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EXPLORING PUBLIC INTEREST IN LIMITED-USE AREAS AND COMPENSATION FROM AIRPORTS IN POLAND: A GOOGLE TRENDS ANALYSIS

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ABSTRACT

This article evaluates online social behavior regarding the establishment of limited-use areas (LUAs) around the airports in Warsaw and Gdansk. The study relied mainly on an analysis of Google Trends statistics, in particular the dynamics of keyword searches. The article suggests that assessments of online behavior can provide a deeper understanding of social behavior. The study involved an OLS regression analysis and a causal impact analysis of the intervention based on a Bayesian structural time-series model. This article analyses different phases of an information society's activity, from the introduction of LUAs around airports to the deadline for submitting compensation claims. The results indicate that the number of searches for the keyword "compensation" increased significantly after the introduction of LUAs and that RSV decreased after the end of the compensation process, which confirms that the intervention significantly influenced the analyzed time series.

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1. Introduction

Airports represent the main category of ground-based aviation infrastructure, and most of their area has been designed to support air transport. In addition to the airport terminal and runways, airports also feature hangars, warehouses, workshops, airport and infrastructure maintenance facilities, and an air traffic control tower. Aviation real estate is classified as commercial property because it is used mainly for commercial activities such as the collection of aviation fees, parking fees, and rental of commercial space in terminals. Effective transport networks are needed to facilitate passenger transport from airports to the surrounding urban areas. Airports situated within city boundaries are one of the main components of the urban fabric that influence the spatial characteristics of a city. Airports are becoming strategic transport hubs that affect the spatial organization of cities, financial decisions concerning new infrastructure projects (roads, tramways, railways), organization of urban life, and the performance of residential and commercial real estate markets.

Aviation real estate is a type of commercial or special-purpose property that plays a very important role on local commercial real estate markets and provides the required facilities for commercial operations both within and around airports (car parks, hotels, restaurants). Airports have to meet numerous legal requirements concerning aviation safety and environmental protection, and the extent to which these requirements are observed affects local communities' quality of life. Airports situated in the vicinity of residential estates often cause neighborhood conflicts. These conflicts frequently erupt when limited-use areas (LUAs) are created around airports. Limited-use areas can be regarded as an act of state intervention to minimize the noise generated by air traffic. It can be assumed (Bełej et al., 2023) that new regulations concerning areas in the vicinity of airports can cause local communities to experience a sense of loss that has not yet been quantified or compensated. These experiences increase local residents' and the general public's awareness of the inconveniences associated with airports and government interventions. Therefore, the bans and orders imposed by the state authorities

should be regarded as a social problem. In different legal systems, the resulting conflicts are resolved with various degrees of state intervention – local communities may not receive any compensation, they may receive financial support to soundproof their homes, they may be compensated for the decrease in the value of their property, or the property may be purchased by the state (Habdas, 2020a; Konowalczuk et al., 2021). In an era of an information society, Internet users' online behavior can be analyzed to determine the social implications of LUAs. An information society is a society whose development is largely determined by access to information and knowledge, and the ability to use various information and communication technologies (Olszak & Ziemba, 2009). The development of the Internet and growing access to information fuel the evolution of the information society, but the social consequences of these processes are not always desirable. According to the memorandum on a "Sustainable Information Society" (Göhring, 2004), the cause and effect relationship is increasingly difficult to determine in a digital world, and information technologies do not always contribute to a decrease in natural resource use in consumption and production. However, unequal access to the Internet can exacerbate the existing social divide despite the use of advanced information and communication technologies. On the one hand, these technologies have provided all citizens with rapid and cheap access to information, regardless of their location. On the other hand, public access to online information has created new challenges relating to content filtration and assessment of data reliability.

Internet users leave digital footprints which can be processed and aggregated to generate valuable data. As a result, the online social activity can be analyzed to derive information about social behavior. Digital footprints constitute a valuable source of information about social preferences, trends, or even the social mood. However, online behavior differs from conventional social behavior, and this difference has to be recognized in order to derive benefits from the acquired information. These data can be also examined to generate insights into specific topics such as the aviation industry, compensation, or social attitudes towards the creation of LUAs around airports. Google Trends is a free tool for analyzing such data. This valuable tool can be used to determine the popularity of specific keywords and to measure search interest in specific topics. The online search statistics provided by Google Trends have been analyzed in numerous studies (Bełej, 2022; Castelnuovo & Tran, 2017; Huarng et al., 2020; Limnios & You, 2021). According to Yang (Yang et al., 2015), the activity of Internet users at any given moment reflects collective behaviors and reveals the interests, fears, and intentions of the observed population. The conceptual framework of the present study was largely based on the above observation.

The present study relied on the assumption that social behaviors relating to spatial changes (which can have social and economic consequences) around Polish airports can be analyzed with the use of Google Trends. The volume of online searches involving keywords associated with airports, in particular LUAs around the airports in Warsaw and Gdańsk, was analyzed.

The research hypothesis postulates that the volume of online searches concerning airports and compensation is related with the introduction of LUAs around the airports in Warsaw and Gdańsk. Therefore, the present study was undertaken to analyze the relationship between changes in the number of online searches associated with airports and compensation vs. state interventions leading to the creation of LUAs around airports. The study relied on the Google Trends tool which generates the relative search volume (RSV) index by normalizing search results based on the highest percentage of search queries in a given time series. Data were analyzed with the use of open-source R software, the 'gtrendsR' package (Massicotte et al., 2016), the 'CausalImpact' package (Brodersen et al., 2015, 2017), and other packages available in R. The study involved various ordinary least squares (OLS) regression models and a causal impact analysis of the state intervention based on the Bayesian structural time-series model. The aim of the study was to determine whether Google Trends is a useful tool for analyzing social behaviors relating to spatial changes around airports. It appears that online search behaviors (measured with the use of Google Trends) can precede real-world behaviors, such as the submission of compensation claims for damages arising from the establishment of LUAs.

2. Materials and Methods

2.1. Study Area and Data Description

The number of online searches relating to the establishment of LUAs around the Warsaw Chopin Airport and Lech Wałęsa Airport in Gdańsk was analyzed. The Warsaw airport is the largest Polish

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airport, whereas the Gdańsk airport is a medium-sized airport. The location of the analyzed airports relative to city boundaries and the LUAs around these airports is shown in Figure 1.

