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Navigating Regional Airport System Economics: Insights from Central Europe and Croatia

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Abstract: This paper delves into regional airport system economics in Central Europe, with a particular focus on Slovakia, Czechia, Poland, Hungary, and Croatia. This research aimed to identify key indicators that shape optimal business models for regional airport systems by analyzing data from 24 airports between 2016 and 2019. Through cluster analysis, airports were categorized based on performance metrics, economic indicators, and ownership structures. The findings reveal distinct groupings among regional airports and shed light on critical factors influencing their operational and financial dynamics. By offering insights into the relationships between airport system characteristics and business model effectiveness, this paper aimed to provide valuable guidance for stakeholders, policymakers, and airport management teams. It facilitates informed decision-making and strategic planning for sustainable aviation infrastructure development in the region.

Keywords: regional airports; airport economics; cluster analysis

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1. Introduction

Airport systems are regarded as important points of air transport at the national and international level. Their infrastructure enables the transport of passengers and goods to different destinations around the world [1]. The wide network of larger airports is complemented by smaller and regional airports. The term "regional airport" is defined according to Article 1. paragraph 153 Commission Regulation (EU) 2017/1084 of June 2017 amending Regulation (EU) No 651/2014 as regards aid for port and airport infrastructure as "an airport with average annual passenger traffic of up to 3 million passengers" [2].

Regional airports with an annual passenger volume of up to 3 million frequently encounter profitability issues [3]. Adler et al. (2013) conducted a regression analysis on small regional airports, finding that those operating efficiently could potentially cover their annual operating costs with as few as 166,000 passengers per year, underscoring the ongoing significance of operational efficiency and profitability in regional airports, a topic of relevance not only in Europe but also in other global regions [4]. Regional airports not only represent important access points to remote locations and parts of countries with limited or lengthy access, but also have a significant economic impact on the surrounding region [5–7].

If one does not consider the situation associated with the COVID-19 pandemic, it is possible to say that regional airports have become very popular and sought after by travelers in recent years. This is not only because of the wide range of destinations but also because of the environment that these airports offer [8]. Regional airports are the backbone of connectivity in Europe, and they have been increasingly competing with larger hub airports, with some regional airports reporting higher passenger growth rates than their hub counterparts. According to a recent survey, passenger traffic at regional airports in Europe has increased by 30% over the past five years, indicating their growing popularity

among travelers [9]. The higher number of passengers has caused an influx of capital and thus the financial situation of many regional airports has started to improve [10].

On the other hand, however, there are many regional airports whose operation is a complex system, especially in terms of covering daily operating costs. Such regional airports are trying to prosper, applying different approaches and strategies to improve their financial situation since their economic sustainability is at a very poor level [11]. Despite all of the challenges and problems these airports have, they are constantly looking for new ways to improve their business models in such a way that they can improve their financial situation. However, the implementation of any changes and new practices at regional airports is very difficult, lengthy, and challenging [12].

This topic is currently popular among researchers. Among the proposed solutions, the possibility that regional airports should change their business models is often proposed [13,14]. However, airport business models are not well defined, nor have the various pillars of airport business models been generally defined. The literature argues that the fundamental pillar of a business model is the ownership structure; for this reason, information on ownership structures is used when examining business models [15–17].

An optimal business model for regional airports involves understanding local market demand; diversifying revenue streams through parking fees, retail rentals, and advertising; fostering airline partnerships; supporting general aviation activities; continually investing in infrastructure development; promoting regional economic growth; striving for cost efficiency; engaging with the community; implementing sustainability initiatives; and maintaining flexibility to adapt to market changes [18–20]. By incorporating these strategies, regional airports can establish a sustainable business model that not only meets the needs of passengers and cargo services but also contributes to the economic development of the surrounding region [18–20]. This focused approach allows us to compare operational performance across different airports by examining measurable factors such as cost efficiency and revenue diversification that are applicable irrespective of varying local geographical and economic conditions.

The issue of airport business models is one of the highly debated scientific topics. In 2021, a case study analyzing Shannon Airport's business model addressed the airport's ownership structure and described how the airport's business model is oriented. According to their findings, it is not possible to assess airport business models, but the authors admit that there are several regional airports in Europe that are like each other, so it is possible to formulate generic solutions that can be applied by several regional airports [21].

In 2022, the business models of regional airports in Thailand were evaluated [22]. Out of a total of 29 regional airports (publicly owned, subsidized, and supported by the Thai government), 22 of them were underperforming and inefficient. As a solution, a value-oriented business model of local entrepreneurship and cooperation, and a business model of the airport as a platform for tourism, was suggested [22].

Regional airports have a decentralized operational business model [23]. There are several business models of airports and ownership structure is a basic pillar of every business model [23].

The business models of the airports in the UK during the COVID-19 pandemic were found to be closely linked to external factors as well as to many other industries [24]. Four approaches that should inspire airport business models in the future are minimizing costs and improving management efficiency; diversifying revenue streams and seeking new business opportunities; intensifying commercial activities; and using digital technologies to improve the customer experience and processes [24]. In addition, there is a need to focus on sustainability and environmental responsibility. Knowing the business model is one of the most important factors during any crisis, as it allows the owner to react flexibly to change and ensure the sustainable development of the airport [24–26].

Successful airline–airport coexistence depends on the integrated management of annual negotiations of target flight load factors and monthly subsidy adjustments. For the

cooperation between the airport and the airline as key partners to be successful, different scenarios need to be simulated to observe the interactions between the two parties [27].

Airport business models vary across European countries, but the common goal of all regional airports is to be profitable and satisfy the political goals of regional governments [28]. Business models and their transformations are influenced by several factors [29]. Differences in the characteristics of business models have a direct impact on the objectives and development of airports. There is no one-size-fits-all airport business model that is applicable to any airport [30–32]. The ownership factor has emerged as one of the important factors affecting airport operations [33]. The inclusion of a private shareholder in the ownership structure has a positive impact on the airport's business model [34]. The business models of airports in Europe are fundamentally different from those of airports in the USA [35].

Regional airport systems struggling to financially survive are forced to apply for various forms of state aid and subsidies [36–38]. According to research from 2021, state aid can be a solution, but only on the border of financial stability of airport companies and should focus more on the development and modernization of regional airports [39]. At the same time, there is a need for open communication with the public, the end user of air transport [40].

Legislation is one of the important factors that needs to be analyzed when examining airport business models [41]. In general, the legislation establishes rules and regulations that affect the operation of regional airports [42]. Examining the legislation can help to understand these regulatory frameworks and their impact on airport business models. Among other things, the legislation establishes rules regarding the financing and provision of substate aid for regional airports [43,44]. In addition to the common legislation created by the EU, it is necessary to monitor the individual legislation of the various countries [45].

