

PERFORMANCE EVALUATION OF TRADITIONAL AND LCC AIRLINES UNDER THE IMPACT OF COVID-19 PANDEMIC: A CASE STUDY ON THE EUROPEAN AIRLINE MARKET

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Abstract

The objective of this study is to investigate the effects of the Covid-19 pandemic on the multidimensional performance of companies operating in the European airline transport sector. In Addition is to compare multidimensional performance of Traditional and LCC (Low Cost Carrier) airlines in the European airline transport sector across the pre-pandemic, pandemic and post-pandemic periods. In this context, the multidimensional performance of 11 airlines (6 Traditional and 5 LCC) operating in Europe for the period 2019–2022 is analysed using the LOPCOW-based AROMAN method. In the initial stage of the analysis, the variables pertaining to the airlines were weighted using the LOPCOW method. The results of the analysis, conducted using the LOPCOW method, indicated that the Total Debt and Greenhouse Gas Emission (GHG) variables were of critical importance in determining the performance of the airlines in question. In the second stage of the study, the performance ranking of the airlines in question was carried out using the AROMAN method. The results of the ranking, as determined by the AROMAN method, indicate that the large-scale traditional airlines (Lufthansa, Air France-KLM, Turkish Airlines, and IAG) have demonstrated superior performance compared to the LCC airlines during the period spanning 2019 to 2022.

Implications for Central European audience: It is anticipated that the findings of the study will significantly contribute to the field of performance management in the European airline industry. Furthermore, they will provide airline managers and other stakeholders in the European air transport sector with insights that can be used to enhance the performance of airlines during crises, such as the recent pandemic caused by Covid-19.

Keywords: European airline transport sector; Covid-19 pandemic, Lopcow Method; Aroman Method

JEL Classification: L93, M21

Introduction

The Covid-19 pandemic has affected all sectors, all industries and all people's lives in an unprecedented way. The imposition of travel restrictions, the implementation of quarantines and the observed shift in passenger behaviour have collectively exerted a significant influence on the operations of airlines (Albers & Rundshagen, 2020). In 2020, global passenger numbers fell by around 60% compared to the previous year. In particular, passenger numbers in Europe and the Middle East fell by 67.4% and 67.6% respectively (IATA, 2021). Following the gradual lifting of lockdowns and associated restrictions in 2021, the air transport sector experienced a partial recovery. In the following year, 2022, the recovery rate continued to increase. However, the figures demonstrate that the air transport sector is still below the level recorded in 2019. The total amount of losses incurred in the air transport sector was \$324 million in 2021 and \$175 million in 2022, in comparison to the figures recorded in 2019. Similarly, the number of passengers worldwide exhibited a 49% decline in 2021 and a 29% decline in 2022 in comparison to 2019 (ICAO, 2023).

The abrupt reduction in passenger demand resulting from the global spread of the Covid-19 pandemic led to a deceleration in the operational activities of airlines and a concomitant decline in revenue. This situation elevated the probability of financial failure for airlines. In order to overcome the detrimental effects of the pandemic, airlines have employed a variety of strategies (Albers & Rundshagen, 2020). The initial strategy deployed by airlines in response to the pandemic was to enhance security measures. This entailed the mandatory use of masks on board, the removal of middle seats, and improvements to aircraft cleaning and cabin ventilation systems (Milne et al., 2023). The second strategy is that of cost reduction. Examples of this strategy include the retirement of old aircraft in the fleet, the grounding of aircraft, the postponement of aircraft orders, the placement of employees on unpaid leave, or the termination of their employment (Scheiwiller & Zizka, 2021; Su et al., 2023). The third strategy is to enhance the sustainability of cash flows. This may be achieved by reducing ticket prices, converting passenger aircraft into cargo aircraft, requesting subsidies from governments, and repositioning aircraft from business-oriented routes to leisure-oriented routes (Adrienne et al., 2020; Dube et al., 2021).

In recent years, studies on airlines have examined environmental performance as well as operational and financial performance (Dorta et al., 2024; Tanrıverdi et al., 2023; Wu, et al., 2024; Ali et al., 2023). It is hypothesised that this situation is a consequence of the measures implemented in recent years to mitigate the environmental impact of the air transport sector. In 2022, carbon emissions from the air transport sector constituted 2% of the total global emissions (IEA, 2023). Consequently, airlines now undertake their activities with consideration of environmental performance in addition to financial and operational performance.

The European air transport market, which accounts for a considerable proportion of global flight traffic, has been profoundly impacted by the global pandemic caused by the Covid-19 pandemic. The decline in passenger demand has resulted in a reduction in the number of daily flights and load factor. The number of daily flights and load factor of the leading European airlines (Easyjet, Lufthansa, Turkish Airlines) have decreased by approximately 60% (Rodrigues et al., 2021). Furthermore, the international travel restrictions imposed during the pandemic led airlines to focus on local networks. The concentration of traditional and low-cost carrier (LCC) airlines on local networks resulted in heightened competition.

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During this period, while traditional airlines received financial support from the relevant authorities, LCC airlines were not provided with this support. Nevertheless, some LCC airlines (Easyjet, Ryanair, Wizz Air) have expanded their flight networks by pursuing different strategies (Zhang et al., 2023). In this context, the question of how traditional and LCC airlines in Europe have been affected by the Covid-19 pandemic has recently been of great interest to both researchers and practitioners. Previous studies have identified discrepancies in the strategies employed by LCC and traditional airlines during the pandemic period, with the LCC airlines exhibiting superior performance (Kaffash & Khezrimotlagh, 2023). However, other studies have yielded contrasting findings (Asker, 2024). Consequently, an investigation into the comparative performance of LCC and traditional airlines is a compelling avenue for further research. In this respect, the aim of this study is to investigate the multidimensional performance of traditional and LCC airlines in European airline transport sector before, during and after the pandemic.

It is anticipated that this study will make significant contributions to the existing literature examining the impact of the Covid-19 pandemic on the aviation industry. The following list outlines the key areas of contribution:

1. This study provides information about the performance of traditional and LCC airlines in Europe in the pre-pandemic period (2019), pandemic period (2020), new normal period (2021) and post-pandemic period (2022).
2. This study compares the multidimensional performance of airlines operating in Europe and utilising disparate business models.
3. In accordance with the model proposed in this study, performance criteria that are critical for the airlines in question have been identified.
4. This study provides an opportunity to evaluate whether the airlines are affected by the Covid-19 pandemic according to the performance criteria used.

The rationale for employing the LOPCOW approach in this investigation can be elucidated as follows: (a) the negative values inherent to the data set can be incorporated into the analysis without any requisite transformation, (b) it has a markedly brief computation time and a robust computational capability, (c) it has an algorithm that permits the discrepancy attributable to data size to be negated, (d) It does not necessitate the utilisation of any software programmes during its operational phase, (e) it is an objective weighting method with a straightforward mathematical structure, (f) it facilitates the assessment of objective data (Ecer & Pamucar, 2022). The rationale behind the utilisation of the AROMAN method can be elucidated as follows: (a) it provides a practical and simple alternative ranking approach by avoiding complex calculations, (b) it enables the ranking process to produce more robust results by applying two types of normalisation processes, (c) it enables the differentiation of cost-oriented and benefit-oriented criteria in the data set, (d) it allows both qualitative and quantitative evaluation of decision alternatives (Bošković et al., 2023a).

