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Influence of Airport Demand in a Shared Airport between Military and Civil Personnel: The Case of Salvador International Airport

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Abstract- The aim of this paper is to analyze the influence of an increase on passengers demand in a shared airport between military and civil personnel. The paper investigates how this increase may influence the military operations of a high strategic airport. Using as a case study the Salvador International Airport, home to the aircraft fleet responsible for maritime patrol in Brazil, an airport demand model was developed and was made a simulation of increased wealth scenarios and consequent increase in demand. The results show that an increase of 1% in the economy will increase the number of 0.75% of domestic passenger. The results also show that increasing wealth may result in daily increases of two to 22 flights depending on the configuration and load factor and it may affect the military operations.

Keywords- *demand, capacity, air space*

I. INTRODUCTION

Oil exploration in the pre-salt layer is a milestone in Brazilian history. According to initial estimates, the region has the potential extraction of 40 to 80 billion barrels of oil, which would put Brazil as the fourth largest oil reserves in the world. According to Petrobras Business and Management Plan 2013-2017, the pre-salt production will reach 1 million barrels per day in 2017 and 2.1 million in 2020, corresponding to 37% of the total domestic production estimated for 2017 and 50 % for 2020 [1].

Allied to this scenario, the Brazilian maritime territory consists of the maritime areas under national sovereignty or jurisdiction and which are divided into internal waters, territorial sea, contiguous zone, exclusive economic zone and continental shelf. Due to its economic and natural wealth, enormous biodiversity source, this area was named Blue Amazon and is comprised by the extension of the Brazilian territorial sea, 12 miles of range, plus the exclusive economic zone of 188 miles range, and the continental platform extension [2].

To ensure the sovereignty and defense of a strategic and extensive area, the Brazilian Air Force (FAB) acquired the P-3 Orion patrol aircraft. The aircraft is operated by 1 ° / 7 ° Aviation Group - Orungan Squadron and is based in Salvador Air Base (BASV). The BASV divides the runway with the Salvador International Airport.

Brazil has experienced in recent decades an improvement of its economy. Economic growth and the inclusion of new customers contributed to the increased on demand for air travel. Allied to this, air passages became cheaper, with companies reducing the average tariff charged to the passenger (yield). The combination of these factors impacted in a greater demand for tourism packages and travel. In this context the cities of northeastern Brazil, a vacation gateway, are much sought after, particularly the city of Salvador.

This paper aims to analyze the influence of the increase in passengers demand on a shared airport and how this increase may influence the operations of a high strategic military airport. The paper contribution, is through econometric analysis, investigate the connection between passengers demand and the runway capacity for the military operations.

The results show that a 1% increase in the economy will bring an increase of 0.75% in the number of domestic passengers. Finally, a simulation will be made in the number of flights considering an increase of Gross Domestic Product (GDP) and what influences will be caused to the military operation in a shared airport runway. The results show that the increase of wealth can lead to daily increases of two to 22 flights depending on the configuration and load factor.

This paper is divided into six sections, including this introduction. The second section presents the airport, its history and its current main features. The third section is an airport demand study, analyzing the database and descriptive statistics. In the fourth section, an econometric analysis of airport demand is made, with the presentation of the model and its result. In the fifth section is simulated the improvement of air demand and finally the sixth section presents the conclusions.

II. ANALYSIS OF SALVADOR AIRPORT

The Salvador International Airport - Luís Eduardo Magalhães is in the city of Salvador, the state capital of Bahia and 35 km far from the city center. It is considered one of the top 20 Brazilian airports and the main airport in the northeast

region. The airport currently has two runways. The main runway (threshold 10/28) with 3005 meters long and 45 meters wide and the auxiliary runway (threshold 17/35) with 1500 meters long and 45 meters wide. Fig.1 shows the airport layout.