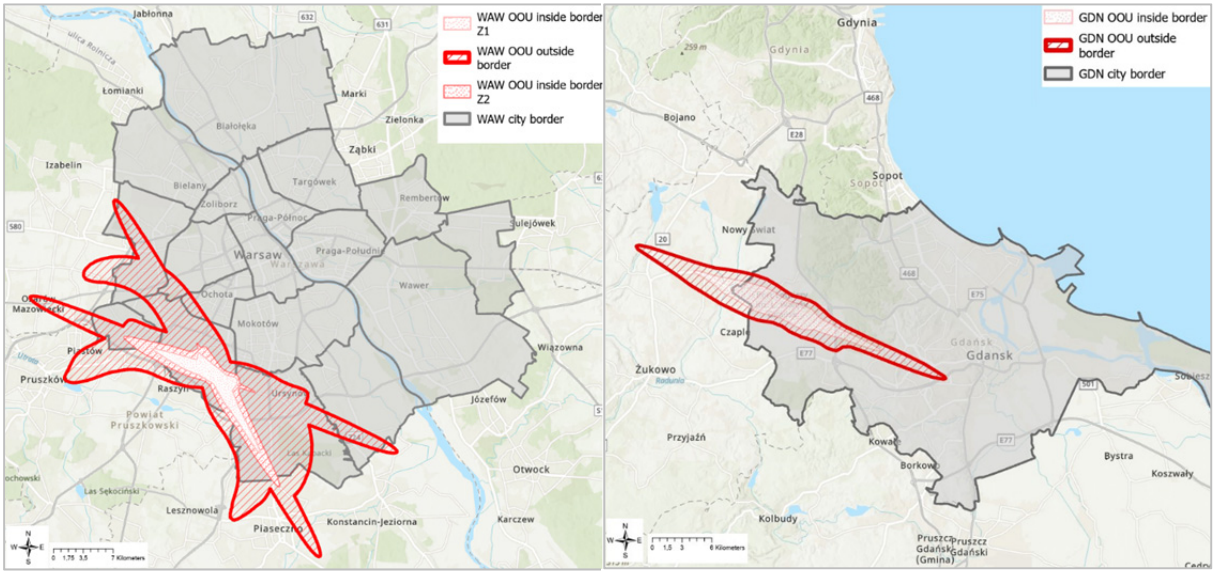

Fig. 1. Location of airports in Warsaw and Gdańsk and limited-use areas (LUAs) around the analyzed airports: a) Warsaw Chopin Airport (WAW), b) Lech Wałęsa Airport in Gdańsk (GDN).

The Lech Wałęsa Airport is situated in the western part of Gdańsk, whereas the Chopin Airport is located in the south-western part of the Polish capital. Both airports have direct access to motorways and public transport. Despite the fact that a part of the LUA in Warsaw is located outside city limits, the rapid development of the Polish capital contributes to the growth of the neighboring counties. The airport in Gdańsk is situated further away from the city center, near the Tricity ring road and the Pomeranian metropolitan railway network. Limited-use areas in Warsaw appear to exert a greater influence on the urban fabric and the local community.

The period of the analysis was divided into two stages. In the first stage of the study, both airports were analyzed between 1 January 2006 and 31 December 2022. In the second stage, the analysis was narrowed down to the periods when LUAs were established in Warsaw (2011) and Gdańsk (2016). The RSV index computed by Google Trends was acquired with the use of the gtrendsR package. R scripts support the acquisition of cohesive and high-quality data, minimize errors, and provide various data aggregation and filtering options. The information about the establishment of LUAs in each city was obtained by reviewing the relevant legal regulations.

2.2. Methods

The number of online search queries associated with airports and LUAs in Warsaw and Gdańsk was analyzed. The RSV index related to selected keywords in Google Trends was analyzed in the first stage of the study. The RSV index is generated by normalizing search results based on the highest percentage of search queries in a given time series. This procedure takes place automatically in Google Trends, and it cannot be influenced by the researchers. The time series for the RSV analysis was only smoothed with the use of the locally estimated scatterplot smoothing (LOESS) method which is based on least squares regression and Gaussian kernel smoothing (with a smoothing parameter of 0.6). The smoothing procedure significantly decreases the amplitude of noise associated with unfiltered raw data and reduces inconsistencies in the analyzed time series without affecting the original data. In the next stage of the study, an OLS regression model and a causal impact analysis of an intervention were applied based on the Bayesian structural time-series model.

Ordinary least squares regression is a statistical technique for analyzing the relationship between a dependent variable and one or more independent variables. A dependent variable is also called a response variable, whereas an independent variable is also known as an explanatory variable or a predictor. An OLS model assumes that a linear relationship exists between response and explanatory variables and that the population mean of the dependent variable can be predicted based on independent variables. The OLS model is related to Pearson's correlation coefficient

(Wilcox, 2003) because it can be used to analyze the relationship between a dependent variable and many independent variables. In the OLS model, the response (dependent) variable should be quantitative, whereas independent variables can be quantitative (continuous or discontinuous), zero-one, other nominal and dichotomous. Independent variables should not be bound by a collinear relationship (strong mutual correlation). In regression analysis, multicollinearity is detected with the use of the variance inflation factor (VIF), and an independent variable that is bound by the weakest relationship with the dependent variable is removed from the model (García et al., 2015; Miles, 2014).

The OLS model is represented by the following equation:

$$Y=\beta_0+\sum^{P}{}_{j=1}\beta_j X_j+\epsilon \quad (1)$$

where: Y is the vector of the dependent variable, β_0 is the intercept, β_j is the coefficient for the j-th explanatory variable (X_j), X_j is the j-th explanatory variable, and ε is the error term.

The OLS regression model is widely used because it is simple and the results are easy to interpret. This model can be also applied to identify trends and predict future values of the dependent variable in time series analyses. Other regression methods can be also used in time series analyses, including autoregressive integrated moving average (ARIMA), vector autoregresssion (VAR), and Bayesian structural time-series (BSTS) models.

A causal impact analysis of an intervention (policy change) is a variant of the BSTS model. The BSTS is a useful tool for analyzing time-series data with an added regression effect. The BSTS model can be represented by the following equations (BSTS, 2023; Scott & Varian, 2014):

$$y_t=\mu_t+\tau_t+\beta^T x_t+\epsilon_t \quad (2)$$

$$\mu_t=\mu_{t-1}+\delta_{t-1}+u_t \quad (3)$$

$$\delta_t=\delta_{t-1}+v_t \quad (4)$$

$$\tau_t=-\sum_{x=1}^{s-1}\tau_{t=-2}+w_t \quad (5)$$

where: y_t is the current value of the target time series in period S; μ_t, δ_t, τ_t and $\beta^T X_t$ are the trend, slope of trend, seasonal and regression components, respectively; ϵ_t, u_t, v_t and w_t are independent Gaussian random numbers with variances σ_ϵ^2, σ_u^2, σ_v^2 and σ_w^2.

