LogForum
> Scientific Journal of Logistics <
2021, 17 (1), 131-145
http://doi.org/10.17270/J.LOG.2021.529
http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X
ORIGINAL PAPER

A SOFTWARE DEVELOPMENT APPLICATION FOR SUSTAINABLE AIRPORT PERFORMANCE ANALYSIS

Fahriye Merdivenci, Ramazan Erturgut, Artuğ Eren Coşkun
Akdeniz University, Antalya, **Turkey**

ABSTRACT. **Background**: In today's rapidly changing global economy, airports have an important role in the social, cultural, and economic development of societies and in building bridges between interconnected markets. Sustainability requires a balance between economic, social, and environmental processes and performance-based progress in efforts on all three dimensions at an optimum level. Therefore, sustainable performance measurement and management is an important function for the control of airports. The suitability of investments in airports to respond to the increasing needs and expectations of the future can be realized through a rational structure that operates technologically, effectively, and efficiently. The need for this structure to be sustainable with above-average performance further increases the importance of the issue. This study aims to develop a sustainable performance software for airports by conducting a sustainable performance analysis based on multiple variables.
Methods: For sustainable performance analysis at airports, it is important to include economic, social, and environmental parameters, which are the three sub-dimensions of sustainability, in all strategic, tactical, and operational processes and decision-making mechanisms. For the performance analysis of airports, the DEMATEL Method, and the Objectives Matrix (OMAX) Method, which evaluates all the criteria together, were used to weight various performance indicators.
Results: The most important criterion at Antalya Airport, which is also the most affected by other criteria, is "economic". Sustainable performance scores of Antalya Airport for 2018 and 2019 were calculated. The airport's performance in 2019 is higher compared to 2018.
Conclusions: The biggest achievement of this research is thought to be developing a "Sustainable Performance Software" for national and international airports. This study will also contribute to the emergence of studies that will reveal the performances of other airports and compare their past performances with their current and national performances.

Key words: airport, airport performance, sustainability, performance analysis, sustainable performance software.

INTRODUCTION

"Air Transportation" and "Airport Management" constitute one of the most functional aspects of logistics and supply chain management today [Yuan et al. 2010]. Aviation, which has undergone a tremendous change in the recent past, has experienced a continuous development trend for the last 20 years and has become one of the fastest-growing sectors of the global economy with an average of 5% growth each year [Kumar et al. 2020]. In this respect, the aviation industry contributes significantly to local economies and facilitates the integration of a country into the global economy, providing socio-economic benefits [Chourasia et al. 2020]. Expectations of an increase in demand for airline freight and passenger transport show that the aviation industry will continue to grow, which means building new airports or expanding existing airports. All these developments in the aviation sector cause an increase in concerns about sustainable development, which includes environmental complexity [Sameh, Scavuzzi 2016] and details of all operational processes

Citation: Merdivenci F., Erturgut R., Coşkun A.E., 2021. A software development application for sustainable airport performance analysis. LogForum 17 (1), 131-145, http://doi.org/10.17270/J.LOG.2021.529
Received: 17.08.2020, Accepted: 10.11.2020, on-line: 12.01.2021.

and costs for all medium-long-term activities [Janic 2010].

Air transportation is positively and negatively associated with society and the environment and has a dynamic interaction with persistence [Janic 2010]. Airports are the places where all logistics activities between land and air modes of transportation are carried out and play a vital role in the value chain [Baxter 2018]. Over the years, the evaluation of airports has focused on the quality of service, which led to pushing significant environmental and social impacts into the background. For instance, the Airport Service Quality (ASQ) Program, an initiative of the International Airports Council (ACI), evaluates and ranks various operations and services at world airports to help improve airport service quality [Chao, et al. 2017]. However, environmental concerns that have increased in recent years have made it necessary for a program that evaluates the environmental pollution of airports. In response to communities' concerns, airport officials try to instill public awareness of the environmental problems of aviation activities and the regulatory measures of local governments and governments; however, they present several factors to reduce the negative impact of their activities on the environment and try to implement the strategies developed accordingly [Sameh, Scavuzzi dos Santos 2018]. In this context, Airports Council International (ACI) has launched the "Airport Carbon Accreditation (ACA)" programme to measure carbon emissions and make it a global standard, which is one of the most important parameters in determining the pollution level of airports. The purpose of this programme is to encourage practices that will benefit most in carbon management with the goal of ultimately minimizing carbon emissions in airports and to validate them with sustainable policies. The programme was developed in accordance with international standards, including the Greenhouse Gas Protocol and ISO 14064. As the related standards develop, the programme is updated accordingly [ACI 2018].

Although the socio-economic benefits created by the aviation sector are frequently emphasized, the limited importance given to environmental sustainability at airports negatively affects the ecology and society around it [Chourasia et al. 2020]. However, it should be noted that the problems posed by airports should not be assessed solely on environmental aspects. In addition to the development of activities aimed at achieving environmental sustainability, it is necessary to focus on the areas of economic and social sustainability [Boons, et al. 2010]. On the other hand, since the Industry 4.0 phenomenon has a content that affects aviation organizations [Rodoplu Şahin, et al. 2019], technical and process dimensions also need to be integrated into the developmental process of sustainability practices.

Increasing the pressure of national and international authorities on airports on sustainability caused airport managers to need new solutions for performance optimization [Kucuyak 2001]. Nevertheless, it is a practical challenge under which criteria the performance is to be examined in a complex and dynamic service environment such as airports [Bezerra, Gomes 2018]. Although the sustainable performance of airports is generally researched under social, environmental, and economic criteria [Koç, Durmaz 2015, Upham 2001], there are also studies in which criteria dimensions such as physical [Chourasia et al. 2020] and operational [Brisbane Airport Corporation 2020, Güngören 2016] are added.

