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Pre-Evaluating Efficiency Analysis of Mergers and Acquisitions of Full-Service Carriers in Korea

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Abstract

In November 2020, Korean Air signs an agreement to acquire and merges with 63.88% of Asiana Airlines' shares, which is conditionally approved by the Korea Fair Trade Commission to address exclusivity concerns. The conditions require both airlines to return certain take-off or landing positions and revise their licenses for 26 international and 8 domestic routes within 10 years. This paper collects passenger traffic data from 2009 to 2019 using Korean data analysis, retrieval, and transfer systems employed by both airlines. Data envelopment analysis is utilized to assess their performance assuming the merger and acquisition. The analysis reveals that Korean Air's super-efficiency performance in 2011 is the highest among all decision making units (DMUs). The best super-efficiency performance is achieved not only by individual companies but also by the combined enterprise in 2019.

Keywords: airline, full-service carrier, DEA, supper-efficiency, mergers and acquisitions

1. Introduction

The deregulation of the air transport industry in the United States led to the birth of many airlines but also resulted in excessive competition that forced small and mid-sized airlines to declare bankruptcy. Major airlines like Delta Air Lines, United Airlines, Northwest Airlines, and US Airways also declared bankruptcy due to events such as the Gulf War in the 1990s, and Attack of September 11, and global economic stagnation in the 2000s. To address the bankruptcy issue, these airlines created mega-carriers with over 800 aircraft through mergers. While global airline alliances recognize the independent management of individual airlines, mergers and acquisitions (M&A) provide governance structures that help airlines survive emergencies. One example of this is Delta's acquisition of around 20% stake in LATAM Airlines by 2020, which is currently on hold due to Covid-19.

In November 2020, Korean Air agreed to acquire a 63.88% stake in Asiana Airlines, and the merger was reported to the Korea Fair Trade Commission (KFTC) in January 2021. After reviewing the monopoly regulation and Fair Trade Act for over a year, the KFTC determined that there was a high risk of restricting competition on 40 routes, including 26 international and 14 domestic routes on February 22, 2022. Korean Air has received approval from regulators in 9 out of 14 countries, while the USA, China, and the UK are currently reviewing the fairness of the merger. The European Union (EU) and Japan have not yet started their review as of SEP 2022 but are expected to do so once the competition regulators decide whether to approve the merger. The merger was approved on the condition that measures to resolve the monopoly be implemented over the next ten years. Rival mergers in the air transport industry have a significant impact on the entry of new airlines, the growth of their economies and market shares, the depth of the market structures, and operational efficiency.

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Predicting how the conditional permission of KFTC will impact the joint managerial effectiveness of both airlines in a decade is challenging. In this study, the transportation traffic results of Korean Air and Asiana Airlines from 2009 to 2019 are analyzed, using data envelopment analysis (DEA) to examine operational efficiency in situations that require a specific airline and company combination.

However, the impact of COVID-19 on international flights in 2020 and 2021 is not considered. Using multiple inputs for the decision making units (DMUs) to be evaluated, proposed by Farrell [1] and developed by Charnes et al. [2], has the advantage of being able to measure relative efficiency in units that produce multiple outputs, making it possible to compare them across various groups. DEA has been used in a variety of fields, and a different approach has been suggested by Tone [3], who developed a super-efficient slacks-based measure (SBM) model based on residual quantity. The SBM model is a super-efficiency method that gives higher ranks to units that are more valuable and effective.

In this study, a model to assess the operational efficiency of airlines was developed. Under the assumption of a business combination with individual airlines for the year and confirmed the super-efficiency value by the input and output variables of Korean Air and Asiana Airlines. This study is organized as follows: Section 2 examines DEA for conceptual analysis of M&A, business performance, and prior research on SBM to clarify the theoretical underpinnings.

The chosen input and output variables and the method for collecting data to measure the effect are in Section 3. Section 4 explains the analyses of findings and offers the research findings through empirical analysis. Finally, Section 5 concludes by summarizing the research findings and discussing the limitations of the study and future directions.

