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EVALUATION OF AIR TRAFFIC IN THE CONTEXT OF THE COVID-19 PANDEMIC

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Abstract:

The Covid-19 pandemic unexpectedly shook the entire global economy, causing it to destabilize over a long period of time. One of the sectors that was particularly hit hard was air traffic, and the changes that have taken place in it have been unmatched by any other crisis in history. The purpose of this article was to identify the time series describing the number of airline flights in Poland in the context of the Covid-19 pandemic. The article first presents selected statistics and indicators showing the situation of the global and domestic aviation market during the pandemic. Then, based on the data on the number of flights in Poland, the identification of the time series describing the number of flights by airlines was made. The discrete wavelet transformation (DWT) was used to determine the trend, while for periodicity verification, first statistical tests (Kruskal-Wallis test and Friedman test) and then spectral analysis were used. The confirmation of the existence of weekly seasonality allowed for the identification of the studied series as the sum of the previously determined trend and the seasonal component, as the mean value from the observations on a given day of the week. The proposed model was compared with the 7-order moving average model, as one of the most popular in the literature. As the obtained results showed, the model developed by the authors was better at identifying the studied series than the moving average. The errors were significantly lower, which made the presented solution more effective. This confirmed the validity of using wavelet analysis in the case of irregular behaviour of time series, and also showed that both spectral analysis and statistical tests (Kruskal-Walis and Fridman) proved successful in identifying the seasonal factor in the time series. The method used allowed for a satisfactory identification of the model for empirical data, however, it should be emphasized that the aviation services market is influenced by many variables and the forecasts and scenarios created should be updated and modified on an ongoing basis.

Keywords: *air traffic, Covid-19 pandemic, passenger transport*

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1. Introduction

The Covid-19 pandemic unexpectedly shook the world economy causing significant and long-lasting destabilization. One of the sectors that was particularly hard hit was transport and tourism, the backbone of the aviation market. The changes that took place in air traffic were incomparable to any other crisis in history. They were the result of restrictions introduced by almost all countries in order to limit the spread of the virus, as well as passengers' fears of becoming infected and not being able to return to their home country. The article presents selected statistics and indicators showing the situation of the global and domestic aviation market in the first months of the epidemic. Then, a mathematical model was proposed to identify domestic passenger air traffic. To identify the time series describing the number of airline passengers, the Discrete Wavelet Transformation (DWT) was used to determine the trend, while the Kruskal-Wallis test and the Friedman test were used to verify the periodicity. The research was carried out on the example of data concerning Poland. The results obtained were compared with the most commonly used and updated in the literature, the moving average model of the order of seven, used, e.g. by Flightradar24, which provides a global flight tracking service and real-time information on thousands of flights around the world (Flight tracking statistics, 2022). The error values obtained show that the proposed model better explains the components of the trend and seasonality in the analysed time series. The structure of the article is as follows. The article first evaluates the impact of the Covid-19 pandemic on global and domestic air traffic over time, presenting the most important statistics and indicators in this area. Then, using the wavelet analysis, the trend function was determined and the seasonality was assessed with the use of spectral analysis. In the next part of the work, matching of the model taking into account both of these elements was compared and then the comparison was made with the moving average model.

2. The state of the problem in the context of world literature

The aviation market is one of the sectors that developed extremely dynamically, strengthening its position on the transport market each year and actively participating in building the global economy, as shown in the literature before the outbreak of the Covid-19 pandemic (Barnhart et al., 2012; Wandelt & Sun 2015; Wensveen, 2018). Prior to this event, the aviation industry had forecasted 4.4% of annual air traffic growth over the next twenty years (Kallbekken & Sælen, 2021). At that time, in addition to the development of this sector, an important element of scientific considerations was the sustainable development of transport - not only air transport - focusing on the reduction of harmful gas emissions (Adedoyin et al., 2020; Gürçam et al., 2021; Kruczyński et al., 2022; Sánchez-Herguedas et al. 2022). Nobody assumed then such drastic problems and changes in the air transport industry. For the first time in history, there has been an unprecedented regression that has shaken up aviation at its base, causing destabilization and losses that are likely to be rebuilt over the years. Events earlier in history that reduced interest in air transport services, such as the 2001 World Trade Center attack, in which commercial passenger planes were weapons used by terrorists (Clark et al., 2009; Goodrich, 2002; Lai & Lu, 2005), and the economic crisis that began in 2008, which was called the most intense and dramatic (Dobruszkes & Van Hamme, 2011; Okulski & Heshmati, 2010), are only fluctuations, almost imperceptible in the graph presenting global passenger traffic in air transport, taking into account the period of the Covid-19 pandemic (Fig. 1). The aforementioned events, so intensely hitting the air transport sector, are practically invisible in the passenger numbers chart over the period 1970-2021.