In the analyses carried out in this study, the sustainable performance of the airport was assessed under economic, social, environmental, process, and technical dimensions. The main source of motivation in the creation of the study addresses the idea of approaching sustainability and performance issues at airports with a business perspective and developing software and scale as an original and innovative idea that will serve logistics management practices in total on an interdisciplinary ground. In line with these objectives and purposes, the relevant literature on sustainable airport performance indicators was reviewed, and in light of the information obtained, sustainable performance criteria were determined to be used in the research method. The DEMATEL method was used to determine the weights of the criteria, and the OMAX method was used to achieve the annual performance score. Total Productivity Index software was developed to ensure easy access to airport sustainable performance scores by airport managers. Within the scope of this study, objective performance data will be presented in all dimensions of sustainability, and it is aimed to make a scientific contribution in reducing the effects of "operational blindness" in airports.

SUSTAINABLE PERFORMANCE INDICATORS AT AIRPORTS

Historically, since the airports are often operated by governments, performance comparisons have been focusing on financial and output metrics. The measurements developed are the workload unit (WLU) defined for a passenger or load handling for 100 kg. The output criteria obtained from these measurements are total cost, labor cost, and total income per WLU. Other measurements were carried out on airport design and operational standards [Frankis, et al. 2002]. The International Civil Aviation Organization (ICAO) provides performance comparisons of airports based on size, organization, planning, terminal passenger flows, waiting times, etc. [Vreedenburg 1999]. ACI has released a guide to help improve the performance of airports worldwide. This guide consists of 6 key performance criteria and 42 sub-indicators. The main criteria are core, safety and security, service quality, productivity/efficiency, financial/commercial, and environmental [Eshtaiwi, et al. 2018]. In the academic literature, it is observed that studies over the last decade have been conducted on the measurement of quality of service relative to passenger perception. As the airport business became commercial, the need for performance measurements increased. Andersson Granberg and Munoz [2013] listed the airport performance indicators they selected from various studies as operational, economic, environmental, safety/security, and customer service. In addition to these criteria, Baltazar et al. [2018] added efficiency/cost-effectiveness.

Bezerra et al. [2016] examined the performance dimensions in airports extensively for the past 45 years in the literature. They emphasized the need to develop reliable performance management issues that will make performance definition, measurement, and analysis important. They listed the percentage of handling performance dimensions at airports, including 38.3% Efficiency/Effectiveness, 21.2% Service Quality, 16% Economic/Financial, 7.9% Environmental, 5% Commercial, 3.6% Security, 3.4% Competitiveness, 2.6% Social, and 1.9% Safety.

There are many studies in the literature, where measurement criteria for determining airport sustainability performance are set. Koç and Durmaz [2015] use the social, economic, and environmental criteria set by the Global Reporting Initiative (GRI) to measure sustainable performance, under the criteria of the sustainable performances of the best airports published in Skytrax's World Airport Awards and ACI's Airport Service Quality (ASQ). Olfat et al. [2016] analyzed sustainable airport performance under policies, commercial, social responsibility, environmental pollution level, and service quality components. Lu et al. [2018] identified forecast indicators to improve sustainable performance at international airports. These indicators are financial, internal business processes, learning, and growth, environmental and social perspective. Wan et al. [2020] evaluated the sustainable development performance of Guangzhou Baiyun International Airport between 2008-2017 by creating a synthetic assessment index model under the dimensions of economy, environment, society, and operation.

In airport management, safety, security operation, customer, human resources, and environmental impact-oriented indicators are also very important besides indicators such as efficiency, profitability, financial situation. In addition, considering the requirements of the International Air Transport Association (IATA) standards, ICAO and the European Civil Aviation Conference (ECAC), which are the organizations where the airport management interacts, are important for performance management effectiveness. In order to evaluate the quality of the service provided at the airports, it is necessary to categorize them into main groups as arriving, departing, transfer and transit passengers, considering that the airport is the main customer base. The reason is that the basic needs and expectations of the passengers in each group will be different. On the other hand, airport enterprises implement some effective environmental management plans to minimize the negative effects on noise, carbon emission, water pollution, birds, and other wild animals due to their activities [Güngören 2016].

METHODOLOGY

The performance measurement system generally includes the system, objectives, measurements, and steps for improvement. Objectives are definitions that must be achieved in order for the business to implement its strategy. Measuring performance does not change alone, but steps to achieve performance improvement are required [Bourne, Bourne 2011]. In this respect, the main objective of the management is to create team spirit and increase performance by directing all contributions and efforts in the same direction, without unnecessary operations, gaps and obstacles around the objectives set by the employees. The company strategy, which is formed with clear and consistent goals, increases the competitive position in the long run and helps to become the leader in the sector if it is well planned and implemented. Since turning to opportunities that can be achieved in the short term without setting long-term goals will fail the business, it is beneficial for the company to pursue a strategy based on strategy and vision that will provide a competitive advantage in the long run [Zaim 2002].

In this study, it is aimed to demonstrate the sustainable performance of Antalya Airport in terms of years and to develop a sustainable airport performance software. For this purpose, firstly, Antalya Airport officials were contacted, and the data to be used in the analysis were provided. In the second step, the weights of the sustainable performance criteria determined were determined by using the DEMATEL Method. In the third step, the OMAX Method was used to reach the sustainable performance scores of Antalya Airport in 2018 and 2019, and the related scores were compared with one another. In the last step, the software called Total Productivity Index, which will directly calculate the annual sustainable performance of airports, was developed, and the findings obtained in this study were tested with the developed software. Except for the software development step, the flow diagram applied in this study is shown in Figure 1.

