ENVIRONMENTAL EFFICIENCY DURING PUBLIC AIRPORT CONCESSION: THE CASE OF RECIFE INTERNATIONAL AIRPORT

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ABSTRACT

Airport concessions have increased worldwide to raise scale efficiency levels and adapt to future demand. Many studies focus on assessing the operational efficiency, but few these assess during the concession period and how management change can affect the environment. Considering the lack of evidence on how privatization can contribute to the airport’s environmental efficiency, this study focuses on analyzing the efficiency of Recife International Airport. Data Envelopment Analysis has been applied with operational and economic variables, followed by the Tobit Regression to understand how the efficiency is affected by infrastructure and environmental factors. The results indicate that during concession, factors such as the construction phase and peak operating costs are likely to reduce operating efficiency. Furthermore, infrastructure improvements provide more efficient traffic movement, and the greater the fuel consumption, the greater the movement of aircraft and consequent operational performance. It is concluded that factors such as the impact of aircraft emissions on air quality near the terminal must be taken into account in concession studies to contribute to measures that maximize environmental efficiency. One of the main contributions of this study refers to the method of analysis of airport operational variables to support management decisions related to airport infrastructure concessions.

Keywords: Air transport, Airport planning, Data Envelopment Analysis, Public concessions.

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1. INTRODUCTION

Considered as the country's economic driver, the air modal has been experiencing a progressive increase in passenger and cargo demand, consequent bottlenecks and recurring concessions. Brazil has adopted measures to increase scale efficiency levels and adapt to future demand. Since the mid-1970s, the sector has been the target of economic deregulation and consequent privatization, which boosted the desire to maximize efficiency within the processing of passengers, aircraft and cargo (Lin & Hong, 2006).

The increased demand for air transport without the infrastructure and planning can negatively impact the quality of service and the relationship with the environment. Kim et al. (2014) confirm that increased efficiency is not guaranteed after privatization of a transport system. Once the quantity of pollutants from aircraft increase, for example, it impacts on air quality and consequently on the health of residents who lives in the airport vicinity.

Data Envelopment Analysis (DEA) estimates the efficiency of airports relative to the inputs and products considered and compares them with the efficiency frontier, obtained by the best sample performances (Ngo & Tsui, 2020). The objective of the model is to calculate the weights of input and output variables so that the efficiency obtained can be maximized (Iyer & Jain, 2019). Additionally, a second stage of analysis can be used to assess the influence of explanatory variables on the efficiency weight obtained in the DEA. Associations with exogenous factors provide a better understanding of the contextual setting in which the airport operates (Iyer & Jain, 2019).

Studies carried out by Lin & Hong (2006), Tsui et al. (2014), and Ngo & Tsui (2020) use DEA models to analyze the efficiency of different airports in different countries. Toledo et al. (2021) evaluate the efficiency of Brazilian airports during periods of concession. Notwithstanding, to the authors knowledge, there are none studies that assess how external factors related to the environment can affect the operational efficiency of airports during the operations of private companies.

The Recife International Airport (SBRF) was granted to Aena Desarrollo Internacional for 30 years, starting operations in 2021. Due to the importance of SBRF for the Northeast region of Brazil and for the national air system, studies regarding its terminal performance and efficiency, allow the analyses of gaps that can contribute to serious environmental costs. That said, the objective of the present study is to evaluate the environmental efficiency of SBRF during the concession horizon, herein, the future operational performance minus the unwanted effect, through the emission of pollutants from the aircraft. In this context, an innovative idea of this paper is to seek the presence of environmental impacts and consequences on airport efficiency during the concession period, since the not commonly evaluated possibility of negative factors associated with management change. This study allows pointing out possible relevant factors in the analysis of operational performance, contributing to the decision-making of airport administrators and operators, and to the literature regarding the use of the second stage analysis of the DEA with an environmental variable.

