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Seasonality in Air Traffic and Incidence of Dangerous Occurrences in the Polish Air Transport Market in 2010-2017

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Abstract:

Purpose: *The aim of the research was to identify the relation between flight operations conducted in the summer and winter seasons, and dangerous occurrences which took place then.*
Design/Methodology/Approach: *The research involved the indicator method used in time series analysis. The interdependence between the quantitative variables was determined with the use of the Pearson line correlation coefficient. Statistical data for the analyses was obtained from the European Coordination Centre for Accident and Incident Reporting Systems (ECCAIRS) and the Polish Civil Aviation Authority.*
Results: *Relations were identified between the variables of the number of passengers carried, the number of flight operations conducted, adverse aviation occurrences in 2010-2017, and the winter and summer seasons of the year. The results indicate that these variables are interrelated.*
Practical implications: *The approach employed in analysing the relation between the variables concerned can be applied to processes of pro-active civil aviation safety management.*
Originality/value: *The approach to analysing the variables shown in the paper has not been widely presented in the literature to date.*

Keywords: *Air transport, seasonality, dangerous aviation occurrences.*

JEL code: *L93, O18, R41, H56.*

Paper type: *Study research.*

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1. Introduction

The functioning of the aviation market, which is comprised of passengers, carriers, airports, and various organisations that regulate the area, manufacture aviation equipment, and provide services to carriers and airports (Sobczyk, 1997; Pilarski, 2007) is a complex matter. It is characterised by seasonal fluctuations in demand which often take place within 12-month cycles.

The matter of seasonality is discussed more broadly in Burda and Wyplosz (2014), Tłoczyński (2014), Hys (2015), *Wpływ…* (2018), Aczel *et al.* (2018), Sitek (2019). The varying demand for air transport services is to a large extent a consequence of seasons of the year, weather conditions and social habits, all of which lead to a clear increase in the number of people using this branch of transport in specific months. Due to these seasonal variations, carriers and airports either underutilise or over utilise their capacities. As a result, many aerodromes have adopted two seasons, i.e., the summer and the winter, which are characterised by different air traffic intensities.

According to the International Air Transport Association, aviation's summer season starts on the last Sunday of March and ends on the last Saturday of October. The remainder of the year (between the last Sunday of October and the last Saturday of March) represents the winter season (Warżała, 2016). Given the large demand for air transport services (*Air Passenger Market Analysis,* 2018; *Aviation benefits beyond borders,* 2018; *Global Networks,* 2017; Wrigley, 2018), rationalising the carriage capacities, maintaining the adequate aerodrome infrastructure capacity, and ensuring an appropriate safety level all represent an important issue (Price and Forrest, 2016; Young and Wells, 2019; Samunderu, 2020; Janić, 2021).

Despite clear benefits from employing air transport in movements of people and goods, adverse aviation occurrences (accidents, incidents) have been around since the human first took to the skies. As this branch of transport developed, various efforts were made to mitigate those occurrences[1]. It was made possible by the increased reliability of aircraft (*ICAO,* 2018; Kierzkowski, 2018), use of state-of-the-art materials, airframe improvements, enhanced cockpit instruments and increased reliability of engines. An important role was also played by better understanding of the human role in aviation accidents and development of safety culture (Kozuba, 2014; *Worldwide Slot Guidelines,* 2017), focus on multi-crew cooperation, personnel training, and implementation of recommendations made commissions appointed to investigate causes of aviation accidents. These efforts have contributed to an improvement in safety indicators (e.g., the number of accidents per million take-offs and the number of fatalities per 100 million passengers) (*Aviation benefits beyond*

[1]*The Safety Management Manual lists the following periods: the technical era - from the early 1900s until the late 1960s, the human factors era - from the 1970s until the late 1990s, and the organisational era - from the mid-1990s until today, in which various measures were undertaken for the safety of air transport (Pilarski, 2007).*

borders, 2016; *ICAO Long-term Traffic Forecast*, 2016; *ICAO Safety Report, 2017; Aviation benefits beyond borders*, 2018).

Actions aimed at enhancing air transport safety are not always sufficient. Unfortunately, dangerous aviation occurrences, which arise from different causes, continue to take place with varying incidence and differing consequences. In the context of a clear and dynamic increase in the number of people using air transport in Poland in 2010-2017[2], leading to a larger number of flight operations, a decision was made to investigate how that increase translated to the incidence of aviation occurrences (incidents, accidents, serious incidents, significant incidents, major incidents)[3] in the summer and winter seasons. Due to the access to and completeness of data, the research was limited to the period of 2010-2017.