The BSTS is a Bayesian technique that combines Kalman filtering, spike-and-slab regression, and Bayesian model averaging. The causal impact analysis is a statistical method for estimating the impact of a planned intervention on the time series. The influence of state intervention on the market is assessed by comparing the time series with a counterfactual prediction of what would have happened without the intervention (Brodersen et al., 2015, 2017). This technique relies on the BSTS model and the following procedure (Brodersen et al., 2015):

- a linear model of the results noted in the experimental group and the control group before and after the intervention is developed,
- differences in the results noted in the experimental group and the control group before and after the intervention are estimated,
- the observed differences, including cumulative differences, are estimated.

In the present study, a causal impact analysis was conducted to analyze the causal effect of state intervention concerning the establishment of LUAs around airports. For the needs of the study, the intervention was defined as the last day on which residents who had been negatively affected by the intervention could submit compensation claims. This method generalizes the difference-in-differences approach by modeling the counterfactual of a time series both before and after the intervention. The model accommodates many sources of variation, such as local trends and seasonality, with an additional regression effect by integrating the uncertainty about the impact exerted by each predictor and the uncertainty about which predictors should be incorporated first to avoid excessive fitting. The model infers the causal impact of the intervention by predicting a counterfactual market response in a synthetic control that would have occurred without the intervention.

3. Results

3.1. Basic research

In the first stage of the study, Google Trends queries were displayed with the use of the gtrendsR package which presents the results as search hits or RSV across time. This method is used to assess the relative (rather than nominal) interest in specific keywords relative to the maximum observed value of a given Google query. The results are expressed on a scale of 0 to 100, where the highest value denotes the highest interest in a given keyword across time and region. The popularity of several keywords can be compared. Public interest in a given keyword can be analyzed to

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identify current trends and changes in trends resulting from, for example, an intervention. The capabilities of the gtrendsR package in processing Google Trends queries have been discussed extensively in the literature (Carneiro & Mylonakis, 2009; Choi & Varian, 2012; Woloszko, 2020).

The popularity of the keyword "limited-use area", composed of three words, was analyzed in the first stage of the study, but the analysis returned very few hits. In line with the Pareto principle (80% of outcomes result from 20% of all causes), the strategies that are most commonly deployed by web users when searching for information were adopted and other keywords were selected for the analysis instead of the above complete keyword. The following Polish keywords were selected: "*Lotnisko*" (Airport), "*Odszkodowanie*" (Compensation), "*Ograniczony obszar*" (Limited area), "*OOU*" (LUA), and "*Port lotniczy*" (Airfield). The number of searches returned by Google Trends is presented in Figure 2.

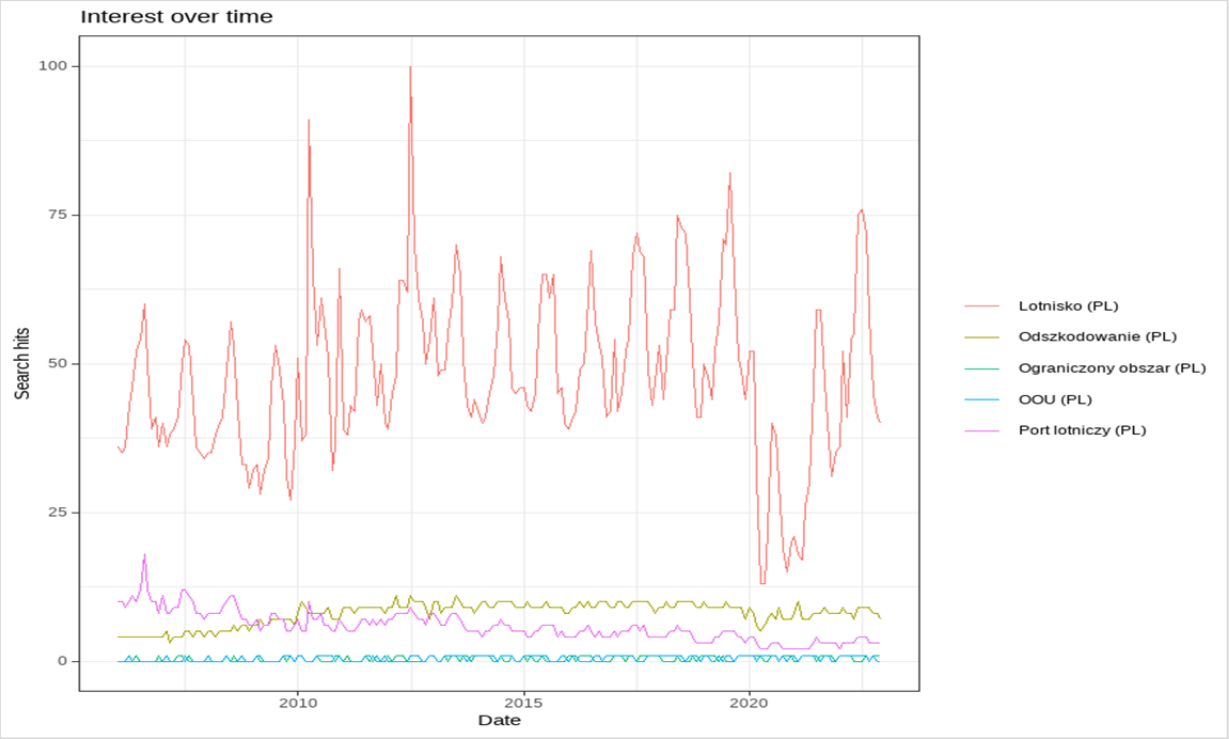

Fig. 2. Number of searches for the analyzed keywords in 2006-2022 in Poland, where: "Airport" (Lotnisko), "Compensation" (Odszkodowanie), "Limited area" (Ograniczony obszar), "LUA" (OOU), "Airfield" (Port lotniczy). *Source*: Own study.

The keyword "Airport" (Lotnisko) is a clear outlier in Figure 2. This term is generally associated with tourist or business activity, and it does not reflect changes in social behavior after the establishment of LUAs around airports. Therefore, this keyword was eliminated from further analyses. However, the fact that the number of searches for this keyword decreased rapidly in 2020 during the COVID-19 pandemic indicates that the adopted method has considerable prognostic power. The keyword "Compensation" (Odszkodowanie) received a high number of hits. In contrast, the RSV index of the keyword "LUA" (OOU) was relatively low, but this term was analyzed in greater detail due to its significance. An analysis of searches for the keyword "LUA" is presented in Figure 3; the spatial distribution of searches is shown in Figure 3a, and the popularity of related search terms is presented in Figure 3b.