2. AIRPORT ENVIRONMENTAL EFFICIENCY AND CONCESSIONS

The global movement of economic deregulation has motivated many countries to privatize their transport systems (Kim et al., 2014). For Brazil, the increased use of air transport in recent decades has driven improvements in operations and terminal infrastructure, promoting the action of private management (Toledo et al., 2021). Rolim et al. (2016) state that privatized airports can be more efficient due to their capacity to expand, attract airlines and produce development strategies, and that they are likely to produce a greater demand because they are linked to more flexible management, allowing, for example, engagement in route development strategies with existing and new airlines.

Measuring airport efficiency is essential both for companies and for the State, to understand the bottlenecks of each airport, as well as to assess the viability of investments and the operational performance of the granted terminals (Toledo et al., 2021). In contrast, there are still uncertainty whether concessions produce favorable and efficient results. It is known though that after the transition in the administration and operation of airport terminals, an increase in the flow capacity of passengers, cargo and aircraft is expected.

Rolim et al. (2016) confirm that a change in management has an effect on the efficiency of airports and airlines in generating demand, however, they do not assess the impact of demand on the environment. Therefore, concession is expected to be a successful solution for airports in an emerging country marked by substantial bottlenecks, as is the case in Brazil, at least on the demand side. In contrast, there is no evidence that the increased flow ensures protection around the airport since, for example, the increased movement of aircraft produces more pollutant emissions and aeronautical noise.

Efficiency assessment is essential to analyze the adequacy of demand and the results of current and future concessions in airport productivity (Toledo et al., 2021). There are few studies in the literature that have evaluated the efficiency of post-concession transport systems. Kim et al. (2014) study the efficiency of four highways in Japan after privatization, and state that the efficiency levels of privatized companies depended on the size of their operational capacity and the sophistication of their technologies. Pagano et al. (2014), whilst studying the privatized ports of Panama and the United States, which have different types of management, state that there is a tendency for privatized maritime terminals to have greater economic performance than public ones.

The involvement of private companies in terminals can promote sustainable measures, which can affect the efficiency of the system, with the presence of, for example, water reuse, installation of smart devices with automatic sensors in stairs, elevators and restrooms and encouragement the saling of reusable and recyclable products. Notwithstanding, Arbolino et al. (2018) state that there is no guarantee that privatization will result in the desired environmental efficiency during the entire contractual period. Thus, in the efficiency analysis, in addition to operational and financial variables, factors that affect the environment must also be taken into account, such as the impact of aircraft emissions, linked to fuel consumption.

It is considered that the analysis of the time horizon during the concession period makes it possible to assess critical management points, especially between the concession models. In this context, the average performance of an airport under concession during a given year compared to other years is relevant, as it indicates whether any period was the one with the best performance in relation to the general efficiency of the terminal (Tsui et al., 2014). That said, as the analysis of efficiency allows to discriminate the positive aspects of the management, operation and infrastructure of airports, there is an increase of studies in the literature on performance evaluation with the premise of defining objectives and growth targets for airport terminals (Lin & Hong, 2006; Tsui et al., 2014; Wanke & Barros, 2017; Ngo & Tsui, 2020; Guner et al., 2021, Toledo et al., 2021).

For the analysis of multiple decision-making units, inputs and outputs, Data Envelopment Analysis (DEA) is essential for evaluating the performance of terminals (Lin & Hong, 2006). Studies that apply Data Envelopment Analysis are identified in assessing the operational efficiency of airports in Eurasia (Guner et al., 2021), Africa (Wanke & Barros, 2017), Oceania (Lin & Hong, 2006; Ngo & Tsui, 2020), Asia Pacific (Tsui et al., 2014; Lin & Hong, 2006), America (Lin & Hong, 2006) and Europe (Lin & Hong, 2006). The studies apply different DEA models to analyze the operational and environmental efficiency, albeit they seek to complete the gap in the literature regarding the understanding of the impact of the concession and the environment on the efficiency weights. A second stage analysis is an option to explain the DEA results, since the results are deterministic between the variables used and there is the possibility of verifying the impact of exogenous factors on the efficiency scores. The second stage commonly applies simple regression, truncated regression or bootstrapping (Toledo et al., 2021).