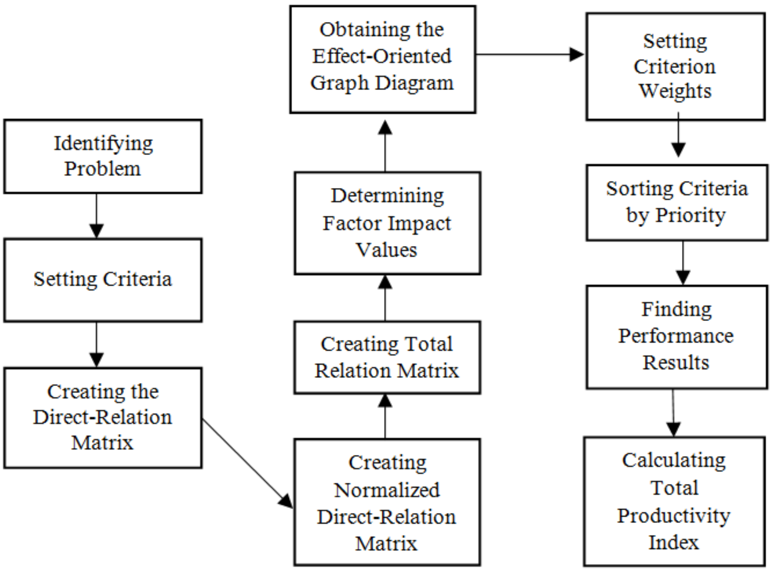


Fig. 1. Flow diagram

DEMATEL METHOD (WEIGHTING METHOD)

The DEMATEL Method (The Decision-Making Trial and Evaluation Laboratory Method) was used as a multi-criteria decision-making method to determine the weights of the criteria for sustainable airport performance. The method was developed in 1972 and 1976 by the Battelle Memorial Institute in Geneva [Wu 2008]. The DEMATEL method can improve the understanding of specific problems and a set of nested problems. It can contribute to the definition of applicable solutions with a hierarchical structure. It differs from the assumption that the criteria discussed in traditional multi-criteria decision-making methods, such as the analytical hierarchy process, are independent. One of the structural modeling techniques, this method can causally determine dependence among the components of a system. The DEMATEL method procedure is summarized with the following steps [Tzeng et al. 2007, Wu 2008]:

Step One: Creating the Direct-Relation Matrix

In this first step, expert opinions are correlated based on the 5-point scale to create a direct-relation matrix. These are as follows:

- 0 indicates that there is no interaction between criteria,
- 1 indicates that the interaction between criteria is low,
- 2 indicates that the interaction between criteria is moderate,
- 3 indicates that the interaction between criteria is high, and
- 4 indicates that the interaction between criteria is very high.

Step Two: Creating a Normalized Direct-Relation Matrix

By adhering to the direct-relation matrix, the normalized direct-relation matrix (M) is obtained by the following equations. It is obtained by using the smallest value (k) in rows and columns by means of equations 2.1 and 2.2.

$$M = k \text{x} A \qquad 2.1$$

$$k = Min\left(1/\max\sum_1^a |a_{ij}|, 1/\max\sum_1^a |a_{ij}|\right) \qquad 2.2$$

$$1 \le i \le 0 \qquad 1 \le j \le 0$$

$$i,j \in \{1,2,3,4 \ldots .. n\}$$

Step Three: Creating a Total Relation Matrix

After the normalized direct-relation matrix is obtained, the total relation matrix is created with the equation (S). The value (I) in this equation is the unit matrix.

$$S = M^1 + M^2 \ldots .. = \sum_{i=1}^{\infty} M^i \qquad 2.3$$

$$= M (I - M)^{-1} \qquad 2.4$$

Step Four: Creating the Sender and Receiver Group

While the value obtained from the sum of the columns in the S matrix is encoded as R, the sum of the rows in the same matrix is encoded as D. D-R and D+R values are obtained after the calculations made using the equation 2.5 and 2.6 given below. These values are expressions that reveal the effect of the criteria on others or the relationship between the criteria. Some of the D-R values may be positive. Although the positive values show that the criteria have a high impact on other criteria, it is concluded that they have high priority over other criteria. D-R values being negative suggest that the criteria are affected more than other criteria. D+R values express the relationship between each criterion and the other. Criteria with high D+R value are more related to other criteria. If the D+R value is low, we can say that the resulting values are less related to other criteria.

$$S = [S_{i,j}]_{nxn}, \ i,j \in \{1,2,3,4 \ldots \ldots .. n\} \qquad 2.4$$

$$D = \sum_1^n S_{i,j} \qquad 2.5$$

$$R = \sum_1^n S_{i,j} \qquad 2.6$$

Step Five: Obtaining the Effect-Oriented Graph Diagram

Decision-makers need to set a threshold for the effect level in order to obtain an impact-oriented graph. In the S matrix, a number of values with impact values greater than the threshold value are selected, and an effect-oriented graph diagram is created. The threshold value is determined by the decision-maker or expert group. The effect-oriented graph diagram is obtained by showing the points in a coordinate plane (D+R, D-R) with the horizontal axis D+R and the vertical axis D-R [Tsai and Chou 2009]. The threshold value determined by the expert group is significant to prevent the complexity of the effect-oriented diagram obtained. The high or low threshold value to be used affects the impact of the relationship between the criteria and can make the solution more complex or simpler [Aksakal and Dağdeviren 2010].

Step Six: Setting Criterion Weights

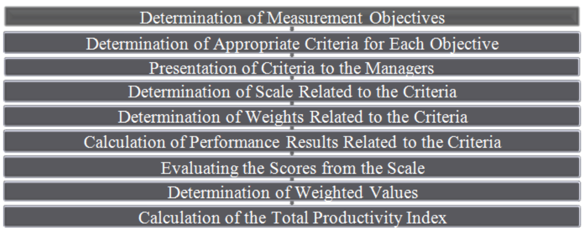
Weights (w) are calculated by taking the squared average of the total effects $(D + R)$ and the net effects $(D - R)$ of the D and R vectors.

$$w = [(D + R)^2 + (D - R)^2]^{1/2}$$

OMAX METHOD (OBJECTIVES MATRIX METHOD)

The original implementation of OMAX is linked to the study of James L. Riggs, the founder and first director of the Oregon Productivity Center in the early 1980s. Other applications were carried out by Carl Thor at the American Center for Productivity and Quality and John Parsons at the National Institute of Productivity in South Africa [Dervitsiotis 1995]. To date, the OMAX efficiency matrix has been used under different names such as multi-criteria performance measurement technique (MCP/PMT), importance-performance matrix, and interpretations of the matrix method. The first application of the matrix method was made by Riggs [1986]. The measurement framework was applied in manufacturing industries, services, and public institutions. Rantanen and Holtari [1999] emphasized that the performance measurement matrix method is one of the most used systems, such as the balanced performance measurement method Balanced Scorecard [Jääskeläinen 2009].

