebuilding air transport may require very large-scale measures, including the use of new innovative technologies at the interstate level. Many experts and world experts predict the rapid growth of e-commerce, the improvement of a sustainable supply chain using blockchain, the shift of many business models towards the sharing economy, as well as an increase in the number of private business jets by 10-20 passengers.

3.5. Mathematical Model

The drug distribution industry is one of the most important industries during COVID-19 outbreak. In this section, we present a mathematical model to design a drug supply chain network. This is a multi-product and multi-objective model with three levels of producers, distributors and customers. In addition, the production and distribution centers have limited capacity. The three objective functions include: 1) minimizing the total cost of the network, 2) minimizing carbon emission rate, and 3) maximizing job opportunities. Given the uncertainty in real-world situations, some of the key parameters of the problem, including the capacity of producers and distributors, demand and fixed installation costs and shipping costs are is considered indefinite. The main objective of the model is to determine the location and the number of production and distribution centers and the flow of products in various supply chain levels. First, the sets, parameters and variables of the problem are expressed, and then the mathematical model is presented.

3.5.1 Sets

J Set of potential locations of production centers

K Set of potential locations of distribution centers

C Set of potential locations of end customers

P Set of end products

T Set of periods

3.5.2. Parameters

$\tilde{F}_J$ Fixed cost of establishing the j-th production center

$\widetilde{F_k}$ Fixed cost of establishing the k-th distribution center

$\widetilde{TJK_{Jkp}}$ The cost of transporting the p-th end product unit between the j-th production center and the k-th distribution center

$\widetilde{TLC_{kcp}}$ The cost of transporting the p-th end product unit between the k-th distribution center and the c-th customer

CJK_{jkp} The amount of carbon emissions per transport of the p-th end product unit between the j-th production center and the k-th distribution center

CLC_{kcp} The amount of carbon emissions per transport of the p-th end product between the k-th distribution center and the c-th customer

h_{kp} The cost of storing the p-th end product in the warehouse of the k-th distribution center

C_{jp} Cost of production of the p-th end product unit in the j-th production center

C_{kp} The cost of distribution of the p-th end product by the k-th distribution center

π_{cpt} Penalty for not meeting the c-th end customer demand for the p-th product at t time

$\widetilde{D_{cpt}}$ The c-th customer demand for the p-th product in t time

$\widetilde{ca_{Jp}}$ The capacity of the j-th production center for the p-th end product

$\widetilde{ca_{kp}}$ The capacity of the warehouse of the k-th distribution center for the p-th end product

Fo_j The number of fixed job opportunities in case of the establishment of the j-th production center

vo_j The number of variable job opportunities in case of the establishment of the j-th production center

ID_j The number of missed working days due to occupational injuries at the j-th production center

Fo_k The number of fixed job opportunities in case of establishing the k-th distribution center

vo_k The number of variable job opportunities in case of establishing the k-th distribution center

ID_k The number of missed working days due to occupational injuries in the k-th distribution center

3.5.3. Decision Variables

Y_{jkpt} The number of p-th end product transferred between the j-th production center and the k-th distribution center at t time

V_{kcpt} The number of p-th end product transferred between the k-th distribution center and the c-th customer at t time

ω_{cpt} The level of unmet demand of the c-th customer for the p-th product at t time

Q_{kpt} The level of inventory of the p-th end product in the warehouse of the k-th distribution center at t time

Z_j 1, in case of the establishment of the j-th product center; otherwise, 0.

Z_k

1, in case of the establishment of the k-th distribution center; otherwise, 0.