This paper emphasizes the importance of the European legal framework in the field of regional airport systems. Despite having the same basis, it has individual national specifics and, together with political and economic specifics, creates separate national frameworks. When comparing the national frameworks of Slovakia and Croatia, many identical areas were identified, but there are also fundamental differences; for example, in the case of the expropriation process of land under the airport or in its perimeter, which subsequently have a major impact on airport planning and development processes. According to the Act on Airports, airports in Croatia are defined as infrastructure in the public interest, while in the Slovakia such a general definition does not apply [46]. Land expropriation in Croatia does not need to be repeatedly demonstrated by the public interest, but in Slovakia, it must be clearly demonstrated at all levels of the ongoing expropriation process [47].

Based on the literature review, it can be seen that most authors admit that the ownership structure is one of the important factors that influence the airport's systems economics. On the other hand, it is not the only factor that affects the whole concept or the system of airport economics. In addition to looking at ownership structures, there are other characteristics that need to be examined when analyzing regional airport economics. Overall, there is a lack of studies focused on regional airport systems in Central Europe that have comprehensively described their business models. For this reason, this paper is focused on selected regional airport systems in the Vysehrad Group and Croatia. Overall, it is difficult to determine the most important conditions that are the basic variables in regional airport research. There are also several definitions of regional airports, which are different, such as e.g., Pauwels et al. in 2024 states that a regional airport is an airport that serves less than 10 million workload units on mainly point-to-point destinations and short-to-medium haul flights for civil purposes [48], which is in contradiction with EU and Commission legislation Regulation (EU) 2017/1084 of June 2017 amending Regulation (EU) No. 651/2014 as regards aid for port and airport infrastructure, which we used as fundamental, since our research focuses on regional airports in the EU. Because of this, as well as with the literature review carried out above, it is possible to understand that currently, there are no known research results in Europe that could demonstrate that it is possible to set up one

business model for all regional EU airports that will work under the same conditions in all EU countries. This finding led us to the preliminary conclusion that regional airports form several groups based on selected characteristics, which led us to the research question of whether we are able to identify such indicators that can be used to demonstrate this. This research aimed to identify key indicators that influence regional airport economics, including performance metrics, economic conditions, and ownership structures to shed light on the complex relationship between airport performance and business models. By examining these factors, we seek to understand how they influence airport management and efficiency across different regions. Our research is focused on regional airport system economics and key indicators of regional airports in central Europe that proved important for categorization into groups and could help us to create a "basic platform of business model" to narrow the operational strategies that enhance airport management and economic viability, providing a robust framework for assessing performance in varied settings.

2. Materials and Methods

The main objective of this paper was to confirm if the identified key indicators could impact the development of optimal regional airport systems economics, particularly focusing on those in Central Europe. The research problem arose from a gap in understanding the comprehensive dynamics of airport system economics in the region. Despite the critical role regional airports play in the transportation network, there is limited research addressing their unique challenges and opportunities.

The research problem revolves around the lack of comprehensive studies trying to describe and find the key indicators, which could have an impact and create the "basic platform of regional airport business models" in Central European countries. This paper aimed to bridge this gap by analyzing the performance metrics, economic conditions, and ownership structures of regional airport systems in the region. The objectives of this paper were:

- Analyze the performance, economic situation, and ownership structure of selected regional airport systems.
- Apply cluster analysis to categorize regional airport systems based on similarities in their characteristics and features.
- Identify key indicators that influence the regional airport systems economics in Central Europe and could create the "basic platform of central Europe regional airport business model".

The research methodology comprised several phases aimed at achieving the outlined objectives. The first phase involved collecting input data related to the performance, economic status, and ownership structure of 24 regional airports across five European countries: Slovakia, Czechia, Poland, Hungary, and Croatia. Table 1 shows the regional airports and their IATA code designator. The data span from 2016 to 2019 and were sourced from reliable airport databases and financial records (see Appendix A). The data used in this paper were obtained from various sources, including the annual reports of each airport, the Statistical Office of the Slovak Republic, the Croatian Bureau of Statistics, and the Civil Aviation Authority of the Czech Republic. To ensure the integrity and accuracy of our data, we implemented a rigorous data cleaning process that included the identification and handling of outliers and the imputation of missing values using established statistical methods. Furthermore, data validation was performed through cross-checks against multiple independent sources to confirm the reliability of the information used in our analyses.

At the outset of our research, we intended to utilize global databases such as those provided by the World Bank and Eurostat. However, we were unable to find comprehensive data on individual regional airports in the required format. Consequently, we resorted to using annual reports and national databases. For data involving different currencies, such as the Polish zloty, Czech koruna, Hungarian forint, and Croatian kuna, we converted

these to the euro using a currency calculator based on the European Central Bank's average annual exchange rates for these currencies.

Table 1. Sample of 24 selected regional airports and their IATA codes.

Country	Airport	IATA Code
Slovakia	Bratislava	BTS
	Košice	KSC
	Poprad	TAT
	Piešťany	PZY
	Sliač	SLD
	Zilina	ILZ
Czechia	Brno	BRO
	Ostrava	OSR
	Pardubice	PED
	Karlovy Vary	KLV
Hungary	Debrecen	DEB
	Győr-Pér	QGY
	Hevíz	SOB
	Pécs-Pogány	PEV
Poland	Lublin	LUZ
	Łódź	LCJ
	Bydgoszcz	BGZ
	Szczecin-Goleniów	SZZ
	Zielona Góra	IEG
	Poznań-Lawica	POZ
Croatia	Split	SPU
	Zadar	ZAD
	Rijeka	RJK
	Osijek	OSI

The initial step in cluster analysis was to determine the optimal number of clusters, which is essential for the effectiveness of the analysis. The preferred metric for evaluating the quality of cluster models is the Average Silhouette Width (ASW) [49], where the optimal number corresponds to its maximum value. This determination was subject to two additional criteria: there must be more than two clusters and each cluster should contain at least two units.

Considering the criteria, we obtain:

- variant A "With State Owner," when the highest value of ASW is 0.544 for 4 clusters,
- variant B "Without State Owner," when the highest value of ASW is 0.635 for 3 clusters.

For the cluster analysis, we selected 4 and 3 clusters. However, to verify all relevant possibilities, a cluster analysis with 2, 3, 4, 5 or 6 clusters was also performed. Subsequently, a visual exploratory method confirmed that the chosen number of clusters (4 and 3) was not only optimal according to the ASW criterion but also the most suitable for interpretation. ASW values for a number of clusters from 2 to 6 are presented in Table 2.