The spatial distribution of the number of searches for the term "LUA" (Fig. 3a) indicates that this keyword attracted the greatest interest in the Polish voivodeships of Mazovia (Warsaw Chopin Airport) and Pomerania (Lech Wałęsa Airport in Gdańsk), which corresponds with the presence of airports and LUAs in these regions. Interestingly, the seven most similar search terms included "Airport", "Compensation", and "Gdańsk airport". The word "airport" can have numerous connotations, and the keyword "Compensation" for selected for further analysis because individuals whose interests were compromised after the establishment of LUAs around airports could have been seeking to file compensation claims in the analyzed period. The practical and theoretical aspects of compensation claims have been

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discussed extensively in the literature (Batóg et al., 2019; Bełej et al., 2023; Habdas, 2020b; Konowalczuk et al., 2021). An analysis of searches for the keyword "Compensation" is presented in Figure 4.

The spatial distribution of the keyword "Compensation" (Fig. 4a) indicates that this search term attracted considerable interest in all Polish voivodeships. The most similar Polish search term was "Lot" (Flight). To compare the popularity of the terms "Compensation" and "LUAs", the number of searches for each keyword across time is presented in Figure 5.

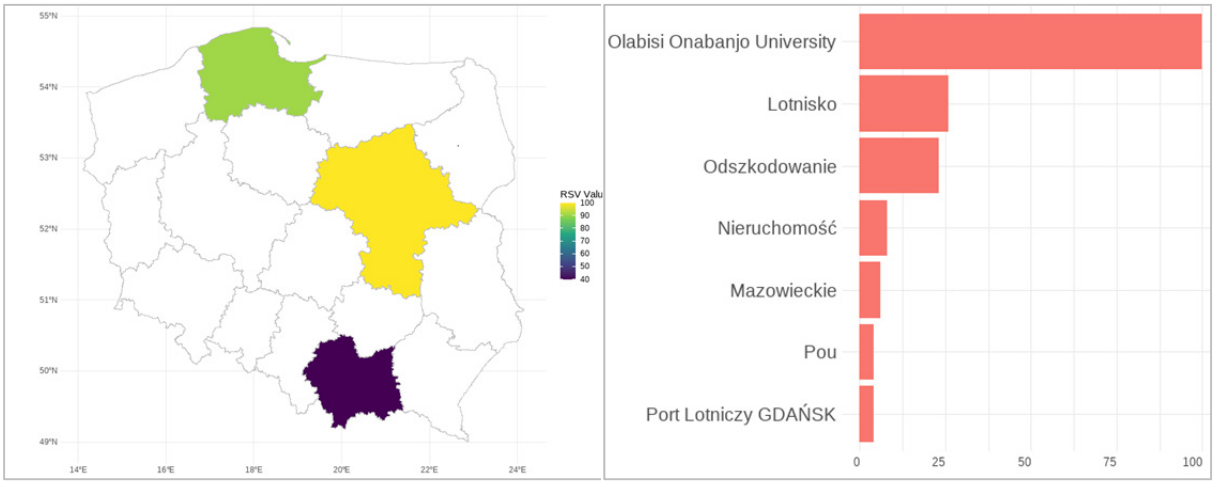

Fig. 3. a) Spatial distribution of the number of searches for the keyword "LUA"(OOU) in Poland (2006-2022); b) Top 7 search terms similar to the keyword "LUA" (OOU), where: "Airport" (Lotnisko), "Compensation" (Odszkodowanie), "Property" (Nieruchomość), "Mazovia" (Mazovia), "Gdańsk Airport" (Port lotniczy Gdańsk). *Source*: own study.

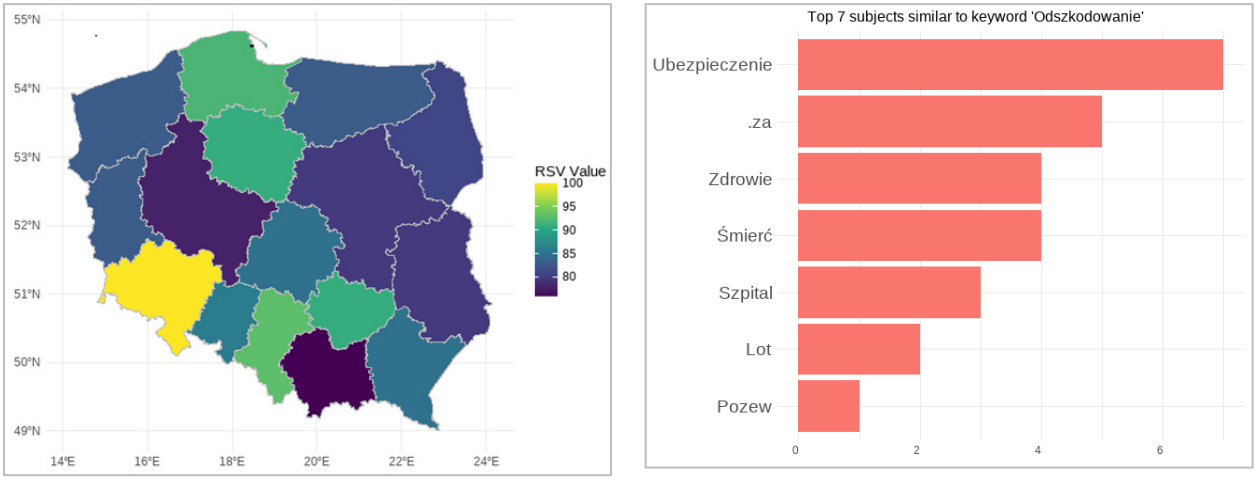

Fig. 4. a) Spatial distribution of the number of searches for the keyword "Compensation"; b) Top 7 search terms similar to the keyword "Compensation", where: "Insurance" (Ubezpieczenie), "Health" (Zdrowie),"Death" (Śmierć),"Hospital" (Szpital),"Fligt" (Lot),"Claim" (Pozew). *Source*: own study.

In Figure 5a, a massive difference can be observed in the number of searches for the keywords "Compensation" and "LUA", and this discrepancy is confirmed by the associated time series. Despite the fact that the term "LUA" is the key concept in the analysis, online users probably searched for the term "Compensation" based on the Pareto principle. The low number of searches for the keyword "LUA" could undermine the reliability of the analysis despite the fact that this term is directly associated with the studied topic. The keyword "Compensation" and its relationship with the deadline for submitting compensation claims, received a high number of hits and was, therefore, selected for further analysis. This term has a broad meaning, and it could refer to various types of compensation claims, not only those relating to airports. The analysis covered a long period (2006-2022), and it was conducted to select a keyword that was most highly associated with compensation for the establishment of LUAs around airports. Limited-use areas around the airports in Warsaw and Gdańsk were introduced in different periods; therefore, the time series related to the establishment of LUAs in and deadlines for filing compensation claims in each city were included in further analysis.