It can be mentioned that Wanke & Barros (2017) apply two stages analyses to assess how the capital-labour ratio and the asset cost ratio reflect on the efficiency of Senegal's airports, and how this can lead to policy formulation. They use probabilistic chance-constrained DEA followed by (Support Vector Machine) SVM Regression, with inputs corresponding to number of employees and runway length and outputs as passenger, aircraft and cargo movement. In addition to these inputs and outputs, they apply cost variables, such as price of capital, price of labor, cost asset ratio, and whether cargo is operating, to control efficiency scores, allowing for operational diversity or scope.

Among the results obtained, it appears that high levels of efficiency for the airports in the sample are influenced by trained employees, which reflects on their salaries, and thus, on the price of labor. Regardless, for airports with low efficiency, performance is associated with cargo operations, price of capital and cost asset ratio, which suggests that economies of scale and scope are ways to maximize operations when efficiency is low (Wanke & Barros, 2017). The authors demonstrate that the efficiency of Senegal's airports is not only associated with infrastructure variables, but rather with the quality of human resources, operational scope and capital intensity.

3. METHODOLOGY

To develop this study, Data Envelopment Analysis (DEA) and Tobit Regression method were used, regarding the prospect of evaluating the environmental efficiency of Recife International Airport (SBRF) during its concession period. With the chosen methodology, it was aimed to evaluate how the efficiency of the concession terminal can be affected by unwanted effects, such as aircraft emissions, correlated to fuel consumption. It is known that, when forecasting the increase in traffic demand and consequent infrastructure expansions, there is a heighten in air pollution around the airport, which affects the surrounding population.

The methodology configuration is defined as the first stage analysis, through DEA, followed by the second stage, through Tobit regression. According to Ngo & Tsui (2020), the DEA is used to estimate the efficiency of airports and compare them with the best practice frontier, whilst the Tobit regression is used to determine the main factors that affect this efficiency.

DEA is the most widespread method in the literature to assess the relative efficiency of airports (Lin & Hong, 2006; Tsui et al., 2014; Iyer & Jain, 2019; Ngo & Tsui, 2020; Guner et al., 2021). Developed by Charnes et al. (1978), DEA is a non-parametric model, which calculates the relative efficiency for a Decision-Making Unit (DMU) considering the weight of several other DMU's (Wanke & Barros, 2017; Iyer & Jain, 2019). According to Lin & Hong (2006), a DMU will be under the efficiency frontier when it has the best combination of inputs and outputs. In this context, the DEA is one of the existing techniques capable of identifying the most efficient DMU's and pointing out inefficiency measures to the others. According to Wanke & Barros (2017), the model compares the production units, and afterwards orders them, according to the inputs used and the products generated. For the case under study, the DMU's are the years, as the performance of the terminal will be analyzed over a period of time.

The relative efficiency comes from the comparison of each weight of the DMU's with the efficiency frontier, which is formed by the DMU's that have the maximum ratio between outputs and inputs (Ngo & Tsui, 2020). The analysis of the indicator results from the correlation amid DMUs that are under or far from the efficiency frontier, which characterize them as efficient or inefficient, respectively (Lin & Hong, 2006; Iyer & Jain, 2019). In the presence of an inefficient DMU, how to bring it closer to the border is evaluated. For the study of relative efficiency, there are possible evaluation methods, including the DEA-CCR and DEA-BCC.

The CCR model was developed to analyze constant returns to scale (Lin & Hong, 2006; Bogetoft & Otto, 2011), that is, maximizing output with the fixed input share or minimizing inputs with the fixed output share. According to Bogetoft & Otto (2011), constant returns to scale indicate that, when a pair of input and output is viable, any point between (0,0) and the pair of input and output is likewise viable.