During the crisis caused by the Covid-19 pandemic, the most important factors affecting the condition of transport were restrictions introduced by most countries, mainly related to the refusal to accept flights from countries and regions with a high incidence rate, a mandatory SARS-CoV-2 test or forced quarantine by passengers, flight restrictions during periods of rapid infection peeks, and ultimately the complete suspension of scheduled passenger flights. The purpose of such restrictions was primarily to limit the spread of the virus and to ensure the highest possible level of safety (Staniuk et al., 2022). The decisions of the travellers themselves to cancel the flight for fear of becoming infected or not being able to return to their home country were also of key importance.

The first European country to introduce air transport restrictions was Italy, which introduced a national blockade on March 9, 2020. On March 11, 2020, the United States banned entry to the US from non-US travellers who had been to China, Iran and 26 European Union (EU) member states, and later extended the ban to non-US travellers who visited Britain and Ireland. On March 17, 2020, the EU's external borders were closed (Monmousseau et al., 2020).

This dramatic sequence of events drastically affected the functioning of air transport, paralyzing it completely. Figure 2 clearly shows the impact of travel restriction measures on the number of passengers within the European Union. The percentage decrease in the number of passengers in individual months is presented in Table 1.

As shown in Table 1, the impact of the pandemic on air transport was already visible at the end of 2019, when in Wuhan, considered to be the source of the spread of a new, dangerous virus, the entire transport, including air connections, was disabled. The most drastic decline, however, took place in March 2020, when the total number of commercial flights in the European Union fell by 60% compared to the previous month and by 65% compared to the same month in 2019. With the introduction of full COVID-19 restrictions and changes in travel preferences, the largest drops in commercial flights were recorded in April (-99% compared to the same month in 2019), May (-98%) and June (-95%).

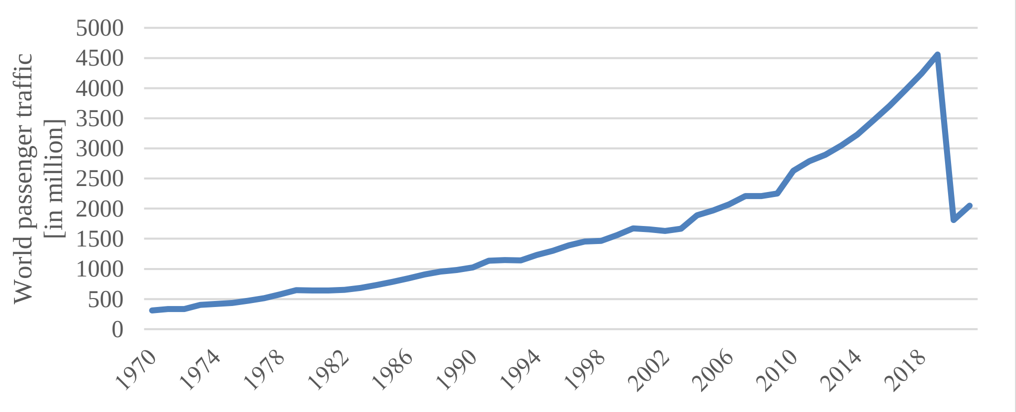

Fig. 1. World passenger traffic evolution, 1970–2021. Source: International Civil Aviation Organization, Civil Aviation Statistics of the World and ICAO staff estimates

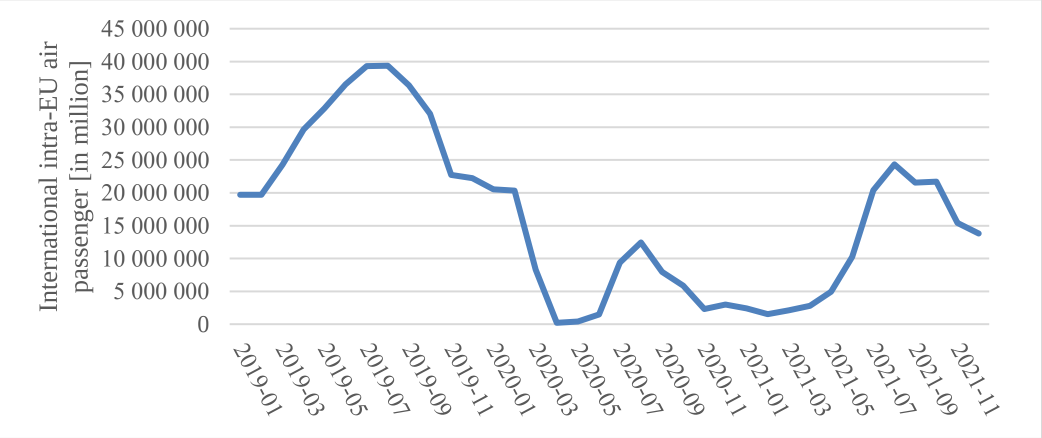

Fig. 2. International intra-EU air passenger monthly chart

Table 1. International EU air passenger - percentage changes in relation to the previous month (ICAO, 2022)