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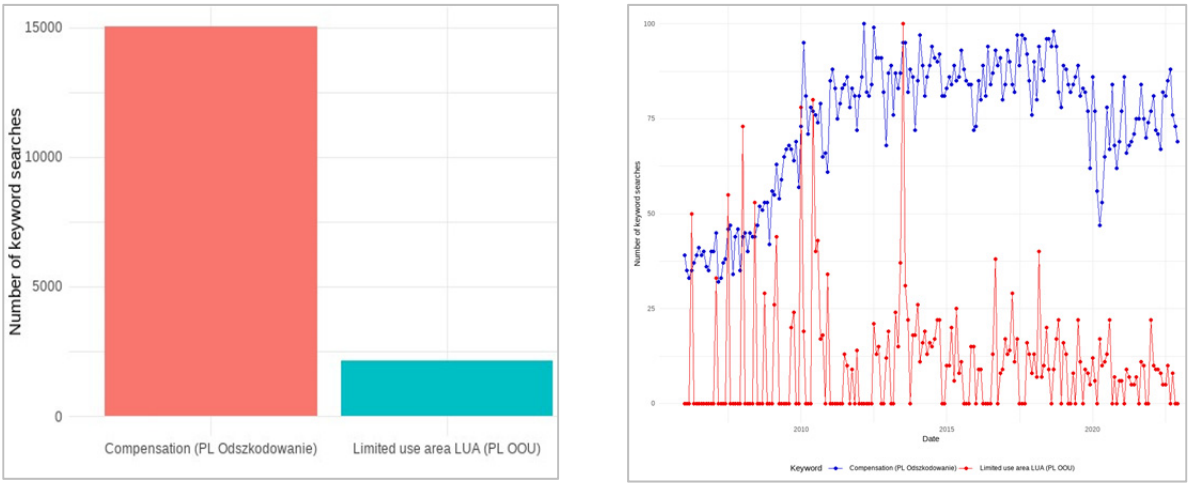

Fig. 5. a) Number of searches for the keywords "Compensation" and "LUA"; b) time series of keyword searches in 2006-2022. *Source*: own study.

3.2. The RSV index for the keyword "Compensation" in Warsaw and Gdańsk

In the next stage of the study, web users' online behavior was analyzed in two separate time series for the Warsaw Chopin Airport and the Lech Wałęsa Airport in Gdańsk. Limited-use areas around the Warsaw airport were created in 2011, and compensation claims could be submitted over a period of two years after their establishment. In Gdańsk, LUAs were introduced in 2016, and compensation claims could be filed until through 2018. Therefore, the territorial scope of the analysis was limited to online searches in the voivodeships of Mazovia (Warsaw) and Pomerania (Gdańsk). The volume of searches returned by Google Trends in each of the two time series (Warsaw and Gdańsk) was displayed with the use of the gtrendsR package.

The analysis focused on the keyword "Compensation". The volume of searches did not correspond to the actual number of compensation claims submitted in each city. However, the RSV index is a reliable measure of public interest in the analyzed subject. Studies examining the number of searches for the keyword "Apartment" also demonstrated that the RSV index was a robust predictor of public interest and that high values of RSV were associated with an increase in the number of transactions on the real estate market and an increase in apartment prices, which was discussed in detail in previous studies (Bełej, 2022; Limnios & You, 2021; Rizun & Baj-Rogowska, 2021). The RSV index of the keyword "Compensation" in the voivodeship of Mazovia (2010-2015) is presented in Figure 6.

The data in Figure 6 indicate that the interest in the keyword "Compensation" continued to increase from the beginning of 2011 despite the fact that LUAs were established in Warsaw only on 20 June 2011. This is not surprising because the interested parties had probably searched for compensation options already before LUAs were introduced. The value of the RSV index increased rapidly around the time when LUAs were created, continued to increase at a slower rate and stabilize until the deadline for submitting compensation claims in Warsaw, and decreased past that date. The RSV index of the keyword "Compensation" in the voivodeship of Pomerania (2014-2020) is presented in Figure 7.

In Pomerania, LUAs around the Gdańsk airport were established on 29 February 2016, and the interest in the keyword "Compensation" increased toward the end of 2016. The RSV index peaked in 2018 and decreased rapidly after the deadline for submitting compensation claims (February 2018). A clear correlation between the RSV index and the deadline for submitting compensation claims can be observed in Figures 6 and 7. These results suggest that the RSV index is a reliable predictor of current social trends (previous week, day, or hour). In the next stage of the study, the causal impact of the intervention was analyzed with the use of statistical methods.

3.3. OLS regression models and causal impact analysis

The values of the RSV index were processed with the use of OLS regression models, followed by the causal impact analysis. The results of the OLS regression model for the number of online searches for the keyword "Compensation" (RSV) and the introduction of LUAs near airports (deadline for the submission of compensation claims) are presented in Table 1.

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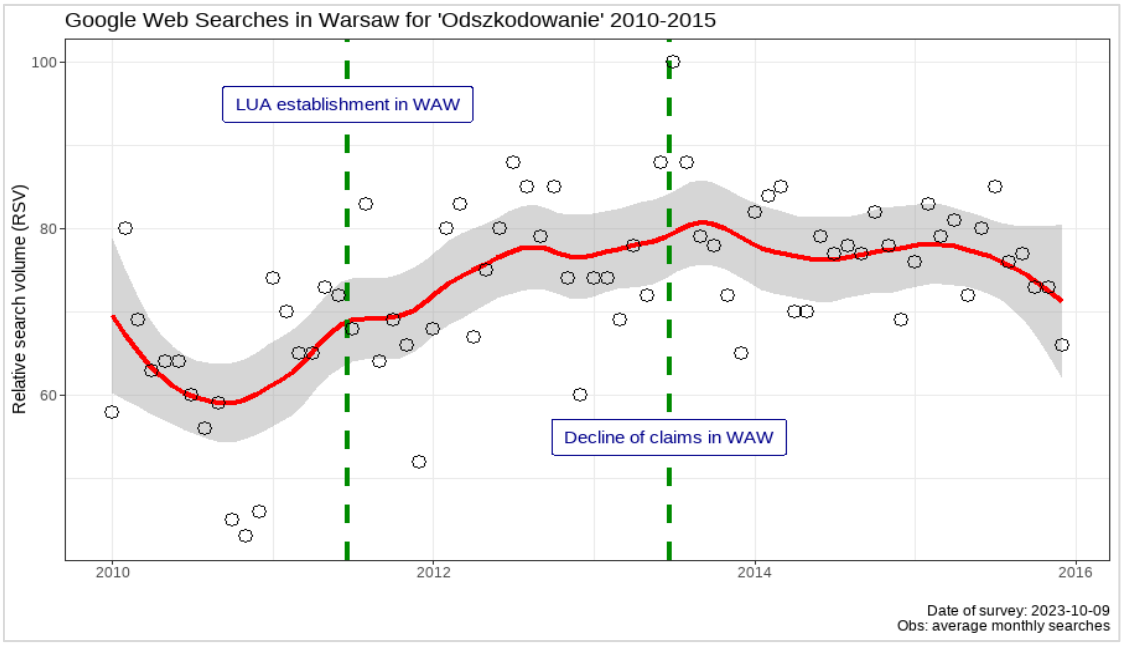