In contrast, the BCC model indicates variable returns to scale, where the efficiency score differs between the choice of input or output orientation. The relative efficiency of the DMU starts at point (0,0), continues to increase, stabilizes, and then decreases, that is, when moving the boundary towards more inputs, the return to scale follows straight lines with different angles, with growth, stabilization and degrowth (Bogetoft & Otto, 2011). Figures 1 and 2 show the production frontiers for the DEA-CCR and DEA-BCC models, respectively.

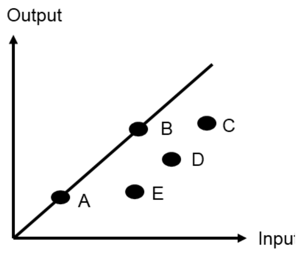

Figure 1: Production Frontier - DEA-CCR

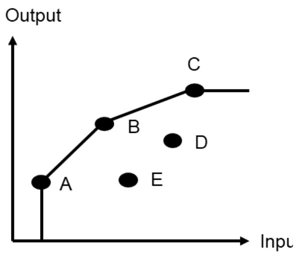

Figure 2: Production Frontier - DEA-BCC

Source: Adaptaded Bogetoft & Otto (2011).

Thus, Figure 1 represents the efficiency frontier by a 45º straight line, indicating that the inputs and outputs are proportional to each other. Figure 2, on the contrary, demonstrates that the efficiency frontier has a convex shape, consisting of a set of straight lines with different angles. As the study in question will use the years as DMU's, the analysis of Figure 1 and Figure 2 would indicate, respectively, years C, D and E and D and E as inefficient.

The approach that combines a first-stage DEA analysis and a second-stage Tobit model is able to identify the determinants that influence the efficiency variation. Initially, DEA scores are computed and then submitted to multivariate analysis for correlation with a set of explanatory variables (Wanke & Barros, 2017). Therefore, in the second stage analysis, Tobit regression is applied to verify the influence of key factors on the DMU's efficiencies. The estimation is carried out using the technique of ordinary least squares (MQO), which minimizes the sum of squares of the deviations between the estimated and observed values of the sample (Gujarati & Porter, 2011). The regression is called Tobit, since the dependent variable comes from the weights of the efficiencies obtained in the first stage analysis, and hence, it is limited to the range from 0 to 1 (Ngo & Tsui, 2020).

Ngo & Tsui (2020) apply the second stage analysis, known as IV-Tobit Regression, in order to solve the problem of the endogeneity of the DEA model and identify the determinants of airport efficiency. Furthermore, they used the dynamic approach of the DEA-Window Analysis to overcome the barrier of low discriminatory power when using few variables. It detects the efficiency trends of each DMU's relative to current technology. The whole DMU performances are compared over time, albeit they are treated differently for each time interval (Ngo & Tsui, 2020). For this, they use a sample of 11 airports in New Zealand during the period 2006 and 2017. The inputs used are expenses with employees, operating expenses and runway length, and the outputs, aeronautical and non-aeronautical revenues and aircraft handling. By applying the DEA-Window Analysis, the results indicate that the airports in the sample are inefficient during the aforementioned period, operating around 23.7% below the optimal level of efficiency and capacity. This corroborates for the introduction of management measures to enhance the inputs.

Regarding the use of the IV-Tobit Regression, it is estimated that among the airports in the sample, the two most efficient ones have greater movements of domestic and international flights and are located in cities with high GDP per capita. Therefore, the regression was applied to examine the impacts of external factors on efficiency, such as tourism, economic development and natural disasters like earthquakes, which were verified as positively correlated with high performance.

Likewise, the study proposes to apply the two stages analysis and to asses which factors affect the annual efficiencies of SBRF. In addition, it is of interest to insert variables that may be related to environmental impact. For this reason, it is applied the concept of aircraft emissions, linked to fuel consumption. The variables used are correlated with the concession of the terminal located in Recife (SBRF). Subsequently, through Tobit regression, the impact of exogenous factors on future efficiency was evaluated.