2. Literature Review

M&A is strategic decision aimed at various goals, such as increasing market share, improving operational efficiency, expanding into new markets, diversifying product lines, and reducing costs through economies of scale. Additionally, M&A can be used to respond to changes in the business environment. A corporate combination involves a strategic process of consolidations or sales that transfers the capacity for management, control, and decision-making. As highlighted by Müller-Stewens et al. [4], a corporate combination involves a strategic process of consolidations or sales that transfers the capacity for management, control, and decision-making. This means that M&A activities are not solely financial transactions, but also involve a strategic decision-making process that seeks to create synergies, increase market share, and enhance overall organizational effectiveness. The transfer of management, control, and decision-making capacity is crucial to this process as it enables the combined organization to leverage resources better, reduce costs, and increase efficiency.

2.1. Mergers and acquisitions in the airline industry

According to the analysis of Khezrimotlagh et al. [5], airlines tend to operate more efficiently after a merger, irrespective of their capacity size. Therefore, if an airline has sufficient capital to acquire the acquired company or can attract investment, it can create an opportunity to increase its market share as a mega carrier through an M&A. Airline achieves economies of scale through corporate planning, finance, IT, and strategic alliances through mergers, joint investment in aircraft purchases or information technology systems, and sharing customer databases to create synergies by reducing costs and increasing sales [6], which is possible to strengthen market dominance over specific routes and major hub cities through network expansion [7].

Therefore, an M&A between airlines must be approved not only by domestic M&A review but also by foreign competition authorities before final approval is granted. Despite this difficult process, the advantages of a merger between airlines are that. The airline's productivity changes surpass competitors, indicating merger-driven efficiency gains rather than industry-wide trends like adopting efficient aircraft that other competitors could adopt. [8].

2.2. Studies in airline mergers

Numerous studies have been conducted on airline mergers, examining changes in airline ticket prices, operational efficiency, productivity, and the impact on customers before and after M&A. Price effects have been the primary focus of empirical studies related to airline mergers, which can be used to assess merger-related market power effects and cost efficiency.

2.2.1. Air transport industry in the U.S.

The U.S. air transport industry suffered its worst recession since the Attack on September 11. Chen and Gayle [9] find that United Airlines and Continental Airlines have cost efficiency gains from mergers. Quality changes in markets due to the Continental/United merger exhibited a U-shaped curve with increasing pre-merger competition. Mergers resulted in quality improvement in non-competing markets but a decline in markets where the firms had prior competition. Vaze et al. [10] use passenger discrete choice models based on the characteristics of airlines and itineraries, they compute changes in consumer surplus. They employ a difference-in-differences approach to evaluate these changes, including frequency and pricing adjustments. The key findings indicate substantial consumer welfare gains resulting from the DL-NW and UA-CO mergers, with improvements particularly prominent in regions where the dominant carrier of the merger operates. However, concentrated sectors experienced welfare losses as a consequence of legacy mergers. The analysis revealed that passengers experienced overall losses with increased ticket prices and a substantial decrease post-merger.

2.2.2. Air transport industry in Europe

Schosser and Wittmer [11] use a comparative case study that includes six significant airline mergers from Europe, North America, and Latin America that occurred between 2003 and 2012. The pre-merger state of the merging airlines, the synergy estimations, and the realized synergies of the cases was compared after each case had been thoroughly examined. According to the findings, pre-merger cost structures, synergy estimations, and synergy realization vary significantly by geographic region. In comparison to mergers in the Americas, European mergers have lower synergy estimates and lower integration costs. North and Latin American airlines anticipate more revenue synergies than cost synergies from airline mergers, in contrast to European airlines that predict cost synergies to be higher than revenue synergies. Greer [12] tries to assess if airlines that combined were more efficient after consolidation. Despite constraints due to the small number of airlines in the dataset, the chapter finds no evidence that the consolidations improved the efficiency of the airlines engaged in comparison to the efficiencies of the airlines that did not participate in consolidations.