Time	Number of passengers	Change [%]	Time	Number of passengers	Change [%]	Time	Number of passengers	Change [%]
2019-01	19 730 412		2020-01	20 519 643	-7,8	2021-01	2 418 640	-19,8
2019-02	19 720 811	0,0	2020-02	20 358 708	-0,8	2021-02	1 525 064	-36,9
2019-03	24 313 848	23,3	2020-03	8 320 357	-59,1	2021-03	2 113 530	38,6
2019-04	29 639 285	21,9	2020-04	209 488	-97,5	2021-04	2 797 736	32,4
2019-05	32 875 392	10,9	2020-05	387 338	84,9	2021-05	4 961 191	77,3
2019-06	36 510 716	11,1	2020-06	1 477 031	281,3	2021-06	10 250 477	106,6
2019-07	39 297 756	7,6	2020-07	9 359 348	533,7	2021-07	20 396 163	99,0
2019-08	39 360 125	0,2	2020-08	12 466 063	33,2	2021-08	24 345 571	19,4
2019-09	36 365 020	-7,6	2020-09	7 940 404	-36,3	2021-09	21 572 235	-11,4
2019-10	32 022 994	-11,9	2020-10	5 887 186	-25,9	2021-10	21 714 069	0,7
2019-11	22 726 556	-29,0	2020-11	2 295 707	-61,0	2021-11	15 397 691	-29,1
2019-12	22 266 415	-2,0	2020-12	3 014 541	31,3	2021-12	13 799 613	-10,4

Currently, passenger air traffic is gradually recovering, slowly moving towards the pre-pandemic level, and the pace of this improvement is considered stable and satisfactory (Rothengatter et al., 2021; Su et al., 2022). From the very beginning, the issue of rebuilding the air services market has been the subject of scientific considerations and focuses primarily on forecasting their growth and estimating the time when passenger flights will return to the level before the COVID-19 pandemic. These forecasts are usually short-term, as increasing the time horizon makes them unstable. This is caused by the difficulty in predicting a phenomenon that is so dependent on many factors, ranging from atmospheric conditions and weather phenomena (Zhou & Chen, 2020), through economic factors (Brons et al., 2002; Frechtling, 1994), political problems, including terrorist attacks (Coshall, 2003; Mitra et al, 2018), political unrest or threats state security, resulting, for example, from armed conflicts (Doroshuk, 2022; Ivanov et al., 2017). The reason for the changes may also be such unexpected events as strikes (de Jong & Lieshout, 2021).

This contributes to the popularity of searching for effective methods of forecasting air traffic among scientists around the world as well as institutions related to air traffic, such as the International Civil Aviation Organization (ICAO) (Hasegawa, 2022) or the International Air Transport Association (IATA, 2018, 2020) and aircraft manufacturers such as Airbus (Airbus, 2019), Boeing (Boeing, 2021).

The most commonly used to predict traffic flow are classical time series models, including stationary models such as Autoregressive (AR) and Moving Average (MA) (Flightradar24 , 2022), and non-stationary models such as Auto Regressive and Integrated Moving Average (ARIMA), which are the most representative time series model used in the transportation industry for traffic flow forecasting. They are used in their basic form (La et al., 2021) or integrated with other predictive approaches. For example, in (Gudmundsson et al., 2021) the authors estimate that the return to the global level of pre-COVID-19 air services demand among passengers will take 2.4 years based on the Auto Regressive Moving Average with exogenous input (ARMAX) model. On the other hand, in (Deb, 2021) the authors used the Generalized Auto-Regressive Conditional Heteroscedasticity model (GARCH) to forecast the volatility of airline share prices.

In addition to time series models, machine learning algorithms such as artificial neural networks or the vector autoregression method (VAR) are used to predict the traffic flow, which, for example in (Xuan et al., 2021), were used to evaluate the impact of coronavirus on the aviation industry from the point of view of its revenues. Artificial intelligence methods were also used in (Jafari, 2022) to study the impact of COVID-19 on domestic passenger demand in the US. In contrast, (Suau-Sanchez, 2020) used a series of in-depth interviews with industry senior management to assess the mid- and long-term effects of Covid-19 on the aviation industry, also pointing to a gradual economic recovery.