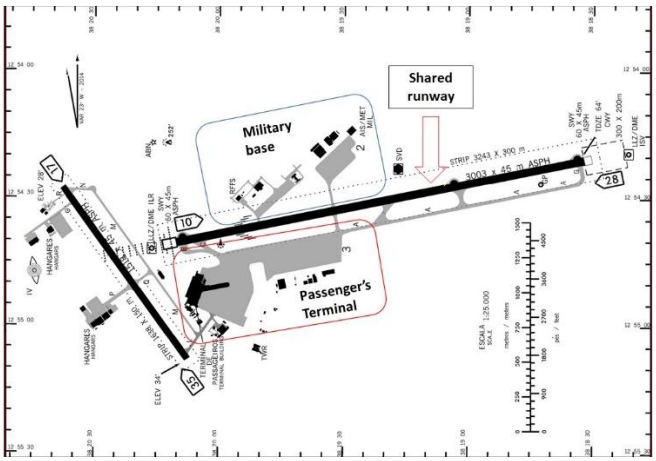

Figure 1. Airport layout

Operating at the airport, performing domestic flights are the following companies: Azul, Avianca, Tam and Gol connecting Salvador to several cities. The Brazilian Air Force (FAB) operates the P-3 Orion, a four-engine aircraft maritime patrol long range and anti-submarine warfare. A total aircraft of 12 were acquired and nine will be used to fulfill missions and the remainder as supply [3].

The main runway, because of its length, is used by commercial aviation, with the runway threshold 10 the most used with 80% of operations for takeoff and landing. 86% of the total operation are IFR (Instrument Flight Rules). The hour capacity under IFR rules with 40%, 50% and 60% of arrivals is 51, 50 and 47 operations per hours respectively [4]. The hour capacity under VFR (Visual Flight Rules) with 40%, 50% and 60% of arrivals is 57, 54 and 52 operations per hour respectively. The annual capacity of the runway with 50% of arrivals is 172.905 movements [4]. Figure 2 shows the daily runway utilization according to the currently Brazilian Air Transportation Hour (HOTRAN).

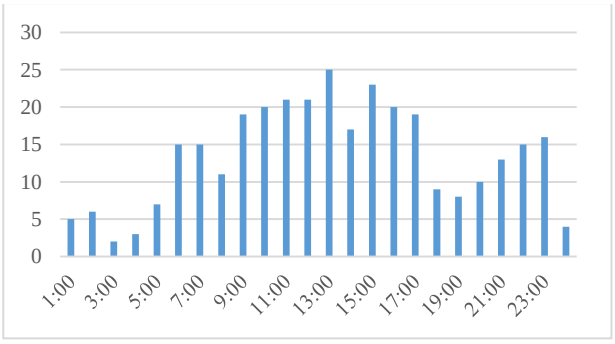

Figure 2. Daily runway utilization Salvador International Airport

The annual amount of domestic passengers has grown in recent years, as shown in Fig. 3. Salvador comprises 3.9% of Brazil's passenger and the main route is the connection with the city of São Paulo [5].

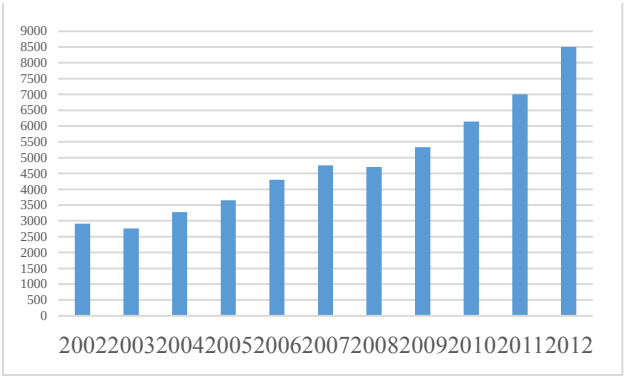

Figure 3. Annual amount of domestic passengers Salvador International Airport

The city of Salvador stands out as the main tourist destination in northeastern Brazil. For domestic travel, is the third most visited destination in Brazil, second only to São Paulo and Rio de Janeiro. Is among the top twenty destinations of Brazilian travel desire [6]. The region is also noted for the Carnival party where only in 2014, the Salvador Airport received 400.000 passengers during the party, comprising the Wednesday before Carnival and the Sunday after the Wednesday of Ash, with a daily average of 180 operations.

III. DATABASE

The database structure consists of a data panel from several sources. The Brazilian Airport Infrastructure Company (Infraero) provided the data movement from local domestic passengers **(paxdl)**. The Brazilian Electric Power Company (Eletrobras) provided the electricity consumption data (**enel**). The Applied Economic Research Institute Foundation (IPEA) provided the economic data (**rcredit**) and currency variation. The National Civil Aviation Agency (ANAC) provided the data on the number of airports connected and the average tariffs.