2.2.3. Air transport industry in Japan

The supply/demand control and previous clearance of airfare were ultimately deregulated in 2000, allowing full market competition in Japan. Japan Airlines and Japan Air System merged in 2003 to become an equal competitor to All Nippon Airways, which had strong market dominance in Japan's domestic air transportation sector. Mizutani [13] analyzed how the market structure was changed because of the merger. Doi and Ohashi [14] estimated that Japan Airlines' horizontal business merger resulted in considerable efficiency gains and found that the welfare effect of the merger was positive, but there was a difference depending on the market structure.

2.2.4. Air transport industry in China

China's government promulgates and declared effective as of August 1, 2002, the provisions on foreign investment in the civil aviation industry, which were adopted at the executive meeting of the Civil Aviation Administration of China, the Ministry of Foreign Trade and Economic Cooperation, and the State Development Planning Commission on December 10, 2001, and approved by the State Council. Therefore, it passed the reform plan for a new civil aviation system that meets the needs of the market economy. Through this, nine air transport companies and four service companies directly under the Civil Aviation Administration of China were organized again. Chow and Fung [15] technically analyzed the impact on the productivity of a merger between China's state-owned airlines. Based on the findings, the average productivity of the 20 state-owned carriers exhibited a slight decline before consolidation, but post-consolidation, it predominantly rose due to technological advances. Zhang and Round [16] confirmed that air ticket fares did not increase significantly in the markets served by China Eastern Airlines and China Southern Airlines, but rather decreased in most markets.

3. Material and Methods

This section in the context of DEA outlines the dataset used, the specific DEA model applied, and the mathematical formulations utilized to measure the efficiency and evaluate the performance of decision-making units. It provides a comprehensive understanding of the methodology employed in conducting the efficiency analysis.

3.1. Data envelopment analysis

DEA is a non-parametric approach used to measure efficiency, defined as the ratio of output to input. Charnes et al. [2] developed constant returns to scale (CRS) model assuming CRS to measure input-based efficiency. However, there was a disadvantage in that it could not be produced at the optimal scale [2]. So, it is difficult to make an objective judgment, which may affect the efficiency evaluation. Banker et al. [17] compensated for the shortcomings by extending the scope of the analysis to the case of variable returns to scale (VRS). Therefore, it has been widely used as a methodology for evaluating the efficiency of public institutions, banks, and universities. Since the 1997 financial crisis, the Korean banking industry has experienced significant structural modifications. Several institutions merged or went out of business, and foreign banks were allowed to enter the banking system. Over the past several decades, the amount of banking research has progressively grown in prestigious journals, and it appears to be higher in nations that have recently gone through significant financial crises.

3.1.1. CCR/BCC model

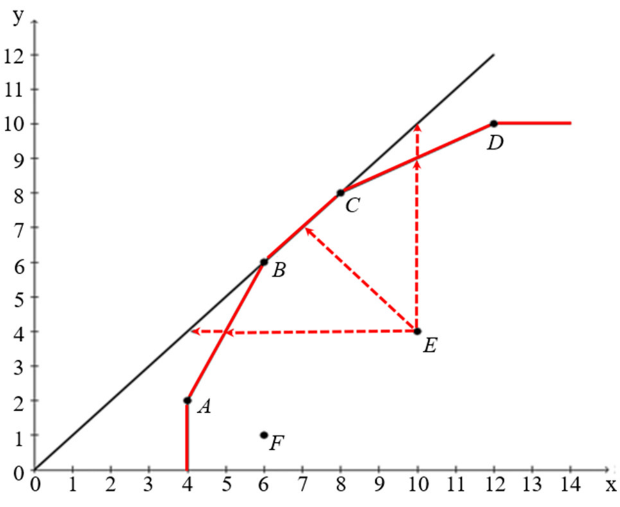

Fig. 1 Two-dimensional examples with six DMUs

It's worth noting that there was a significant increase in the use of DEA in Korean journals immediately after the 1997 and 2008 financial crises. However, the Charnes, Cooper and Rhodes (CCR)/Banker, Charnes and Cooper (BCC) models used for efficiency measurement have limitations when it's not possible to find an efficient reference that can lower all inputs in the same proportion to provide the same outputs. The CCR model's underlying technology isn't strictly convex, which means that non-zero slacks in inputs or outputs may exist in general situations. These non-radial non-zero slacks are not accounted for by the efficiency metric of the CCR/BCC models, even after computing the greatest proportional input reduction. As a result, the efficiency measure of a DMU with non-radial non-zero slacks in certain inputs or outputs may be excessively high according to the CCR/BCC models. The six DMUs A to F, which each produce exactly one output y from exactly one input x, serve as a straightforward numerical example to illustrate the eight model variants and their relationships [18]. This illustration is shown in Fig. 1.