The literature review shows that the forecast scenarios for the reconstruction of the aviation market can be divided into more optimistic ones - assuming recovery by the end of 2022, and less optimistic ones, indicating its recovery in the next 4-6 years (Gudmundsson et al., 2021; Kallbekken & Sælen, 2021). Various scenarios (in this case for Europe) are also presented by Eurocontrol, which in its report (Eurocontrol, 2022) published a five-year forecast for European air traffic for 2020-2024. Using three scenarios, a full recovery to 2019 levels was forecast for 2024 (best case scenario), 2026 (most likely scenario) and 2029 (worst case scenario).

However, as mentioned, such forecasts - due to the multitude of factors influencing the demand on the air services market, should be constantly monitored and updated, and the methods used should be adjusted to changes in time series and improved. In this article, the Discrete Wavelet Transformation - DWT was used to determine the trend and to identify the time series describing the number of airline passengers, and the spectral analysis and Kruskal-Wallis and Friedman tests to determine the periodicity. The research was carried out on the example of data concerning Poland.

3. Using wavelet analysis to determine the trend

The identification and description of individual elements of the time series is crucial in understanding the structure of a given phenomenon and in selecting the appropriate mathematical model. In the time series, we identify systematic components (trend, periodic fluctuations) and a random component. With regard to the identification of periodic fluctuations, most of the methods used allow to determine regular, sinusoidal frequencies for which the frequency and amplitude remain constant over time. Meanwhile, frequency analysis should be carried out using decomposition composed of selective functions in the time and frequency domains. Spectral analysis enables better detection in the case of irregular behaviour of the time series (Castilla-Gutiérrez et al., 2021).

When identifying a trend in a time series, the most common techniques are moving average, exponential weights of the moving average, and polynomial approximation (e.g. using the least squares method to estimate polynomial coefficients). In the case under consideration, wavelet analysis was used to determine the trend in the time series, which relies on dividing the signal into smaller parts, using weight windows with changing dimensions, and then analysing each of them by comparing with the shifted and scaled function $\Psi(x)$ called basic (base, parent) wavelet (Kozłowski et al., 2021; Maciuk, 2022).

Let $\{x_t\}_{1\le t\le n}$ be an analysed time series, $\Psi(t)$ - the basis (mother) wavelet and $\phi(t)$ - the scaling function (father wavelet) corresponding to the mother wavelet $\Psi(t)$.

To determine the trend first we decompose the time series as follows (Kozłowski et al., 2021).

$$x_t = \sum_{k=0}^{\frac{n}{2^j}-1} c_{jk}\,\phi_{jk}(t) + \sum_{i=0}^{j}\sum_{k=0}^{\frac{n}{2^i}-1} d_{ik}\,\Psi_{ik}(t)\,, \tag{1}$$

for decomposition level $j \in \mathbb{N}$ $(1 \le j < \frac{n}{2^j})$, where the sequences of mother wavelets $\{\Psi_{jk}\}_{k\in\mathbb{Z}}$ and father wavelets $\{\phi_{jk}\}_{k\in\mathbb{Z}}$as follows:

$$\Psi_{jk}(t) = \frac{1}{2^{j-1}}\Psi\left(\frac{t}{2^j}-k\right) \tag{2}$$

$$\phi_{jk}(t) = \frac{1}{2^{j-1}}\phi\left(\frac{t}{2^j}-k\right) \tag{3}$$

The sequence of scaling (approximation) coefficients $\{c_{jk}\}_{0\le k\le\frac{n}{2^j}-1}$ and the sequences of detailed coefficients $\{d_{0k}\}_{0\le k\le\frac{n}{2^j}-1}$, …, $\{d_{jk}\}_{0\le k\le\frac{n}{2^j}-1}$ we determine by applying the formulas:

$$c_{jk} = \sum_t x_t \phi_{jk}(t) \tag{4}$$

$$d_{ik} = \sum_t x_t \Psi_{ik}(t) \tag{5}$$

for $0 \le k \le \frac{n}{2^j} - 1$ and $0 \le i \le j < \frac{n}{2^j}$.

From (1) the time series $\{x_t\}_{0\le t\le n}$ can be presented in different forms for the sake of decomposition level j and $\Psi(t)$ mother wavelet. According to Daubechies (Daubechies, 1998), for level j and the base sequence $\{\phi_{jk}(t)\}_{0\le k\le\frac{n}{2^j}-1}$we define the projection operator of time series $\{x_t\}_{1\le t\le n}$.

$$\hat{x}_t = \sum_{k=0}^{\frac{n}{2^j}-1} c_{jk}\,\phi_{jk}(t) \tag{6}$$

The sequence $\{\hat{x}_t\}_{0\le t\le n}$ presents the trend in the analyzed series $\{x_t\}_{0\le t\le n}$. More about DWT can be found in (Daubechies, 1992; Percival, 2000; Walnut, 2004). In next step from sequence $\{\varepsilon_t\}_{0\le t\le n}$, $\varepsilon_t = x_t - \hat{x}_t$ for $0 \le t \le n$ we determine the another components of series.