2. Organisation of the Research

Data for the analyses was obtained from the Department of Air Transport Market and the official website of the Polish Civil Aviation Authority. It regarded the number of passengers carried and flight operations conducted at all airports across Poland in 2010-2017[4]. Information on aviation occurrences in Polish transport aviation in the period of 2010-2017 was received, via the Polish CAA, from the European Coordination Centre for Accident and Incident Reporting Systems (ECCAIRS) database.

For the analyses, flight operations where dangerous occurrences took place were divided into two groups, i.e., Commercial Air Transport (CAT)[5] (60.3%) and Other Operations[6] (39.7%). Prepared and verified in Excel, the data was then imported to Statistica v 12.0, the software used for principal analyses (Figure 1).

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[2]*Towards the end of the period in question, the annual increase in the number of passengers reached 17.5%. This came as a result of an increased number of flight operations conducted at individual airports. Data in this respect is presented on the website of the Polish Civil Aviation Authority (Urząd Lotnictwa Cywilnego), https://www.ulc.gov.pl/pl/statystyki-analizy/statystyki-i-analizy-rynku-transportu-lotniczego/3724-statystyki-wg-portow-lotniczych, (access 09.06.2021).*

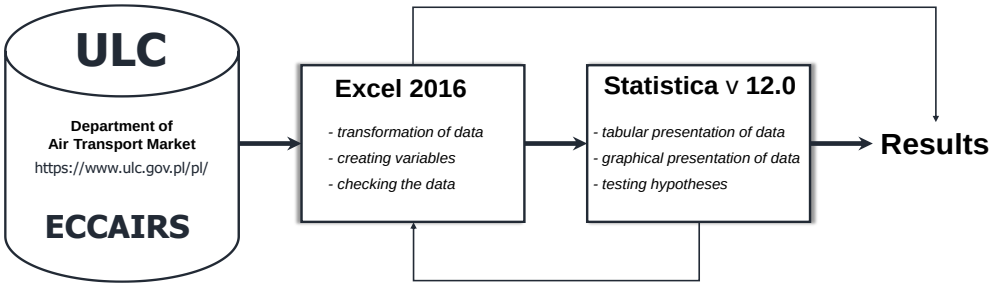
[3]*These groups of occurrences are listed in: ECCAIRS Aviation 1.3.0.12 Data Definition Standard, English, Attribute Values, https://www.icao.int/safety/airnavigation/AIG/Documents/ADREP%20Taxonomy/ECCAIRS%20Aviation%201.3.0.12%20(VL%20for%20AttrID%20%20431%20-%20Occurrence%20Classes).pdf (access 14.06.2021).*

[4]*Information on aerodromes, carriers, flight operations conducted, number of passengers carried and other is published at https://www.ulc.gov.pl/pl/statystyki-analizy and https://www.ulc.gov.pl/pl/publikacje/publikacje For clarity reasons, the research data presented in Figure 4 concern only the largest aerodromes in Poland.*

[5]*Operations undertaken to transport passengers, cargo or mail for remuneration or other valuable consideration.*

[6]*Operations undertaken by state aviation, general aviation, training aviation and other.*

Figure 1. *Use of software for data preparation and analysis.*



Source: *Own work.*

The analyses of the numbers of passengers, flight operations and aviation occurrences in successive time units throughout 2010-2017 were conducted with the indicator method employed in analysing time series with trends and seasonality. The interdependence between the quantitative variables was described with the Pearson line correlation coefficient ("r"). The degree of changes in the variables (the number of flight operations and the number of aviation occurrences) over time was determined with the use of fixed-base growth rate indicators. The statistical hypotheses were tested with the Shapiro-Wilk and Mann-Whitney tests. The standard threshold of significance of $\alpha = 0.05$ was adopted.