The choice of the study for SBRF comes from this being one of the airports granted as a block in Brazil in 2019. In one of the most recent concessions, the Northeast block consists of six airports, in which SBRF has the largest passenger movement. The airports were granted to Aena Desarrollo Internacional, with operations beginning in 2020. Due to its area of influence and local economy, SBRF is Azul Airlines' regional hub, making it the company's flight hub in the Northeast. Therefore, the airport shows significant importance in the Brazilian airport sector.

The sample used includes operational and environmental variables for SBRF, during the concession years, between 2020 and 2048. To carry out the study, the following variables were used as inputs: i) runway length; ii) total area of the TPS; iii) operating costs; iv) parking spaces. For the outputs, the following were considered: i) annual movement of passengers; ii) cargo handling. The description and units of the variables used can be seen in Table 1.

Table 1: Inputs and outputs data

		Description	**Unit**
Inputs variables	Runway length	Runway Length	Meters
	Total area of TPS	Passenger terminal area, plus the parking area	Square meters
	Operating costs	Costs and expenses with personnel, outsourced service, utilities, consumables, variable grant, communication and air control and others	Real currency
	Parking spaces	Number of parking spaces	n
Outputs variables	Movement of passengers	Passengers (boarding and landing)	n
	Cargo handling	Cargo (and post)	n

The variables presented in Table 1 are derived from the EVTEA (2018), which gathers data on the existing situation of the terminal under study and assesses the direct and indirect benefits arising from investments during the concession period. For the application of the method, according to Bogetoft & Otto (2011), the number of DMU's behave according to Equation 1.

$$K \geq 3 * (m + n), K \succ m * n \qquad (1)$$

For Equation 1, m refers to the number of inputs and n the number of outputs. That said, the amount of DMU's corresponds to the expected number of years of concession of the terminal. Therefore, the minimum number of DMUs for the study is 9. As the interval adopted for analysis is from 2020 to 2048, which accounts for 28 years, the minimum criterion is accorded. In the present study, the output-oriented DEA-BCC model was applied since the airport sector is interested in maximizing products. Data were processed in MaxDEA (2021). Subsequently, the Tobit Regression was applied to verify how the environmental efficiency of SBRF could be affected during concession period.

Equation 2 represents this regression, with the dependent variable corresponding to the airport efficiency weights amid the years of study, originated from the first stage analysis, that is, from the DEA model.

$$Efficiency = \beta_0 + \beta_1 * FuelConsumption + \beta_2 * AreaTPS + \text{u} \qquad (2)$$

where β0 and β1 are, respectively, the intercept and slope and u the stochastic error.

Initially, tests were performed to assess the collinearity and statistical significance amid the variables that explain the efficiency of SBRF over the years. Several variables were tested, namely, runway length, operating costs, quantity of parking spaces and passenger and cargo movement, but their inclusion in the model resulted in inadequate statistical measures. Therefore, when starting the analysis between the variables, it was observed that the best correlation with efficiency resulted from the association with fuel consumption (ANAC, 2021) and the passenger terminal area (EVTEA, 2018). The explanatory variables have the same time horizon as those applied in the DEA.

The choice of the statistical model was based on the significance of the variables and the quality of the statistical tests verified through the R-squared (R^2), p-value and stat-t. The p-value must have a value less than or equal to 0.10 for the null hypothesis of the test to be rejected and the stat-t must have a modulus greater than 1.96 for a significance of 5% (Gujarati & Porter, 2011).

It is noteworthy that, with the premise of inserting a variable that reflects on the environment, the quantity of fuel of the aircraft to land and take off in SBRF was used during the years of study, since the aircraft use fuel as a primary source to activate the engines. Thus, the fuel proxy variable seeks to quantify emissions around the airport, on the premise that they are correlated with each other.

According to the National Emissions Inventory of Civil Aviation (ANAC, 2019), emissions in the cruise flight phase are not considered, since the aircraft is at an altitude of more than 914.4 meters, deemed negligible its impact on air quality. In this context, the measurement of emissions to the surroundings of the terminal takes place through the LTO (Landing and Take-Off) cycle, which includes the steps of flights close to the aerodrome, corroborating to the premise of the analysis through aircraft fuel consumption to land and take off.