The yield is the metric used in air transport to indicate average revenue generated to carry a passenger for a kilometer. The **ncon** variable is the addition of new consumers in the economy; it is a binary variable and covers the period from July 2009. To measure consumption, we used the proxy variable of electricity consumption (**enel**) instead of the Domestic Gross Product (GDP). The choice for electricity consumption was made because in Brazil, the GDP is not disaggregated by region. Credit (**rcredit**) was the availability of credit for consumption, translating into greater purchasing power of the population.

The study period was from January 2002 to June 2013 on a monthly basis. Table I presents the descriptive statistics of the most important variables used in the econometric study.

TABLE I. DATA DESCRITIVE STATISTICS

Variable	Average	Standard Deviation	Minimum	Maximum
paxdl	415766,3	155698,8	194346	845113
yield	0,47	0,16	0,25	0,89
enel	7048,35	1179,56	4711,28	8968,1
rcredit	0,40	0,11	0,25	0,60

Following the improvement of income of the Brazilian population (enel), demand in the airline industry, in particular the demand for flights to the city of Salvador (paxdl), presented a high growth in recent years, as shown in Fig. 4.

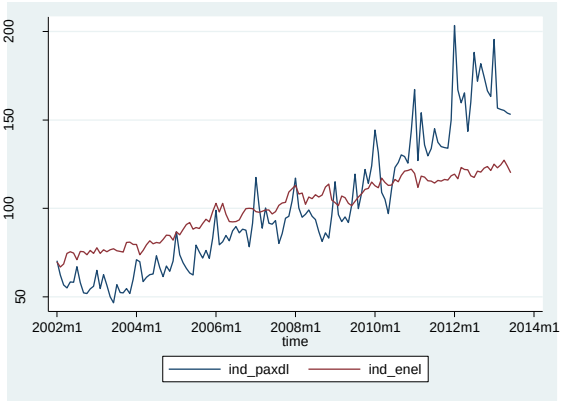

Figure 4. Demand (paxdl) and wealth / economic activity (enel)

The growth in passenger numbers resulted in a "price war" between airlines, with the decrease in the average amount paid per passenger per kilometer flown (yield). For this route in particular, people are flying more and paying a lower rate when compared to the beginning of the series in 2002, taking place the aviation popularization phenomenon. Table II correlates the variables.

TABLE II. CORRELATION BETWEEN VARIABLES

	paxdl	enel	yield	rcredit
paxdl	1			
enel	0,8898	1		
yield	-0.778	-0,8344	1	
rcredit	0,929	0,9194	-0,8137	1

The analysis shows that the movement of domestic passengers (paxdl) is positively correlated with economic activity (enel) and credit (rcredit). The paxdl variable is negatively correlated with yield.

IV. ECONOMETRIC STUDY

Regression analysis is a powerful tool for describing and make inferences between the variables of the study, understand how different variables in a study model relate with each other in a non-deterministic way and allows predicting the behavior, as well as magnitude of the variation of a variable when another varies.

Two types of variable form a regression: the independent variable and the dependent variable. The independent variable or exploratory variable is named for vary independently, deterministically, is the variable x_n (n = 0,1,2,3 ... k) of the equation. The dependent variables are random and depend on the independent variables to be estimated, are the y variables. The variable u, called the error term is other factors beyond the variables x_n that affect y, are unobserved factors of the equation.

The estimation model of the demand for domestic passengers in Salvador is:

$$\mathbf{lnpaxdl = \beta_0 + \beta_1\, yield + \beta_2\, yield\_ncon + \beta_3\, enel + \beta_4\, enel\_ncon + \beta_5\, rcredit + \beta_6\, rcredit\_ncon + \sum_m \gamma m\, sazonality\ month\ m + u} \quad (1)$$

The dependent variable is paxdl in its logarithmic form and the explanatory variables are yield, yield_ncon, enel, enel_ncon, rcredit and rcredit_ncon.