OMAX is a performance measurement method that evaluates various performance indicators together with the method of weighting to obtain a total performance indicator [Balkan 2011]. In this method, it is encouraged to use other indicators instead of real output. The main feature of the method is the approach followed in determining the indicators that determine performance. The basis of this approach is based on the argument that the performance criteria can be determined by those who know the factors that affect the performance in the organization, group, or individual studies in the best way. Employees can more easily evaluate which activities and efforts will positively support organizational performance and which can be ineffective or insignificant. There are different job characteristics unique to each group. Based on these characteristics, it is possible to differentiate the factors that affect organizational performance (group performance). The important thing is to choose the ratios that have known effects on the common result (output) and which can reveal measurable behavior types [Akal 2005]. The workflow of the method is as follows [Balkan 2011].



Source: Balkan 2011

Fig. 2. Objectives Matrix Method Workflow Chart

In the implementation phase of the specified workflow process, the lowest and highest measurement values targeted for each criterion are determined after the objectives and criteria for the targets are determined, and the approval of the managers is obtained. Since each criterion has different weights in terms of organization, weights are given to each to complete one hundred percent. As a result of calculating the scores and multiplying them by their weight, an efficiency score is generated for each criterion. With the sum of all these weighted scores on the scales, the Total Performance Index is calculated by taking into account the objectives of the enterprise and showing how close it is to its objectives [Akal 2005].

SOFTWARE DEVELOPMENT

The C# programming language was used for the software developed as part of this study. C# is an object-oriented programming language developed by Anders Heljsberg and his team for Microsoft's .NET platform [ECMA 2001]. The interface of the software is shown in Figure 3.

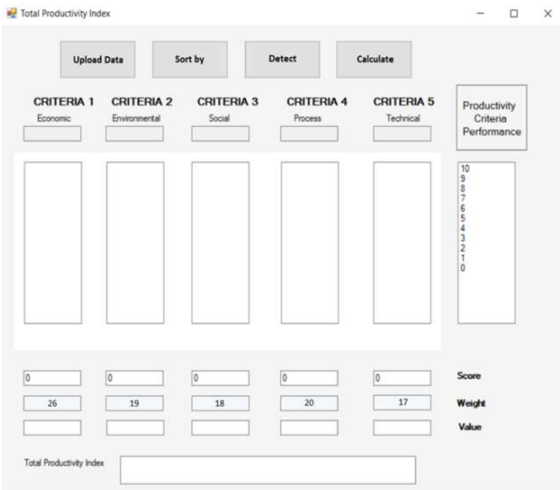


Fig. 3. The Interface of the Software

OPERATING PRINCIPLE OF SOFTWARE

The software consists of 5 key stages for calculating the Total Productivity Index. The flow diagram of the software is seen in Figure 4.

The data used in the software is kept annually in the Excel file (.xls) file. The user selects the file containing the data using the "Upload Data" button. Target values are uploaded to Textbox, and monthly data to Listbox controls.

The user sorts the data using the "Sort by" button. Economic, Social, Process and Technical data are sorted descending, while Environmental data are listed as ascending.

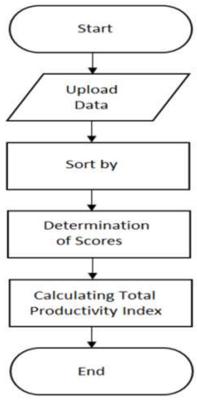


Fig. 4. Flow Diagram of Software

Scores are calculated for each criterion using the "Detect" button. For this, the maximizing method is used for Economic, Social, Process and Technical criteria and minimizing method for the Environmental criterion.

Total Productivity Index calculation is made using the "Calculate" button. For this, the determined score value and the weight value are multiplied, and the value obtained is the value of that criterion. The Total Productivity Index value of that year is obtained by summing the values determined for each criterion.

RESULTS

At the application stage of the method, the sustainable airport performance criteria and sub-criteria obtained from the literature are listed under 5 main headings. These are as follows:

1. Process (C1): Air traffic control performance, Hourly aircraft landing-take-off number, Taking slots at any time, Waiting times in taxi and apron, Delay performance due to airport service, Bridge usage rate.
2. Technical (C2): Technical systems operating performance, IT systems operating performance, Failure response times.

3. Social (C3): turnover rate, absenteeism rate, average training hours per person, employee satisfaction rate, social activities.
4. Environmental (C4): Emission, noise.
5. Economic (C5): Profitability (net income/net expense), Air traffic revenues, Landing-accommodation revenues, Commercial Efficiency (Non-Aviation revenues/Total revenues), Non-aviation passenger income, Advertising space occupancy rate, Commercial space occupancy rate.

The analysis of whether the relationship between the data obtained based on expert opinions and the criteria is causal is presented in the following steps.

Step One: Creating the Direct-Relation Matrix

Criteria for determining airport performance the direct-relation matrix created according to the scores given to measure the effect of each of the 5 criteria on the other is presented in Table 1 in accordance with the information obtained from the experts.

Table 1. Direct-Relation Matrix

	C1	C2	C3	C4	C5
C1	0	2	3	2	4
C2	1	0	3	1	4
C3	1	1	0	1	3
C4	1	3	3	0	3
C5	4	1	1	3	0

Then the rows and columns of each criterion of the direct-relation matrix obtained in Table 1 are summed. The C5 criterion (s value: 14), where the sum of the criteria in the rows and columns is the highest, is determined as the s value for use in the method.