Fig. 6. Relative search volume (RSV) index of the keyword "Compensation" in the voivodeship of Mazovia (Warsaw, WAW) (2010-2015). Black circles denote the value of the RSV index; the red line denotes the smoothed value of the RSV index; green lines denote the establishment of limited-use areas and the deadline for submitting compensation claims in Warsaw. *Source*: own study.

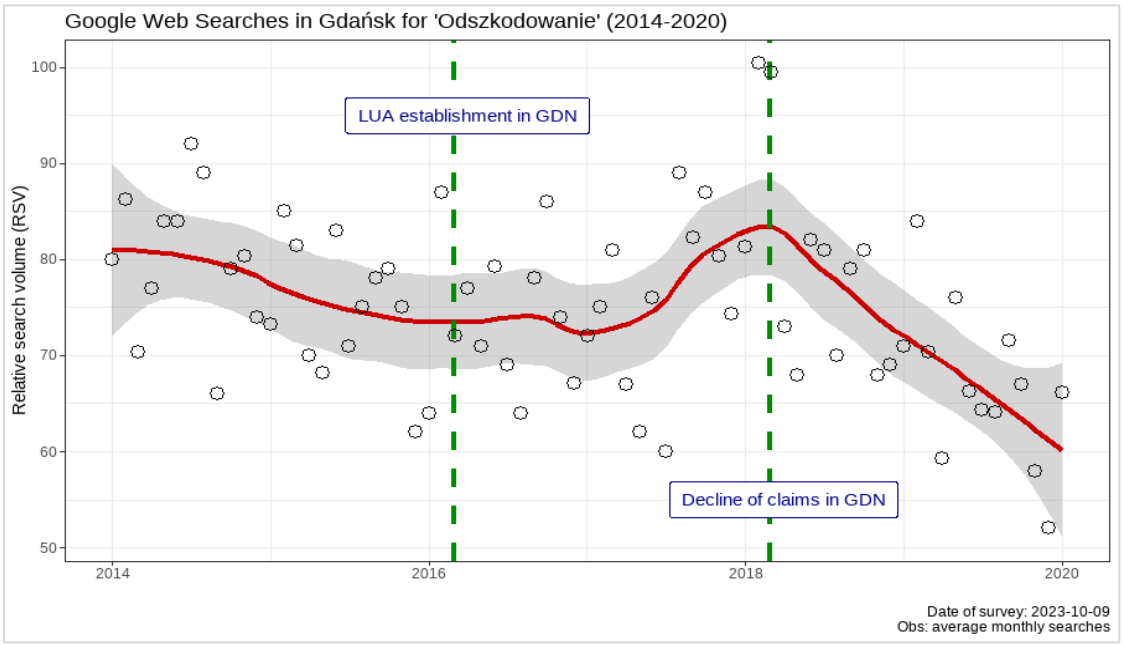

Fig. 7. Relative search volume (RSV) index of the keyword "Compensation" in the voivodeship of Pomerania (Gdańsk, GDN (2010-2020). Black circles denote the value of the RSV index; the red line denotes the smoothed value of the RSV index; green lines denote the establishment of limited-use areas and the deadline for submitting compensation claims in Gdańsk. *Source*: own study.

Table 1

Results of the OLS regression model for relative search volume (RSV) and the implementation of limited-use areas (LUAs) near airports

	WAW airport				GDN airport			
Term	**Est.**	**SE**	**p-value**		**Est.**	**SE**	**p-value**	
(Intercept)	77.492	0.594	0.000	***	70.400	1.284	0.000	***
LUA	-0.029	0.008	0.001	**	0.056	0.017	0.002	**
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1								
	Multiple R-squared: 0.175				Multiple R-squared: 0.185			

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	Adjusted R-squared: 0.161 p-value: 0.001	Adjusted R-squared: 0.1667 p-value: 0.002

Source: own study.

The results of the OLS regression model for Warsaw and Gdańsk (Table 1) point to a significant, but moderate relationship between the establishment of LUAs around the studied airports and the value of the RSV index of the keyword "Compensation". The values of the coefficient of determination R^2 were low (0.175 for WAW and 0.185 for GDN), which indicates that independent variables did not explain the substantial variation in the values of RSV despite the presence of a significant relationship. In the next step, time series (Date) were incorporated into the OLS regression model as an additional independent variable, and the results are presented in Table 2.

The OLS regression model (Table 2) did not reveal significant relationships. Therefore, new calculations were performed; data were filtered based on the deadline for the submission of compensation claims (Deadline) in Warsaw and Gdańsk to induce changes in the variable Date; the results are presented in Table 3.

Table 2

Results of the OLS regression model for relative search volume (RSV) and the implementation of limited-use areas (LUAs) near airports

	WAW airport				GDN airport			
Term	**Est.**	**SE**	**p-value**		**Est.**	**SE**	**p-value**	
(Intercept)	51.790	26.400	0.055	.	148.600	65.670	0.029	*
LUA	-0.015	0.017	0.393		-0.021	0.034	0.546	
Date	0.000	0.000	0.335		0.000	0.000	0.240	
	Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1							
	Multiple R-squared: 0.191 Adjusted R-squared: 0.159 p-value: 0.004				Multiple R-squared: 0.209 Adjusted R-squared: 0.174 p-value: 0.005			

Source: own study.

Table 3

Results of the OLS regression model for relative search volume (RSV) and the implementation of limited-use areas (LUAs) near airports

	WAW airport				GDN airport			
Term	**Est.**	**SE**	**p-value**		**Est.**	**SE**	**p-value**	
(Intercept)	177.100	15.170	0.000	***	683.200	7.214	0.000	***
LUA	-0.030	0.009	0.002	***	-0.000	0.003	0.931	
Deadline (2013-01)	-0.000	0.000	0.000	***				
Deadline (2018-02)					-0.000	0.000	0.000	***
	Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1							
	Multiple R-squared: 0.574 Adjusted R-squared: 0.547 p-value: 0.000				Multiple R-squared: 0.998 Adjusted R-squared: 0.997 p-value: 0.000			

Source: own study.