3.5.4. Mathematical Formula of the Problem

The mathematical model is presented below based on the parameters, variables and hypotheses:

$$\text{Min } z_1 = \sum_{j=1}^{J} \tilde{F}_j Z_j + \sum_{k=1}^{K} \widetilde{F_k} Z_k + \sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{t=1}^{T} h_{kp} Q_{kpt} + \sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{t=1}^{T} \widetilde{TJK_{jkp}} Y_{jkpt} + \sum_{k=1}^{K}\sum_{c=1}^{C}\sum_{p=1}^{P}\sum_{t=1}^{T} \widetilde{TLC_{kcp}} V_{kcpt} + \sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{t=1}^{T} C_{jp} Y_{jkpt} + \sum_{c=1}^{C}\sum_{p=1}^{P}\sum_{t=1}^{T} \pi_{cpt}\omega_{cpt} \quad (1)$$

$$Min\ z_2 = \sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{t=1}^{T} CJK_{jkp} Y_{jkpt} + \sum_{k=1}^{K}\sum_{c=1}^{C}\sum_{p=1}^{P}\sum_{t=1}^{T} CLC_{kcp} V_{kcpt} \quad (2)$$

$$Max\ z_3 = \sum_{j=1}^{J} Fo_j Z_j + \sum_{k=1}^{K} Fo_k Z_k + \sum_{j=1}^{J} vo_j Z_j + \sum_{k=1}^{K} vo_k Z_k - \sum_{j=1}^{J} ID_j Z_j - \sum_{k=1}^{K} ID_k Z_k \quad (3)$$

s. t =

$$Q_{kpt} = \sum_{j=1}^{J} Y_{jkpt} - \sum_{c=1}^{C} V_{kcpt} . \forall k.p.t = 1 \quad (4)$$

$$Q_{kpt} = Q_{kpt-1} + \sum_{j=1}^{J} Y_{jkpt} - \sum_{c=1}^{C} V_{kcpt} . \forall k.p.t < t < T \quad (5)$$

$$\sum_{c=1}^{C} V_{kcpt} \le Q_{kpt} . \forall k.p.t \quad (6)$$

$$\sum_{k=1}^{K} V_{kcpt} + \omega_{cpt_{t<T}} - \omega_{cpt-1} \ge \widetilde{D_{cpt}} . \forall c.p.t \quad (7)$$

$$\sum_{c=1}^{C} V_{kcpt} \le \widetilde{ca_{kp}} Z_k . \forall k.p.t \quad (8)$$

$$\sum_{k=1}^{K} V_{jkpt} \le \widetilde{ca_{jp}} Z_j . \forall j.p.t \quad (9)$$

$$\sum_{j=1}^{J} Y_{jkpt} \le \widetilde{ca_{kp}} Z_k . \forall k.p.t \quad (10)$$

$$Y_{jkpt} . V_{kcpt} . \omega_{cpt} . Q_{kpt} \ge 0 \quad (11)$$

$$Z_j . Z_k \in \{0.1\} \quad (12)$$

The objective function (1) minimizes the total cost, which includes the cost of establishing production and distribution centers, the cost of storing pharmaceutical products in the distributor warehouse, the cost of transporting drugs from producer to distributor, the cost of

transporting from distributor to the end customer, the cost of drug production and the cost of not meeting the end customer's demand. In addition, objective function (2) minimizes the level of carbon emission caused by drug transportation between the producer and distributor and transferring drugs from the distributor to the end customer. Moreover, objective function (3) maximizes the number of job opportunities caused by the establishment of production and distribution centers while minimizing the number of missed days due to occupational injuries. On the other hand, constraints (4) and (5) show the balance of the inventory level of drugs in the distribution center. Moreover, constraints (6) express that the number of pharmaceutical products transported to the end customer should be less than the inventory level of the distribution warehouse. Constraints (7) guarantee that the total customer demand is satisfied for each product by the end of the period. Constraints (8-10) demonstrate the capacity of distribution and production centers. It is notable that the maximum capacity of a center can be used in case of its establishment. Ultimately, constraints (11) and (12) determine the approximate decision variables.