Step Two: Normalized Direct-Relation Matrix (M)

Table 2. Normalized Direct-Relation Matrix

	C1	C2	C3	C4	C5
C1	0	0.142857	0.214286	0.142857	0.285714
C2	0.071429	0	0.214286	0.071429	0.285714
C3	0.071429	0.071429	0	0.071429	0.214286
C4	0.071429	0.214286	0.214286	0	0.214286
C5	0.285714	0.071429	0.071429	0.214286	0

The normalized direct-relation matrix is obtained by dividing the intersection of each row and column in the direct-relation matrix to the "s value" to clear the numbers in Table 2 from residual values and to perform calculations on a unit basis.

Step Three: Creating the Total Relation Matrix (S)

Table 3. Creating the Total Relation Matrix

	C1	C2	C3	C4	C5
C1	0.268327	0.341442	0.471523	0.376768	0.641711
C2	0.295092	0.171596	0.414148	0.276955	0.567147
C3	0.233015	0.194015	0.168751	0.220568	0.41972
C4	0.30343	0.376096	0.446471	0.220238	0.551302
C5	0.465122	0.275691	0.343457	0.404665	0.371973

The normalized-relation matrix (M) in Table 2 is subtracted from the unit (I) matrix to obtain the total relation matrix. Then the reciprocal of the resulting matrix is taken. The resulting new matrix is multiplied by the normalized-relation matrix to obtain the total relation matrix.

Step Four: Determining the Sender and Receiver Group

Table 4. Determining the Sender and Receiver Groups

	D+R	D-R
C1	3.664756	0.534785
C2	3.083779	0.366099
C3	3.08042	-0.60828
C4	3.396731	0.398343
C5	4.41276	-0.69095

As a result of taking the sum and difference of the D and R lines in Table 3, the values of (D+R) and (D-R) in Table 4 above are obtained. These values reveal the effect of the criteria on other criteria or the existence of a relationship between the criteria.

Step Five: Obtaining the Effect-Oriented Graph Diagram

From the D+R values showing the relationship between the criteria, it is seen that the Economic (C5), Process (C1), and Environment (C4) criteria are in more relation with the other criteria, respectively. It was found out that the Social (C3) and Economic (C5) criteria, which are called as receiving or affected, have lower priority and are more affected by other criteria in comparison with the other criteria. The D-R (positive) values, which are referred to as sender or effectual, have higher effects and a higher priority, were found to affect Process (C1), Environment (C4), and Technical (C2) criteria, respectively, more than other criteria. In Figure 5, an effect-oriented graph diagram showing the interaction between D+R and D-R values in Table 4 was created.

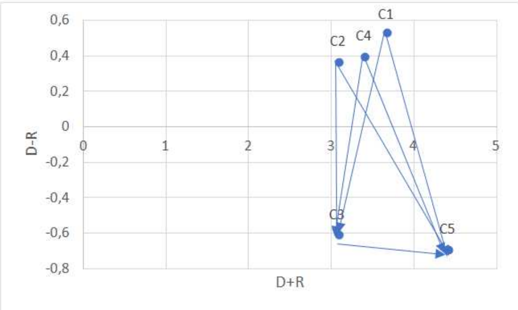


Fig. 5. Effect-Oriented Graph Diagram

Step Six: Determining the Priorities of the Criteria

In this step, the importance weights of the criteria in Table 4 are shown respectively. According to Table 5 below, priority criteria can be given as Economic, Process, Environment, Social, and Technical.

Table 5. Determining the Priorities of the Criteria

Criteria	*w*	Sorting
C1	0.207652	2
C2	0.174116	5
C3	0.176049	4
C4	0.191754	3
C5	0.25043	1

The criteria used in the method were obtained from Güngören's study [2016]. In the implementation of the method, performance scales were created with the lowest and highest levels of performance that can be reached according to performance criteria. The upper and lower scale values that constitute the objectives of the airport enterprise were determined by the business management, and the intermediate values were distributed equally on the scale of 1 - 10 intervals. In this context, performance calculation results for 2018 and 2019 of the subject airport business by objectives are shown in Table 6 and Table 7.

Table 6. Antalya Airport 2018 Sustainable Performance Evaluation

2018	Economic	Environmental	Social	Process	Technical	Performance Criteria
	58,2	20,72	83,81	76,10	99,9925	**Target Performance Figures**
						Performance Scale
Actual Performance Figures	59,14	18,41	99,50	83,62	99,9924	**10**
	57,95	19,13	98,40	82,93	99,9923	**9**
	56,75	19,98	92,80	80,21	99,9922	**8**
	56,48	21,47	89,20	78,57	99,9922	**7**
	56,01	22,18	86,40	76,56	99,9921	**6**
	53,57	23,00	83,50	74,97	99,9921	**5**
	52,94	25,82	79,60	70,34	99,9921	**4**
	50,55	26,63	74,90	67,22	99,9921	**3**
	48,77	26,81	72,10	64,98	99,9920	**2**
	48,52	27,13	71,60	61,24	99,9920	**1**
	47,72	28,08	68,50	54,97	99,9919	**0**
	9	7	5	5	10	**Scores**
	26	19	18	20	17	**Weights**
	234	133	90	100	170	**Value**
					727	**Total Productivity Index**

Table 7. Antalya Airport 2019 Sustainable Performance Evaluation

2019	Economic	Environmental	Social	Process	Technical	Performance Criteria
	60,00	20,00	85	77,50	99,9985	**Target Performance Figures**
						Performance Scale
Actual Performance Figures	59,14	16,90	99,99	86,30	99,9949	**10**
	59,07	17,72	99,10	84,50	99,9949	**9**
	56,75	18,54	97,40	84,40	99,9948	**8**
	56,48	19,36	94,90	82,55	99,9948	**7**
	56,01	20,18	88,20	79,80	99,9948	**6**
	53,57	21,00	83,00	76,77	99,9948	**5**
	52,94	21,82	81,00	76,65	99,9947	**4**
	50,55	22,64	75,60	74,18	99,9947	**3**
	48,77	23,46	74,40	73,75	99,9947	**2**
	48,52	24,28	73,10	72,62	99,9947	**1**
	47,72	25,1	70,20	56,25	99,9943	**0**
	10	6	5	5	10	**Scores**
	26	19	18	20	17	**Weights**
	260	114	90	100	170	**Value**
					734	**Total Productivity Index**

In the method, while finding the equivalent of the actual performance values in the scale, the highest scale level that the actual value can reach is also taken into consideration. For example, the economic criterion for 2018 is 58.2 on average. The objectives set in these criteria were determined in a way to maximize the value (minimize the environmental criterion) at high performance.