Table 2. ASW values for different numbers of clusters.

Number of Clusters	2	3	4	5	6
ASW-Variant A	0.598	0.541	0.544	0.540	0.521
ASW-Variant B	0.659	0.635	0.631	0.502	0.498

In addition to traditional data analysis methods, Principal Component Analysis (PCA) is used to explore the underlying patterns and relationships within a dataset. PCA is a statistical technique used to reduce the dimensionality of multivariate data while preserving most of its variance. By transforming the original variables into a smaller set of orthogonal components, PCA facilitates the identification of dominant factors driving variation among regional airports.

Cluster analysis was conducted separately for each year in two forms: Cluster Analysis A included all input variables, while Cluster Analysis B excluded the ownership structure parameter due to its unclear influence observed in the initial analysis and literature review. Cluster analysis serves several purposes in this research. Firstly, it categorizes regional airport systems into groups based on similarities in characteristics and features, facilitating the identification of similar airports in Europe. Secondly, it helps identify key indicators influencing airport clusters, thereby enhancing understanding of the relationships between variables and parameters affecting regional airport clusters. Cluster analysis is deemed suitable for identifying different types of regional airport systems economics in terms of their basic platform of business model, enabling personalized approaches, resource optimization, performance comparison, and strategy development to support efficient management and development of regional airports.

3. Results

Beginning with Section 3.1, the analysis delves into the identification of important indicators for airport business models. Subsequent sections present the outcomes of cluster analyses, providing insights into the economic dynamics and operational characteristics of regional airport systems.

3.1. Identification of Indicators for Cluster Analysis That Influence the Regional Airport Economics

For cluster analysis, it is necessary to identify the indicators that influence the regional airport economics. Amongst the selected indicators are handled passengers, total revenues, total costs, transported cargo, number of employees, cost indicator and ownership structure. All selected indicators of individual airports in the monitored period are shown in Appendix A.

Based on the literature review and analysis, the ownership structure was selected as one of the indicators. It was found that ownership structure varied from airport to airport even within the same country. A private ownership factor is seen as beneficial (Košice Airport, Gratz Airport, Győr-Pér Airport) because these airports achieve positive economic results. At the same time, some state-owned airports (whether it is by a ministry, by a higher territorial unit or by a city who manages the shares), for example Zielona-Góra Airport, Hevíz and Split, also have favorable economic results. This occurrence and inconsistency mean that the ownership structure presumably cannot be identified as the most important key indicator.

Another indicator for cluster analysis is the cost indicator, where the average value in the period under review was 115.7% for Bratislava Airport, 77.4% for Košice Airport, 112.5% for Poprad Airport, 101.7% for Sliač Airport, 157.4% for Piešťany Airport and 114.8% for Žilina Airport. These partial results were also confirmed by the conclusions of a study from 2019 [36], which focused on the ex-post financial analysis of Slovak airports as well as the conclusions of the ex-ante financial analysis in a study from 2019 [39]. For Czech regional airports, it was a cost indicator of 92.7% for Brno Airport, 112.8% for Ostrava Airport, 124.3% for Pardubice Airport and even 144.1% for Karlovy Vary Airport. Based on the cost

indicator, Hungarian airports had a significantly more balanced economy, with Debrecen Airport having a value of 117.3%, Győr-Pér Airport 99.5%, Heviz-Balaton Airport 98.7%, and Péc-Pogány Airport 91.2%. In this case, it is not possible to confirm the relationship between the airport's economic results and the ownership structure. Győr-Pér Airport, whose 48% is owned by the private investor Audi Hungaria, performed worse than the 100% publicly owned airports such as Heviz-Balaton (100% owned by the city of Heviz) and Pécs-Pogány, whose 41.2% of the shares were managed by the Republic of Hungary and 58.8% by the city of Péc. The results of regional airports in Poland differ fundamentally. Their cost indicator has unfavorable values—Lublin Airport 468.8%, Łódź Airport 448.7%, Bydgoszcz Airport 161.6%, Szczecin-Goleniów Airport 128.1%, and Poznań-Lawica Airport 98.9%. The only airport with a balanced or profitable management is Zielona-Góra Airport, whose indicator value is 36,0%, which is based on a specific management method linked to the Lubuskie region, which owns 100% of this airport. Other Polish airports are also in the public ownership. Conclusions on the correct support of airport development and planning from a previous study [50] has been confirmed by the results of Croatian regional airports, whose cost indicator for Split Airport was 63.3%, Zadar Airport 90.3%, Rijeka Airport 94.9% and Osijek 104.6%.

3.2. Cluster Analysis A

Given the fact that from the literature review, as well as from the analysis of Slovak airports, the form of ownership structure repeatedly proved to be a very important factor for the financial stability of the airport, this indicator is included in the first form of cluster analysis. In Cluster Analysis A, all of the listed indicators in Appendix A are used as input parameters.

Cluster Analysis A considers the percentage share of the state and the private entity in the ownership of the airport. Efficiency of airport systems is being monitored in the years 2016 to 2019 and since there are only minimal changes recorded between individual years, the airport performance can be considered as stable in a given period. Therefore, year 2019 was chosen as the period under consideration. Based on the Scree Plot method and the Average Silhouette Width method, it was found that the ideal number of clusters into which the set of monitored airports can be divided ranges from two to six. The division of airports into four clusters was chosen as it provides the most detailed information on the structure of airports. A graphical representation of the division of airports into four clusters is shown in Figure 1.

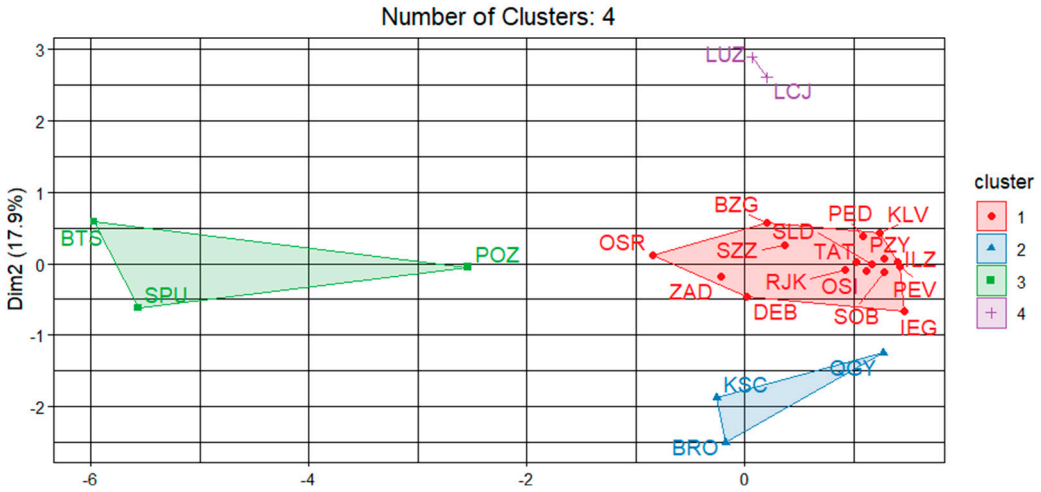

Figure 1. Graphic representation of clusters from Cluster Analysis A.