The OLS regression model (Table 3) revealed significant relationships, with average or high values of fit statistics. The coefficient of determination denoting the proportion of total variation in RSV that was explained by independent variables reached R^2 = 0.57 in the OLS model for Warsaw and R^2=0.99 in the OLS model for Gdańsk, but the LUA variable was not statistically significant. The deadline for submitting compensation claims was bound by a strong negative relationship with the RSV index in both cities, which implies that the value of the RSV index decreased over time, with increasing values of the independent variable Date. The above confirms the previous observation that the deadline for submitting compensation claims significantly influenced the number of searches for the keyword "Compensation". It should also be noted that the values of the RSV index were very low after these deadlines (-7.061e-08 and -3.949e-07).

In the last stage of the study, the causal impact of the intervention was determined with the use of the BSTS model which infers the causal impact of market interventions. In this model, the intervention was defined as the deadline for submitting compensation claims (Table 3). This BSTS method generalizes the difference-in-differences approach by modeling the

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counterfactual of a time series both before and after the intervention. The results of the causal impact analysis of the intervention in the vicinity of Warsaw and Gdańsk airports are presented in Table 4.

Table 4

Causal impact analysis of the intervention in the vicinity of Warsaw and Gdansk airports

	WAW airport		GDN airport	
	Average	**Cumulative**	**Average**	**Cumulative**
Actual	77.03	2234	70.04	1541
Prediction (SD)	99.43 (6.5)	2883 (189.9)	77.03 (2.2)	1695 (48.0)
Absolute effect (SD)	-22.4 (6.5)	-649 (189.9)	-6.99 (2.2)	-154 (48.0)
Relative effect (SD)	-22% (5.2%)	-22% (5.2%)	-9% (2.6%)	9% (2.6%)
	Posterior tail-area probability p: 0.001 Posterior prob. of a causal effect: 99.9%		Posterior tail-area probability p: 0.001 Posterior prob. of a causal effect: 99.9%	

Source: own study.

In the causal impact analysis of the intervention in the vicinity of the Warsaw (WAW) airport (Table 4), the average value of the response variable was estimated at 77.03 after the intervention, whereas the predicted average value would have reached 99.43 without the intervention. The above indicates that the value of the response variable predicted by the model would be higher if the intervention had not occurred. The absolute effect was determined at -22.40, which points to a significant decrease of around 22% in a scenario without the intervention. These results suggest that the establishment of LUAs initially increased the number of searches for the keyword "Compensation", whereas the deadline for submitting compensation claims led to a significant decrease in the RSV index of that term. This observation is confirmed by the causal effect of the intervention on the analyzed time series. The probability that this effect was accidental is very low (p = 0.001), which confirms the statistical significance of the causal impact of the intervention.

In the causal impact analysis of the intervention in the vicinity of the Gdańsk (GDN) airport (Table 4), the average value of the analyzed variable was estimated at 70.04, whereas the predicted value would have reached 77.03 without the intervention. These results imply that the value of this variable would have increased if the intervention had not occurred. The absolute effect was determined at -6.99, which points to a significant decrease of around 9% in a scenario without the intervention. The analysis revealed that the establishment of LUAs initially increased the number of searches for the keyword "Compensation", whereas the RSV index of that term decreased significantly around the deadline for submitting compensation claims. The analysis confirmed the causal impact of the intervention on the examined time series. The probability that this effect was accidental is very low (p = 0.001), which confirms the statistical significance of the causal impact of the intervention. The results of the causal impact analysis are presented in Figure 8a for Warsaw and in Figure 8b for Gdańsk.

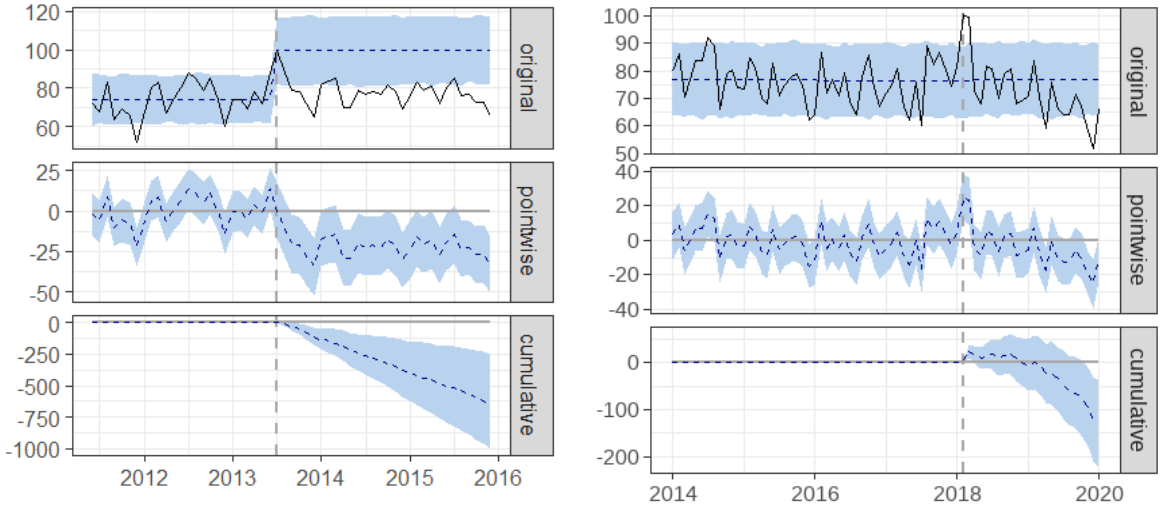

Fig. 8. Causal impact analysis of the intervention based on the deadlines for submitting compensation claims in: a) Warsaw, b) Gdańsk. *Source*: own study.

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The plots in Figure 8 are divided into three panels presenting the original, pointwise, and cumulative impact estimates. The original panel displays the time series and the counterfactual prediction after the intervention. The grey dotted line denotes the intervention; the black line denotes differences in impact estimates; and the blue dotted line denotes the predicted impact for the analyzed time series if the intervention had not occurred. The second panel displays the pointwise effect estimated by the model, whereas the third panel presents the cumulative effect of the intervention. The causal impact analysis was performed with the use of the CausalImpact package (Brodersen et al., 2017). The plots reveal similar trends, but they differ significantly in the obtained values. In both cities, the deadline for submitting compensation claims was negatively correlated with the number of Google searches for the keyword "Compensation".