3.6. Robust Optimization Model

In the model presented in the previous section, the key parameters are uncertain. In this study, we use a conservative and risk-averse robust optimization approach to handle uncertainty. In this section, we first express the generalities of robust optimization based on the research by Ben-Tal and Nemirovski and Pishvaei et al., followed by presenting the robust optimization model of the problem (16, 17). Consider the following linear programming model:

$$Min\ fy + cx \tag{13}$$

$$st: Ax \geq d \tag{14}$$

$$Hx = r \tag{15}$$

Phrases (9) to (11) should be expressed as follows in order to turn a non-definitive model into a solvable robust counterpart model:

$$cx \leq Z - fy \quad \forall c \in u_{Box}^{c} | u_{Box}^{c} = \{c \in \Re^{n_c} : |c_t - \overline{c_t}|\} \leq \rho_c G_t^c \qquad t = 1,2, \dots, n_c \tag{16}$$

The left side of Inequality (11) includes the vector of non-definitive parameters while the parameters on the right side are definitive and clear. Therefore, the above inequality can be written, as follows:

$$\sum_{t}(\bar{c}_t x_t + \eta_t) \le Z - fy \tag{17}$$

$$\rho_c G_t^c \times x_t \le \eta_t \qquad \forall t \in \{1,2,\dots,n_c\} \tag{18}$$

$$\rho_c G_t^c \times x_t \ge -\eta_t \qquad \forall t \in \{1,2,\dots,n_c\} \tag{19}$$

$$Min\ z_1 \tag{20}$$

s.t (2)-(6)

$$\begin{aligned}\sum_{j=1}^{J}\left(\overline{F_j}.Z_j + \eta_j\right) + \sum_{k=1}^{K}(\overline{F_k}.Z_k + \eta_k) + \sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{t=1}^{T}\left(\overline{TJK_{jkp}}.Y_{jkpt} + \eta_{jkp}\right)\\ + \sum_{k=1}^{K}\sum_{c=1}^{C}\sum_{p=1}^{P}\sum_{t=1}^{T}\left(\overline{TLC_{kcp}}.V_{kcpt} + \eta_{kcp}\right)\\ \le z_1 - \sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{t=1}^{T}h_{kp}Q_{kpt} - \sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{p=1}^{P}\sum_{t=1}^{T}C_{jp}Y_{jkpt}\\ - \sum_{c=1}^{C}\sum_{p=1}^{P}\sum_{t=1}^{T}\pi_{cpt}\omega_{cpt}\end{aligned} \tag{21}$$

$$\sum_{k=1}^{K}V_{kcpt} + \omega_{cpt_{t<T}} - \omega_{cpt-1} \ge \overline{D_{cpt}} + \rho_D.G_{cpt}^D.\forall c.p.t \tag{22}$$

$$\sum_{c=1}^{C}V_{kcpt} \le \left(\overline{ca_{kp}} + \rho_{ca_{kp}}.G_{kp}^{ca_{kp}}\right)Z_k.\forall k.p.t \tag{23}$$

$$\sum_{k=1}^{K}Y_{jkpt} \le \left(\overline{ca_{jp}} + \rho_{ca_{jp}}.G_{jp}^{ca_{jp}}\right)Z_j.\forall j.p.t \tag{24}$$

$$\sum_{j=1}^{J}Y_{jkpt} \le \left(\overline{ca_{kp}} + \rho_{ca_{kp}}.G_{kp}^{ca_{kp}}\right)Z_k.\forall k.p.t \tag{25}$$

$$\rho_{Fj}.G_j^{F_j}.Z_j \ge -\eta_j.\forall j \tag{26}$$

$$\rho_{Fj}.G_j^{F_j}.Z_j \le \eta_j.\forall j \tag{27}$$

$$\rho_{Fk}.G_k^{F_k}.Z_k \ge -\eta_k.\forall k \tag{28}$$

$$\rho_{Fk}.G_k^{F_k}.Z_k \le \eta_k.\forall k \tag{29}$$

$$\rho_{TJK}.G_{jkp}^{TJK}.Y_{jkpt} \ge -\eta_{jkp}.\forall j.k.p.t \tag{30}$$

$$\rho_{TJK}.G_{jkp}^{TJK}.Y_{jkpt} \le \eta_{jkp}.\forall j.k.p.t \tag{31}$$

$$\rho_{TLC}.G_{kcp}^{TLC}.V_{kcpt} \ge -\eta_{kcp}.\forall k.c.p.t \tag{32}$$

$$\rho_{TLC}.G_{kcp}^{TLC}.V_{kcpt} \le \eta_{kcp}.\forall k.c.p.t \tag{33}$$

$$Y_{jkpt}.V_{kcpt}.\omega_{cpt}.Q_{kpt}.\eta_j.\eta_k.\eta_{jkp}.\eta_{kcpt} \ge 0 \tag{34}$$

$$Z_j.Z_k \in \{0.1\} \tag{35}$$

4. Numerical Results

4.1. Data

In order to optimize a robust mathematical model, it is necessary to specify the inputs of the mathematical model in the form of a set of parameters. For this purpose, based on the inspiration of the subject literature in the field of robust optimization such as [6,7,9,10], a table of how to generate parameters has been created. This information is shown in Table 3.