The remainder of the paper is structured as follows. Section 2 presents a review of the literature on airline performance, with a particular focus on methods related to multi-criteria decision-making (MCDM). Section 3 provides detailed information about the methodology

and the dataset used in the study. Section 4 presents the results of the applied model. Section 5 discusses the findings obtained. In the final section, the results of the study are evaluated, and suggestions for future studies are presented.

1 Literature

A review of the literature reveals that a variety of analytical techniques are employed to assess the performance of airlines. These include Data Envelopment Analysis (DEA) (Arjomandi & Seufert, 2014; Choi et al., 2015; Gramani, 2012), Malmquist Total Factor Productivity Index (MTFP) (Asker, 2022; Asker & Ustaomer, 2022; Dorta et al., 2024), and Stochastic Frontier Analysis (SFA) (Aydin & Kaya, 2021). However, recently, Multi-Criteria Decision-Making (MCDM) methods have also been employed for the evaluation of airline performance. For example, Dinçer et al. (2017) evaluated the performance of European based airlines with Fuzzy DEMATEL, ANP and MOORA methods using the Balance Score Card perspective. The findings of the research indicated that companies with a high number of flights and passengers exhibited optimal performance. Ömürbek and Balcı (2017) employed the ENTROPY-based COPRAS method to evaluate the performance of airlines operating in European Union countries. The study revealed that airlines operating in the United Kingdom, France, Germany, Belgium and Turkey exhibited optimal performance (Pineda et al., 2018). In order to enhance the operational and financial performance of airlines and to ascertain the pivotal criteria for performance, they examined the performance of 12 airlines for the period 2005–2014 with DANP and VIKOR methods. Perçin and Aldalou (2018) evaluated the financial performance of airlines operating in Turkey for the period 2012–2016 with the fuzzy AHP and fuzzy TOPSIS methods. The analysis revealed that Pegasus exhibited optimal financial performance. Avcı and Çınaroğlu (2018) examined the financial performance of 5 airlines operating in Europe for the period 2012–2016 using AHP based TOPSIS method. The findings of the research indicated that Lufthansa exhibited the poorest performance, whereas Ryanair demonstrated optimal financial performance (Kıracı & Bakır, 2019). To investigate the influence of the global and financial economic crisis of 2008 on the aviation industry, they assessed the operational performance of 13 airlines over the period 2005-2012 using the CRITIC and EDAS methods. The analysis revealed a decline in the performance of these airlines during the global and financial crisis period (2008) and in the subsequent period (2009–2012). Macit and Göçer (2020) evaluated the financial performance of Turkey-based airlines operating in 2018 using the Gray Relational Analysis (GIA) method. The research findings indicate that Pegasus exhibits optimal financial performance. Kıracı and Bakır (2020) evaluated the operational and financial performance of airlines that are members of the Star Alliance for the period 2015–2017 with the CRITIC-Based CODAS method. The analysis revealed that Singapore Airlines exhibited optimal performance. Furthermore, it was determined that financial variables exert a more pronounced influence on total performance. Bakır et al. (2020) examined the operational performance of 11 airlines operating in developing countries using the PIPRECIA-based MAIRCA method. The analysis revealed that Air China exhibited optimal performance during the specified period. Additionally, operational expenses were identified as the variable with the greatest impact on performance.

A number of studies in the literature have employed the MCDM method to examine the impact of the pandemic on the performance of airlines. These studies have typically focused on the financial, environmental and operational performance dimensions of airlines. For example;

Kiracı and Asker (2021) investigated the influence of the Covid-19 pandemic on USA airlines employing CRITIC, EDAS and trend analysis techniques. The analysis yielded the conclusion that the Covid-19 pandemic had a detrimental impact on the performance of airlines. Keleş (2022) evaluated the performance of Turkish Airlines for the period between 2016 and 2020 using a CRITIC-based MABAC method. The findings of the research indicate that Turkish Airlines exhibited its best performance in 2019 and its worst performance in 2016 (Tanrıverdi & Eryaşar, 2022). The performance of 35 airlines that are members of three major airline co-operations (Star Alliance, SkyTeam, Oneworld) for the period 2017–2020 was examined with the CRITIC-based CoCoSo method. The research findings revealed that the SkyTeam group demonstrated optimal performance during the period of the pandemic, while the Oneworld group exhibited optimal performance prior to the pandemic. Asker (2023) conducted an evaluation of the financial performance of 10 LCC airlines during the period of the global pandemic caused by the Covid-19 pandemic, from the fourth quarter of 2019 to the fourth quarter of 2021. This evaluation was conducted using the CRITIC-based ARAS method. The findings of the research indicated that small-scale LCC airlines demonstrated superior performance compared to their medium and large-scale counterparts during the pandemic period. Sarıgül et al. (2023) investigated the financial performance of six airlines operating in Europe before and during the pandemic, employing the CRITIC-based MARCOS and MAUT methods. The analysis yielded the following findings: Pegasus and Easyjet exhibited optimal financial performance according to the MARCOS method, while Air France demonstrated optimal financial performance according to the MAUT method. Tanrıverdi et al. (2023) examined the environmental, operational and financial performance of 56 airlines operating in different regions of the world before and during the pandemic with MEREC, CoCoSo and BORDA methods. The results demonstrated that small-scale traditional airlines and LCC airlines operating in domestic networks exhibited optimal performance. Asker (2024) conducted an analysis of the financial performance of 46 airlines over the period 2018–2021, employing the MEREC-based COBRA method. The findings of this analysis indicated that LCC airlines demonstrated superior performance compared to traditional airlines prior to the advent of the Covid-19 pandemic. Conversely, traditional airlines exhibited enhanced performance during the pandemic.

A review of the literature on the impact of the Covid-19 pandemic on the air transport sector reveals a focus on the effects of the pandemic on airlines (Andreana et al., 2021; Atems & Yimga, 2021). Other studies have concentrated on the strategies employed by airlines in response to the pandemic (Albers & Rundshagen, 2020; Jaroenjitrkam et al., 2023). Some studies have investigated the impact of the pandemic on airlines' business models (Asker, 2024; Kaffash & Khezrimotlagh, 2023; Perez et al., 2022). However, it has been observed that these studies only cover the pre-pandemic and pandemic periods. Accordingly, this study, which examines the performance of airlines in Europe before and after the pandemic, is thought to fill this gap in the literature.