3.1.2. Slack-based model

Tone [3] presented the Slack-based model to overcome this problem. The SBM is a non-radial approach based on slackness measurement that is useful for assessing efficiency when input and output change in a non-proportional. The primary principle behind the super-efficiency evaluation technique is to remove the effective evaluation unit from the set and re-evaluate it; hence, the original non-effective value evaluation stays intact, and if the original effective value evaluation is more than 1, it may be compared.

3.1.3. Efficiency of airlines using SBM

Table 1 shows previous studies on the efficiency of airlines using SBM during data envelope analysis. Tavassoli et al. [19] proposed assessing the efficiency of DMUs with multistage processes. In most real-world scenarios, DMUs may have an internal or network structure and can be divided into several components in series and/or parallel. In such cases, certain components are critical in creating final outputs by consuming intermediate outputs generated from earlier components.

As a result, the basic DEA model cannot be used to directly assess the performance of such systems and their components. Chang et al. [20] estimated the economic and environmental efficiency of 27 airlines in 2010 using the SBM. It was envisioned that airlines would exert every effort to reduce their input and output slacks to include poor disposability into the model. Although output slacks are lessened when disposability is weak, airlines still create more undesired outputs. In keeping with this idea, they use an SBM DEA model with poor disposability.

3.1.4. Efficiency of airlines using network DEA

Lozano and Guiterrez [21] conclude that the network DEA enables a more in-depth study that results in a more accurate evaluation of the whole system production possibility set (PPS). In contrast to network DEA, traditional single-process DEA, in other words, is an aggregated analysis that combines all system processes with their inputs and outputs while ignoring their internal flows.

Li et al. [22] developed a new three-stage airline efficiency strategic operational structure. The inputs are chosen purposefully to make the efficiency structure more thorough. The notion in this study adds to the theory and practice of airline management research and provides a new perspective for evaluating airline performance. Cui and Jin [23] present a new network Modified slacks-based measure (MSBM) model to measure airline environmental efficiency when the carriers' inputs or outputs are negative. Unlike previous models, this approach can handle negative data and combines the network DEA with the MSBM model. Mahmoudi and Emrouznedjad [24] used the Malmquist index to examine the performance of Iranian domestic airlines for eight years from 2013 to 2020.

Table 1 Literature review of airlines' efficiency using SBM-DEA models

Author (Year)	Airlines	Methods
Chang et al. (2014) [20]	27 International airlines	SBM DEA
Lozano and Guiterrez (2014) [21]	16 European airlines	Two-stage SBM
Li et al. (2015) [22]	22 International airlines	Virtual frontier network SBM
Cui and Jin (2020) [23]	25 Norway airlines	MSBM
Mahmoudi and Emrouznedjad (2023) [24]	12 Iran airlines	SBM-NDEA

3.1.5. Equation

To measure the airline's super-efficiency, the theory development process of the SBM model was confirmed in this study. Assume there is a collection of n DMUs (DMUj: $j = 1, 2, \dots, n$) that consume m inputs to produce s outputs (y_{rj} ($r = 1, 2, \dots, s$)). Assume that all of the inputs and outputs for the vector of x_{ij} ($i = 1, 2, \dots, m$) are positive and opposed to zero. The following definition applies to the PPS that spans all DMUs:

$$P = \left(x_1,\dots,x_m,y_1,\dots,y_s\right)\Big| x_i \geq \sum_{j=1}^{n}\lambda_j x_{ij}, i=1,\dots,m, y_r \leq \sum_{j=1}^{n}\lambda_j y_{rj}, r=1,\dots,s,\lambda_j \geq 0 \tag{1}$$