Regressions were performed with the OLS, 2SLS, GMM2S estimators. The OLS model uses the Ordinary Least Squares method and choose the estimation that minimize the sum of squared residuals. The method assumes that the independent variables and the error are uncorrelated. The 2SLS (Two-Stage Least Squares) and GMM2S (Two-Step Generalized Method of Moments) models are used when some of the explanatory variables are correlated with the error (u) of the regression model. This phenomenon is called endogenous and should be controlled to obtain more consistent β_k estimators. It is present when the variables are obtained by simultaneous equations, for example supply and demand.

In the present study, for air transportation the variable average rate charged per passenger (yield) is endogenous. To correct this phenomenon, all estimators above, use one or more instrumental variables that are correlated with the endogenous variables but uncorrelated with the dependent variable, differing by the instrument's choice of and the single or joint estimation form of estimation.

A. Diagnosis Tests

The analysis of statistical significance was given through the t-statistic and the p-value. The values will be more statistically significant when presenting a high t-statistic and low p-value.

The multicollinearity is a problem that occurs when the regressors are correlated. It is a matter of degree and not of kind. VIF test (Variance Inflation Factor) was performed in the model, with low level of multicollinearity (VIF covariates of less than 10 and average less than 1).

In time series is very common to find autocorrelation problems when successive observations often have intercorrelations. It was performed the Cumby-Huizinga test and the errors are not autocorrelated at 15 ° order.

The heteroskedasticity occurs when the variance of the error is no longer constant. It were performed the following

tests: Pagan and Hall, Pagan and Hall assuming normality, White and Koenker, Breusch and Pagan, Godfrey and Cook and Weisberg indicating heteroskedasticity in the sample. The regression was run with control of the phenomenon.

Despite having evidence of unit roots in the time series, for the following variables enel, paxdl and yield were performed the Dickey-Fuller tests in Eliot, Rothenberg and Stock version, Engle and Granger with tendency cointegration tests and Johansen's VEC without trend or lag and with linear trend levels. In most tests, the evidences showed that the variables cointegrate effectively, i.e., there are no signs of issues related to the problem known as "spurious regression" and therefore can work with the variables in levels and not differences.

Seasonality is a phenomenon that may be present in time series. It can be defined as a periodic variation, which occurs repetitively around a trend line of annual period. The seasonal control was performed with the addition of a set of dummy variables to account for seasonal seasonality in the dependent variable, the independent variables, or both.

The variable for the average rate charged per passenger (yield) and with the inclusion of new consumers (yield_ncon) are determined by simultaneous equations, and treated as endogenous in the econometric model. To control the endogeneity, instrumental variables were used. Profit shifters in normal, square and logarithmic level performed a search of the variables.

Tests were conducted to verify the relevance and orthogonality of the instruments by Kleibergen-Paap tests, Hansen J test, F statistic of Cragg-Donald and F Statistics of Kleibergen-Paap. The tests suggested that the chosen instruments showed statistical significance, relevance and validity to carry out econometric analysis.

The instruments chosen were: number of airports connected to the Salvador airport in regular flight connections in its quadratic form (netsize2); average exchange rate of the US Dollar for sale associated with the period of inclusion of new consumers in logarithmic form (lagusd_ve_med_ncon) and a floating exchange rate for sale associated with the period of inclusion of new consumers (usd_ve_fim_ncon).

Among the verified model estimators, the estimator that best suited was the GMM2S. The OLS model presented bias due two variables, yield and yield_ncon. Those variables are determined by simultaneous equations, presenting with this estimator biased results. The 2SLS estimator presented test p-value Reset (0.5591) less than the GMM2S (0.5644).

To measure the strength of the instruments used jointly the Stock-Yogo test was performed. In the first stage, the result indicated the sub-identification for a single endogenous regressor of 20% maximum and 15% for two regressors maximum. In Kleibergen-Paap sub-identification and significance of the instruments test, instruments passed a 0.05% level of significance. Statistical F Cragg-Donald Wald instruments passed with 20% maximum, but did not pass the F Kleibergen-Paap Wald statistic test.

To investigate joint significance of endogenous regressors, β estimators different of zero and orthogonality conditions, presenting significance of 0.01% for the Anderson-Rubin test and 0.10% for the Stock Wright.

In the second stage, the Kleibergen-Paap sub-identification test passed at 0.05% level of significance. Cragg-Donald Wald Statistical F instruments test continued in the second stage with 20% maximum, but continued not passing the statistic F Kleibergen-Paap Wald test.