2 Data and Methodology

This study employs the LOPCOW and AROMAN methods to analyse the multidimensional performance of 11 airlines operating in Europe from 2019 to 2022. The rationale for selecting this temporal scope is that Covid-19 pandemic originated in the latter half of 2019, had

a significant impact on the majority of the world's population in 2020, began to subside gradually in 2021, and its residual effects diminished considerably in 2022. To assess the influence of the pandemic on Traditional and LCC airlines operating within the European region, data pertaining to the 2019–2022 period were incorporated into the analytical framework.

In order to conduct an effective analysis and comparison of the responses of numerous airlines to an external situation, it is essential that the context and characteristics of the situation are consistent for all parties involved (Sartal et al., 2017). The impact of the Covid-19 pandemic on the air transport sector has been observed to vary across regions. For instance, the quarantine practices and support plans implemented by countries have exhibited notable differences between regions and countries. Consequently, the decision was taken to analyse airlines in Europe, which accounts for a substantial proportion of global flight traffic. Five of these airlines are LCC airlines (Easyjet, Norwegian Air Shuttle, Pegasus, Ryanair, Wizzair). LCC airlines offer tickets at a lower price than traditional airlines by reducing the service activities provided during the flight process (Malighetti et al., 2009).

The sample of this study consists of airlines that are included in the list of the world's 100 largest airline companies in 2022 according to RPK (Revenue Passenger Kilometre) by Airline Business magazine and whose data can be accessed (Airline Business, 2024). Airline Business magazine is a paid magazine published by Flight global organization. The operational variables employed in the research, namely ASK, Employees, Fleet Size, Load Factor, Number of Passengers and RPK, have been derived from the annual reports of the airlines in question for the period spanning 2019 to 2022. Environmental variables, namely greenhouse gas emissions, are sourced from the airlines' sustainability and ESG reports. Financial variables, including earnings before interest, taxes, depreciation and amortisation (EBITDA), net profit, operating expenses, operating income, total assets, total capital, total debt and total revenue, are obtained from the Bloomberg database and the airlines' annual reports.

The financial, operational and environmental performance criteria employed in the study are presented in Table 1.

Table 1 | Variables utilised in the study

Classification	Indicators	Code	References
Financial	EBITDA	C1	Serrano et al. (2018), Macdiarmind et al. (2018)
	Total Revenue	C2	Tanriverdi et al. (2023), Wang et al. (2017), Gramani (2012)
	Net Profit	C3	Tanriverdi et al. (2023), Pineda et al. (2018), Kiracı and Asker (2021)
	Operating Expense	C4	Losa et al. (2020), Yu et al. (2017), Wang et al. (2017)
	Operating Income	C5	Choi et al. (2015), Mallikarjun (2015), Jenatabadi and İsmail (2014)
	Total Asset	C6	Asker (2022), Losa et al. (2020)
	Total Capital	C7	Asker (2022), Cui and Li (2017a), Arjomandi and Seufert (2014)
	Total Dept	C8	Asker and Ustaömer (2022), Asker (2022), Wang et al. (2017)
Classification	Indicators	Code	References
Operational	Employees	C9	Yu and Thi Nguyen (2023), Cui and Li (2017a), Omrani and Soltanzadeh (2016)
	ASK (Available Seat Kilometer)	C10	Losa et al. (2020), Yu et al. (2017), Omrani and Soltanzadeh (2016)
	RPK (Revenue Passenger Kilometer)	C11	Wu et al. (2024), Yu and Thi Nguyen (2023), Yu et al. (2017)
	Number of Passenger	C12	Wu et al. (2024), Asker (2021), Kiracı and Bakır (2020)
	Fleet Size	C13	Asker (2021), Kiracı and Bakır (2020), Li et al. (2016)
Environmental	Load Factor	C14	Tanriverdi et al. (2023), Li et al. (2016), Min and Joo (2016)
	Green House Gas Emission (GHG)	C15	Wu et al. (2024), Cui and Li (2017b), Arjomandi and Seufert (2014)

Source: Author's own elaboration

As illustrated in Table 1, eight variables were selected for the evaluation of the financial performance of European airlines. The Earnings Before Interest, Taxes, Depreciation, and Amortisation (EBITDA) measure was chosen as it provides an indication of a company's earnings based on operations without the influence of interest, taxes, and depreciation. The EBITDA is regarded as one of the most effective variables for reflecting a company's financial performance, and is also one of the most closely monitored indicators by financial analysts

and stock market investors (Serrano et al., 2018). Total revenue can be defined as the total amount of revenue obtained by an airline over a specified period (Tanriverdi et al., 2023). Net profit can be defined as the earnings of an airline remaining after all expenses have been deducted from total revenue. Net profit represents the most crucial profitability indicator for a company (Pineda et al., 2018). Operating expenses are defined as the costs incurred by airlines for the maintenance of passenger and cargo transportation activities, including aircraft maintenance, salaries for personnel, and the purchase of aviation fuel (Wang et al., 2017). Operating income represents the revenue generated by airlines as a result of their operational activities. Operating income is considered a significant financial indicator due to its sensitivity to changes in airline operations (Mallikarjun, 2015). Total asset is used to describe the aggregate value of all tangible and intangible assets owned by airlines (Losa et al., 2020). Total capital refers to the total amount of capital owned by airlines (Arjomandi & Seufert, 2014). Total Debt refers to the sum of all financial liabilities of airlines, both short-term and long-term (Asker & Ustaömer, 2022).

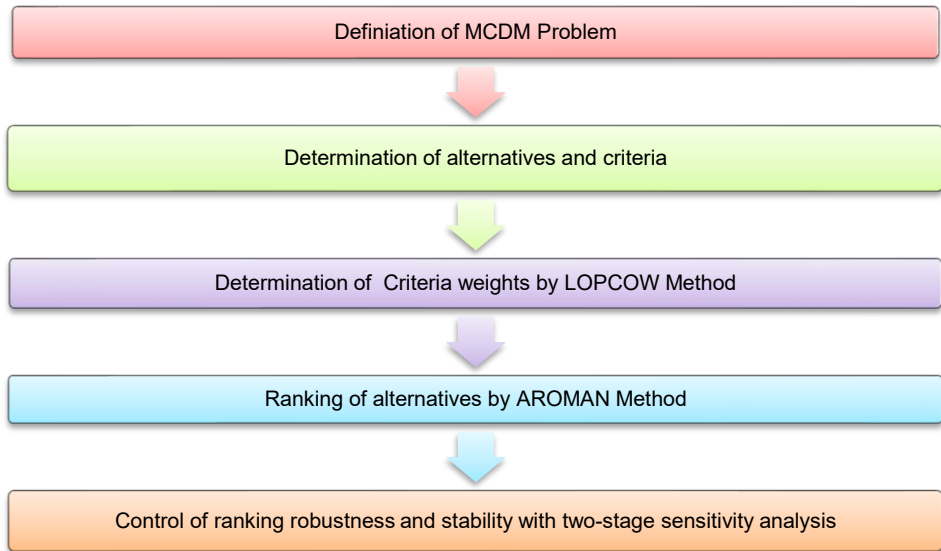
In the context of the study, six variables were identified for the purpose of evaluating operational performance. The Available Seat Kilometer (ASK) is calculated by multiplying the available seat capacity by the distance flown. Available seat kilometer (ASK) is one of the most frequently utilised criteria for the evaluation of operational performance in the aviation industry Yu et al. (2017); Losa et al. (2020); Asker (2021); Tanriverdi et al. (2023); Wu et al. (2024). ASK shows the current capacity of airlines (Omrani & Soltanzadeh, 2016). RPK (Revenue Passenger Kilometer) is calculated by multiplying the number of seats sold by the distance flown (Barros & Peypoch, 2009). RPK shows how effectively the airline is using its available capacity. In this regard, it has a direct impact on both operational and financial performance (Yu & Thi Nguyen, 2023). RPK is the primary factor influencing total revenue in the airline industry. However, it is not sufficient alone. Because total revenue in airline companies consists of the sum of RPK, RTK (Revenue Ton Kilometer) and other operational revenues (Wu et al., 2013). Number of passenger refers to the total number of passengers carried by airlines in a year (Kiracı & Bakır, 2020). Fleet size indicates the total number of aircraft owned and leased by airlines (Li et al., 2016). Load factor shows the utilisation rate of the seats in the aircraft owned by the airlines. In other words, it is an important criterion that shows how efficiently the aircraft are used (Min & Joo, 2016).

