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# Measuring the Technical Efficiency of Oceania Continent Airports: Does Workload Unit Matters?

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## Abstract

Recently, there has been a rise in interest on measuring the efficiency and performances of international airports around the world by researchers. As there are more airlines in the industry competing with one another, airports as well started to compete with each other in order to become hub airports which provoke them to increase their efficiency. The principal objective of this research is to investigate and measure the efficiency of airports from the view of panel data analysis. We have applies a two-stage analysis methodology to determine the factors that could possibly sway the technical efficiency level by using ten different airports from year 2007 to 2016 in the Oceania continent countries. Model 2 shows that GDP per capita and Airport Hub significantly interact with Workload Unit (HUBXWLU) and towards the technical efficiency. In a nutshell, airport efficiency is important to many aspects of the society especially businesses that depends on better connectivity, airport operators that depends on passenger volume and governments that depends on economic development all of which are tools to building a more prosperous nation.

**Key word:** GDP; Oceania continent airports; Technical efficiency; Workload unit (HUBXWLU).

## 1. Introduction

With the market liberalization of commercial airliners and the globalization of business, commerce, trade, and travel, the demand of air travel had achieved records highs every year since the last two decades. Besides that, the airport had also assumed important roles that represent the country's image and reputation. Its growing importance had also helped airports to gain equal status as seaports in some nations that are tasked to attract foreign investments and create jobs. However, recent discovery had revealed some of the many issues that plague the airports of the Oceania continent. With a steady rise of international visitors to the continent, there is an urgent need to gauge the technical efficiency of airport infrastructures in the continent to find out whether they are operating at its maximum efficiency or there are inefficiencies that could be further improve. Regional governments might need to upgrade their respective airport infrastructure to handle the ballooning amount of passengers if they were already operating at their maximum efficiency. Moreover, this study is conducted to know how the efficiency of airports in the Oceania continent perform after the 2014 mining bust in Australia caused by the fall in iron ore and coal prices as well as the 2015 dairy price slump in New Zealand, which accounts for 40% of the country's export. We are keen to find out how do these two incidents that affect Australia and New Zealand's GDP per capita changes the efficiency of the airport industry.

Besides that, through this study we would also like to validate the concept that is widely held by most of the public which is governments or government owns companies are inefficient due to bureaucracy and red tape. From the data about the airports that is collected, we found that there are three airports that has yet to be privatized and still remains the asset of regional governments. Hence, we are eager to find out does the government owned status of the

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airports affect its efficiency. Lastly, the problem that most of the airports in the Oceania continent is currently facing are airport congestion. The increasing number of flights and passengers that airports needs to handle every day had resulted it to have limited resilience, especially during bad weather where flights need to be diverted or delayed which brings inconvenience not only to the passenger but also losses to the airports. (A mixed bag of opportunities and challenges for airports,n.d.). Therefore, the number and the length of the runway needs to be taken into consideration as it may provide a sign of airport size, and it also can be treated as a proxy of capital investment of an airport for handling aircraft traffic movements (Kan *et al.*, 2014). The purpose of this research is to measure the technical efficiencies of the 10 airports in Australia and New Zealand and determine the factors that affect them from year 2007 to year 2016. iv.To investigate the relationship between external variables and the interaction variables and its possibility of influencing the technical efficiency level of airports.

## 2. Literature Review

Higher airport efficiency also help the airport to generate more profit as it can generate more demand where there is a lots of passengers. However, according to a research in New Zealand illustrated that the city population could has a negative impact on the efficiency of airport. This is because as the amount of city

population increase, the possibility to build up a larger airport infrastructure and capacity is needed to accommodate the amount of city population, thus it will cause the efficiency in the airport become lower Kan *et al.* (2014) and Merkert and Mangia (2014). Based on Marques (2014), GDP is usually positive correlated with the standard of wealth and living. A higher GDP would generate more flights, so it has positive effect on the technical efficiency (Abdullah and Kumaran, 2015). It is not only influence by the economy growth that is correlated with the increase of the transportation costs and also others factor like household income which also will affect GDP. According to Zou *et al.* (2015), the sign of the hub status is expected to be negatively to the airport efficiency because of the larger size hubs will lead to a higher efficiency of the airport when compare with medium hub airports. Although the estimated result for non-hub airports are statistically insignificant, but the coefficients of non-hub and small airports still show a similar downward effects when compare to large hubs. This supported by Kan *et al.* (2014) which indicate that international airports were less efficient than non-hub airports or regional airports.