3. Research Results

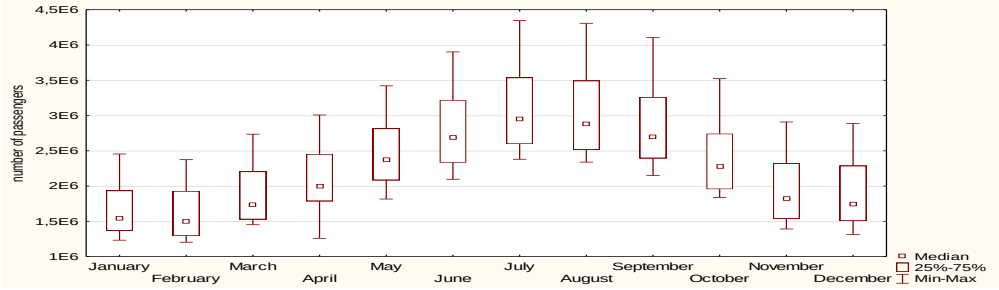
3.1 The Phenomenon of Seasonality

Travellers in Poland used air transport with varying intensity in individual months in 2010-2017. This is illustrated in Figure 2, which shows the number of airline passengers in the summer and winter seasons. Throughout the period in question, seasonality made the number of passengers in certain months lower than the monthly average (by 28.0% in January, 29.9% in February, 18.6% in March, 9.9% in April, 15.7% in November, and 17.9% in December), while putting it above the monthly average in others (by 6.5% in May, 20.9% in June, 33.9% in July, 31.4% in August, 23.5% in September, and 3.9% in October). Figure 3 shows the trends in the number of passengers in Poland in 2010-2017. It also presents the seasonality indicator (trns), adjusted passenger number (tr 2) and random element (tr 3).

Further analyses demonstrated that the phenomenon of seasonality was present at Poland's largest aerodrome, i.e., Warsaw Chopin Airport, which had the largest share in passenger traffic, as well as at other public aerodromes which followed the Warsaw airport in terms of passengers carried in 2010-2017. In Q1 and Q4 (the Polish CAA's website shows quarterly data), the number of passengers was below the quarterly average (Warsaw Chopin Airport by 23.4% in Q1 and 10.2% in Q4, Balice Airport by 22.7% in Q1 and 5.2% in Q4, Pyrzowice Airport by 36.5% in Q1 and 22.7% in Q4, L. Wałęsa Airport by 23.8% in Q1 and 9.5% in Q4) – see Figure 4. Seasonal

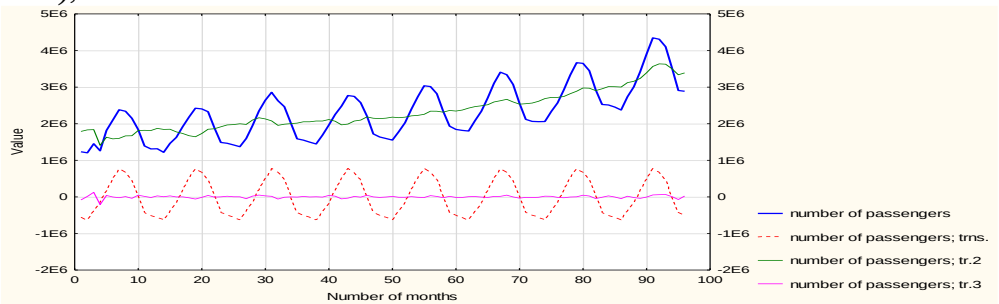
variations could be seen also at smaller airports, e.g., Łódź's Lublinek and Rzeszów's Jasionka, where the number of passengers in Q1 and Q2 was lower than the quarterly average by respectively 22.9% in Q1 / 14.1% in Q4 and 22.6% in Q1 / and 10.7% in Q4.

Figure 2. *The number of passengers in successive months throughout 2010-2017.*



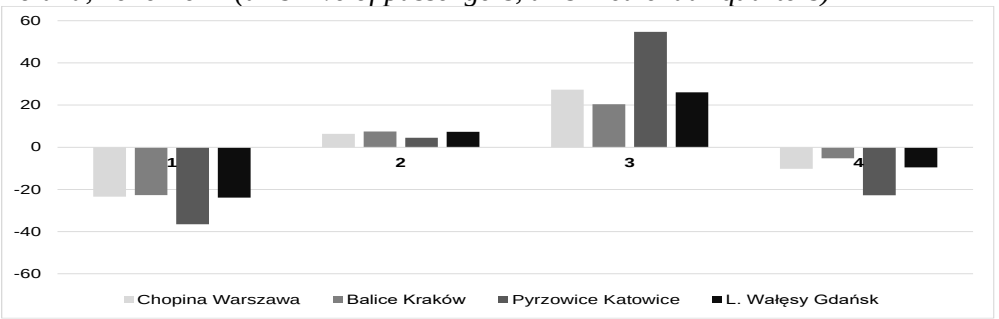
Source: *Own work based on data from the Polish Civil Aviation Authority.*