In the case of cluster no. 3 (green) Bratislava, Split and Poznań airports are included in a common group. In general, these are regional public-owned airports, whose common key indicators are total revenues, total costs, number of employees, but to some extent also the number of handled passengers. Košice, Brno and Győr-Pér airports are included in the second cluster (blue), where the most important common feature of these airports is the dominance of the private owner. Cluster no. 4 (purple) consists of Lublin Airport and Łódź Airport, which have a very high-cost indicator (about four times larger than the others). All of the other airports were included in cluster no. 1 (red).

The graphical clustering of the airports in Figure 1 was simulated by using PCA, where two variables were identified—dimensions one and two, which together describe approximately 85.5% of the variance in the data. Through this analysis, it is shown that all seven indicators could be replaced by four variables, yet 98.6% of the variance would be maintained. However, only two dimensions can be represented graphically. Despite this reduction in variables, the division of the airports into clusters is obvious.

The variables that most affect the classification of airports are visible in Figure 2. The values on the horizontal axis were affected almost equally by the value of total revenues, total costs, and the number of employees. The values on the horizontal axis are influenced to a lesser extent by the number of handled passengers and to the smallest extent by the amount of transported cargo. The values on the vertical axis are most affected by the cost indicator, which is dominant on this axis. To a lesser extent, the values on the vertical axes are affected by the share of public ownership.

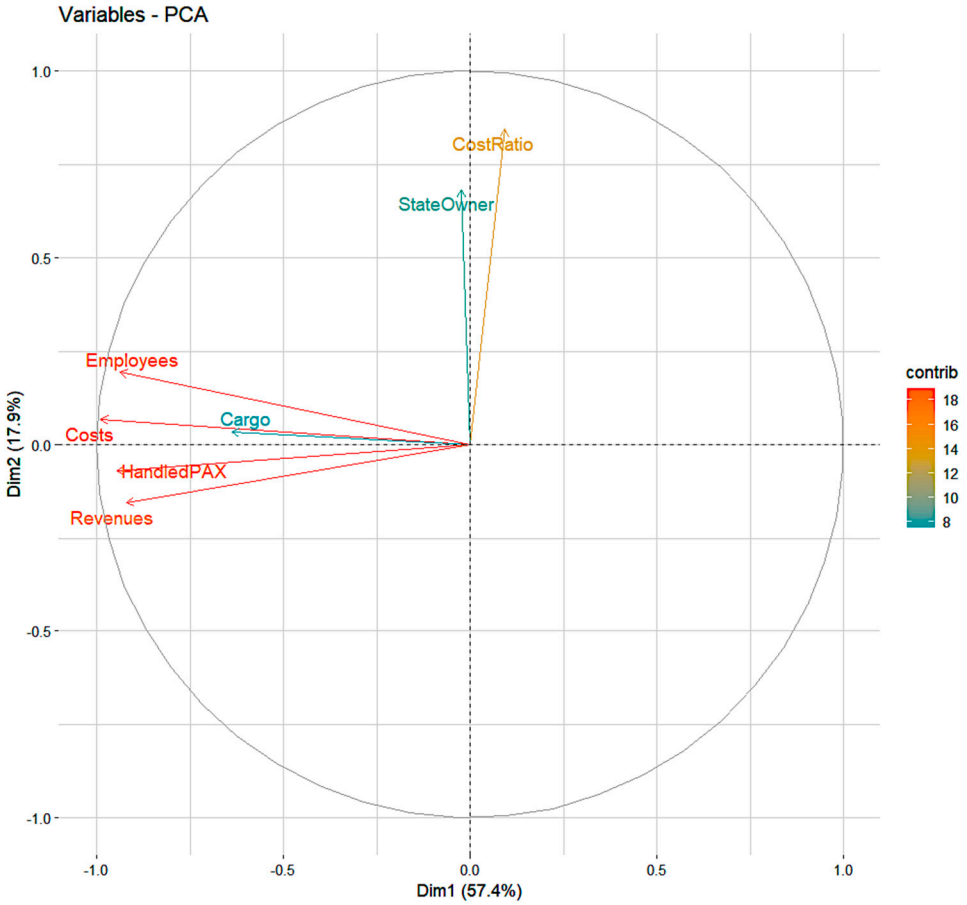

Figure 2. The degree of influence of individual indicators on the results of Cluster Analysis A.

Within the characteristics of the clusters, the key indicators for Bratislava, Split and Poznań airports (cluster no. 3) are listed above. In addition, the classification of airports is also affected to a lesser extent by the amount of cargo transported, the cost indicator and the share of public ownership, as shown in Figure 3. The Lublin and Łódź Airports cluster

(cluster no. 4) have the worst economic results of the entire sample of airports examined, which is reflected in the cost indicator, which is dominant for this cluster. To a lesser extent, classification was also affected by the value of total costs. For cluster no. 2—Brno, Košice and Győr-Pér airports—the share of the private owner is key, and a weaker dominance of other indicators is visible. The last cluster, no. 1, unites all of the other airports, where the cost indicator influenced their classification. Other parameters were less pronounced.