In this method, scores were formed according to the levels at which the realized performance values can reach in the performance scale. The scores of the performance criteria formed a performance value in proportion to their weight calculated according to the DEMATEL method, and the total performance index of the airport was obtained with the sum of all these values. As a result of the performance measurement, the 2019 performance index of the airport was calculated as "734" and the 2018 performance index as "727".

CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH

Based on the literature and the mass data obtained from the interviews at the Antalya Airport, evaluation criteria for sustainable airport performance were firstly determined in this study. Then, by using the DEMATEL method, an effect-oriented graph diagram was obtained, and the effect levels of the criteria against one another were obtained, and the weights of the relevant criteria were determined and ranked according to their importance levels. The criteria weights determined by the DEMATEL method were used in the OMAX Method to reach the annual performance index of Antalya Airport. In addition to reaching comparable performance values of Antalya Airport on a yearly basis, the software called "Total Productivity Index," which has a user-friendly interface that can be used by all airport authorities in the world, was developed in the evaluation of sustainable performance in this study.

According to the research findings, the "economic" criterion with a weight of 0.250 was the most important criterion, as well as the one most affected by other criteria. Process and environment criteria followed the economic criteria with weights of 0.207 and 0.191, respectively, with regards to the significance but appeared as the two criteria with the power to affect the other criteria the most. Social and technical criteria were relatively low in terms of significance. Considering the difference between them, it is seen that the social criterion is influenced by other criteria, and the technical criterion affects the other criteria. Although the criteria weights determined in practice vary from airport to airport, the sustainable performance criteria obtained from the study and the hierarchical model established were determined to provide an effective, sustainable performance assessment that the aviation sector can utilize.

This study contributes to the literature by showing that the "DEMATEL" method, which is one of the structural modeling techniques, and "OMAX," which is one of the performance evaluation methods, can be integrated into each other and used in the physical performance evaluation of an airport enterprise. On the other hand, the research also provides significant benefits to many practitioners, especially airport businesses. Thanks to this study, airports can make their own self-assessments on sustainable performance, and a "benchmarking tool" can be established between airports and innovation-based practices. The index obtained as a result of the sustainable performance evaluation study can be compared with the index values in the previous period, and the change occurring can be observed by the airport operators. Public organizations and private sector business executives who are stakeholders of airports will look at airport performance management practices through a sustainability window, and this will help them develop a prospective strategy by providing a self-assessment opportunity on which steps and which priorities can be implemented to achieve desired results in the sector. Another sectoral contribution of the research is the development of "Total Productivity Index" software, which has a simple interface in which the analyzes used in this study can be performed quickly. The developed software can be used not only for aviation organizations but also for the purpose of evaluating sustainable performance in operational units of other organizations.

The resulting performance index is a subjective value, as airport performance is evaluated within the framework of the objectives and weights set by the enterprise in the method. If the objectives, criteria, and weights determined in different airport businesses differ, it would be more appropriate to use performance index values in internal evaluations. However, as the current physical structure, financial structure, and/or management of the airport business change or develop, the criteria used in the performance assessment, their weight, or the objectives may change. Despite various subjective effects, index values, in general, are comparable values.

The integrated use of the data obtained in this study with different performance evaluation methods will also be useful for future studies. In addition, it is thought that the evaluation method by objectives will make significant contributions to airport businesses by giving an index value for a given period and ensuring that management sets out its performance objectives clearly.

ACKNOWLEDGMENTS AND FUNDING SOURCE DECLARATION

This study is derived from a scientific research project called "Developing Sustainable Performance Software and Scale for Airports in the Western Mediterranean Region" supported by Akdeniz University Scientific Research Projects (BAP).

REFERENCES

ACI 2018. Airport Carbon Accreditation Annual Report 2017-2018, Airports Council International. Available from Internet: https://www.airportcarbonaccreditation.org/library/annual-reports.html

Akal Z., 2005. İşletmelerde Performans Ölçüm ve Denetimi [Performance Measurement and Control in Enterprises]. Milli Prodüktivite Merkezi Yayınları 473: Ankara.

Aksakal E., Dağdeviren, M., 2010. "ANP ve DEMATEL Yöntemleri ile Personel Seçimi Problemine Bütünleşik Bir Yaklaşım [An integrated approach for personnel selection with DEMATEL and ANP methods]", Gazi Üniv. Müh. Mim. Fak. Dergisi, 25(4), 905-913. Available from Internet: https://dergipark.org.tr/en/pub/gazimmfd/issue/6686/88614

Andersson Granberg T., Munoz A.O., 2013. Developing key performance indicators for airports. In 3rd ENRI International Workshop on ATM/CNS, February 19, Singapore. Available from Internet: http://liu.diva-portal.org/smash/get/diva2:618079/FULLTEXT01.pdf

Balkan D., 2011. Enterprise productivity measurement in services by OMAX (Objective Matrix) method and an application with Turkish emergency service. In Reser Conference, Productivity of Services Next Gen–Beyond Output/Input. Hamburg, 1-13.