Figure 3. *The number of passengers using air transport in successive months (2010-2017), and other time series elements.*



Source: *Own work based on data from the Polish Civil Aviation Authority.*

Figure 4. *Seasonal variations in the number of passengers at selected aerodromes in Poland, 2010-2017 (axis Y % of passengers, axis X calendar quarters)*



Source: *Own work based on data from the Polish Civil Aviation Authority.*

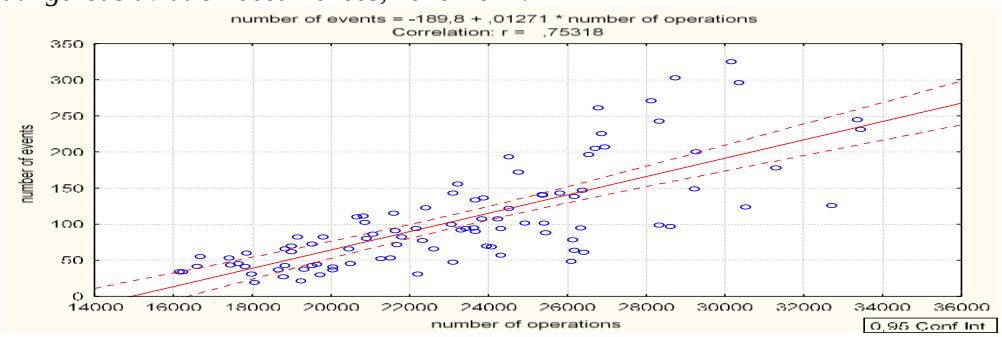
Due to the varying demand for passenger carriage, Warsaw Chopin Airport announces summer and winter timetables every six months, and they remain in force in

accordance with the definition adopted by IATA. The airport checked out (on average) 67% of all passengers in the summer season in 2010-2017. The largest numbers of passengers were recorded in July, August, and September, when carriers would open the largest number of routes and the activity of charters carriers would increase.

3.2 Seasonality and Aviation Occurrences

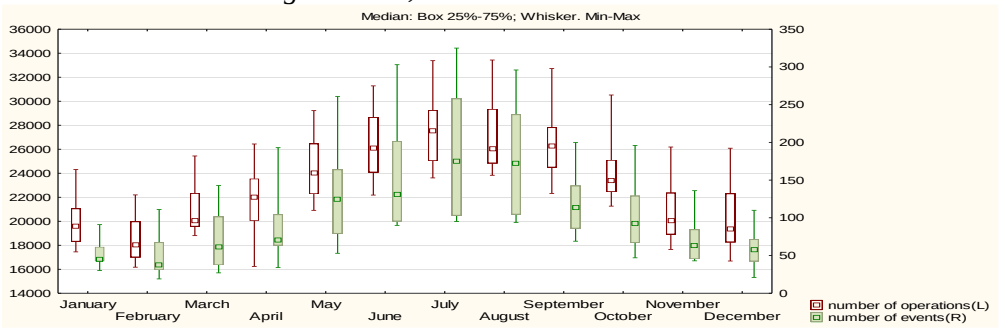
In 2010-2017, the greater number of passengers carried was accompanied by an increase in flight operations (r = 0.976), which led to a rise in the number of aviation occurrences (Figure 5). An analysis of the growth rates in flight operations and aviation occurrences in successive months throughout 2010-2017 demonstrated that a change in one factor in a specific month was accompanied by a change in the other. The distribution of the number of flight operations and the corresponding number of aviation occurrences in successive months throughout the period in question is illustrated in Figure 6. The figure shows a difference between the distribution of flight operations and the number of occurrences in winter and summer months.