GHG (Green House Gas Emission), which is used to evaluate the performance of airlines in the environmental dimension, is expressed as scope 1 emissions and is related to fuel consumption and also direct emissions from flight operations. GHG is the most important indicator used to assess the environmental performance of all airlines (Wu, et al., 2024).

The variables presented in Table 1 have been selected on the basis of their frequent use in studies of airline performance measurement (Gramani, 2012; Arjomandi & Seufert, 2014; Jenatabadi & İsmail, 2014; Choi et al., 2015; Mallikarjun, 2015; Omrani & Soltanzadeh, 2016; Cui & Li, 2017a; Wang et al., 2017; Yu et al., 2017; Macdiarmind et al., 2018; Pineda et al., 2018; Serrano et al., 2018; Losa et al., 2020; Kiracı & Asker, 2021; Asker, 2022; Asker & Ustaömer, 2022; Tanriverdi et al., 2023; Yu & Thi Nguyen, 2023; Wu et al., 2024). Furthermore, a Spearman correlation was conducted to ascertain the direction and strength of the relationship between these variables. As illustrated in Appendix 1, the analysis revealed that there was no problematic correlation between the performance measurement criteria.

Figure 1 illustrates the application stages of the LOPCOW-AROMAN performance measurement model in a flow chart. Firstly, the issue of Multi-Criteria Decision Making (MCDM) was identified, and subsequently, the potential solutions and the financial, operational and environmental criteria associated with these solutions were established. Subsequently, the pertinent criteria were assigned weights in accordance with the LOPCOW methodology. In the subsequent phase, the performance of the airlines (alternatives) was evaluated utilising the AROMAN approach. Finally, a two-stage sensitivity analysis was conducted to enhance the validity and reliability of the proposed LOPCOW-AROMAN model.

Figure 1 | Flowchart of the implementation model



Source: Author's own elaboration

2.1 LOPCOW Method

The LOPCOW (Logarithmic Percentage Change-driven Objective Weighting) method, which obviates the necessity for subjective opinions in the calculation of criterion weights, was developed by Ecer and Pamucar (2022). The LOPCOW method allows for the evaluation of alternatives with negatively valued criteria (Görçün et al., 2024). The method differs from other objective weighting methods (ENTROPY, MEREC, CILOS) in this respect. The LOPCOW method was developed to address the significant variations that arise in the performance measurement of alternatives due to the inclusion of large-sized decision matrices, criterion types and negatively valued criteria (Keleş, 2023). The most significant attribute of the LOPCOW method is its expression as a percentage of the standard deviation of the mean squares of the series, which serves to eliminate the discrepancy arising from data size (Bektaş, 2022).

The LOPCOW method was developed in 2022 (Ecer & Pamucar, 2022). In this regard, the LOPCOW method represents a relatively novel approach to objective weighting. Despite its

recent inception, the LOPCOW method has already been employed in numerous studies. For example; Ecer and Pamucar (2022) employed the LOPCOW-based DOBI method to assess the sustainable performance of Turkish banks. Bektaş (2022) evaluated the financial performance of insurance companies in Turkey with LOPCOW, MEREC, EDAS and COCOSO methods. Biswas et al. (2022) examined the impact of the Covid-19 pandemic on emerging markets with the LOPCOW -EDAS method. Gülcemal and İzci (2023) examined the financial performance of participation banks in Turkey using LOPCOW based MOOSRA method. Ulutaş et al. (2024) evaluated the performance of third party logistics service providers in the automotive sector in Turkey using LOPCOW-PSI based MACONT method. Ecer et al. (2025) evaluated the performance of sustainable fuel suppliers for airlines with LOPCOW and MARCOS methods.

The application steps of the LOPCOW method are outlined below (Ecer & Pamucar, 2022):

Step 1: To solve the decision problem, an initial decision matrix (IDM) consisting of 'm' alternatives and 'n' criteria is constructed. This is shown in Equation (1).

$$IDM = \begin{bmatrix} y_{11} & y_{12} & \dots & y_{1n} \\ y_{21} & y_{22} & \dots & y_{2n} \\ \dots & \dots & \dots & \dots \\ y_{m1} & y_{m2} & \dots & y_{mn} \end{bmatrix} \quad (1)$$

Step 2: The variables in the Initial Decision Matrix (IDM) are normalised using the Linear Normalisation technique. Equation (2) is used for cost type criteria and equation (3) is used for benefit type criteria.

$$r_{ij} = \frac{x_{max} - x_{ij}}{x_{max} - x_{min}} \quad \text{if } j \in C \quad (2)$$

$$r_{ij} = \frac{x_{ij} - x_{min}}{x_{max} - x_{min}} \quad \text{if } j \in B \quad (3)$$

Step 3: The percentage value (PV) for each criterion is calculated by means of equation (4).

$$PV_{ij} = \left| \ln \left\{ \frac{\sqrt{\frac{\sum_{i=1}^m x_{ij}^2}{m}}}{\sigma} \right\} * 100 \right| \quad (4)$$

In the formula, the value σ represents the standard deviation, while m denotes the number of alternatives.