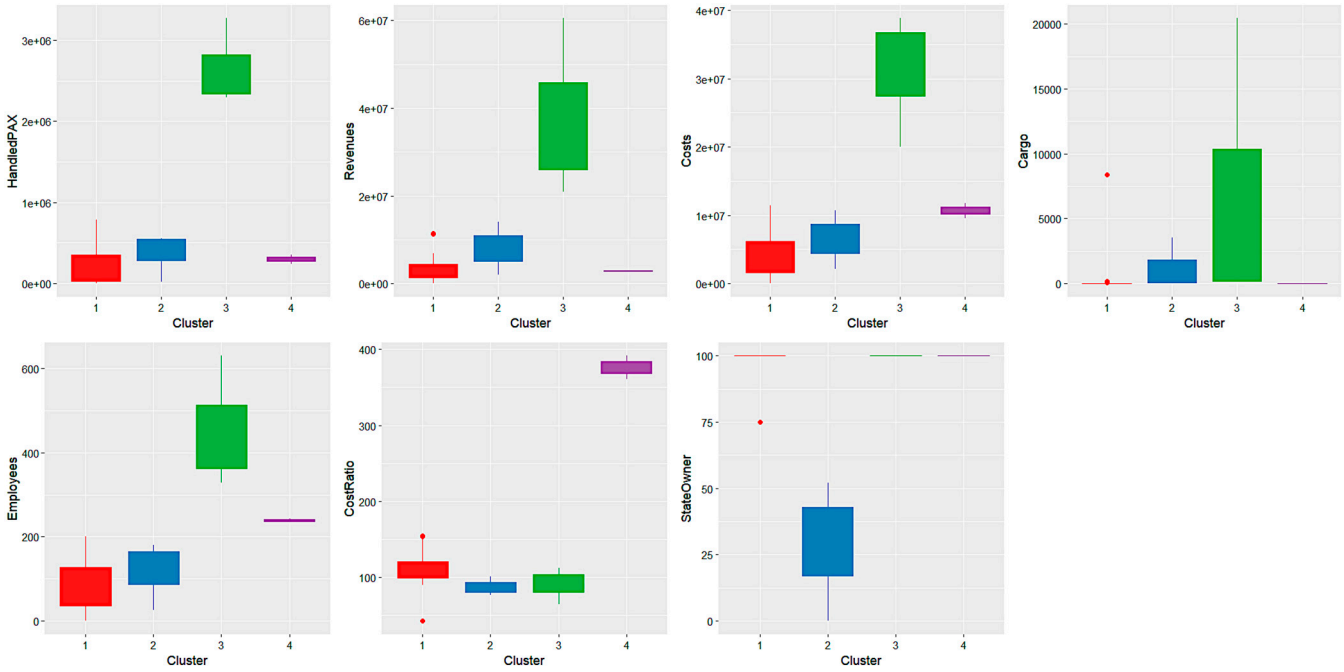

Figure 3. The degree of dominance of individual key indicators—Cluster Analysis A.

Table 3 shows the average values of the individual indicators (represented by the median) for individual clusters. The distribution of the values of all indicators and the differences between the individual clusters are clearly visible in Figure 3.

Table 3. Median of individual key indicators for individual clusters—Cluster Analysis A.

Median:	Handled PAX	Total Revenues €	Total Costs €	Transported Cargo (t)	Number of Employees	Cost Indicator (%)	Public Ownership (%)
Cluster no. 1	78,341.5	2,401,884	2,732,339	1.2	51	109.5%	6.255
Cluster no. 2	543,633	7,958,389	6,756,475	59	149	84.9	34
Cluster no. 3	2,379,635	31,111,000	34,793,000	253	397	95.8	100
Cluster no. 4	299,537	2,828,267	10,666,775	0.4	239.5	376.2	100

3.3. Cluster Analysis B

The ownership structure is not considered in Cluster Analysis B. This decision stems from findings at Gyoŕ-Pér Airport, where Audi Hungaria, a private entity owning 48%, shows weaker financial stability compared to airports solely owned by the public, like Heviz-Balaton Airport and Pécs-Pogány Airport. These findings challenge previous conclusions and lead to a cluster analysis without considering ownership structure. This necessity is also supported by the examination of Croatian airport systems, which are economically strong and publicly owned. Both the Scree Plot and the Average Silhouette Width method suggest that three clusters would be ideal, as shown in Figure 4.

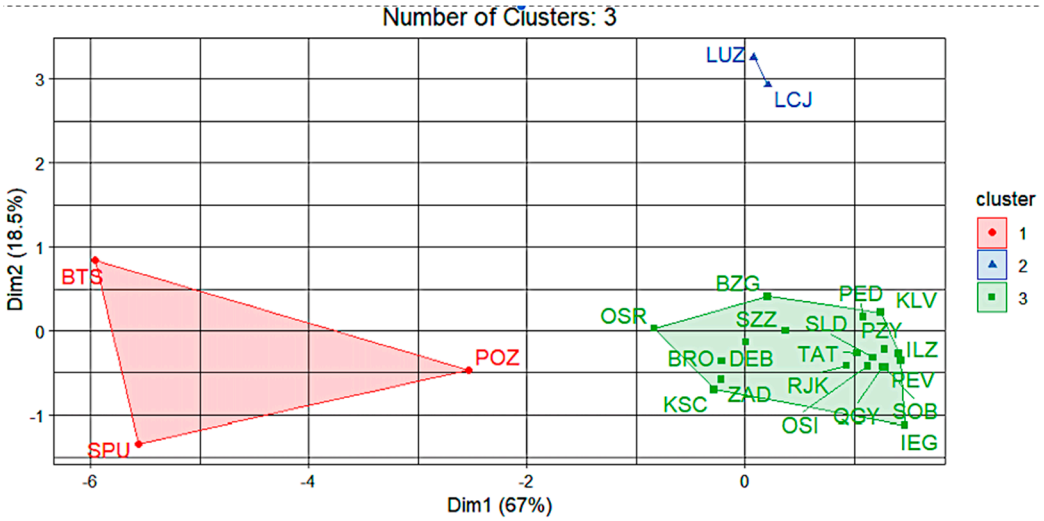

Figure 4. Graphic representation of clusters from Cluster Analysis B.

The graphical representation is again simulated based on PCA, where two variables are identified—dimensions one and two, which together describe approximately 85.5% of the variance in the data. Through this analysis, it is shown that all six indicators could be replaced by three variables, and still 98.3% of the variance would be maintained. However, only two dimensions can be represented graphically. Figure 5 shows how the variables on the horizontal and vertical axes are created and how they relate to the original variables.