Airport size is also used as one of the internal variables, which is measured in the terms of workload unit (WLU). According to Barros (2008), airport size is significant to airport efficiency with a positive coefficient, which indicating that larger airport is likely to have higher overall efficiency and scale efficiency as compared to smaller airport. The result shows that airport size is significant to the airport efficiency at the significance level of 1%. Tsekeris (2011), further supported that the size of operation can be attributed to the economies of scale and needed for development of airports by enhancing the scale of operations. In the research, result also shows a positive effect of airport operation size is statistically significant on efficiency at 10%, which largely relates to the increased output of airports sited. Besides that, (Martini *et al.*, 2011) also stated that airport with different size will affect the efficiency and is positively related to the airport efficiency. The positive impact of airport size suggest that larger airport size will have higher achievement on the airport overall efficiency in term of technical and environmental efficiency.

Size is significant but it has negative sign which indicating that there are scale economies also only when desirable outputs are taken into account. Lastly, in the research of Marques, Marques *et al.* (2014), they found out that high percentages of international passengers will have negative influence on the efficiency of small scale airport and a positive influence on the efficiency of those medium and large scale airport. They suggest that airport should expand their size in order to achieve greater efficiency and also to increase the percentages of international passengers.Previous researchers such as Oum *et al.* (2008); Randrianarisoa *et al.* (2015), and Yap and Oum (2014) had included interaction variables into their studies on airport efficiency to research on the combined effects of two variables on the technical efficiency of airports. Despite using non-similar variables as the previous researchers had in their studies, we would still adopt the model to provide a more comprehensive approach and perspective on the issue and geographical location that we had chosen to focus on. As a result, we had formed four interaction variables by interacting all of the external variables with Workload Unit (WLU), an internal variable.

## 3. Methodology

According to researchers Kumbhakar and Lovell (2000), efficiency is all about obtaining maximum output given a set of fixed inputs (output oriented) or to obtain a set of fixed outputs with minimum inputs (input oriented). Silva *et al.* (2017); Kumaran *et al.* (2015) agreed to the advantages of SFA in a way that SFA is able to provide a general relationship relating outputs and inputs of organization and at the same time also accounts for random shocks. In this study, other than determining the efficiency of 10 pinpointed airports in the Oceania continent using SFA, it would also include the linear regression analysis to determine the effects of internal and external factors on the efficiency. As depicted in the model above, we have substituted the inputs and outputs determined for this study to calculate the technical efficiency of the 10 airports that we have pinpointed by adopting the model which is first proposed by Battese and Coelli (1992). The calculations are conducted using a computer by running a programme written by Coelli named Frontier Version 4.1 and the final outcome of the calculations is provided in the form of technical efficiency.

$$TE_{it} = \frac{TP_{it} + TAM_{it} + TOR_{it}}{f(TOE_{it} + NOR_{it}; \beta) + \varepsilon_{it}}$$

Where: TE = Technical Efficiency, TP = Total Passengers, TAM = Total Aircraft Movements, TOR = Total Operating Revenue, TOE = Total Operating Expenses, NOR = Number of Runways, $i$ = Airport of Adelaide, Brisbane,……, Dunedin, $t$ = Year 2007, 2008, ……., 2016, $\varepsilon_{it}$ = Error Term, $\beta$ = Vector of Unknown Parameters.

## 3.1. Second Stage Analysis

Second stage analysis used to test the relationship between external variables also known and interaction term towards airport technical efficiency. We had used Pooled Ordinary Least Square (POLS), Random Effect Model (REM) and Fixed Effect Model (FEM) in this stage. These external variables are factors which are beyond the control of the airport authorities and could not be manipulated whatsoever within its own means. This model that regress technical efficiency against four independent external variables would hereinafter be known as Model 1.By using the same linear regression analysis utilized in the two previous models, the interaction variables are regressed against the technical efficiency values obtained using the programme Frontier Version 4.1. EViews is then used to find out the correlation between the technical efficiency values and these interaction variables. By looking into the p-value of the variables, we could also gain an insight on which are the few variables that is significant in affecting the technical efficiency of the airports that we have targeted for this research. The interaction variable is formed by interacting an internal variable with the external variables of the targeted airports to obtain a more comprehensive perspective on the relationship between the independent variables and technical efficiency scores of the targeted airports. This model that regress technical efficiency against four interaction variables would hereinafter be known as Model 2.