4. Periodicity identification

The Kruskal-Wallis test, which is a rank test comparing medians (Grzelak et al., 2021; Ivanov et al., 2017; Borucka, 2019), and Friedman test, ranking means, were used to analyse the existence of periodicity in the time series. Additionally, the spectral density function was analysed.

For a fixed seasonality $k \in \mathbb{N}$ for the Kruskal-Wallis test, the series $\{\varepsilon_t\}_{0\le t\le n}$ is divided into k disjoint groups $\{c_j\}_{0\le j\le k-1}$ of the form $c_j = \{\tilde{\varepsilon}_{lj}\}_{0\le l\le n_j}$, where $\tilde{\varepsilon}_{lj} = \varepsilon_{kl+j}$, $n_j \ge \left[\frac{n}{k}\right]$ and $n = n_0 + n_1 + \cdots + n_{k-1}$, while [ ] is the integer part from dividing. In order to test seasonality, a working hypothesis was formulated at the significance level of $\alpha = 0{,}05$:

H_0: there is no seasonal component in the analysed series (distributions in the groups are equal or not significantly different),

and the alternative hypothesis:

H_1: there is a seasonal component in the analysed series (distributions in the groups differ significantly).

Let R_{ij} denote the sample rank for the element $\tilde{\varepsilon}_{lj}$. The test statistic of the Kruskal-Wallis test is given by the formula (Borucka et al., 2021):

$$T = \frac{12}{n(n+1)}\sum_{i=0}^{k}\left(\overline{R}_i - \frac{n+1}{2}\right)^2 n_i \qquad (7)$$

where $\overline{R}_i = \frac{1}{n_i}\sum_{j=1}^{n_i} R_{ij}$.

The T test statistic is a measure of the deviation of the mean sampled ranks from the mean value of all ranks, equal to (n + 1) / 2. The T statistic has a distribution of χ^2 with k-1 degrees of freedom.

For the Friedman test we analyse the series $\{\varepsilon_t\}_{0\le t\le mk-1}$, where $m = \max\{l\colon l \le \left[\frac{n}{k}\right]\}$, and we present this series in the form $\{\breve{\varepsilon}_{lj}\}_{\substack{1\le l\le m\\ 1\le j\le k}}$, where $\breve{\varepsilon}_{lj} = \varepsilon_{k(l-1)+j-1}$. For each element $\breve{\varepsilon}_{lj}$ we determine the rank for the j-th element from the l-th group and denote r_{lj} (i.e. the rank in the group $\{\breve{\varepsilon}_{l1}, \breve{\varepsilon}_{l2}, \dots, \breve{\varepsilon}_{lk}\}$). The statistics for Friedman test is given by the formula:

$$\chi^2 = \frac{12}{k(k+1)\acute{n}}\sum_{i=1}^{k}\Big(\sum_{i=1}^{m} r_{ij}\Big)^2 - 3(k+1)\acute{n}\,, \qquad (8)$$

and has the distribution χ^2 but with k-1 degrees of freedom and $\acute{n} = mk \le n$.

Spectral analysis was also used to verify the periodicity. The basis of spectral analysis is the assumption that each time series can be expressed as a combination of cosine and sine waves with different periods and amplitudes (Wandelt & Sun, 2015; Suau-Sanchez et al., 2020). For the series $\{\acute{\varepsilon}_t\}_{1\le t\le n}$ of the form $\acute{\varepsilon}_t = \varepsilon_t - \bar{\varepsilon}$, $1 \le t \le n$ where $\bar{\varepsilon} = \frac{1}{n}\sum_{t=1}^{n}\varepsilon_t$, we determine the spectral density function:

$$f(\omega) = \frac{1}{2\pi n}\left(\left(\sum_{t=1}^{n}\acute{\varepsilon}_t\cos\omega t\right)^2 + \left(\sum_{t=1}^{n}\acute{\varepsilon}_t\sin\omega t\right)^2\right) \qquad (9)$$

for angular velocities $\omega \in [-\pi, \pi]$. The presence of the spectral density function peaks for specific angular velocities indicates the existence of periodicity τ and the correlation between the elements of the time series $\{\acute{\varepsilon}_t\}_{1\le t\le n}$ with the time shift $\tau \approx \frac{2\pi}{\omega}$ and $\tau \in \mathbb{N}$.