Step 4: In the last stage, the objective weight value " W_j " for each criterion is calculated with the help of Equation (5).

$$W_j = \frac{PV_{ij}}{\sum_{i=1}^n PV_{ij}} \quad (5)$$

2.2 AROMAN Method

The AROMAN (Alternative Ranking Order Method Accounting for Two-Step Normalization) method was first presented in the literature by Bošković et al. (2023a) as a means of addressing MCDM problems. The principal objective of the AROMAN method is to provide

an approach that examines MCDM problems with greater precision by employing vector and linear normalisation techniques in conjunction (Cubranic-Dobrodolac et al., 2023). The method combines the values resulting from the two-stage normalisation process through the parameter β (Nikolić et al., 2023). The AROMAN method offers a powerful and practical approach to ranking alternatives, avoiding the need for complex computational procedures (Kara et al., 2024a).

The AROMAN method was developed in 2023 (Bošković et al. 2023a). In this regard, the AROMAN method represents a relatively novel alternative ranking method. Nevertheless, despite its relative novelty, the AROMAN method has been employed in a considerable number of studies. To illustrate, the AROMAN method was employed by Bošković et al. (2023b) in the context of the selection process for a cargo bike delivery concept. Yalçın et al. (2023) employed the AROMAN method to evaluate the performance of numerous European ports in terms of Ecoport. Bakır and İnce (2024) utilised the Lopcow-based AROMAN method to examine the performance of member airlines within the Star Alliance airline cooperation in terms of passenger satisfaction. Kara et al. (2024a) employed the Merce-based AROMAN method to assess the sustainable competitiveness of Turkey in comparison to its neighbouring countries. Pala (2024) employed the SIGI (Social Institutions and Gender Index) index with the AROMAN method to examine the extent of gender discrimination in OECD countries. Kara et al. (2024b) employed the SF-DIBR II-AROMAN hybrid model to assess the sustainable performance of wind power plants in Çanakkale. Kahreman (2024) utilised the LOPCOW-based AROMAN method to evaluate the sustainable development performance of European Union countries in the aftermath of the 2008 crisis.

The implementation steps of the AROMAN method are outlined below (Bošković et al., 2023a; Bošković et al., 2023b).

Step 1: The initial decision matrix (IDM) is organised in accordance with the specified alternatives and criteria, as expressed in Equation (1), in the first step of the method.

Step 2: In the second step of the method, the decision matrix is subjected to linear normalisation by Equation (6) and vector normalisation by Equation (7), respectively.

$$T_{ij} = \frac{X_{ij} - X_{min}}{X_{max} - X_{min}}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (6)$$

$$T_{ij}^* = \frac{X_{ij}}{\sqrt{\sum_{i=1}^m X_{ij}^2}}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (7)$$

Step 3: The matrices resulting from linear and vector normalisation are combined with the help of Equation (8) in this step.

$$T_{ij}^{norm} = \frac{\beta * T_{ij} + (1 - \beta) * T_{ij}^*}{2}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (8)$$

The term T_{ij}^{norm} in the formula represents the normalised and combined normalised matrix. The variable β , on the other hand, expresses a weighting value that ranges between 0 and 1 (Bošković et al., 2023a). proposed a value of 0.5 for the β variable.

Step 4: The normalised matrix T_{ij}^{norm} obtained in the previous step is multiplied by the weight values (W_j) of the criteria obtained by the LOPCOW method, as illustrated in Equation (9).

$$T^{\wedge}_{ij} = W_{ij} \times T_{ij}^{norm}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (9)$$

Step 5: In this step, the weighted normalised values for the cost type criteria are summed using Equation (10), while the weighted normalised values for the benefit type criteria are summed using Equation (11).

$$A_i = \sum_{j=1}^n T^{\wedge}_{ij}{}^{max}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (10)$$

$$L_i = \sum_{j=1}^n T^{\wedge}_{ij}{}^{min}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (11)$$

Step 6: The power λ of the A_i and L_i values calculated in this step is calculated using the formulas provided in Equations (12) and (13), respectively.

$$A^{\wedge}_i = A^{1-\tau}_i = \left\{ \sum_{j=1}^n T^{\wedge}_{ij}{}^{max} \right\}^{1-\tau}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (12)$$

$$L^{\wedge}_i = L^{\tau}_i = \left\{ \sum_{j=1}^n T^{\wedge}_{ij}{}^{min} \right\}^{\tau}, \quad j = 1, 2, \dots, n; i = 1, 2, \dots, m. \quad (13)$$

The λ value in the formula represents the coefficient degree of the criterion type. In order to calculate the degree of benefit of the alternatives, it is necessary to ensure that the value of λ is within the range of $0 < \lambda < 1$.

Step 7: In the last stage of the method, the R_i value is obtained by calculating the difference between the A_i and L_i values with the help of Equation (14). The alternative with the highest R_i value is accepted the optimal alternative.

$$R_i = e^{(A^{\wedge}_i - L^{\wedge}_i)}, \quad i = 1, 2, \dots, m. \quad (14)$$

3 Results

In this part of the study, the performance of 5 LCCs (Easyjet, Norwegian Air Shuttle, Pegasus, Ryanair, Wizzair) and 6 traditional airlines (Aegean Airlines, Air France-KLM, Finnair, IAG, Lufthansa, Turkish Airlines) operating in the European airline market for the period 2019-2022 is analysed by focusing on 8 financial, 6 operational and 1 environmental variables using the LOPCOW-based AROMAN method. Subsequently, a sensitivity analysis is employed to ascertain whether a modification in the weighting of the criteria would result in a change in the ranking outcomes. Finally, in order to enhance the reliability of the results obtained through the application of the aforementioned model, the ranking results obtained are compared with other MCDM methods (COCOSO, CRADIS, MARCOS).

3.1 LOPCOW Results

In this section, the weights of the variables (criteria) in the initial decision matrix of airlines (alternatives) are determined using the LOPCOW method. The initial decision matrix (IDM) comprises the values of the alternatives and criteria. In this study, an 11×15 decision matrix was constructed for each year of the 2019–2022 period. Table 2 demonstrates the fluctuations of the variables (criteria) both in terms of time and in relation to themselves. It can be observed that the variable with the lowest weight in terms of airline performance is operating income in 2019 and 2022, while in 2020 and 2021, it is total revenue. Conversely, the variable with the highest weight is total dept in 2019, 2020, and 2022, and Greenhouse Gas Emission (GHG) in 2021.