**Model 1**

$$TE_{it} = \beta_0 + \beta_1 CP_{it} + \beta_2 GDP_{it} + \beta_3 HUB_{it} + \beta_4 IP_{it} + \varepsilon_{it} \qquad (1)$$

Where: TE = Technical Efficiency, CP = City Population, GDP = ln GDP per Capital, HUB = Airport Hub DummyIP = Percentage of International Passenger, $\beta_0$ = y-intercept, $i$ = Airports of Adelaide, Brisbane, ….., Dunedin, $t$ = Year 2007, 2008, ….., 2016, $\varepsilon_{it}$ = Error Term

**Model 2**

$$TE_{it} = \beta_0 + \beta_1 CP * WLU_{it} + \beta_2 GDP * WLU_{it} + \beta_3 HUB * WLU_{it} + \beta_4 IP * WLU_{it} + \varepsilon_{it} \qquad (2)$$

Where:TE = Technical Efficiency, CP*WLU = City Population Multiply Workload Unit, GDP*WLU= ln GDP per Capita Multiply Workload Unit, HUB*WLU = Airport Hub Dummy Multiply Workload Unit, IP*WLU= Percentage of International Passenger Multiply Workload Unit, $\beta_0$ = y-intercept, $i$ = Airports of Adelaide, Brisbane, ….., Dunedin, $t$ = Year 2007, 2008, ….., 2016, $\varepsilon_{it}$ = Error Term

# 4. Results and Discussions

Technical efficiency values lies within the interval unit of zero (0) to one (1). The justification for this occurrence is provided by McDonald (2009), where the researcher had clearly stated that the minimum and maximum limit of technical efficiency values to be zero and one respectively. Hence, this had verified our efficiency scores to be valid all of which falls between the interval of zero and one. From Table 1, we could see that Melbourne airport in year 2007 and 2008 is the most efficient within all of the airports that we studied by having a technical efficiency value of 0.9699; while the least efficient airport would be Dunedin in 2007 by having a technical efficiency value of 0.1915. After analysing the mean efficiency values of the airports we could see that the overall efficiency of airports throughout the years fluctuated consistently without any regular pattern observable. From the mean value, we could conclude that the best efficiency performance of all the 10 airports is attained in 2011with a mean score of 0.9011; while the worse efficiency performance of all the 10 airports is attained in 2007 with a mean score of 0.6176.

**Table-1.** Technical Efficiency Score from 2007 to 2016 for each airports based in Oceania continent

| DMU | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Adelaide | 0.5951 | 0.6346 | 0.7695 | 0.9542 | 0.9525 | 0.9512 | 0.9563 | 0.9598 | 0.9615 | 0.9580 |
| Brisbane | 0.9360 | 0.9145 | 0.9194 | 0.9283 | 0.9381 | 0.9386 | 0.9583 | 0.9681 | 0.9685 | 0.9587 |
| Melbourne | 0.9699 | 0.9699 | 0.9697 | 0.9686 | 0.9679 | 0.9684 | 0.9600 | 0.9098 | 0.9195 | 0.9191 |
| Perth | 0.8834 | 0.8736 | 0.8003 | 0.9667 | 0.9700 | 0.9278 | 0.9674 | 0.9670 | 0.9671 | 0.9575 |
| Sydney | 0.9480 | 0.9624 | 0.9119 | 0.9560 | 0.9600 | 0.9603 | 0.9195 | 0.9198 | 0.9193 | 0.9290 |
| Auckland | 0.6127 | 0.6378 | 0.6580 | 0.9672 | 0.9663 | 0.9670 | 0.9693 | 0.9605 | 0.9188 | 0.9188 |
| Christchurch | 0.4738 | 0.5016 | 0.9460 | 0.9467 | 0.9437 | 0.9444 | 0.9472 | 0.9525 | 0.9549 | 0.9587 |
| Wellington | 0.3103 | 0.3341 | 0.8338 | 0.9509 | 0.9496 | 0.9498 | 0.9526 | 0.9551 | 0.9569 | 0.9532 |
| Queenstown | 0.2256 | 0.2451 | 0.2940 | 0.5918 | 0.6334 | 0.5927 | 0.5086 | 0.4738 | 0.5019 | 0.5889 |
| Dunedin | 0.1915 | 0.2072 | 0.3314 | 0.6364 | 0.6246 | 0.5470 | 0.4163 | 0.2839 | 0.6298 | 0.1940 |
| Mean | 0.6176 | 0.6341 | 0.7464 | 0.8983 | 0.9011 | 0.8897 | 0.8703 | 0.8551 | 0.8367 | 0.8191 |