5. Flights analysis

In the presented study, a discrete wavelet transformation was used to identify the trend in the studied series $\{x_t\}_{0\le t\le n}$, presented in Fig. 3, which additionally shows the period of changes in air traffic resulting from the Covid-19 pandemic. The beginning was considered to be January 23, 2019, when the Chinese authorities quarantined Wuhan with its international airport, in practice cutting it off from the world, and as a result, along with the increase in the number of infections and the introduced restrictions, the authorities of other countries introduced unprecedented restrictions on flights to and from China, and also for passengers from this country. The end date is 01/14/2021. This is due to the fact that on January 13, 2021, at midnight, the regulation of the Council of Ministers of January 5, 2021 on air traffic bans expired, which enabled to land in Poland of planes from Great Britain and Northern Ireland, which were then the last of the countries against which the flight ban to Poland was in force.

The trend in the time series was estimated using the formula (5). In Fig. 4, the trend $\{\hat{x}_t\}_{0 \le t \le n}$ for the Daubechies wavelet transformation of the order of 12 and the decomposition level 3 is shown in red.

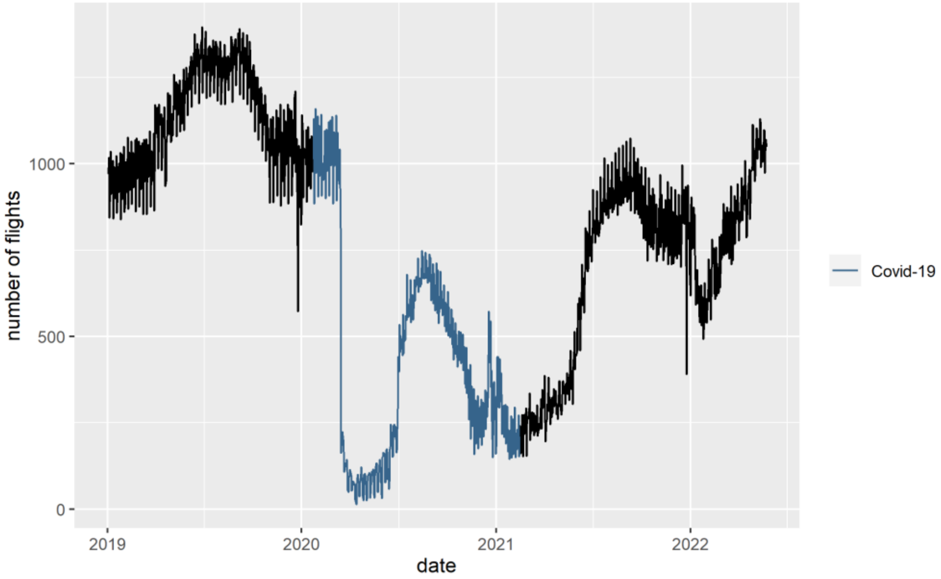

Fig. 3. The number of flights performed in Poland in 2019-2022 (until May 2022)

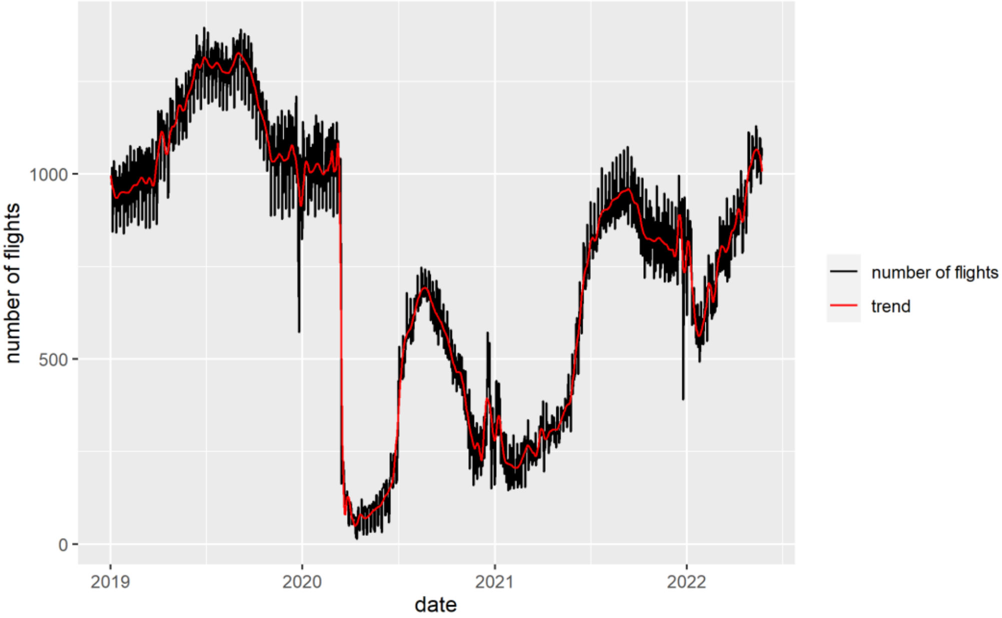

Figure 4. Graph of the trend function matching determined based on the wavelet transformation