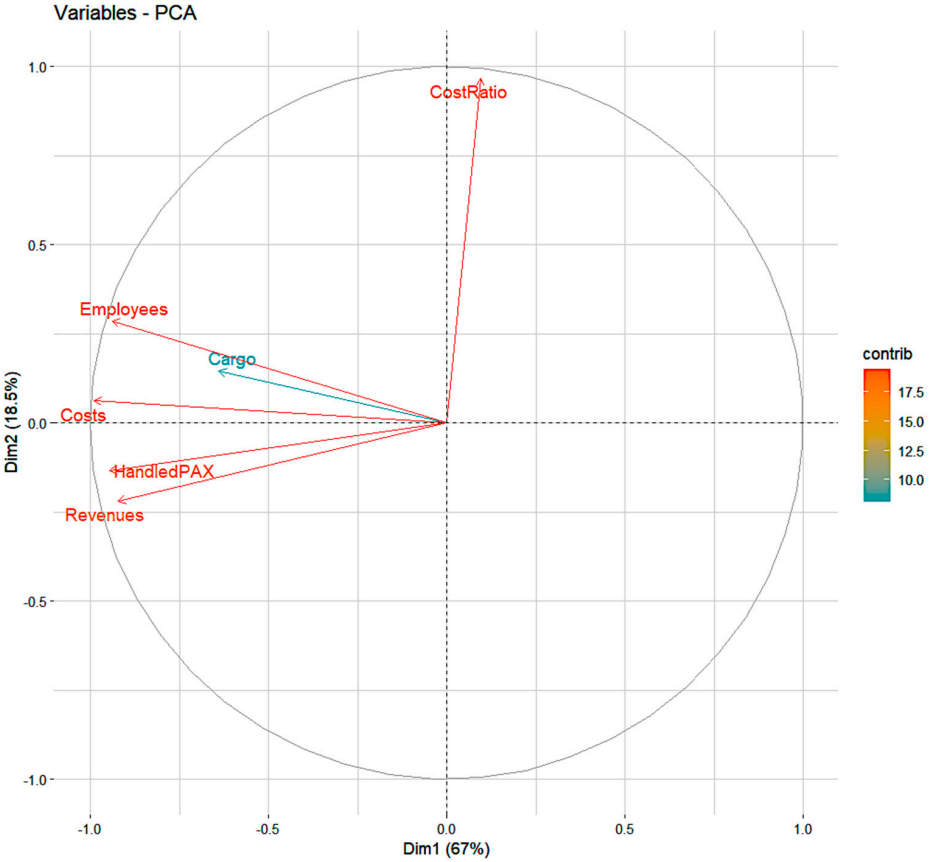

Figure 5. The degree of influence of individual indicators on the results of Cluster Analysis B.

The number of handled passengers, total revenues, total costs, and the number of employees contribute approximately equally to the values on the horizontal axis. The

amount of transported cargo has a significant but slightly lesser influence. On the vertical axis, the dominant variable is the cost indicator, while the other variables contribute mainly to the horizontal axis. Based on these findings, it is possible to characterize individual clusters according to their key variables, which in the case of cluster no. 1 (red), consists of Bratislava, Split and Poznań airports; number of handled passengers; total revenues; and total costs as well as number of employees. The amount of transported cargo and the cost indicator contribute to a lesser extent. Cluster no. 2 (blue), consisting of Lublin and Łódź airports, can be characterized by a very high cost ratio, which is similar to a case when the ownership structure was considered. Cluster no. 3 (green) is formed by all other airports, where we see a non-dominance of individual indicators, which repeatedly confirms the great variability of regional airports with common basic traits. The graphical representation of these statements is in Figure 6.

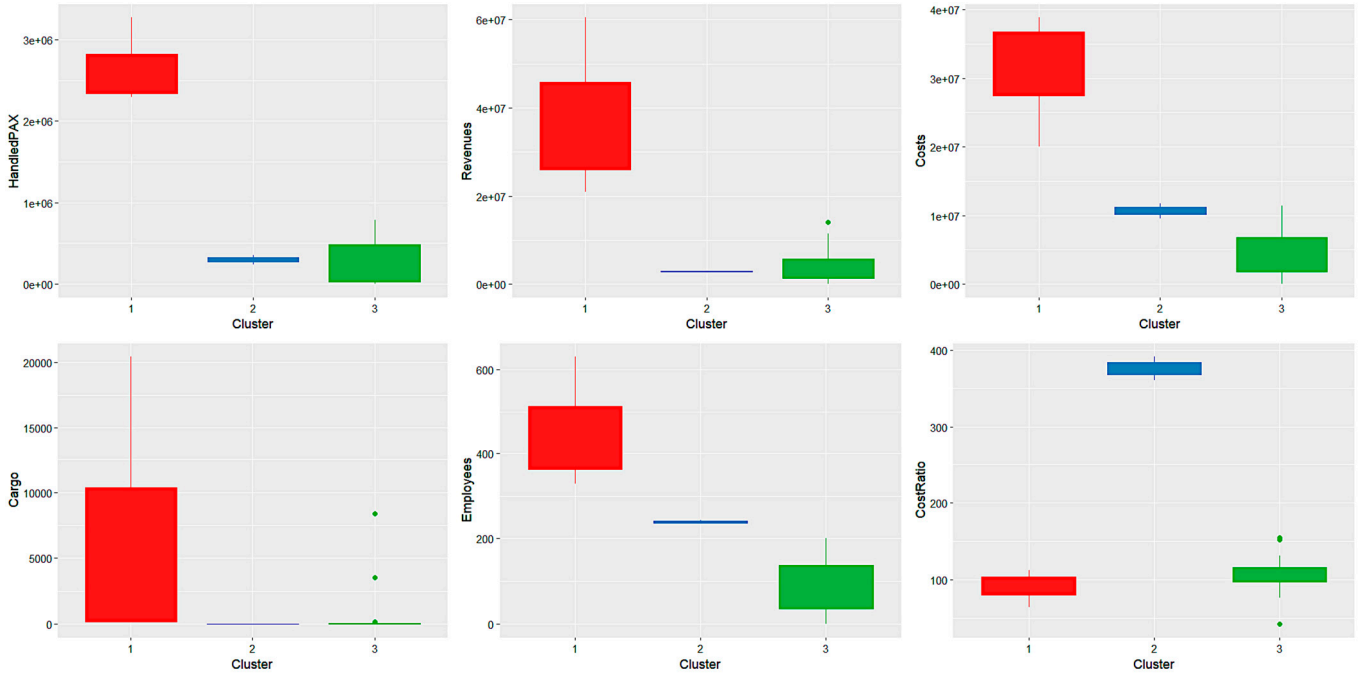

Figure 6. The degree of dominance of individual key indicators—Cluster Analysis B.

The average values of individual variables for individual clusters are in Table 4.

Table 4. Median of individual key indicators for individual clusters—Cluster Analysis B.

Median:	Handled PAX	Total Revenues €	Total Costs €	Transported Cargo (t)	Number Personnel	Cost Indicator (%)
Cluster no. 1	2,379,635	31,111,000	34,793,000	253	397	95.8
Cluster no. 2	299,536.5	2,828,126.5	10,666,774.5	0.4	239.5	376.2
Cluster no. 3	94,249	2,588,625	3,071,373	2	60	108.0

The results of the cluster analysis point to the multifaceted nature of regional airport economics in Central Europe and Croatia, highlighting the varying degrees of operational efficiency and financial sustainability across different airport clusters, which could help us find the basic platform of a regional airport business model.