For second stage analysis based on panel data, the Hausman Test for the model consist of external variables (Model 1) showed probability of 0.1809 more than significant level, 0.05. Whereas, Model 3 shows the probability of 0.1284 also more than the 0.05 significance level. There is insufficient evidence to conclude that FEM is more

suitable than REM. Thus, REM is preferred for both models. For the Model 1, which are to test the relationship between external variables and technical efficiency, two variables that are statistically significant at 1% significant level which are ln GDP per capita (GDP) and the Airport Hub Dummy (HUB); there is another variable that is statistically significant at 5% significant level which is city population (CP). However, city population (CP) is considered to be less impactful based on their very small coefficient value which implies little to no change to the technical efficiency value of the airports. The tax breaks then creates a domino effect which attracts companies and corporations to invest in the region which would increase the local GDP per capita in the region which would draw employments into the region that increases its population. Last but not least, with the increase in city population, strong demands of air services in the region, governments could approve the airport's hub status which would also positively contribute to the rise in airport efficiency.

For Model 2 which are the interaction of Workload unit with external variables towards technical efficiency, two variables that are statistically significant at 1% significant level in Model 2 which are in GDP per capita multiply Workload Unit (GDPXWLU) and Airport Hub Dummy multiply Workload Unit (HUBXWLU). GDP per capita multiply Workload Unit and Hub Status multiply Workload Unit is found to be significant in influencing the technical efficiency of airports. However, Hub Status multiply Workload unit (HUBXWLU) is considered to be less impactful on technical efficiency value of the airports. The rise in GDP that comes mainly from these investments increases the workload unit of the airport. When more and more people travel to the region to seek for employment and leisure, the flights and cargoes that the airport needs to handle increases thus the rise in the workload unit. The rise in workload unit caused by the rise in GDP would reflect positively on the airport's efficiency.

**Table-2.** Relationship between External Variables and Technical Efficiency

| Model 1 | | | |
|---|---|---|---|
| Model | POLS | FEM | REM |
| C | -8.905849 | -8.479663 | -8.647078 |
|  | (1.074005)*** | (1.006274)*** | (0.988255)*** |
| CP | -2.52E-08 | -2.27E-08 | -2.37E-08 |
|  | (1.14E-08) ** | (1.04E-08)** | (1.03E-08)** |
| GDP | 0.882692 | 0.843101 | 0.858646 |
|  | (0.099832)*** | (0.093458)*** | (0.091797)*** |
| HUB | 0.336623 | 0.325359 | 0.329686 |
|  | (0.058873)*** | (0.052862)*** | (0.052761)*** |
| IP | -0.002088 | -0.001803 | -0.00191 |
|  | (0.001711) | (0.001531) | (0.001530) |
| R-squared | 0.643066 | 0.742034 | 0.671482 |
| Adjusted R-squared | 0.628038 | 0.703039 | 0.65765 |
| D-W test stat | 0.81144 | 0.834805 | 0.82374 |

**Note:** The asterisks ,**,***indicate rejection of the null hypothesis at 10%, 5% and 1% level of significance respectively. Standard Error in parentheses

**Table-3.** Interaction between External Variables and Workload Unit (WLU) towards Technical Efficiency

| Model 2 | | | |
|---|---|---|---|
| Model | POLS | FEM | REM |
| C | -3.343796 | -3.076074 | -3.138374 |
|  | (0.437121)*** | (0.365169)*** | (0.364925)*** |
| CP*WLU | -0.071875 | -0.031906 | -0.041228 |
|  | (0.049529) | (0.041800) | (0.041592) |
| GDP*WLU | 0.383871 | 0.287391 | 0.309857 |
|  | (0.126275)*** | (0.106222)*** | (0.105773)*** |
| HUB*WLU | -4.95E-09 | -5.52E-09 | -5.39E-09 |
|  | (1.77E-09)*** | (1.47E-09)*** | (1.47E-09)*** |
| IP*WLU | -0.034449 | -0.018295 | -0.022035 |
|  | (0.039959) | (0.033202) | (0.033156) |
| R-squared | 0.674488 | 0.799034 | 0.737391 |
| Adjusted R-squared | 0.660782 | 0.768655 | 0.726334 |
| D-W test stat | 0.871375 | 1.070564 | 1.005505 |

## 5. Conclusion

In order to increase the competitiveness of the airports within their country, governments are allowed and encouraged to step in with policies that would benefit the development and advancement of airports. But, prudent decisions should be considered by the government when implementing policy changes that are related to the airport industry. The government also plays an important role when it comes to dealing with the technological gap in airport technology. Governments could launch initiatives such as introducing adjustable lane technology and variable speed limits to help airports overcome the landing difficulties by airplanes during bad weather. With this technology, less planes would need to be diverted and thus a rise in airport revenue and its efficiency.

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