Baltazar M.E., Rosa T., Silva J., 2018. Global decision support for airport performance and efficiency assessment. Journal of Air Transport Management, 71, 220-242. http://doi.org/10.1016/j.jairtraman.2018.04.009

Baxter G., Srisaeng P., Wild G., 2018. An Assessment of Airport Sustainability, Part 1—Waste Management at Copenhagen Airport. Resources, 7(1), 21. http://doi.org/10.3390/resources7020032

Bezerra G.C., Gomes C.F., 2018. Performance measurement practices in airports: Multidimensionality and utilization patterns. Journal of Air Transport Management, 70(C), 113-125. http://doi.org/10.1016/j.jairtraman.2018.05.006

Bezerra G.C.L., Gomes C.F., 2016. “Performance measurement in airport settings: a systematic literature review”, Benchmarking: An International Journal, 23(4), 1027-50. http://doi.org/10.1108/BIJ-10-2015-0099

Boons F., Van Buuren A., Teisman G., 2010, November. Governance of sustainability at airports: Moving beyond the debate between growth and noise. In Natural resources forum, 34, 4, 303-313. Oxford, UK: Blackwell Publishing Ltd. http://doi.org/10.1111/j.1477-8947.2010.01314.x.

Bourne M., Bourne P., 2011. Handbook of Corporate Performance Management. Chichester, UK: Wiley.

Brisbane Airport Corporation, 2020. Brisbane Airport 2020 Master Plan, Available from Internet: https://www.bne.com.au/corporate/projects/airport-master-plan

Chao C.C., Lirn T.C., Lin H.C., 2017. Indicators and evaluation model for analyzing environmental protection performance of airports. Journal of Air Transport Management, 63, 61-70. http://doi.org/10.1016/j.jairtraman.2017.05.007

Chourasia A.S., Jha K., Dalei N.N., 2020. Development and planning of sustainable airports. Journal of Public Affairs, e2145. http://doi.org/10.1002/pa.2145

Dervitsiotis K., 1995. The objectives matrix as a facilitating framework for quality assessment and improvement in education. Total Quality Management & Business Excellence, 6: 5, 563-570. http://doi.org/10.1080/09544129550035215

ECMA., 2001. C# language specification. Standard-ecma334

Eshtaiwi M., Badi I., Abdulshahed A., Erkan T.E., 2018. Determination of key performance indicators for measuring airport success: A case study in Libya. Journal of Air Transport Management, 68, 28-34. http://doi.org/10.1016/j.jairtraman.2017.12.004

Frankis G., Humphreys I., Fry J., 2002. The benchmarking of airport performance. Journal of Air Transport Management, 8, 239-247. http://doi.org/10.1016/S0969-6997(02)00003-0

Güngören M., 2016. Havaalanlarında Performans ve Kalite Yönetimi [Performance in Airports and Quality Management], in F. Kuyucak Şengür (Ed.), Havaalanı Yönetimi, Anadolu Üniversitesi Yayınları, Eskişehir, Türkiye, 142-167.

Jääskeläinen A., 2009. Identifying a Suitable Approach for Measuring and Managing Public Service Productivity. Electronic Journal of Knowledge Management, 7(4): 447-458. Available from Internet: http://www.ejkm.com/issue/download.html?idArticle=196

Janic M., 2010. Developing an indicator system for monitoring, analyzing, and assessing airport sustainability. European Journal of Transport and Infrastructure Research, 10(3). http://doi.org/10.18757/ejtir.2010.10.3.2889

Koç S., Durmaz V., 2015. Airport corporate sustainability: An analysis of indicators reported in the sustainability practices. Procedia-Social and Behavioral Sciences, 181, 158-170. http://doi.org/10.1016/j.sbspro.2015.04.877

Kucuyak F., 2001. Havaalanlarında performans analizi için bir model önerisi ve Türkiye'deki havalimanlarında uygulanması [A Proposal for a performance analysis model in airports and application to airports in Turkey], Yüksek Lisans Tezi Anadolu Üniversitesi Sosyal Bilimler Enstitüsü, Eskişehir. Available at: https://tez.yok.gov.tr/UlusalTezMerkezi/ (Thesis No: 101570).

Kumar A., Aswin A., Gupta H., 2020. Evaluating green performance of the airports using hybrid BWM and VIKOR methodology. Tourism Management, 76, 103941. http://doi.org/10.1016/j.tourman.2019.06.016.

Lu M.T., Hsu C.C., Liou J.J., Lo H.W., 2018. A hybrid MCDM and sustainability-balanced scorecard model to establish sustainable performance evaluation for international airports. Journal of Air Transport Management, 71, 9-19. http://doi.org/10.1016/j.jairtraman.2018.05.008.

Olfat L., Amiri M., Soufi J.B., Pishdar M., 2016. A dynamic network efficiency measurement of airports performance considering sustainable development concept: A fuzzy dynamic network-DEA approach. Journal of Air Transport Management, 57, 272-290. http://doi.org/10.1016/j.jairtraman.2016.08.007

Rodoplu Şahin D., Haitmurodov U., Turan P., 2019. Industry 4.0; Opportunities, Challenges of Airport And Airline Management Practices. The European Proceedings of Social & Behavioural Sciences EpSBS, 568–577. http://doi.org/10.15405/epsbs.2019.01.02.48

Sameh M.M., Scavuzzi J., 2016. Environmental Sustainability Measures for Airports. Occasional Paper Series: Sustainable International Civil Aviation, 7. Available from Internet: https://mcgill.ca/iasl/files/iasl/vii_sustainability_and_environmental_protection_measures_for_airports_final.pdf

Sameh M., Scavuzzi dos Santos J., 2018. "Environmental Sustainability Measures for Airports" in A. De Mestral, P. Fitzgerald, & M. Ahmad (Eds.), Sustainable Development, International Aviation, and Treaty Implementation (Treaty Implementation for Sustainable Development). Cambridge: Cambridge University Press. 62-80. http://doi.org/10.1017/9781316594216.005