Figure 5. *The relation between the number of flight operations and the number of dangerous aviation occurrences, 2010-2017.*



Source: *Own work based on data from the Polish Civil Aviation Authority.*

Figure 6. *The number of flight operations conducted /left axis Y/ and the number of aviation occurrences /right axis Y/, 2010-2017.*



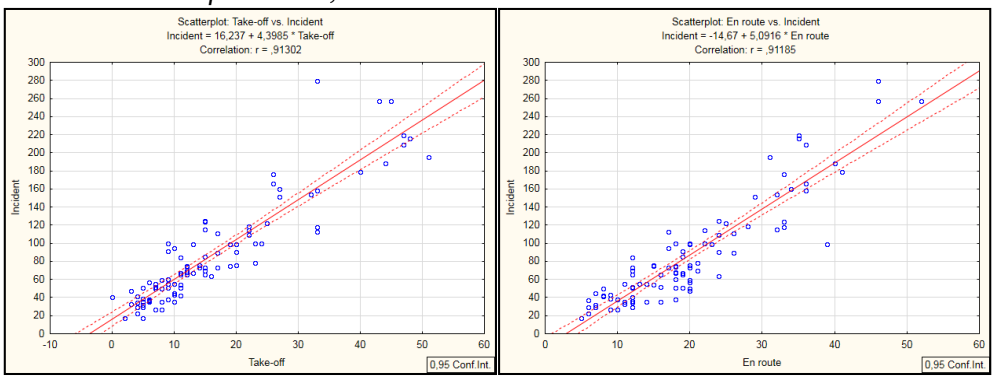
Source: *Own work based on data from the Polish Civil Aviation Authority.*

Occurrences reported in Polish transport aviation in 2010-2017 were categorised in the following groups: incidents 81.4% of all occurrences, accidents 8.5%, serious incidents 8.1%, significant incidents 6.9% and major incidents 1.4%. It was found during the analysis that the distribution of occurrences in the respective groups for Civil Air Transport and other operations was dissimilar: incidents - CAT operations 81.4% / other operations 68.1%; accidents - 8.5%/21.2%; serious incidents - 1.8%/3.3%; significant incidents - 6.9%/5.9%; and major incidents - 1.4%/1.5%.

Further analyses confirmed the differences between the number of dangerous occurrences in the winter and summer seasons across all occurrence groups. Analysing the results of the Shapiro-Wilk test for each group, the authors found that the assumption on the normal distribution of a variable was not met. In this light, the authors assessed the differences in the occurrence average for each group in the summer and winter seasons with the Mann-Whitney test, which is used for assessing differences in variables on independent samples. The largest difference in the number of occurrences between the seasons, expressed in percentage points (pp), was found in the accidents group (80 pp), whereas the smallest one was fund in the significant incidents group (46.7 pp).

Occurrences in different flight phases were reported in Polish transport aviation in 2010-2017 at various levels of incidence. Characteristically, incidents prevailed in every phase. In the period in question, the number of flight operations conducted, and the number of incidents reports were found to be correlated. A particularly strong relation was found for the take-off and en route phases (Figure 7).

Figure 7. *The relation between the number of flight operations (take-off, en route) and the number of incidents, 2010-2017.*

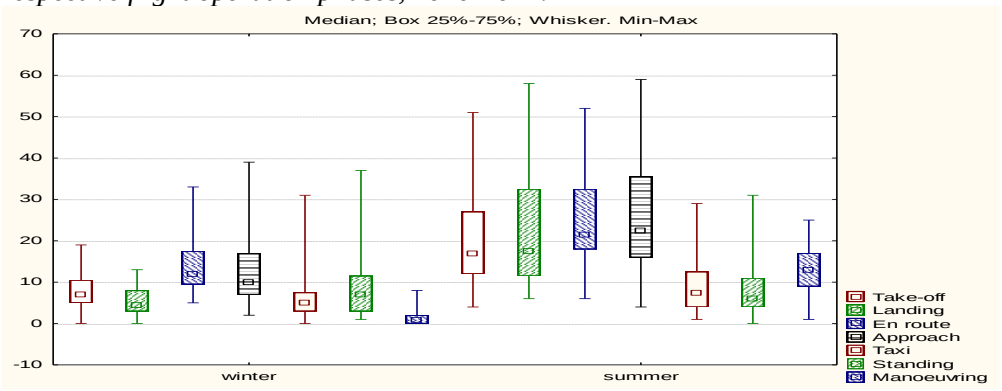


Source: *Own work based on data from the Polish Civil Aviation Authority.*

Accidents and incidents happen in various phases of flight (11). Aviation the distribution of occurrences which happened in Polish transport aviation in respective flight phases in the winter and summer seasons is shown in Figure 8. One can notice a characteristic similarity between the percentage of occurrences in the approach phase both in the winter and summer seasons (0.9 pp difference). The other phases