The SBM model is explained using the CRS as a foundation. It was assumed that $y_{rj} > 0$ ($r = 1, 2, \dots, s, j = 1, 2, \dots, n$) and $x_{ij} > 0$ ($i = 1, 2, \dots, m, j = 1, 2, \dots, n$) were true.

$$\begin{aligned} &\text{Min}:\ \rho = \frac{1-(1/m)\sum_{i=1}^{m} z_i^-/x_{ik}}{1+(1/s)\sum_{r=1}^{s} z_r^+/y_{rk}} \\ &\text{s.t.}:\ \sum_{j=1}^{n}\lambda_j x_{ij} + z_i^- = x_{ik},\ i=1,\dots,m \\ &\qquad \sum_{j=1}^{n}\lambda_j y_{rj} - z_r^+ = y_{rk},\ r=1,\dots,s \\ &\qquad \lambda_j \geq 0,\ z_r \geq 0,\ z_i \geq 0 \end{aligned} \tag{2}$$

Definition: DMUk in Eq. (2) is defined as an efficient unit if and only if $\rho^* = 1$. In other words, whenever $z_i = 0, z_i^+ = 0$, DMUk is SBM-efficient.

$$\rho_c' = \left(x_1,\dots,x_m,y_1,\dots,y_s\right)\Big| x \geq \sum_{j=1, j\neq k}^{n}\lambda_j x_j, y \leq \sum_{j=1, j\neq k}^{n}\lambda_j y_j, \lambda_j \geq 0, j \neq k \tag{3}$$

To define the SBM that corresponds to Eq. (2) and to derive without taking into account DMUk, $P_c^{'}$ is as Eq. (3).

Tone [3] introduced a method for calculating the super-efficiency of DMUs based on the PPS:

$$\begin{aligned} &\text{Min}:\ \delta = \frac{(1/m)\sum_{i=1}^{m}\left(x_i^-/x_{ik}\right)}{1+(1/s)\sum_{r=1}^{s}\left(y_r^-/y_{rk}\right)} \\ &\text{s.t.}:\ \sum_{j=1, j\neq k}^{n}\lambda_j x_{ij} \leq x_i^-,\ i=1,\dots,m \\ &\qquad \sum_{j=1, j\neq k}^{n}\lambda_j y_{rj} \geq y_r^-,\ r=1,\dots,s \\ &\qquad \lambda_j \geq 0,\ j=1,\dots n,\ j\neq k,\ x_i^- \geq x_{ik},\ i=1,\dots,m,\ y_r^- \geq 0,\ y_r^- \leq y_{rk},\ r=1,\dots,s \end{aligned} \tag{4}$$

Using the above model to evaluate all nonefficient units would result in an efficiency score of 1 for all of them, making it impossible to distinguish between efficient and nonefficient units. Therefore, both types of units must be considered separately, which involves solving the SBM model for all DMUs, identifying the efficient and nonefficient units, and calculating the super-efficiency. The crucial step in measuring super-efficiency is to subtract the target from the technical efficiency score to ensure that the super-efficient SBM of the efficient unit is above 1.

3.2. Decision-making unit selection and data collection

In the context of DEA, the selection of decision-making units and collection of relevant data entail identifying entitles to evaluate, specifying suitable variables and inputs/outputs, and acquiring reliable data. This section offers a comprehensive overview of unit selection criteria and data collection methods used in DEA Analysis.

3.2.1. Input and output variables

The process of selecting input and output variables in the efficiency analysis through the DEA model is important because the efficiency measurement results may vary depending on the selection of variables. Cao et al. [25] selected the number of employees, fuel consumption, and the number of aircraft operated as input variables to analyze the efficiency of Chinese state-owned and non-state-owned airlines and used the total number of aircraft and revenue ton kilometer (RTK) as output variables. Cui and Li [26] selected the number of employees, total business income, and aviation kerosene as input variables for 11 airlines around the world, and selected revenue passenger kilometer (RPK), RTK, and emission reduction index as output variables. The number of paying passengers multiplied by the distance traveled yields RPK.