Table 2 | LOPCOW method performance criteria weight

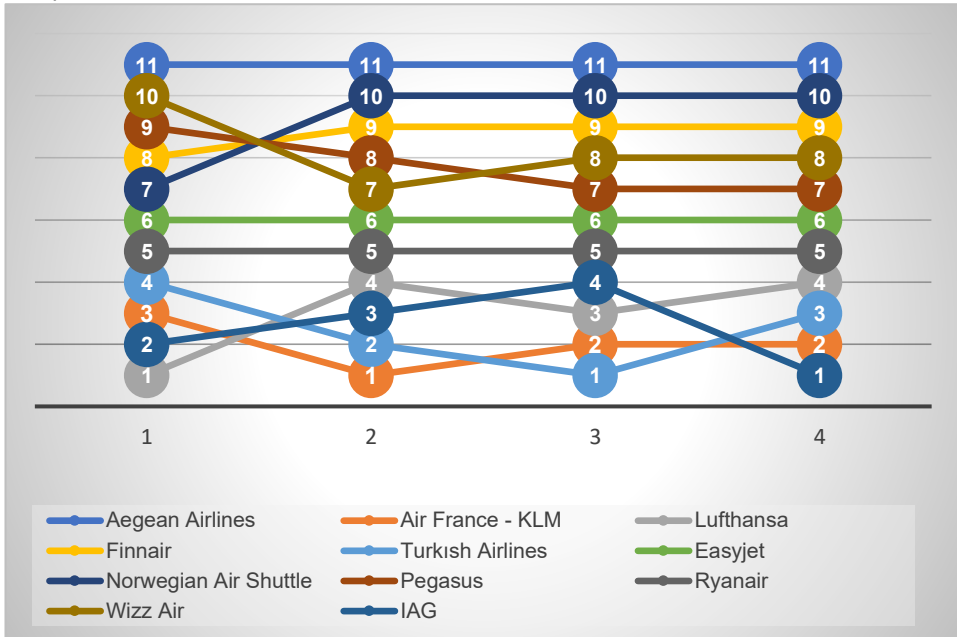
CRITERIA	2019	2020	2021	2022
C1	0.04340	0.09064	0.09032	0.03519
C2	0.03531	0.03750	0.02434	0.03444
C3	0.06287	0.07424	0.08719	0.05607
C4	0.12135	0.09167	0.10688	0.11382
C5	0.01166	0.10000	0.09281	0.01861
C6	0.04660	0.04058	0.04137	0.04600
C7	0.04993	0.04896	0.03377	0.03894
C8	0.14414	0.10749	0.11066	0.15647
C9	0.04942	0.03895	0.04076	0.05102
C10	0.06012	0.05189	0.04102	0.05799
C11	0.05536	0.05970	0.04189	0.05659
C12	0.04271	0.06032	0.03851	0.04428
C13	0.05997	0.04950	0.05171	0.05640
C14	0.09661	0.09746	0.08631	0.09685
C15	0.12056	0.05111	0.11247	0.13734

Source: Author's own calculation

4.2 AROMAN Results

In this section, the performance ranking of the airlines operating in Europe is analysed by AROMAN method. The ranking results obtained from this analysis are displayed in Figure 2.

Figure 2 | Performance Ranking of European Airlines According to The AROMAN Method (2019–2022)



Source: Author's own calculation

As illustrated in Figure 2, the AROMAN ranking methodology indicates that in 2019, Lufthansa; in 2020, Air France-KLM; in 2021, Turkish Airlines; and in 2022, IAG, were the most successful airlines. Aegean Airlines demonstrated the poorest performance of all airlines over the entire period (2019–2022). Air France-KLM, IAG, Lufthansa and Turkish Airlines ranked high in terms of overall performance over the entire period (2019–2022), while Aegean Airlines, Finnair, Norwegian Air Shuttle, Pegasus and Wizz Air ranked last. There were no observed changes in the performance rankings of LCC airlines such as Ryanair and Easyjet.

Figure 2 illustrates that the performance of Finnair, Lufthansa, IAG and Norwegian Air Shuttle in 2020 is significantly inferior to that of 2019. This indicates that these airlines exhibited a less favourable performance than other airlines during the pandemic period. Conversely, Air France-KLM, Turkish Airlines, Pegasus and Wizz Air demonstrated an enhanced performance ranking in 2020 relative to 2019. This suggests that these airlines demonstrated superior performance compared to other airlines during the pandemic period.

According to the ranking results obtained with the AROMAN method, it is determined that the performance rankings of Air France-KLM, IAG, Turkish Airlines, Pegasus and Wizz Air in 2022 are better than 2019. This indicates that these airlines have demonstrated a more rapid recovery in terms of overall performance compared to other airlines. Furthermore, it was determined that major, traditional airlines such as Air France-KLM, IAG, Lufthansa, and Turkish Airlines outperformed all LCC airlines in the sample over the entire period (2021–2022). One potential explanation for this phenomenon is that traditional airlines have been able to utilize their wide-body passenger aircraft for cargo transportation during the pandemic,

whereas low-cost carriers have limited options due to the narrow-body configuration of their aircraft (Jaroenjitrkamet et al., 2023).

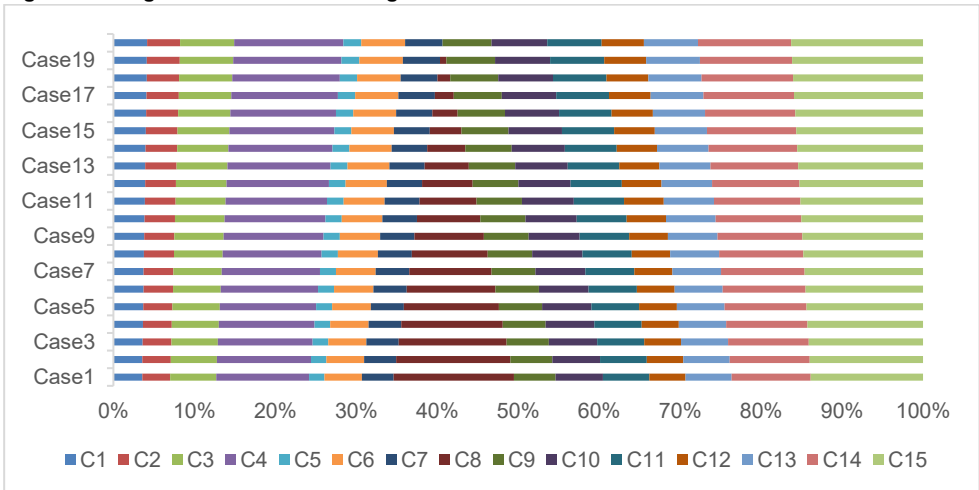
4.3 Robustness and Validation

In this phase of the analysis, a sensitivity analysis comprising two stages was conducted to assess the robustness and applicability of the proposed model. In the initial stage of the analysis, the impact of varying the weights of the criteria on the results was evaluated. To this end, 20 distinct scenarios were devised, based on the criterion (C8), which, as a consequence of the LOPCOW method analysis conducted for the year 2022, was identified as having the greatest weight. The weights assigned to these scenarios were calculated using Equation (15).