5. Discussion

The behavior of Internet users should be explored in depth to promote a better understanding of an information society. The members of an information society have a growing demand for online information and are increasingly likely to make decisions based on the information acquired on the Internet. These types of analyses provide valuable insights into human interests, queries, and needs. Studies that rely on historical data concerning, for example, real estate purchases or compensation claims are retrospective and have *ex post facto* design. In turn, *ante factum* studies analyze information preceding the investigated event, and in an information society, future decisions are often based on information that has been accessed online.

Considerable research has been done on online search patterns, overlaps between keywords, and online users' emotions to predict change trends in an information society. The significance of the affective component of online search behavior was analyzed by Flavián-Blanco et al. (2011) who described the emotional profiles of Internet users. In the cited study, emotional outcomes were analyzed based on Internet users' perceptions of success and effort invested in the search process, their initial affective state, and the emotions felt during the search process. The study demonstrated that emotional outcomes are likely to influence the actions performed by Internet users. Chatzakou et al. (2017) proposed a system for categorizing a wider spectrum of emotions in online activities and found that the developed method was effective in detecting various emotional responses in datasets collected from Twitter and Facebook. Priya (2020) developed a technique for monitoring and evaluating public mood in social media which was effective in 90% of the examined cases. In addition to social media, researchers have also analyzed the possibilities offered by Google Trends statistics. According to Matias (2013), the interest in what can be learned from search trends has increased since the launch of Google Trends. Other researchers also noted that Google Trends is a valuable tool for assessing public interest in specific topics or events (Carneiro & Mylonakis, 2009; Castelnuovo & Tran, 2017; Choi & Varian, 2012). In Google Trends, search data are normalized based on the time and location of a query, and the results are presented in terms of RSV. The importance of this search tool was also recognized by Mavragani et al. (2018) in an article entitled "Assessing the Methods, Tools, and Statistical Approaches in Google Trends Research: Systematic Review". The cited authors analyzed 109 published papers (2006-2016) and found that Google Trends data were used for correlation and modeling in 69% of the studies, for examining seasonality in 23% of the studies, and for predictions and forecasting in 9% of the studies. They concluded that tools for monitoring online queries provide valuable insights into human behavior and that their popularity is likely to increase in the future because these tools provide unique research data that could not have accessed otherwise.

This succinct analysis of the literature indicates that the discussed topic has attracted considerable research interest. The results of the present study validate previous observations that Google Trends is a valuable tool for exploring current social needs and expectations. This study makes a pioneering contribution to Polish scientific literature, in particular in the context of airports. Public responses to the creation of LUAs around airports, identified with the use of Google Trends, have not been sufficiently investigated to date. The present findings expand our knowledge about the impact of aviation regulations in the vicinity of airports on the wider public and social interactions. Online social activity related to this topic increased after the establishment of LUAs around the airports in Warsaw and Gdańsk. The study confirmed that the introduction of LUAs increased the number of Google searches for the keyword "Compensation", and the RSV index of that term decreased significantly after the deadline for the submission of compensation claims. The analyzed time series was also significantly influenced by the intervention. To the best of the

authors' knowledge, the number of online searches for the keyword "Compensation" has never been analyzed with Google Trends in the scientific literature, and the present study was undertaken to fill in this knowledge gap. The term "Airport" was frequently examined based on Google Trends statistics (Khafidli & Choiruddin, 2022; Li Long et al., 2021), but mostly to forecast air traffic or flight destinations.

6. Conclusions

This study relied on the assumption that the digital footprints left by Internet users can be used in research to analyze social preferences, the evolution of social trends over time, and potential cause and effect relationships. However, analyses of online search statistics require a thorough understanding of human behavior, especially in the process of selecting keywords. In the present study, the keyword "LUA" (Limited-use area) did not receive any hits in Google Trends, and the number of searches for the keyword "Limited area" was also low, which prevents the formulation of reliable conclusions. In contrast, the keyword "Airport" received a very high number of hits, but this term has multiple connotations in private and business tourism, and it cannot be directly correlated with the establishment of LUAs in Warsaw or Gdańsk. The keyword "Compensation" also has many meanings, but it was selected for further analysis because clear changes in its RSV index were noted after the establishment of LUAs and the deadline for submitting compensation claims. These relationships are presented in Figure 6 for Warsaw and in Figure 7 for Gdańsk. These results indicate that the number of searches for the keyword "Compensation" increased significantly around the dates on which LUAs were introduced and decreased after the deadline for the submission of compensation claims.

The social impacts of the intervention were also analyzed with the use of different OLS regression models and the causal impact analysis. The OLS models for Warsaw and Gdańsk revealed a moderate relationship between the establishment of LUAs and the RSV index of the keyword "Compensation". Despite the fact that these variables were bound by a significant relationship in the statistical model, the presence of such a relationship was undermined by very low values of the coefficient of determination R^2. In the next stage of the analysis, time series were incorporated into the OLS regression model as an additional independent variable, but the results were not satisfactory either. In the following step, data were filtered based on the deadline for submitting compensation claims, which significantly improved the results. In Warsaw, the coefficient of determination R^2 reached 0.57, and the variables LUA and Date were significant, which implies that the deadline for submitting compensation claims was significantly correlated with the number of searches for the keyword "Compensation". The coefficient of determination was very high in Gdańsk (R^2=0.99), but the variable LUA was not significant. In the final step, the causal effect of the intervention was examined in a causal impact analysis based on the BSTS model, which revealed that the establishment of LUAs had an actual effect on the number of online searches relating to this topic. The causal impact analysis revealed a significant decrease in public interest after the intervention, in particular after the deadline for submitting compensation claims.

In conclusion, the study revealed that the establishment of LUAs significantly influenced the demand for online information about compensation (increase in the RSV index). However, subsequent changes in legal regulations decreased the number of online searches (decrease in the RSV index), in particular after the deadline for submitting compensation claims. The causal impact analysis confirmed that the studied time series was significantly affected by the intervention.

The main limitation of this study is that it relied on data from only two Polish cities. Therefore, any attempts to extrapolate the result to all Polish airports are burned with a high risk of error. The broader macroeconomic context should be considered to gain a deeper insight into social behaviors relating to state interventions in the vicinity of airports. Further research is needed to minimize these limitations. Diverse sources of data should be used in future research to validate the present findings. The novelty of this study is lies in the fact that online social behavior was analyzed based on Google Trends statistics. The study demonstrated that Google Trends is a valuable research tool for analyzing changes in an information society.

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