The analysis in this paper utilized data from the annual reports of Korean Air and Asiana Airlines from 2009 to 2019. The passenger traffic data using the Korean data analysis, retrieval, and transfer system was collected. The input variables for the DEA models were the number of flights and available ton kilometers (ATK) for each airline's domestic and international flights, while the output variables were RTK and gross sales, as presented in Table 2. Additionally, Fig. 2 depicts the conceptual DEA model for airlines.

Table 2 Inputs and outputs

Year/Airline		Output variables		Input variables	
		RTK (million km)	Gross sales (thousand won)	Flights	ATK (million km)
2009	Korean Air	55,127	9,393,700,000	132,920	78,941
	Asiana Airlines	24,418	3,887,200,000	93,563	34,713
2010	Korean Air	60,527	11,238,258,214	134,542	79,511
	Asiana Airlines	29,249	5,027,600,000	94,050	36,895
2011	Korean Air	64,844	11,762,042,330	136,592	84,285
	Asiana Airlines	30,311	5,331,003,000	97,711	39,514
2012	Korean Air	68,834	12,171,306,608	146,308	88,305
	Asiana Airlines	32,870	5,638,069,000	101,033	42,232
2013	Korean Air	68,361	11,262,741,118	145,550	89,110
	Asiana Airlines	34,523	5,463,295,000	104,803	44,513
2014	Korean Air	67,948	11,083,189,580	154,288	90,955
	Asiana Airlines	37,036	5,552,678,000	107,057	46,779
2015	Korean Air	71,647	10,628,613,485	144,656	93,142
	Asiana Airlines	37,626	5,204,309,000	104,721	49,674
2016	Korean Air	75,908	10,995,413,116	150,047	96,654
	Asiana Airlines	42,473	5,418,238,000	106,245	51,436
2017	Korean Air	77,843	11,464,249,580	150,063	98,131
	Asiana Airlines	49,286	5,897,231,000	106,021	60,241
2018	Korean Air	80,189	12,426,389,730	151,090	99,943
	Asiana Airlines	52,706	7,076,267,000	104,381	62,843
2019	Korean Air	83,273	11,993,219,154	150,137	101,108
	Asiana Airlines	56,890	6,791,192,000	102,626	68,398

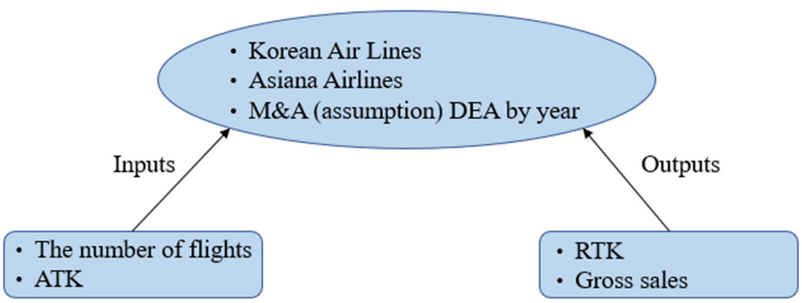

Fig. 2 Conceptual DEA model for airlines

3.2.2. Adjustment of limited competition route

To cope with the crisis brought on by COVID-19 and to compete with global airlines in the US, Europe, and the Middle East, Korean Air has opted to pursue an M&A strategy to become a mega carrier. However, the analysis, assumed that no M&A took place, and thus based the processing of input and output variables on the review results of the Korean Fair-Trade Commission (KFTC).

On 26 out of 65 international routes and 8 out of 22 domestic routes, the number of flights and ATK on duplicate routes were adjusted. The number of international and domestic routes with limited competition is 33. If the M&A had occurred, the number of flights on a route with limited competition would have been attributed to only one airline, and the ATK value would have been based on the operation of large aircraft by the two airlines to maximize the supply for the route.