Figure 4 clearly shows the oscillation of the empirical values around the trend line. Then, the existence of periodicity in the series $\{x_t - \hat{x}_t\}_{0 \le t \le n}$. was examined. After estimating the statistics of the K-W test and Friedman for each order of seasonality ($k = 2{:}\,10$ was analised) we obtain the p-value graphically presented in Fig. 5. It can be clearly seen that only for the period *k = 7* (for weekly seasonality) we reject the working hypothesis for advantage of the alternative hypothesis, so group distributions differ significantly. The value of the Kruskal-Walis test statistic is 705.3, and p - value = 0. On the other hand, the statistic of the Friedman test is 584.31 and the p-value = 0. Therefore, we can conclude that there is a seasonality component in the series with period 7.

Spectral analysis was also used to verify the existence of seasonality in the $\{x_t - \hat{x}_t\}_{0 \le t \le n}$ series. Fig. 6 shows the values of the spectral density function, by means of which we can capture the periodicity in the tested series. For specific angular velocities ω, the graph shows clear peaks (places where the value of spectral density reaches local maxima). The peaks in the graph correspond to the cycles (seasonality) of the series. We designate the period size as $T = \frac{2\pi}{\omega}$. Table 2 shows the local maxima for the angular velocity and the corresponding values of the spectral density. The peaks in the graph occur for speeds of ± ω, ± 2ω, ± 3ω, where ω = 0.896. As a period in the time series we assume $\mathrm{t} = \mathrm{T} = \left[\frac{2\pi}{\omega}\right] = [7{,}01] = 7$.

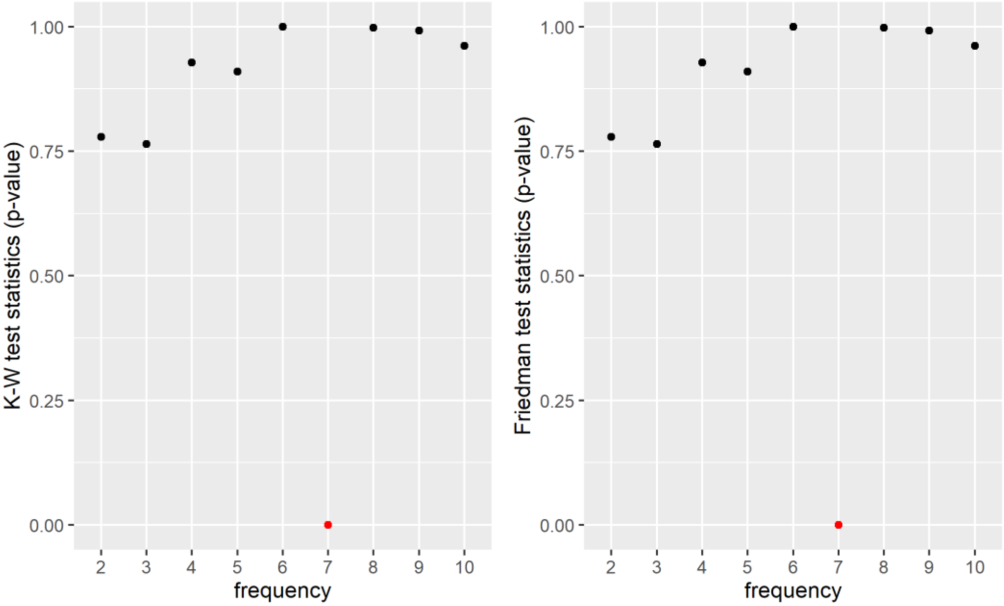

Fig. 5. Results of statistical tests for selected orders of k periodicity

Table 2. Results of the highest values of spectral density for the $\{x_t - \hat{x}_t\}_{0 \le t \le n}$ series.

Angular velocity ω	**Spectral density**	**Period T**
-2,695	125,093	-2,331
-1,796	228,339	-3,499
-0,896	114,571	-7,011
0,896	114,571	7,011
1,796	228,339	3,499
2,695	125,093	2,331

The dominant frequency values and the corresponding density values are presented in Fig. 6.
Confirmation of the weekly seasonality made it possible to identify the series as the sum of the previously determined trend and the seasonal component, as the mean value from the observations on a given day of the week. The matching of functions is shown in Fig. 7.

The proposed model was compared with the identification using a moving average of order 7. First, the values of the moving average were determined for the data representing the number of flights $\tilde{x}_t = \frac{1}{m}\sum_{\tau=1}^{m} x_{t-\tau}$ for $m = 7$, where $\tilde{x}_t$ represents the predicted value of the time series for the t moment.