To verify if there was over-identification of all the instruments used, or check if there is within the instruments used one that is not valid, J Hansen's test returned a p-value 0.9555 demonstrating the validity of the instruments.

B. Study results

It was attempted with the results, to estimate the elasticity of the air demand. Elasticity is a concept used to measure the sensitivity of demand to changes in the independent variables such as income, profit, among others. Numerically is defined as the percentage change in demand when the change of 1% occurs in the independent variable.

$$\mathbf{E} = \frac{\%\mathbf{\Delta Q}}{\%\mathbf{\Delta X}} = \frac{\boldsymbol{dQ}}{\boldsymbol{dX}}\frac{\boldsymbol{X_0}}{\boldsymbol{Q_0}} \quad \text{where:} \qquad (2)$$

Q = domestic passengers

X = independent variables as income, profit, yield.

The result of the regression of domestic passengers (paxdl) with the dependent variables is shown in Table III.

TABLE III. RESULTS WITH OLS, 2SLS, GMM2S ESTIMATOR

Dependent variable: lnpaxdl	**(1)**	**(2)**	**(3)**
	OLS	**2SLS**	**GMM2S**
yield	-0,2336***	0,4678***	-0,4659***
	[0,051]	[0,102]	[0,096]
yield_ncon	-0,0177	-0,1360**	-0,1361**
	[0,026]	[0,068]	[0,068]
enel	1,0859***	0,7440***	0,7447***
	[0,087]	[0,143]	[0,142]
enel_ncon	-0,3520***	-0,2699**	-0,2695**
	[0,079]	[0,105]	[0,105]
rcredit	0,1323*	0,0860	0,0885
	[0,080]	[0,109]	[0,099]
rcredit_ncon	0,4255***	0,4607***	0,4603***
	[0,073]	[0,076]	[0,075]
R-sq	0,9620	0,9485	0,9487
RMSE	0,0766	0,0893	0,0892
F	578,2137	531,5233	550,2929
F_PValue	0,0000	0,0000	0,0000
RESET	0,4345	0,3413	0,3322
RESET_PValue	0,5098	0,5591	0,5644

[a] Standard errors of heteroskedasticity and autocorrelation robust estimates in brackets. *, ** And *** represent, respectively, 10%, 5% and 1% of significance level. Elasticity estimated in the sample mean. Monthly seasonality dummies omitted.

An increase in the average price charged by the airlines would mean a decrease in demand of 0.47%. We can interpret, as the demand is sensitive to price variations, but due to its inelasticity (less than 1), the quantity demanded is less sensitive to price change.

The fact that Salvador is a recognized tourist destination in the northeast of Brazil, makes that even with price increasing a continue demand happen, but some consumers through the increase in the ticket price, might seek other destinations with similar characteristics.

A price increase would keep away new consumers in a minor level when compared to the regular consumer. A 1% increase in the price would mean a decrease of 0.1361% in passengers demand in Salvador. The new consumers represent a class that always had the desire to consume and is only now being inserted with the increase in credit. Traveling to a paradisiac destination is the realization of a dream and new ways of credit a possibility to achieve the desired vacation.

An increase in economic activity will lead to an increase in air transport demand to Salvador. A 1% increase in economic activity will result in an increase of 0.7447% in the demand for Salvador. The improvement in income and economic activity allows people to better dedicate themselves to leisure and tourism trips, in the same way the region of Salvador has emerged as petrochemical and industrial hub, bringing more activity that is commercial to the area and the increase need for aircraft utilization.

The econometric model presented a problem on the income of new consumers. The elasticity was negative, which means that a 1% increase in income would result in a decrease of 0.2695% in the demand for Salvador. Perhaps the explanation for this phenomenon is the fact that new customers have already traveled to the city and are looking for other destinations. The phenomenon must be better study in the future.

Credit for new customers is a stimulus for tourism and for the demand in air travel. An increase of 1% will result in an increase of 0.4603% in air travel demand to Salvador. The increase of credit has boosted the Brazilian economy. It has generated greater demand of the population for new products. One such product is tourism and the purchase of travel packages. Salvador stands out as one of the tourist destinations sought by people, who for the most part never flew by plane.