Table 3. Generated data for the proposed mathematical model

Parameter	Data generation	Parameter	Data generation
Fix cost of production	~U(200,250)	Production capacity	~U(700,850)
Fix cost of distribution	~U(150,200)	Distribution capacity	~U(300,450)
Transportation costs	~U(2,7)	Production jobs	~U(42,55)
Co2 emission per product	~U(11,20)	Distribution jobs	~U(12,23)
Holding cost	~U(4,6)	Loosed working days	~U(3,7)
Demand	~U(10,25)		

Source: [6,7,9,10]

4.2. Numerical Analysis

The numerical results obtained from solving the definitive model and the robust counterpart model by GAMS software are presented below. Given the multi-objective model, we use the Epsilon-constraint model to turn the multi-objective model into a single-objective one. In addition, the allowed Epsilon range for the second objective function (carbon emission level) and third objective function (employment rate) is presented in Table 3.

Table 4. Allowed range of ε for the second and third objective functions

	z_2	z_3
ε	[0.1105797]	[0.775]

To solve the model, three problems (P1, P2 and P3) with different sizes are considered. The values of the objective function for the deterministic model and the robust optimization model for the different levels of confidence are given in Table 4.

Table 5. The value of the objective function for different values of ρ

Sets	J	K	C	P	T	Objective function of robust optimization model			Definitive objective function
						$\rho = 0.2$	$\rho = 0.5$	$\rho = 0.7$	
P1	4	4	5	4	5	287 63	301 87	327 92	34845
P2	6	6	7	6	5	663 41	704 51	734 58	76964
P3	10	10	8	8	6	735 16	821 45	942 14	86541

The results presented in Table 4 show that increasing the value of the robust optimization parameter can have a negative effect on the value of the objective function and reduce its value. However, the maximum value of the objective function is obtained in the definite objective function, where all parameters are considered definitive.