4. Discussion

The research problem addressed in this paper originated from a notable gap in understanding the dynamics of regional airport systems economics in Central Europe. Despite their pivotal role in the regional transportation network, there have not been many compre-

hensive studies explaining how they operate and if the airports are economically viable. This paper addressed this gap by analyzing key indicators impacting the development of optimal regional airport system economics and tried to find the indicators for basic platforms of regional airport business models in Central Europe and Croatia on the basis of which the categorization of the airports is possible.

By examining performance metrics, economic conditions, and ownership structures across a sample of 24 regional airports from Slovakia, Czechia, Poland, Hungary, and Croatia, this paper sheds light on the factors driving the variability in airport system economics. The findings underscore the heterogeneity among the regional airport systems in the region and emphasize the need for tailored strategies to enhance their operational efficiency and financial sustainability.

The results of the cluster analysis revealed distinct patterns and similarities among the regional airport systems, allowing for the identification of key indicators that significantly influence their economics and could be a part of a basic platform of regional airport business models. While certain airports exhibited robust performance metrics and favorable economic conditions, others faced challenges associated with cost management and revenue generation. Moreover, the analysis highlighted the interplay between ownership structures and airport performance, indicating the importance of considering governance models in designing effective business strategies.

This paper contributes to the existing literature by providing valuable insights into the operational dynamics of regional airport systems in Central Europe and Croatia. By identifying key indicators and clustering airports based on similarities in their characteristics, our findings offer practical implications for airport management, policymakers, and industry stakeholders. Additionally, the analysis underscores the need for ongoing research and data-driven insights to inform decision-making in regional airport management. Continual monitoring of key indicators and performance metrics can provide valuable feedback for refining strategies and optimizing resource allocation. Moreover, leveraging emerging technologies and innovative practices can enhance operational efficiency and passenger experience, contributing to the long-term viability of regional airport systems.

5. Conclusions

In conclusion, this paper offers a comprehensive examination of regional airport systems economics in Central Europe and Croatia. By investigating the relationships between ownership structures, operational indicators, and external factors, it provides a nuanced understanding of the challenges and opportunities facing regional airport systems.

Moving forward, it is imperative for stakeholders to adopt a collaborative and adaptive approach to regional airport system management. Embracing sustainable practices, fostering stakeholder engagement, and leveraging data-driven insights can empower regional airport systems to thrive in an ever-evolving aviation landscape.

Ultimately, the insights from this paper can serve as a valuable foundation for future research and strategic planning initiatives aimed at enhancing the economic resilience and competitiveness of regional airport systems. By embracing innovation and embracing a holistic approach to airport management, regional airport systems can continue to serve as vital conduits for connectivity, economic development, and regional prosperity.

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Appendix A

Table A1. Input indicators of Cluster Analysis A and B, Slovakia, Source: [51].

Airport	Year	Handled PAX	Total Revenues €	Total costs €	Transported Cargo (t)	Number of Employees	Cost Indicator (%)	Ownership Structure
Bratislava	2019	2,290,242	31,111,000	34,793,000	20,449	631	111.8%	SR 100%
	2018	2,292,712	32,190,000	33,355,000	24,458.02	608	103.6%	
	2017	1,942,069	28,481,000	32,453,000	26,246.07	617	113.9%	
	2016	1,756,808	24,834,000	33,159,000	22,895.36	612	133.5%	
Košice	2019	558,064	14,047,516	10,681,624	59	149	76.0%	KSC Holding 64%
	2018	542,026	13,345,853	10,068,424	32	147	75.4%	SR 34%
	2017	496,708	11,401,873	9,045,861	106.36	139	79.3%	
	2016	436,696	9,121,438	7,202,546	88.359	134	79.0%	
Poprad	2019	94,249	2,774,035	3,071,373	0	63	110.7%	SR 97.61%
	2018	88,387	2,785,600	3,007,000	0	62	107.9%	Poprad city 1.67%
	2017	80,140	2,529,400	2,745,700	0.61	60	108.6%	City of Vysoké Tatry 0.72%
	2016	84,030	2,275,500	2,795,600	5.512	62	122.9%	
Sliač	2019	40,624	2,215,143	2,393,305	61.643	42	108.0%	SR 100%
	2018	41,866	2,344,409	2,317,236	73.922	38	98.8%	
	2017	34,827	2,420,191	2,312,855	485.286	40	95.6%	
	2016	22,511	2,152,734	2,242,142	592.2	37	104.2%	
Piešťany	2019	10,498	1,418,048	1,655,882	0.487	36	116.8%	Trnava region 59.31%
	2018	768	886,188	1,229,560	8.68	26	138.7%	SR 20.65%
	2017	1294	659,533	980,746	36.517	27	148.7%	City of Piešťany 20.04%
	2016	912	502,530	1,132,655	5.512	30	225.4%	
Žilina	2019	349	675,063	770,619	0	19	114.2%	Žilina region 65.99%
	2018	523	815,861	860,476	0.434	19	105.5%	SR 34.01%
	2017	421	712,116	856,287	0.526	19	120.2%	
	2016	286	707,441	844,631	1.2	19	119.4%	

Table A2. Input indicators of Cluster Analysis A and B, Czech Republic, Source: [52].

Airport	Year	Handled PAX	Total Revenues €	Total Costs €	Transported Cargo (t)	Number of Employees	Cost Indicator (%)	Ownership Structure
Brno	2019	543,633	x	x	3529	180	x	South Moravian region 100%
	2018	500,727	x	x	3750	159	x	
	2017	470,285	x	x	3893	143	x	
	2016	417,725	6,908,412	6,406,044	4150	143	92.7%	
Ostrava	2019	323,320	11,215,894	11,408,454	8392	200	101.7%	Moravian-Silesian region 100%
	2018	377,936	10,549,109	10,868,133	5448	176	103.0%	
	2017	324,116	9,235,129	9,813,872	5363	182	106.3%	
	2016	258,223	8,204,816	11,487,312	4152	182	140.0%	
Pardubice	2019	102,206	2,588,625	3,926,529	187	36	151.7%	City of Pardubice 66%
	2018	147,064	3,860,374	4,480,758	183	38	116.1%	Pardubice region 34%
	2017	88,490	2,775,507	2,973,790	265	32	107.1%	
	2016	31,174	1,783,606	2,178,220	142	29	122.1%	
Karlovy Vary	2019	62,434	1,271,367	1,966,997	0	42	154.7%	Karlovy Vary region 100%
	2018	45,003	1,688,330	2,044,341	0	45	121.1%	
	2017	21,404	1,121,864	1,705,614	0	48	152.0%	
	2016	25,235	1,138,104	1,690,538	0	51	148.5%	

Table A3. Input indicators of Cluster Analysis A and B, Hungary, Source: [53–56].