showed clearer differences, in the standing phase (7.9 pp), manoeuvring phase (7.4 pp) and landing phase (7.2 pp). The distribution of dangerous occurrences in the "CAT" group and "Other operations" group was as follows: during standing in CAT operations the percentage was 11.8%/while in other operations it was 4.4%; during taxiing it was 8.9%/6.1%; during take-off 17.4%/12.7%; en route 20.8%/17.4%, during approach 26.4%/10.5%; during landing 11.7%/20.1%; and during manoeuvring 0.02%/21.0%.

Figure 8. *Incidence of aviation occurrences in the winter and summer seasons in respective flight operation phases, 2010-2017.*



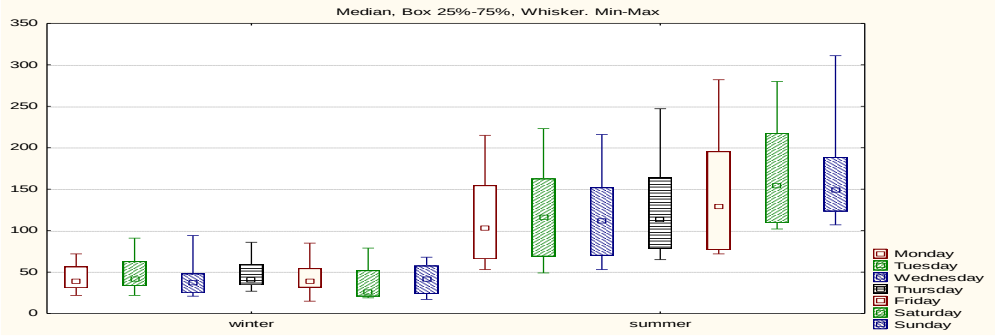
Source: *Own work based on data from the Polish Civil Aviation Authority.*

It was found during the analyses that occurrences from the respective groups prevailed in specific months. In 2010-2017, 40.4% of occurrences categorised in the incidents group took place in June, July, and August, 66.2% of accidents took place in May, July, August, and September, while serious incidents dominated in May, July, and August (43.2%), significant incidents peaked in June, July, and August (39.3%), and major incidents in May, June, and August (38.9%).

Comparing the percentage share of occurrences in the "CAT" and "Other operations" groups in successive months, the authors found the percentage of dangerous occurrences to be higher in the "CAT" group between October and March. During other months, it was higher in the “Other operations” group. Further analyses involved investigating the distribution of dangerous occurrences in the summer and winter seasons per day of the week (Figure 9) and diurnal (Figure 10).

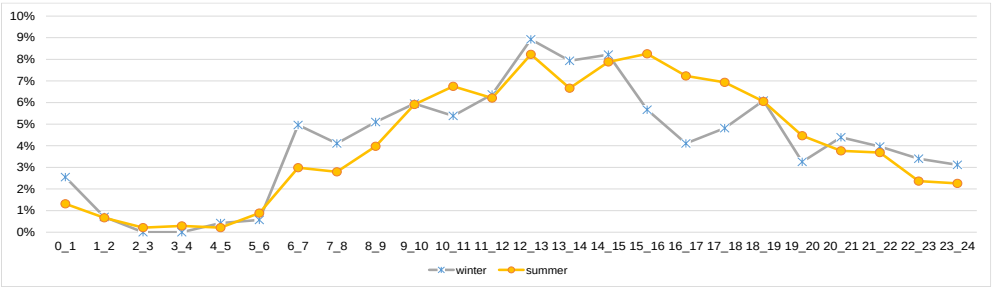
It was found that more than half (53.2%) of all occurrences from the accident’s groups and 41.0% from the serious incidents group took place on Saturdays and Sundays. One out of five occurrences in the major incidents group happened on Thursday. The analyses also demonstrated that between Monday and Thursday the number of dangerous occurrences was lower than the weekly average (by 12.6% for Mondays, 6.1% for Tuesdays, 12.0% for Wednesdays, and 2.7% for Thursdays), but higher than the weekly average on other days (by 4.4% for Fridays, 13.5% for Saturdays, and 15.6% for Sundays).