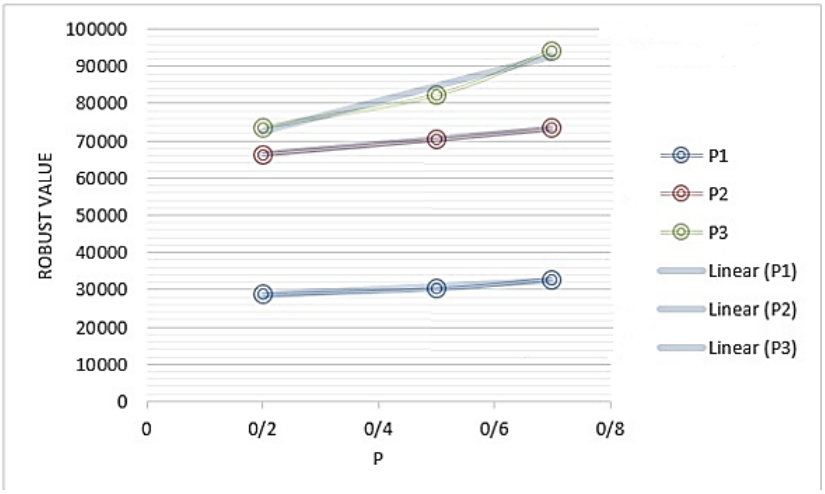


Figure 2. The trend of objective value in each test problem

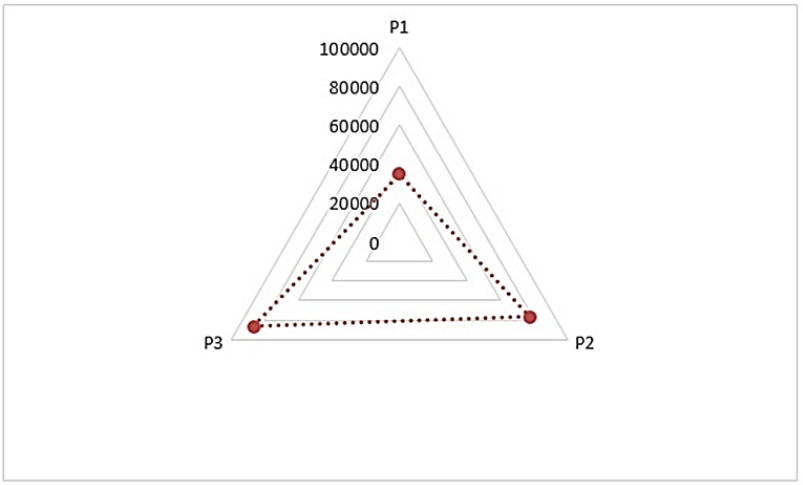


Figure 3. Definitive value in each test problem

Figure (2) shows the objective function changes of the robust optimization model for different levels of reliability. As can be seen, with increasing confidence levels, supply chain costs increase. In fact, uncertainty increases network costs. Given that the second problem is larger than the first problem, sensitivity analysis has been performed for the second problem. To analyze the sensitivity of changes, the objective function has been examined in order to increase the capacity of production and demand centers and reduce fixed costs by establishing production and distribution centers. The results in Figure 1 show that in all 3 solved problems, an increasing trend is observed. The analysis of this graph shows that the more severe the uncertainty in the parameters of the mathematical model, the higher the value of the objective function. Figure (3) shows the changes in the objective function with respect to increasing the capacity of production centers. As can be seen, network costs increase with increasing capacity. In this figure, the degree of influence of the dimensions of the problem is well observed. According to Figure (3), as the number of production and distribution centers increases, the value of the definite objective function will also increase.

5. Discussion

In the prevailing era, COVID-19 is a worldwide crisis that tests the resilience of the aviation industry and the entire global economy. Airlines in most countries are experiencing double-digit declines in demand, and traffic has collapsed on many routes. The planes remain on the ground, and employees are asked to take unpaid leave or leave from work. In this emergency, governments need to consider maintaining air transport. The suspension of the 80/20 slot rule and exemption from taxes at airports where demand has disappeared are two critical steps that can support airlines during the crisis and, ultimately, recovery. COVID-19 pandemic has affected the airport industry a lot. One hundred ten countries significantly restricted air traffic, which accounted for about 98% of the world aviation market. COVID-19 caused a global economic recession and a decline in international trade, which significantly affected the entire airport industry. The business activity went online due to quarantine, and in

addition to this, the business will cut travel budgets in the future. The growth of passenger traffic will also be constrained by new requirements for observing the minimum distance between passengers in the terminal and the plane, new visa restrictions, and concerns of the passengers. The devaluation of national currencies and limited government support for businesses and the population will lead to an additional decrease in the population's purchasing power. The financial cushions of the vast majority of airports will be exhausted by that time, and obligations to staff and banks will need to continue to be fulfilled. The result of the analysis of the current economic situation in the airport industry is the conclusion that the restoration of passenger traffic will take at least two years.

Airports have formed a consolidated industry position on the package and have turned to the government for support. The set of measures includes state guarantees for the ten largest airlines to fulfill their obligations for the period from April 1 to December 31, 2020, full or partial subsidies for the cost of airport services and fuel complexes for airlines, abolition of rent for the use of state airfield infrastructure for 2020 and also tax deferrals and exemptions, financial incentives for staff retention and suspension of dividend payments to the government where applicable. Several states have released amounts equal to 11% of Gross Domestic Product (GDP) to support the economy, a considerable part of which is the support of the airport industry. Canada has allocated $ 331 million to support the airport industry, United States: $ 58 billion, Singapore: $ 7 billion, New Zealand: $ 4 billion, etc.