Tests were done to see how the chosen model would behave when used for forecasting and performance out of the sample. The criterion used to check the quality of the model prediction was the average difference between the value predicted by the model and the value found in the sample. The forecast included 30 months, from January 2011 through June 2013.

Comparison of linear and nonlinear model using logarithm (linlog, loglin and loglog models) for predicting showed linear, linlog and loglin models with very close average. The linlog model presented the lowest average and loglog model the largest. The GMM2S instrumented model showed best to forecast with a lower average of 43% when compared to the non-instrumented OLS model. The comparison between sub specification model, with the lack of variables, and the full model showed that the full model showed a lower average of 43% that the sub specification model.

V. AIR DEMAND SIMULATION FOR SALVADOR INTERNATIONAL AIRPORT

The demand for air transportation to the airport of Salvador, according to econometric evidence tends to increase with increased consumption of electricity, GDP proxy variable. An increase in demand will result in the increase of flights by the airlines.

1% and 5% increases in enel were considered affecting directly the increase in domestic passengers from 2013 to 2019. Two types of aircraft were considered operating at the airport, with a capacity of 180 passengers and one for 100 passengers. For the load factor, two scenarios were considered, with 50% on scenario A and 75% on scenario B. Annual and daily increase were simulated, whereas the demand was evenly distributed between 365 days.

The annual increase of domestic passengers is shown in Fig. 5.

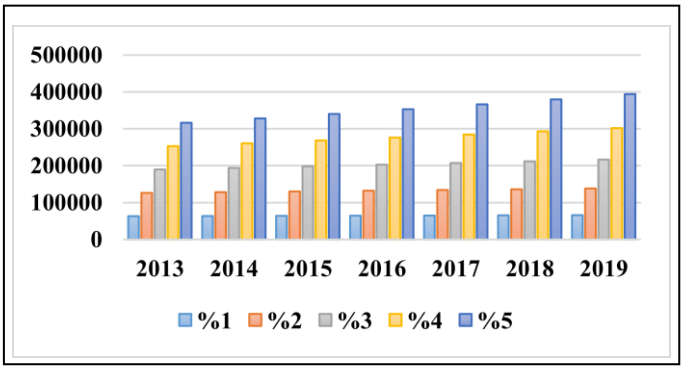

Figure 5. Increase in domestic passengers

In 1% increase scenario, the number of passengers increases annually on average 64.730 passengers. In the 5% increase scenario, the number of passengers increases annually on average 354.123 passengers.

The increase in annual flights considering that the airlines will use aircraft with capacity for 180 passengers in the two load factor scenarios (A for 50% load factor and B for 75% load factor) , as shown in Fig. 6.

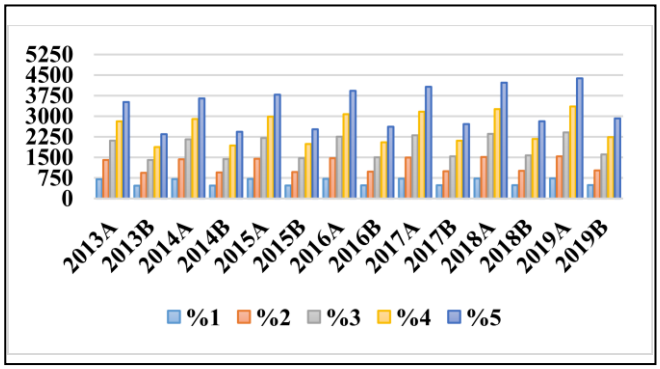

Figure 6. Annual flight increase for 180 passengers aircraft

In scenario A, the aircraft stand with their low occupancy rates, resulting in a greater number of aircraft to meet the demand. However, due to high costs and demand, aircraft tend in periods of high season fly at full capacity, maintaining an annual average of approximately 75%.

The increase of annual flights whereas 100 passenger capacity aircraft are used is represented in Fig.7.