4. RESULTS ANALYSIS

After applying the output-oriented DEA-BCC model, an analysis of the annual efficiency of SBRF was carried out during the years 2020 and 2048, considering what was expected for the period of concession of the terminal. In Figure 3, the results of the efficiency sample for the aforementioned years are presented.

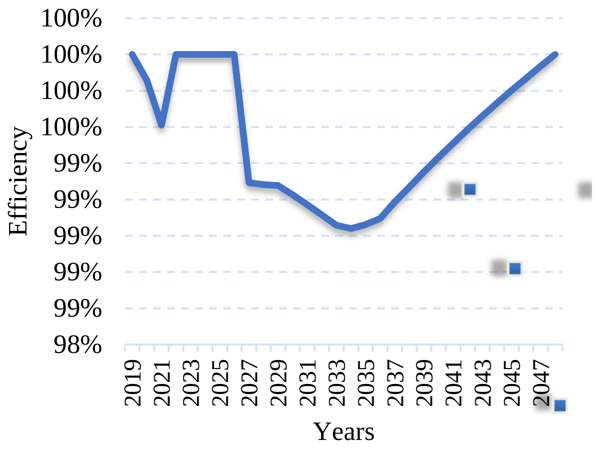

Figure 3 Annual Efficiency of SBRF.

The results in Figure 3 show efficiency values above 99.00%, indicating that, during the years of study, the airport has a high operational performance for the variables considered. It is observed that in the first two years of the concession, 2020 and 2021, SBRF is inefficient due to possible factors such as the length of the runway, which will go from 3.008 m to 2.497 m in 2021, due to the insertion of the RESA (Runway End Safety Area). The RESA allows for an increase in the safety of operations, and thus, the consequent efficiency.

Furthermore, for these two years, the operating cost is heightened, about 4 times more than the other years, due to the interventions foreseen in the first phase of construction of the development plan proposed by EVTEA (2018).

Between 2022 and 2026, SBRF will present maximum level of efficiency. The period coincides with the end of the first phase of construction, so that the airport will have infrastructure to meet the expected demand until the year 2028 (EVTEA, 2018), with the expansion of the TPS area and quantity of parking spaces, by example. In contrast, from 2027 onwards, which corresponds to the beginning of the second phase of construction, the airport will suffer a reduction of 99.77% by 2035. Thus, it can be said that during the occurrence of renovations, carried out to meet the expected growth of the output variables, SBRF tends to reduce the efficiency of operations. This is mainly due to possible interventions and layout reorganizations on the landside and airside during operations. Solely from 2036 onwards, will the airport show an increase in efficiency, reaching the frontier again in 2048, the last year of the concession. Table 2 shows the ranking of concession years in descending order of efficiency. The inefficiency of a few years may be related to fluctuations in the forecast for the movement of passengers, aircraft and cargo, as well as operating costs.

Table 2 Ranking of SBRF's concessions years

Year	Efficiency	Year	Efficiency
2019	100,00%	**2041**	99,51%
2022	100,00%	**2040**	99,43%
2023	100,00%	**2039**	99,35%
2024	100,00%	**2027**	99,29%
2025	100,00%	**2028**	99,28%
2026	100,00%	**2029**	99,28%
2048	100,00%	**2038**	99,27%
2047	99,93%	**2030**	99,23%
2046	99,87%	**2037**	99,19%
2020	99,86%	**2031**	99,17%
2045	99,80%	**2032**	99,11%
2044	99,73%	**2036**	99,10%
2043	99,66%	**2035**	99,06%
2021	99,61%	**2033**	99,06%
2042	99,59%	**2034**	99,04%

According to Table 2, it is noted that only 7 years presented themselves as efficient (2019, 2022, 2023, 2024, 2025, 2026 and 2048). Therefore, considering the evaluation of every year, 23.33% are efficient. These can be considered as benchmarking years, so that inefficient years should seek to reduce the weight of input variables and increase the outputs to reach the frontier. It is worth mentioning that the proposal to reduce resources to reach the border does not mean that investments in the airport should be minimized (Toledo et al., 2021).