The most effective measures to support the airport industry are tax incentives and government guarantees. Leading world experts call tax incentives and government guarantees to independent players, first of all, airlines, as the most effective and most feasible measures to support the airport industry. Passenger traffic will help overcome the industry's confidence crisis and gain the maximum possible pace for the situation when passenger traffic begins to recover. The forecasts for the recovery of the airport industry in Russia are non-optimistic. According to an optimistic scenario, recovery in passenger traffic at the level of 2019 can be expected only in 2021, and losses will amount to about 80.4 billion rubles. However, according to the pessimistic scenario, i.e., if an economic activity does not recover in 2021, passenger traffic may decrease by 70% per year, and the aviation industry will lose 155 billion rubles.

6. Conclusion

Overall, the study's main aim was to inspect the main trends and issues in the development of the different industries during the covid-19 pandemic. To meet that aim, various methods of theoretical and practical research: analysis, generalization, synthesis, and abstraction are taken into account. Based on the results acquired, if mass vaccination of travelers becomes available in summer or at the end of 2021, European air traffic will be able to return to the 2019 level as early as 2024. The second scenario provides for mass vaccination in 2021-2022, in this case, until 92% of the volume of 2019 is restored, it will take two years more, and if events develop according to the most pessimistic forecast, the aviation sector in Europe will return to a pre-pandemic level only by the 2029 year. In forecasting, Eurocontrol was guided by the experience of previous crises. So, in 2001, about 200 thousand flights were lost in Europe, and it took 1.5 years to restore the market, and the global crisis of 2008 already "ate" 600 thousand flights: to return to the former volume of transportation, it took eight years. In 2020, Europe lost 6 million flights, which may develop just according to the pessimistic scenario. As for Russia, experts find it difficult to forecast. However, the volume of passenger

traffic has dropped significantly: according to Federal Air Transport Agency, in 10 months of 2020, 59.44 million people were transported in the Russian Federation. (46.1% less than in the same period in 2019), and in October 2020, Russian companies served 6.78 million passengers (39.2% less than in 2019). At the same time, Pobeda Airlines, a subsidiary of Aeroflot, even increased the number of customers served to 1.04 million (+ 10.6%).

Globally, the aviation industry is doing badly. Based on the open data, Bloomberg experts have compiled a list of airlines that, due to the difficult financial situation, may declare default before the end of 2020. It mainly contains mid-level companies from Asia, Africa, and Latin America (there are no European ones in this blocklist yet), for example, Thai Airways, which put up for sale at once a third of its fleet: 34 passenger aircraft. These are mainly long-haul Boeing models: 747-400, 777-200 and 777-300, built-in 1993-2000, as well as, less age, Airbus A340-600 airliners that rolled off the assembly line in 2005-2008. However, trying to sell every third aircraft is seen as a sure sign that the carrier is on the edge of a financial abyss.

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Appendix 1:

Table 2. Identifying scenario challenges for aviation industry in COVID-19 crisis

Suggestions/ Factors	Fast recovery scenario (from 3 to 6 months)	Progressive recovery scenario (from 6 to 12 months)	Slow recovery scenario (from 1 to 2 years)
Introduction of certain types of travel restrictions	All restrictions will be lifted when possible	Gradual easing of restrictions: plausible scenario includes initial lifting of restrictions domestically and regionally, then internationally	Severe restrictions on various international transportations over a long period of time; domestic/regional air traffic prevails
Analysis of current economic environment	Indicators of current economic activity are gradually beginning to recover and go to pre-crisis level	Economy has suffered partial damage; rather slow recovery of commercial activity and level of consumer spending	Global economic downturn; widespread weak economic sector, budget and labor cuts
Airline opportunity assessment	Operational capabilities in this case are practically not affected (air fleet, etc.); workforce is fully available for the recruitment procedure; issuance of various interest-free loans and cash injections from the state to maintain the level of current capabilities	Vast majority of airlines are still operating; airlines remaining on the market significantly reduce their activities to minimize risks, priority is given to Russian flights; loans and cash infusions are an important and necessary condition in order to maintain the minimum acceptable level of opportunity	Possibilities that airlines have are very limited, which in the end will inevitably lead to default (bankruptcy); airlines remaining on the market are curtailing their activities, international passenger traffic will be heavily curtailed or canceled altogether
Air travel demand research	Normalization of level of demand for passenger transportation after a short break, as a result, will lead to a decrease in prices	Travel demand will decline, but higher supply levels, for example, while operating capacity declines, may result in slightly higher prices	The activities of airlines will be reduced or limited, which will inevitably lead to an increase in prices, which means that stimulation of demand, will be impossible.