4. Results and Discussion

Before delving into the following section on the efficiency analysis of scale, it is important to understand the methodology used. Super-efficiency represents the highest level of efficiency attainable by decision-making units. This section discussed the application of super-efficiency in DEA, its significance in identifying best-performing units, and the methodology employed to calculate super-efficiency scores.

4.1. Efficiency analysis of scale

To determine the scale efficiency, the maximum productivity obtained at the current scale is compared to the highest productivity seen at the ideal scale. The efficiency of scale is then analyzed by calculating each efficiency figure through the input-based CCR/BCC models and analyzing the ratio. If the efficiency of this scale is less than 1, inefficiency exists, and if it is 1, it is considered optimal.

Table 3 presents the scale efficiency analysis by year and airline, assuming M&A. The results show that Korean Air has optimal scale efficiency, except for 2009 and 2010, whereas Asiana Airlines' scale efficiency was not optimal, except for 2010, 2012, 2017, and 2019. Assuming an M&A, the scale efficiency is not optimal, except in 2014, 2018, and 2019. Therefore, it is necessary to adjust the overlapping routes after the M&A.

Table 3 Efficiency of scale

Year	Korean Air	Asiana Airlines	M&A (assumption)
2009	0.978	0.88	0.988
2010	0.99	1	0.99
2011	1	0.989	0.99
2012	1	1	0.99
2013	1	0.989	0.989
2014	1	0.989	1
2015	1	0.978	0.989
2016	1	0.98	0.989
2017	1	1	0.989
2018	1	1	1
2019	1	1	1

4.2. Super-efficiency analysis results

Table 4 and Fig. 3 compare the super-efficiency analysis of airlines and assume M&A by year. To relatively evaluate operational efficiency by airline and year, super-efficiency analysis can analyze the difference in efficiency for each DMU and reflect the remaining amount of input and output variables in efficiency to accurately measure efficiency.

Table 4 Super-efficiency scores with ranking/total DMU

Year	Korean Air	Asiana Airlines	M&A (assumption)
2009	0.888 (31/33)	0.876 (33/33)	0.882 (32/33)
2010	0.994 (10/33)	1.009 (4/33)	0.991 (12/33)
2011	1.031 (1/33)	0.979 (17/33)	0.987 (13/33)
2012	1.009 (5/33)	0.983 (14/33)	0.994 (11/33)
2013	0.968 (19/33)	0.953 (25/33)	0.962 (21/33)
2014	0.942 (28/33)	0.961 (22/33)	0.948 (26/33)
2015	0.946 (27/33)	0.907 (30/33)	0.929 (29/33)
2016	0.958 (23/33)	0.982 (15/33)	0.958 (24/33)
2017	0.974 (18/33)	0.980 (16/33)	0.967 (20/33)
2018	1.003 (7/33)	1.018 (2/33)	0.998 (9/33)
2019	1.018 (3/33)	1.007 (6/33)	1 (8/33)
Total	10.736	10.658	10.620