Tsai W.H., Chou W.C., 2009. Selecting management systems for sustainable development in SMEs:A novel hybrid model based on DEMATEL, ANP, and ZOGP, Expert Systems with Applications, 36: 1444–1458. http://doi.org/10.1016/j.eswa.2007.11.058

Tzeng, G.H., Chiang, C.H., Li, C.W., 2007. Evaluating intertwined effects in e-learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL. Expert systems with Applications, 32(4), 1028-1044. http://doi.org/10.1016/j.eswa.2006.02.004

Upham P., 2001. A comparison of sustainability theory with UK and European airports policy and practice. Journal of environmental management, 63(3), 237-248. http://doi.org/10.1006/jema.2001.0469

Vreedenburg M., 1999, December 13. International Civil Aviation Organization Airport Privatization Seminar for the N.A.M./C.A.R./S.A.M. Regions. I.C.A.O. Available from Internet: https://www.icao.int/Meetings/AMC/MA/1999/aps/05_pp_vreedenburgh_e.pdf

Wan L., Peng Q., Wang J., Tian Y., Xu C., 2020. Evaluation of Airport Sustainability by the Synthetic Evaluation Method: A

Case Study of Guangzhou Baiyun International Airport, China, from 2008 to 2017. Sustainability, 12(8), 3334. http://doi.org/10.3390/su12083334.

Wu W.W., 2008. Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. Expert Systems with Applications, 35(3), 828-835. http://doi.org/10.1016/j.eswa.2007.07.025

Yuan X.M., Low J.M., Tang L.C., 2010. Roles of the airport and logistics services on the economic outcomes of an air cargo supply chain. International journal of production economics, 127(2), 215-225. http://doi.org/10.1016/j.ijpe.2009.08.005

Zaim S., 2002. “Hedeflerle Yönetim, Balanced Scorecard ve Stratejik Kalite Yönetimi [Management by Goals, Balanced Scorecard and Strategic Quality Management]” Akademik Araştırmalar Dergisi, C: III, 12.

ROZWÓJ APLIKACJI SŁUŻĄCYCH DO ANALIZY ZRÓWNOWAŻONEJ DZIAŁALNOŚCI LOTNISKA

STRESZCZENIE. **Wstęp:** We współczesnej, szybko się zmieniającej globalnej gospodarce, lotniska odgrywają ważną rolę w socjalnym, kulturalnym i ekonomicznym rozwoju społeczności oraz w budowaniu nowych mostów pomiędzy różnymi rynkami. Rozwój zrównoważony oznacza zachowanie balansu pomiędzy ekonomicznymi, społecznymi i środowiskowymi procesami oraz postępem we wszystkich tych trzech wymiarach na optymalnym poziomie. Dlatego też pomiar jak i zarządzanie zrównoważonej działalności odgrywa istotną funkcję w kontroli lotnisk. Zachowanie zasada zrównoważonego rozwoju w inwestycjach lotniskowych, będących odpowiedzią na zwiększający się popyt na ich usługi może być realizowany efektywnie w ramach zracjonalizowanej struktury. Struktura ta powinna odpowiadać zasadom rozwoju zrównoważonego, który to będzie odgrywał coraz istotniejszą rolę i zwiększał swoje znaczenie. Celem pracy jest opracowanie oprogramowania oceny rozwoju zrównoważonego lotnisk poprzez analizę działalności zrównoważonej obejmującą wiele zmiennych.
Metody: Do przeprowadzenia analizy działalności zrównoważonej lotniska, istotne jest uwzględnienie ekonomicznych, społecznych oraz środowiskowych czynników, które są trzema podwymiarami rozwoju zrównoważonego we wszystkich strategicznych, taktycznych i operacyjnych procesach i mechanizmach decyzyjnych. W celu przeprowadzenia analizy, zastosowano metody DEMATEL oraz OMAX (Objectives Matrix), umożliwiające uwzględnienie tych wszystkich czynników równocześnie, poprzez zastosowanie wskaźników wagowych.
Wyniki: Najważniejszym czynnikiem dla lotniska Antalya, jak również o największym znaczeniu, jest czynnik ekonomiczny. Współczynniki działalności zrównoważonych dla lotniska Antalya zostały obliczone dla lat 2018 oraz 2019. Działalność lotniska w 2019 była większa aniżeli w 2018.
Wnioski: Największym osiągnięciem tej pracy jest opracowanie “aplikacji oceny działalności zrównoważonej” dla zarówno krajowych jak i międzynarodowych lotnisk. Praca ta przyczynia się również do pogłębienia prac badawczych nad działalnością innych lotnisk oraz porównania ich działania z poprzednimi ich osiągnięciami.

Słowa kluczowe: porty lotnicze, działalność lotniska, rozwój zrównoważony, analizy działalności, aplikacja oceny rozwoju zrównoważonego

Fahriye Merdivenci ORCID ID: https://orcid.org/0000-0001-8956-7051
Department of International Trade and Logistics
Faculty of Applied Sciences, Akdeniz University
Dumlupınar Bulvarı, Akdeniz Üniversitesi Kampusü, 07070, Konyaalti, Antalya, **Turkey**
e-mail: fahriye@akdeniz.edu.tr

Ramazan Erturgut ORCID ID: https://orcid.org/0000-0002-0240-5787
Department of International Trade and Logistics
Faculty of Applied Sciences, Akdeniz University
Dumlupinar Bulvari, Akdeniz Universitesi Kampusu, 07070, Konyaalti, Antalya, **Turkey**
e-mail: rerturgut@akdeniz.edu.tr

Artuğ Eren Coşkun ORCID ID: https://orcid.org/0000-0002-9285-6062
Department of International Trade and Logistics
Faculty of Applied Sciences, Akdeniz Universitesi
Dumlupinar Bulvari, Akdeniz Üniversitesi Kampusu, 07070, Konyaalti, Antalya, **Turkey**
e-mail: erencoskun@akdeniz.edu.tr