$$W_{n\beta} = (1 - W_{n\alpha}) * \frac{W_{\beta}}{(1 - W_n)} \tag{15}$$

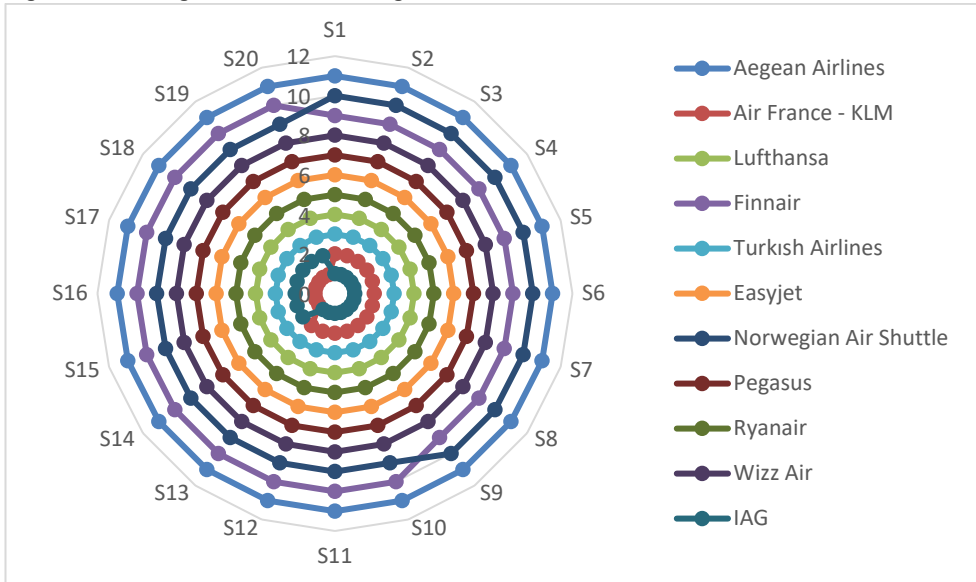
In the formula, the W_n value represents the original weight of the criterion with the largest weight (C8), while the W_{β} value represents the original weight of the criteria. The $W_{n\beta}$ value represents the weights for each scenario, and the $W_{n\alpha}$ value represents the reduced values for the criterion with the largest weight (C8) (Kirkwood, 1997). The reduction rate for the $W_{n\alpha}$ value was set at 5% due to the 20 scenarios. The weight values of these criteria for the 20 scenarios are presented in Figure 5. Additionally, the rankings of the airlines for each scenario are illustrated in Figure 6. The performance ranking of only a few airlines (Air France-KLM, Finnair, Norwegian Air Shuttle) exhibited a change in their performance ranking for each scenario. This supports the reliability and robustness of the proposed model.

Figure 5 | Weights of criteria according to 20 scenarios



Source: Author's own calculation

Figure 6 | Ranking of airlines according to 20 scenarios



Source: Author's own calculation

In the second stage of the sensitivity analysis, the results of the proposed model were compared with other multi-criteria decision-making (MCDM) methods (COCOSO, CRADIS, MARCOS) using similar methodology to determine the validity and robustness of the ranking results obtained by AROMAN method. As a result, COCOSO, CRADIS and MARCOS methods were applied on the available sample. The ranking results of these airlines for 2022 compared to other methods are presented in Table 3.

Table 3 | Aggregated airline ranking results for each method

AIRLINES	AROMAN	COCOSO	CRADIS	MARCOS
Aegean Airlines	11	11	9	10
Air France - KLM	2	4	3	2
Lufthansa	4	5	6	6
Finnair	9	8	10	11
Turkish Airlines	3	1	2	1
Easyjet	6	3	5	4
Norwegian Air Shuttle	10	9	11	9
Pegasus	7	6	7	8
Ryanair	5	7	4	5
Wizz Air	8	10	8	7
IAG	1	2	1	3

Source: Author's own calculation

Table 3 indicates that IAG exhibits the optimal performance according to the AROMAN and CRADIS methods, whereas Turkish Airlines demonstrates the optimal performance according to the COCOSO and MARCOS methods. Furthermore, analogous ranking outcomes were attained through the utilisation of four disparate methodologies. These findings substantiate the veracity and practicality of the proposed model. A Spearman correlation was performed to determine the strength and direction of the relationship between the ranking outcomes obtained through the proposed model and those obtained through other MCDM methods. The results of the Spearman correlation are presented in Table 4.

Table 4 | Spearman correlation results for each method

METHODS	AROMAN	COCOSO	CRADIS	MARCOS
AROMAN	1			
COCOSO	0.863636	1		
CRADIS	0.936364	0.845455	1	
MARCOS	0.890909	0.845455	0.927273	1

Source: Author's own calculation

As evidenced by the correlation results presented in Table 4, there is a robust positive correlation between the four MCDM methods. These findings align with those of the LOPCOW-based AROMAN method.

4 Discussion

This study makes a contribution to the existing literature on the impact of the pandemic on the multidimensional performance of airlines operating in Europe by employing the LOPCOW-based AROMAN method. Firstly, airlines operating within the same region were included in the analysis, given that the measures taken and restrictions imposed during the period of the Covid-19 pandemic vary significantly between regions. The findings of the analysis indicate that, throughout the entire period, Air France-KLM, IAG, Lufthansa and Turkish Airlines outperformed LCC airlines. It is hypothesised that this discrepancy is attributable to the varying scale sizes of the airlines in question in the pre- and post-pandemic periods. However, it is also postulated that the simple business model of LCC airlines in the years when the pandemic was most effective (2020-2021) may also be a contributing factor. In LCC airlines, tickets are sold at a low price in order to achieve a high load factor and high profitability. Consequently, low-cost carriers (LCCs) require a substantial volume of passenger traffic to maintain financial and operational viability. LCC airlines must reduce their operating costs to alleviate the financial difficulties arising from operational activities. One of the largest expenses for LCC airlines is fuel costs. Unpredictable changes in crude oil prices threaten the profitability of airlines. In this respect, LCC airlines can employ various strategies to maintain a constant fuel cost. For example, they may remove less demanding and less profitable routes or use more sophisticated financial derivatives to keep fuel prices stable.

The results of the LOPCOW method (Table 2) indicate that GHG emissions are among the top three variables with the highest weight on performance in 2019, 2021 and 2022.

Conversely, the weight of GHG emissions on performance decreased in 2020, coinciding with a significant reduction in the number of flights. In light of these findings, a series of recommendations are put forth for consideration by airlines. These include the modernisation of fleets and investment in aircraft with lower fuel consumption, with the objective of enhancing environmental performance. Additionally, the consideration of biofuels or sustainable aviation fuels as alternatives to traditional fuels has been recommended.

The results of the AROMAN ranking methodology indicate that the performance of Lufthansa, Finnair, Norwegian Air Shuttle and IAG in 2020 is significantly inferior to that observed in 2019. One possible explanation for this phenomenon is the deterioration of the liquidity structure of these airlines, which has resulted in a reduction in operational revenues. In contrast, the performance rankings of Air France-KLM, Turkish Airlines, Pegasus and Wizz Air have improved in 2020 compared to 2019. This can be attributed to the fact that these airlines have a robust liquidity structure.