Assessment of current state of aviation industry	Experts and leading specialists expect a fairly quick recovery of the industry, if all restrictions and rules are lifted	Less air travel will have a negative impact on virtually the entire aviation industry, which will not only reduce its financial income, but also lead to a reduction in staff	Airlines activities will be almost completely reduced, which will lead to disastrous consequences for the industry, the number of players in the market will decrease
Predicting problems for each assumed development scenario			
Assessment of level of financial capabilities of industry/airline	Almost all airlines are experiencing financial difficulties against background of decrease in passenger traffic due to pandemic to varying degrees; state becomes the main driver for maintaining airlines; budget adjustment for sufficiently reduced passenger traffic and significant cost reduction	All international aviation companies are experiencing quite serious difficulties due to restrictions; market recovery process will be long enough; risk of pandemic is unpredictable, which will lead to fluctuations in airline quotes; launch of program packages aimed at subsidizing air transportation within the country	Level of financial capabilities that all stakeholders currently have is in a critical situation, which will inevitably lead to the transformation of all models operating in commercial aviation: state subsidies, elimination of the premium segment, transition from hub model to point-to-point
Determining of level of employment	Hiring process will be suspended for approximately 1 year; decrease in the level of human capital, which means that there will be decrease in the pace of economic, scientific and technical process	Unemployment is projected to be at medium or higher levels due to the ongoing decline in the workforce; also, some employees may not want to return and work in less attractive conditions	Unemployment rate will reach the highest possible level in the industry, which will ultimately lead to a shortage not only of pilots, but also of employees employed in ground services (dispatchers, etc.).
Determination of degree of investment attractiveness	According to various groups of specialists and experts, no additional investments or high-tech projects and no commercial proposals are expected in the near future	Significant reduction in the number of investments within the framework of existing projects, as well as for the maintenance of current activities, for example, sharp reduction in the number of air routes, etc.	Investments in the industry are almost completely absent, main priority is to make only flight safety and aviation security, while all other areas of investment are considered non-priority and are not supported

Forecasting development of trade and tourism	Estimated recovery in trade and tourism is not expected until Q4 2021	Significant financial assistance from states will be required to organize full support and restore the tourism sector	Recovery process in tourism and trade will directly depend on the level and quality of government support, while financial assistance will be just a component of overall assistance programs
Analysis of freight traffic	Sudden reduction in freight capacity has disrupted air traffic flows, but the sector has room for quick adaptation and is able to return to pre-crisis levels in no time; forecast is favorable, there is a possible growth in demand for transportation of goods; in the face of a decrease in the number of flights and passengers, airlines resorted to re-equipment of aircraft to accommodate commercial cargo in the cabin, and not only in the luggage compartment	Recovery scenario assumes a favorable nature, freight transport plays a leading role in the maintenance and subsequent recovery of the entire global supply chain and economy; current rules will be amended, which will return the cargo transportation indicators to the pre-crisis level; air cargo carriers should also have a stimulating effect on air traffic at many airports	Air freight will be virtually a major player in the global economic recovery in the long term
Analysis of standards and procedures	Little or no additional procedures in the industry, i.e., for passengers; all procedures will remain unchanged	Establishment of various temporary and medium-term, including additional procedures, for example, medical examination at airports, keeping distance on airplanes, etc.	Implementation of permanent procedures to prevent similar crises in the future: special training for the crew, cargo standards, etc.
Assessing the level of consumer confidence	Consumer confidence will be restored through a range of effective marketing activities and promotional offers	Passenger confidence will be influenced by a prolonged period of uncertainty and anxiety, as well as a general distrust of international travel	Passenger confidence will be very low, passengers will most likely prefer regional travel or choose other modes of transport