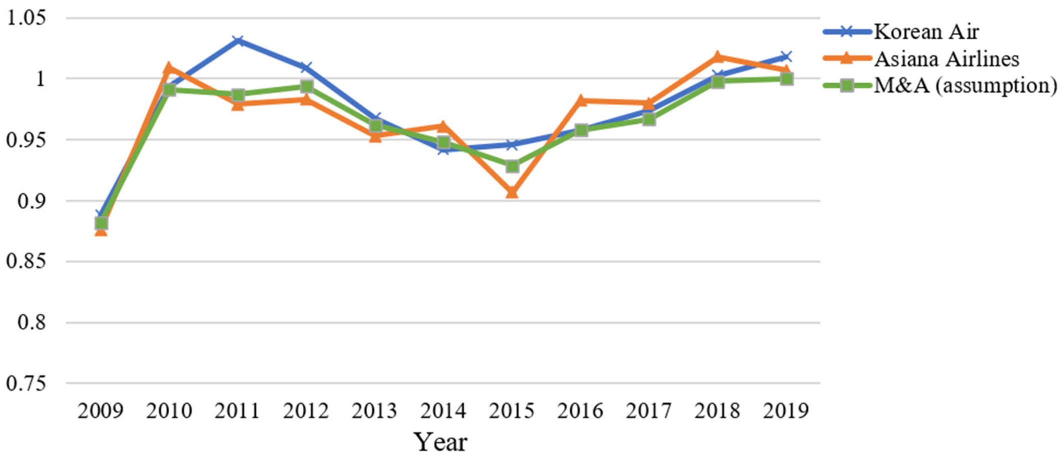

Fig. 3 Super-efficiency by year using SBM

4.2.1. Korean Air's super-efficiency

From Table 4, it can be observed that in 2011, Korean Air achieved the highest level of super-efficiency among all DMUs. Furthermore, the data indicates that the super-efficiency of airlines in 2019 was also commendable, considering both individual airlines and M&A. Korean Air's operating profit in 2011 was 394.1 billion won, but it declined from the previous year due to a surge in oil prices.

However, gross sales increased 4.7% Year on Year, thanks to increasing passenger traffic on Southeast Asia routes, as well as China and the US network. This is why it was determined that the super-efficiency was the highest in 2011. In 2019, the total passenger traffic in Korea reached a record high of 123.37 million, a 5% increase from the previous year. Since the official launch of a joint venture with Delta Air Lines in May 2018, Korean Air and Delta Air Lines have strengthened their cooperation, resulting in a 4% increase in RPK and a 10% increase in first and business-class traffic in 2019.

4.2.2. Asiana Airlines' super-efficiency

Asiana Airlines also expanded its global network through the world's largest global alliance, Star Alliance, resulting in increased sales across both its passenger and cargo business. However, in all cases analyzed, the lowest super-efficiency was observed in 2009. This was due to the significant depreciation of the Korean won following the financial crisis that occurred in the United States in 2008. It is believed that the decrease in consumer sentiment led to a decline in demand for international passengers departing from Korea, resulting in a decrease in demand for international tourism, and subsequently leading to a low super-efficiency.

4.2.3. Super-efficiency of M&A company

The analysis indicates that the super-efficiency of a merged company is consistently lower than that of individual companies. Even though the two companies' networks are not concentrated in any specific region, they still have many duplicate routes that require adjustments. By operating a network that can complement each other post-merger, it will be possible to increase operational efficiency.

5. Conclusions

The air transportation industry in Korea has faced significant challenges due to the prolonged COVID-19 outbreak. However, Korean Air managed to achieve the highest sales in 2021 by swiftly shifting focus to the cargo transportation sector. To prevent Asiana Airlines from bankruptcy, the Korean government took proactive measures in October 2020. Airlines generally follow similar business models that benefit from economies of scale through effective cost reduction and network expansion via M&A. However, restrictions on competition and the KFTC measures might limit the integrated synergies resulting from the acquisition of Korean Air and Asiana Airlines.

The present research centered its focus on three distinct aspects. First, the study aims to evaluate the operational efficiency of airlines during a merger and identify opportunities for cost reduction and operational enhancements. Second, the research focuses on identifying specific areas where airlines can improve their performance and achieve greater efficiency through the merger process. Finally, the study emphasizes the relevance of its findings in informing government policies.

However, the study acknowledges limitations such as limited access to detailed passenger and cargo traffic data, absence of unit price of jet fuel data, and reliance on a single input-output model. Despite these limitations, the results suggest that the proposed network DEA approach shows promise in evaluating the operational efficiency of merged airlines. Furthermore, the study recognizes uncertainties in the measurement of input and output variables due to measurement errors, missing data, and other factors. Future research could expand on these findings by exploring additional factors influencing the efficiency and performance of merged airlines. It could also compare the results of the network DEA approach with alternative methods like stochastic frontier analysis or DEA based on different assumptions.

The outcomes of this study have implications for government policies related to M&A activities in the airline industry, and the methodology employed can be adapted to other research areas within operations management or economics. This study provides valuable insights for academia and the industry, contributing to a better understanding of operational efficiency in the airline.

Conflicts of Interest

The authors declare no conflict of interest.

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