Figure 9. *Distribution of aviation occurrences in the winter and summer seasons per day of the week, 2010-2017.*



Source: *Own work based on data from the Polish Civil Aviation Authority.*

Figure 10. *Diurnal incidence of aviation events in the winter and summer seasons, 2010-2017.*



Source: *Own work based on data from the Polish Civil Aviation Authority.*

A comparison between the percentage share of occurrences per day of the week in the "CAT" and "Other operations" groups showed the percentage to be higher for CAT operations between Monday and Friday, with other operations taking the lead on Saturdays and Sundays. The analyses demonstrated also diurnal differences in the incidence occurrences in the winter and summer seasons. In 2010-2017, the number of aviation occurrences was higher than the diurnal average between 10:00 hrs and 20:00 hrs, and lower throughout the rest of the day. In the period in question, the greatest number of occurrences took place between 12:00 hrs and 13:00 hrs, and the lowest between 2:00 hrs and 3:00 hrs (local time).

The diurnal incidence of dangerous occurrences can be affected by several factors. From the operating day perspective, carriers consider the fact that there is a specific daily pattern that determines how their flight timetables are shaped. Passengers prefer starting their flights in the morning, so that they can arrive at their destination at a convenient time of day (24). In addition to the demand preference, there are certain limitations on the supply side, for a significant number of airports (including Warsaw Chopin Airport) are subject to bans on night-time flights due to the proximity of residential zones. Such a "night curfew" has been in force for Warsaw Chopin Airport

since 25 March 2018[7] and covers the time between 23:30 hrs and 5:30 hrs, generally on all days of the week. At other aerodromes, the curfew starts at 22:00 hrs at the earliest and ends, in general, between 5:00 hrs and 6:00 hrs, effective for all flight operations, except ones conducted by state and military aviation, and emergency and rescue flights.

The incidence of aviation occurrences in respective months and times of day is affected also by wildlife activity. As it transpires from the data presented in a study by the Polish CAA (35), there were 2,170 bird-related aviation occurrences reported in Poland in 2010-2017. In addition, 286 occurrences related to mammals were also reported. According to the study, the number of bird-related occurrences was the highest in the third and fourth quarters of each year. During the day, the highest incidence of such occurrences was between 12:00 hrs and 13:00 hrs, and between 15:00 hrs and 16:00 hrs.

4. Summary

A dynamic increase in the number of air transport users could be seen in Poland and elsewhere around the world[8] in 2010-2017. Characteristics of that branch of transport in the period in question included seasonal fluctuations in demand which translated into the number of flight operations, during which, in turn, aviation occurrences took place that affected the safety of passengers and crews. The increase or decrease in flight operations over successive months was accompanied by a corresponding increase or decrease in aviation occurrences. The distribution of dangerous occurrences in the summer and winter seasons differed. In the months categorised by IATA as summer months (excluding April), the number of number occurrences was higher than the monthly average.

In the period in question, there were differences in the number of occurrences reported in respective flight phases in the summer and winter seasons. A strong correlation between flight operations conducted and aviation occurrences reported could be seen during take-offs and en route. There were also some differences between Commercial Air Transport operations and other operations. Certain summer-winter differences were found also for respective days of the week as well as during the day. During the week, the weekly occurrence average was exceeded on Fridays, Saturdays, and Sundays. Diurnally, the largest number of adverse occurrences was reported between 10:00 hrs and 20:00 hrs.

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[7] *https://www.lotnisko-chopina.pl/pl/aktualnosci-i-wydarzenia/0/757/szczegoly.html (access 15.06.2021).*

[8] *In 2017, global passenger traffic expressed in revenue passenger kilometres (RPKs) grew by 7.5% compared with 2016 (9). In that period, the available seat kilometre (ASK) figure increased by 6.1%, and the global load-factor (LF), which is a % of the ASK usage, grew by 0.3 percentage point to 81.9% (3).*

Information about aviation occurrences can be obtained from government reports, operators, manufacturers, and news services. In the era where airlines store more and more data, accessing and analysing it with big data processing tools can lead to identifying relations that have to date been unknown. Given the increase in flight operations, which in turn entails a rise in aviation occurrences, actions undertaken by aviation authorities should focus on *inter alia* collecting data that is essential for analysing the causes of such occurrences so that constructive lessons could be learnt for the future.

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