It is inevitable that events such as the global pandemic caused by the Covid-19 pandemic will occur with some regularity and are likely to recur. Such crises present significant challenges for the air transport sector. It is possible for authorities to learn from these experiences and implement a series of measures to assist the air transport sector in overcoming these challenges. These measures can be divided into two categories: short-term and long-term. In the short term, when such a crisis occurs, governments can reduce airport landing and usage fees in order to reduce airlines' operating costs. Furthermore, they can offer financial assistance to airlines in order to avert bankruptcy, sustain liquidity and guarantee the continuity of operational activities. Moreover, in light of the ever-changing nature of the pandemic, competent authorities can establish unified health protocols and guidelines with the aim of minimising inconsistent practices in different countries. In the long term, competent authorities play an important role in ensuring the sustainability of the airline transport sector. To assist airlines in reducing their greenhouse gas (GHG) emissions from flight activities, authorities can provide subsidies for investment in more advanced aircraft and the adoption of sustainable fuels. Additionally, they can recognise the significance of environmental sustainability in the air transport sector and encourage airlines to invest in greener technologies.

In addition to the managerial issues previously outlined, it is also necessary to consider the policy implications that arise from the findings of this study. The air transport sector is inextricably linked with the policies and regulations established by the relevant authorities. This situation gives rise to the possibility that the consequences of crises such as Covid-19 pandemic may be influenced by political decisions. It is therefore evident that the competent authorities have an important role to play in shaping the operational activities of airlines, especially in times of crisis. In light of these findings, it is imperative that authorities implement proactive measures to ensure the resilience and stability of the air transport sector. To this end, the necessity for internationally coordinated strategies to effectively manage crises is paramount. For instance, if the competent authorities collaborate with other authorities in implementing international measures for crisis intervention and mitigation, a unified approach will enhance the efficacy of crisis management.

Conclusion

This study represents the inaugural application of the LOPCOW-AROMAN performance measurement model to the European airline transport sector. The study analyses the period between 2019 and 2022 and evaluates the impact of the Covid-19 pandemic, social distancing practices and travel restrictions on the multidimensional performance of European-based airlines. Although the global pandemic caused a decline in profitability and operational activity, it also led to a reduction in carbon emissions. Therefore, the objective is to assess the multidimensional performance of these airlines in the pre-pandemic period (2019), pandemic period (2020), New Normal period (2021) and post-pandemic period (2022) using MCDM methods.

The research findings indicate that the proposed LOPCOW-based AROMAN method yields meaningful, robust, and valid results with respect to both the criteria weights obtained and the overall performance ranking. The analysis conducted with the LOPCOW method revealed that certain financial performance indicators (total debt, operating expense, and operating income) play a pivotal role in determining overall performance over the entire period. This result is to be expected, given the crucial role that financial performance plays in enabling airlines to maintain their operations. It was observed that the weight attributed to the GHG variable, which is an environmental performance indicator, decreased during the period of the pandemic (2020). This is believed to be due to a reduction in the number of international flights during the pandemic period, the grounding of aircraft and the removal of older aircraft from the fleet. In the subsequent period (2021), it was observed that the weight of the GHG variable increased. Among the potential reasons for this is the fact that the number of flights increased in 2021 as a result of the pandemic having receded.

As a result of the performance measurement with the LOPCOW based AROMAN method, it was determined that Lufthansa (2019), Air France-KLM (2020), Turkish Airlines (2021) and IAG (2022) exhibited the most optimal performance. While traditional airlines such as Lufthansa and IAG demonstrated optimal performance prior to the advent of the pandemic (2019), a decline in their performance rankings was observed during the period of the pandemic's prevalence (2020-2021). Despite receiving state support during the pandemic, some large-scale traditional airlines with international flight networks (Lufthansa, IAG) recovered later than other large-scale traditional airlines (Turkish Airlines, Air France-KLM). The analysis further reveals that large-scale traditional airlines (Air France-KLM, IAG, Lufthansa, Turkish Airlines) outperformed LCC airlines throughout the entire period. This discrepancy can be attributed to the differing scale of operations between the pre- and post-pandemic periods. Additionally, during the pandemic, large-scale traditional airlines were able to leverage their wide-body passenger aircraft to carry cargo, a capability not available to LCC airlines due to the narrow-body configuration of their aircraft (Jaroenjitkam et al., 2023). Additionally, LCC airlines are unable to leverage government subsidies, which further exacerbates the discrepancy in their performance compared to traditional airlines.

It is anticipated that this study will make a valuable contribution to the existing literature examining the impact of the Covid-19 pandemic on the air transport sector. In the study, the LOPCOW-based AROMAN method was successfully applied to a sample of 11 airlines (6 Traditional and 5 LCC) operating in the European air transport sector. In this context, the

multidimensional performance of these airlines has been evaluated. It is thought that the findings obtained will greatly contribute to the performance management of airlines and will provide airline managers and stakeholders of the air transport sector with the opportunity to make managerial inferences to improve the performance of airlines in crisis periods similar to the Covid-19 pandemic.

Although this study offers valuable insights into the performance of European airlines before and after the pandemic, it is important to acknowledge its limitations. The first of these limitations is that the study focuses only on 11 airlines carrying passengers in Europe. Future studies may enlarge the relevant sample or examine the performance of airlines operating in different regions to examine regional differences. Secondly, the study analysed environmental performance with only one variable. This is due to the limited availability of data in the air transport sector. Future research can examine environmental performance in more detail by including more environmental criteria in the analysis. Thirdly, the relative evaluation of the performance measurement of MCDM methods. In this respect, future studies can apply non-parametric methods such as DEA (Data Envelopment Analysis), Malmquist TFP (Total Factor Productivity) or parametric methods such as SFA (Stochastic Frontier Analysis) to the existing data set. In this way, more robust conclusions can be drawn about the performance of the airlines in question.

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Appendix 1 | Spearman correlation coefficient of performance criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1	1														
C2	0.734	1													
C3	0.847	0.530	1												
C4	0.710	0.873	0.484	1											
C5	0.747	0.624	0.874	0.576	1										
C6	0.689	0.875	0.595	0.872	0.710	1									
C7	0.872	0.653	0.706	0.643	0.530	0.650	1								
C8	0.300	0.760	0.375	0.746	0.636	0.860	0.200	1							
C9	0.577	0.686	0.497	0.666	0.670	0.731	0.403	0.686	1						
C10	0.513	0.726	0.446	0.715	0.578	0.843	0.491	0.751	0.710	1					
C11	0.472	0.678	0.402	0.669	0.522	0.800	0.470	0.705	0.664	0.875	1				
C12	0.001	0.104	0.064	0.099	0.127	0.307	0.130	0.319	0.250	0.734	0.785	1			
C13	0.469	0.723	0.350	0.720	0.469	0.828	0.505	0.708	0.629	0.873	0.872	0.754	1		
C14	0.649	0.776	0.564	0.759	0.691	0.859	0.544	0.733	0.802	0.870	0.871	0.609	0.874	1	
C15	0.056	0.077	0.085	0.078	0.033	0.160	0.143	0.061	0.222	0.469	0.528	0.716	0.523	0.364	1

Source: Author's own calculation