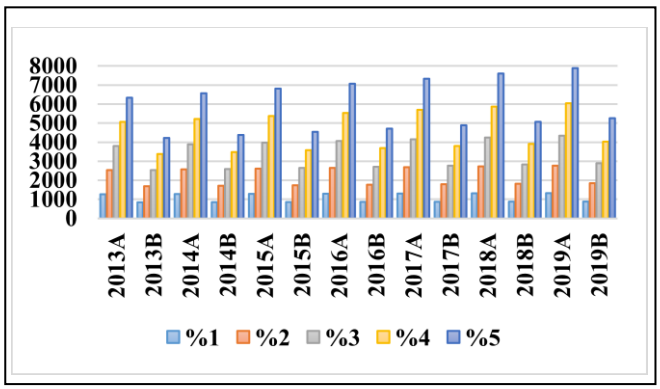

Figure 7. Annual flight increase for 100 passengers aircraft

The use of smaller aircraft tend to make greater use of airport capacity by 80%. For airports that do not have restrictions, the use of smaller aircraft brings the advantage of a higher rate of occupancy and higher profitability for the airlines.

The daily increase of flights considering aircraft with capacity for 180 passengers, and the number of flights rounded to the next whole number, as shown in Fig. 8.

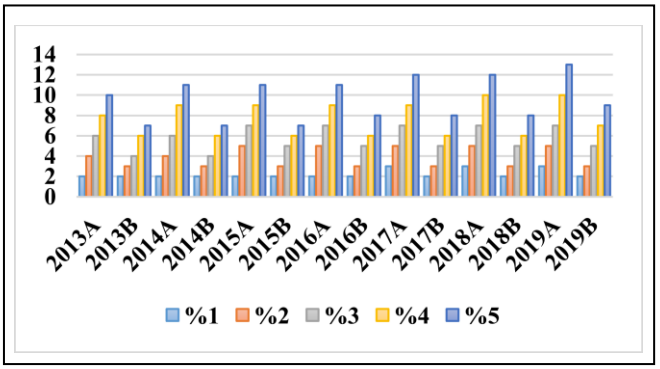

Figure 8. Daily flight increase for 180 passengers aircraft

Depending on the level of growth and the load factor, can occur daily increase of two to 13 flights. The daily increase of flights considering aircraft with capacity for 100 passengers, and the number of flights rounded to the next whole number, as shown in Fig. 9.

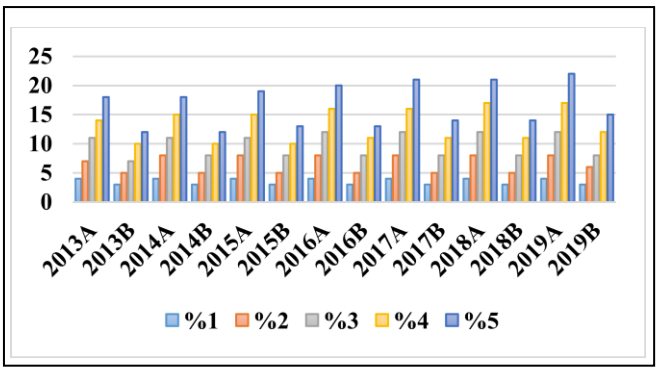

Figure 9. Daily flight increase for 100 passengers aircraft

The number of daily flights can increase three to 22, depending on the increasing wealth of the country and the load factor of the aircraft.

In a more conservative scenario the capacity will be little affected by the year 2020 does not represent problems for the military operation.

VI. CONCLUSION

Salvador International Airport has no current capacity problems. According to [3], the peak time occurs at 13 hours with 25 moves. Whereas [4] and 50% of arrivals, the airport's capacity is 50 operations.

Depending on the combination of the country's growth levels and the choice of aircraft to equip the fleets of airlines, the airport can experience operating levels near capacity, analyzing only domestic flights, leaving little room for the operation of aircraft for flights international, general aviation and military aviation.

It is important to notice that the airport has not yet many regular international flights such other Brazilian airports such as Galeão in the city of Rio de Janeiro and Guarulhos in the city of São Paulo. For this reason, it was not carried out a demand study for international passengers. Similarly, general aviation movements were not counted because of lack of frequency in comparison with the commercial aviation.

The problem of the model is that it is not possible to say that the country's wealth growth will occur at constant rates, just as we cannot guarantee what will be the airlines choice for aircraft fleet.

However, the planner must take scenarios and assume that some features of the past will help describe the future in making forecasts, especially in a strategic air base for maritime air patrol operations.

The airport expansion projects cost large amounts of money and require a certain amount of time. In this respect, the use of econometric tools, when used for understanding and predicting a phenomenon, can also help to ensure the defense of the nation's interests.

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