Subsequently, the second stage analysis was applied, through the Tobit Regression, with the premise of identifying variables that can influence the efficiency measured in the DEA and the possible relationship with the environment, not explored in previous studies. The analysis of environmental sustainability would take place through the impact of aircraft emissions, associated with fuel consumption, hence linked as a proxy variable. The coefficients and statistical tests can be seen in Table 3.

Table 3: Results from Tobit Regression

	Coefficient	Standard Deviation	Stat-t	p-value	
Constant	1,01744	0,00299	339,90000	<0,0001	***
Fuel consumption	3,76E-12	4,95E-13	7,60000	<0,0001	***
Total area of TPS	−7,74E-07	9,59E-08	−8,06600	<0,0001	***

It is noteworthy that there is statistical significance in the influence of the total area of the TPS and fuel consumption. Through the signs of the coefficients, it can be seen that the size of the passenger terminal is positively related to the greater measured efficiency, as it seeks to improve the infrastructure to deal with the movement of traffic more efficiently.

Furthermore, it is understood that operational efficiency is greater as fuel consumption increases. This indicates that higher consumption provides greater aircraft movement and consequent satisfactory operation for SBRF during the concession period. In contrast, it is not possible to verify the impact of aircraft emissions, associated with fuel consumption, around the terminal.

A study proposed by Toledo et al. (2021) evaluated the operational efficiency of privatized air terminals but did not insert variables that would explain the impact on the environment. Hence there is no evidence that privatization provides more efficient airports in terms of environmental sustainability. There is the possibility of aggravation of pollutants from aircraft for air quality as well as for the residents surrounding the airport, and this aspect needs to be evaluated in future studies. It is emphasized that the results are limited to the availability of variables and sample size, and that concession studies explore demand forecasts that may take longer to materialize due to the country's economic instability.

5. CONCLUSIONS

Brazil has established the concession policy as a way to improve the administration and management of national airports, promoting competitiveness in the sector and reducing public resources. Under concession management, airports are expected to increase their passenger and aircraft processing capacity, which can positively impact in operational efficiency, but not necessarily environmental efficiency.

As far as the authors know, there are few studies in the literature that analyze the efficiency of just one air terminal, and none that assess how external factors related to the environment can affect the operational efficiency of the airport.

DEA is a widespread method in the literature to measure the efficiency of terminals. This study applies DEA to assess the operational efficiency of Recife International Airport (SBRF), operated by Aena Desarrollo Internacional, during the concession period and futhermore, through the Tobit Regression, to analyze how unwanted factors, such as aircraft emissions, affect efficiency.

In this context, the objective of this study is to evaluate the impact of the concession of SBRF around the airport, that is, how operational efficiency can be affected by the unwanted effect of aircraft emissions. Fuel consumption is adopted as a proxy variable to assess emissions during the LTO (Landing and Take-Off) cycle, in which the aircraft are at an altitude of up to 914.4 meters.

For this study, DEA results indicate that seven years will be over the efficiency frontier, and that for the remaining years, factors such as construction phase period and peak operating costs are likely to reduce performance.

Additionally, the influence of infrastructure and fuel consumption variables on the terminal's efficiency was evaluated. It appears that the passenger terminal area and fuel consumption are positively and negatively related to higher measured efficiency, respectively. It is understood that improvements in infrastructure provide more efficient traffic movement, and that the greater the consumption, the greater the movement of aircraft and consequent operational performance for SBRF during the concession period. In contrast, it is not possible to verify the impact of aircraft emissions, associated with fuel consumption, on air quality in the vicinity of the terminal.

The limitation of this study is due to the availability of data on aircraft emissions in the LTO cycle and the statistical correlations between the variables that affect the weights of annual efficiencies obtained in the DEA. In this context, for future studies, it is necessary to test new variables correlated with emissions to conclude the concession's inferences on the impact on the environment and population around the airport.

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