Airport	Year	Handled PAX	Total Revenues €	Total Costs €	Transported Cargo (t)	Number of Employees	Cost Indicator (%)	Ownership Structure
Debrecen	2019	601,236	6,840,736	7,731,572	0	182	113.0%	City of Debrecen 49.96% Debreceni Holding 25.02% Property Manager in Debrecen 25.02%
	2018	381,391	5,508,900	6,851,827	0	84	124.4%	
	2017	318,184	5,318,953	6,004,389	0	70	112.9%	
	2016	284,965	4,045,065	4,807,734	0	102	118.9%	
Győr-Pér	2019	x	2,071,184	2,088,221	x	25	100.8%	Audi Hungaria 48% City of Győr 40% Hungarian State 12%
	2018	20,076	2,365,668	2,324,149	x	20	98.2%	
	2017	22,785	1,949,792	1,942,153	x	17	99.6%	
	2016	21,454	1,614,642	1,607,299	x	19	99.5%	
Hevíz-Balaton	2019	9123	1,403,763	1,370,784	0	37	97.7%	City of Hevíz 100%
	2018	11,466	1,376,133	1,369,899	0	35	99.5%	
	2017	13,229	1,360,658	1,331,592	0	19	97.9%	
	2016	17,663	1,188,365	1,184,310	0	14	99.7%	
Pécs-Pogány	2019	5983	624,980	676,754	0	13	108.3%	City of Pécs 58.80% Hungarian State 41.20%
	2018	5345	573,994	572,812	0	13	99.8%	
	2017	4595	644,293	573,480	0	13	89.0%	
	2016	3644	827,664	561,210	0	13	67.8%	

Table A4. Input indicators of Cluster Analysis A and B, Poland, Source: [57–62].

Airport	Year	Handled PAX	Total Revenues €	Total Costs €	Transported Cargo (t)	Number of Employees	Cost Indicator (%)	Ownership Structure
Lublin	2019	357,366	2,999,880	11,749,971	0	235	391.7%	City of Lublin 52.3604% Lublin Region 44.8570% City of Swidnik 2.7772% Swidnik district 0.0054%
	2018	455,188	3,404,223	12,561,298	0.490	246	369.0%	
	2017	430,346	2,276,877	12,346,993	0.014	253	542.3%	
	2016	377,606	1,748,373	10,002,035	1.070	x	572.1%	
Lodž	2019	241,707	2,656,373	9,583,578	0.857	244	360.8%	City of Lodž 95.509% Lodž Region 4.489% Aeroclub Lodž 0.002%
	2018	217,014	2,553,594	9,556,441	17.178	252	374.2%	
	2017	204,676	2,385,249	11,588,371	0	247	485.8%	
	2016	241,076	2,469,494	14,170,984	0	287	573.8%	
Bydgoszcz	2019	425,230	4,509,142	6,917,604	9.22	195	153.4%	Kujawsko-Pomorskie region 71.416% City of Bydgoszcz 22.913% St. enterpise Polish airports 4.867% City of Toruň 0.036% City of Inowroclaw 0.0065% P.P.U. Nordtechnik Sp. Z.o.o 0.6905% Targi Pomorskie Sp. Z.o.o 0.0017% 3 persons 0.0008%
	2018	413,245	4,639,390	6,934,742	7.07	189	149.5%	
	2017	331,300	4,391,252	7,202,904	23.55	185	164.0%	
	2016	337,556	3,976,067	7,127,773	0	180	179.3%	
Szczecin-Goleniów	2019	576,037	x	x	10.95	x	x	St. enterprise Polish Airports 40.10% City of Szszecin 37.97% Zapadnio-Pomorskie region 21.93%
	2018	598,971	4,659,526	4,659,526	37.33	132	126.8%	
	2017	578,691	3,800,142	3,800,142	149.9	131	132.2%	
	2016	467,877	3,571,513	3,571,513	574.9	127	125.4%	

Table A4. *Cont.*

Airport	Year	Handled PAX	Total Revenues €	Total Costs €	Transported Cargo (t)	Number of Employees	Cost Indicator (%)	Ownership Structure
Zielona-Góra	2019	33,783	38,568	38,568	0	0	42.4%	Lubuskie region 100%
	2018	21,934	30,780	30,780	0	0	23.4%	
	2017	17,702	29,755	29,755	0	0	27.9%	
	2016	9443	10,085	10,085	0	0	50.2%	
Poznań-Lawica	2019	2,379,635	20,925,905	20,925,905	100.72	x	95.8%	St. enterprise Polish airports 38.99%
	2018	2,476,304	21,099,337	21,099,337	73.16	x	92.9%	City of Poznań 36.99%
	2017	1,852,655	16,576,267	16,576,267	466.40	330	108.3%	Wielkopolskie region 24.02%
	2016	1,710,116	14,684,458	14,684,458	212,291	336	98.4%	

Table A5. Input indicators of Cluster Analysis A and B, Croatia, Source: [63].

Airport	Year	Handled PAX	Total Revenues €	Total Costs €	Transported Cargo (t)	Number of Employees	Cost Indicator (%)	Ownership structure
Split	2019	3,271,000	60,533,981	38,846,610	253	397	64.2%	Croatian state 55%
	2018	3,096,000	54,516,739	33,807,140	273	347	62.0%	Splitsko-Dalmatinska country 15%
	2017	2,791,000	49,365,501	30,136,094	294	357	61.0%	Kaštela City 15%
	2016	2,263,000	41,778,103	27,530,281	346	352	65.9%	Trogir City 15%
Zadar	2019	783,000	11,456,527	10,302,609	2	127	89.9%	Croatian state 55%
	2018	585,000	9,832,825	8,637,312	27	128	87.8%	Zadar county 20%
	2017	574,000	9,054,032	8,148,149	5	172	90.0%	Zadar city 20%
	2016	502,000	7,938,190	7,420,031	8	158	93.5%	Donji Zemunik municipality 5%
Rijeka	2019	197,000	3,454,036	3 443,554	95	60	99.7%	Croatian state 55%
	2018	179,000	3,835,109	3,488,759	-	68	91.0%	Primorsko-Goranska county 20%
	2017	137,000	2,584,789	2,300,906	-	55	89.0%	Rijeka city 10%
	2016	141,000	2,240,765	2,236,534	-	53	99.8%	Crikevnica city 4% Omišalj municipality 3%
Osijek	2019	46,000	2,140,934	2,064,431	12	61	96.4%	Croatian state 55%
	2018	67,000	1,617,367	1,954,797	-	65	120.9%	Osječko-Baranjska county 20%
	2017	43,000	1,658,368	1,693,896	-	56	102.1%	Osjek city 25%
	2016	30,000	1,977,096	1,958,299	-	52	99.0%	

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