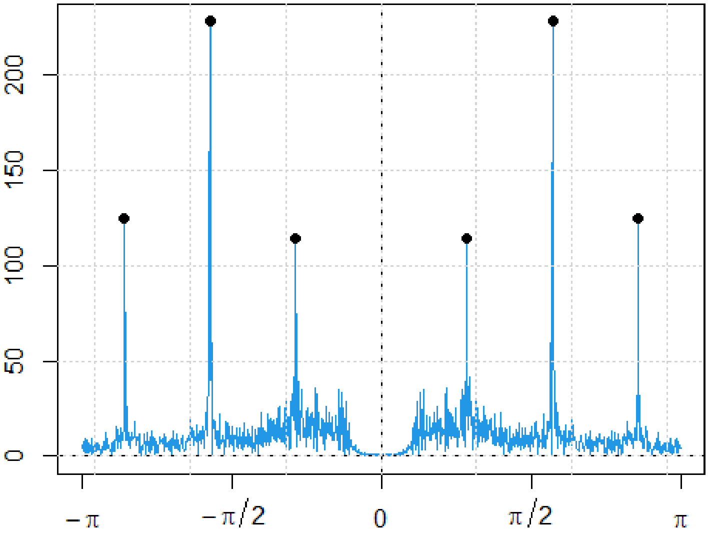

Fig. 6. Spectral density graph of the tested series

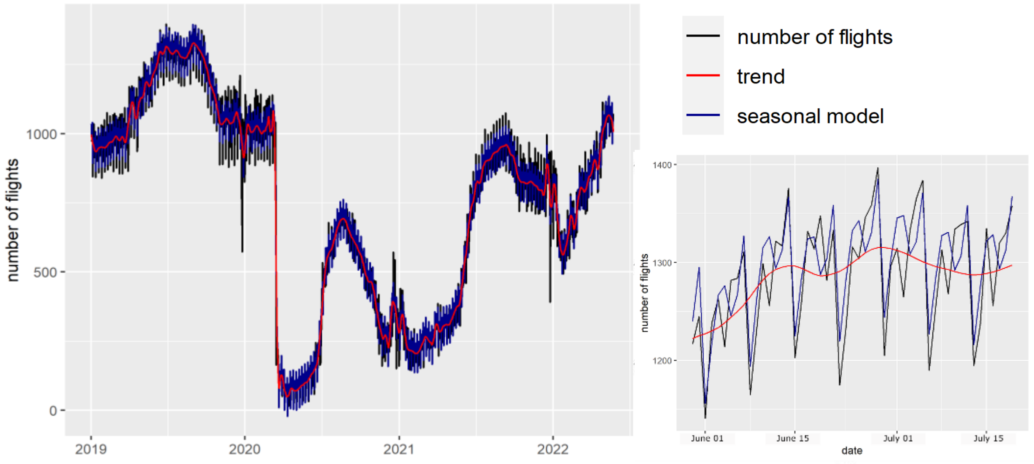

Fig. 7. Matching of the proposed seasonal model to empirical data

Table 3. Estimation errors for the moving average model and the model consisting of wavelet projections and the seasonality component

	SSE	RMSE	MAE	MAPE
MA filtering	4661070	61.33	46.83	0.11
Wave projection with seasonality	2573422	45.57	32.28	0.09

The degree of compliance of the models with empirical data was also compared. For this purpose, basic indicators such as Sum of Squared Errors (SSE, Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) were estimated. The results of matching the models with empirical data are presented in Table 3. As the above results show, the model proposed by the authors coped better with the identification of the studied series than a simple moving average. The errors are significantly lower. Therefore, the proposed solution can be considered more effective. Nevertheless, as mentioned in the introduction, the air services market is influenced by many variables and the scenarios created should be constantly updated and modified.

6. Conclusions

The impact of the COVID-19 pandemic on air transport was a precedent throughout its history. Never before has an impact on this sector been so dramatic. Isolation measures, mobility restrictions and quarantine almost destructively limited the activities of airlines and airports around the world - including Poland. Therefore, the processes of planning, designing and implementing reconstruction programs in this sector are extremely important. They require reliable and credible tools. One of them is presented in this article. The authors presented a model that allows to identify the number of flights using Poland as an example, taking into account the degree of recovery of the Polish air transport industry after the economic shock of the Covid-19 pandemic. The proposed model identified the analysed series more efficiently than the simple moving average, the estimation errors were smaller, which may mean more effective forecasts.

Such forecasts are important for air traffic, they can improve the performance of airlines and positively affect their profits. However, many of the existing air flow forecasting methods are not accurate. This is due not so much to the quality of the models themselves, but to the complexity of the analysed phenomenon. Such inaccurate traffic forecasting models not only are of no benefit, but may be a waste of the airline's potential to some extent. Therefore, it is legitimate and important to develop models that can provide a more accurate forecast of airflow. Such a proposal is presented in this article.

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