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# Predicting Passenger Volume from the Regional Airport Mário de Almeida Franco to City-Pairs

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# An Introduction to

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# Predicting Passenger Volume from the Regional Airport Mário de Almeida Franco to City-Pairs

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## Abstract

In the air transport sector, predicting the volume between city-pairs of an airport is extremely important for its development. With the support of this OD (Origin – Destination) matrix, it is possible to analyze the main destinations and origins of an airport, favoring the creation of new routes, new agreements or withdrawal of routes prioritizing the balance and financial development of the airport and the region. The air transport system transported 4 billion passengers in the year of 2017. The average of annual trips in developed countries is three times higher than in Brazil, although this difference has been decreasing. However, at Uberaba Airport, which we studied, the flow of passengers has decreased, amounting to only sixty thousand in 2017. The gravity model used to estimate the passenger volume has not been previously applied between city-pairs in Brazilian airports, nor on the studied airport. Based on such forecasts, airlines can make decisions regarding new routes or additional flights on existing routes. The purpose of this study is to predict the volume between city-pairs, using the gravity model, in order to improve the current scenario and hence the addition of new routes to Uberaba Airport, in Brazil. The study started from an analysis of the economic and social scenario of the region and city-pairs. The required data was collected by ANAC, IBGE, INFRAERO, HORUS and other Brazilian organs, and through a questionnaire with the city locals. This study used the gravity model that includes variables describing the general economic activity, geographical characteristics and air service characteristics of city-pairs. This paper presents a gravity model that can be used for air passenger volume forecasting between Uberaba and city-pairs. The estimate from the gravitational model shows that the most demanded destination in Uberaba had been excluded (Viracopos/Campinas-SP) in 2017/2018, causing a drastic decrease of its users in a short period. Through these results, airport operators can show this estimate to attract airlines to operate in the area, so they may offer more flights to serve the local demand. It is inferred from the present work the main factors that influences the volume of passengers of the Mário de Almeida Franco Airport, such as: GDP of the city-pairs, time of a car trip and population of these municipalities.

**Keywords:** Passenger Demand, Gravity Model, Regional Airport, Origin-Destination, Attraction.

**Acknowledgments:** Our thanks to Federal University of Triângulo Mineiro and the administration of Infraero Airports in Uberaba Airport.

## Introduction

The air mode, besides playing a very important role in the economic scenario of a country, is the fastest means of transportation when it comes to passengers, surpassing any other means in times of high globalization, and its annual growth rate keeps increasing more and more.

According to the report of the National Civil Aviation Secretary (SAC, 2017), in 2017 Brazil had a flow of 205.91 million passengers at Brazilians airports (boarding and disembarkation), and the domestic market, which is the focus of Uberaba Airport – Mário de Almeida Franco, grew by 2.12% in the respective year.

Given this context, it is interesting to analyze Brazilian airports that still have low infrastructure when compared to other poles of world aviation, but increase their annual flow of passengers regardless, especially Uberaba Airport, which is classified as a regional airport, and is highly important for the city and the state of Minas Gerais.

Understanding the origin and destination of an airport is one of the pillars for the proper functioning of this facility, as well as being the first step for a correct planning of the transport, especially the aerial, in this case. Through this study, airlines propose new routes or expansion for existing routes with their respective fleets, and the deactivation or reduction of existing routes, observing whether the movement grows or decreases.

According to Kodanda and Verma (2011), the origin-destination search of an aerodrome is crucial for its annual traffic forecast and its hierarchy in relation to other airports, whether it is regional or not, if it has the potential to be a hub for some airline and if it is viable.

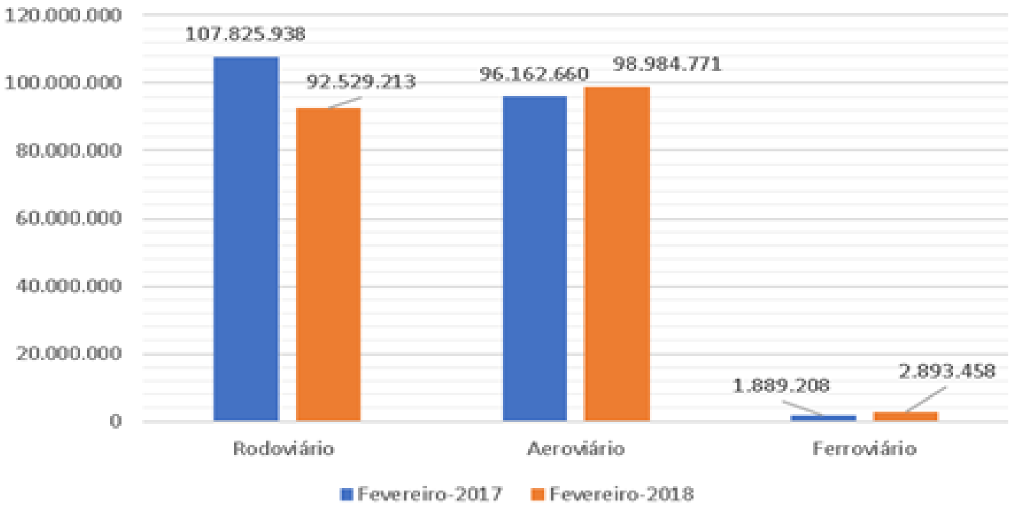
According to the Brazilian Institute of Geography and Statistics, in 2018 (IBGE, 2018), Uberaba had a population of 330361, which consolidated it as the eighth most populated city in Minas Gerais. Its Airport, in 2017, had a flow of only 61494 regular and non-regular passengers (INFRAERO, 2018); its usage rate has been dropping year after year.

Many airport users report difficulty in accessing destinations, due to the small number of flights that the airport in question provides. In 2018, the airport operated flights to only one destination, Belo Horizonte International Airport – Confins, and only one company served the city, Azul Brazilian Airlines.

Therefore, this work is very important to help understand the current state of the Airport, for, considering the population of the city and of Triângulo Mineiro, there was supposed to be a much higher demand than there was in 2017. There are cities with similar populations where the airport is busier than Mário de Almeida Franco.

Figure 1 shows the flow of passengers about main types of transport modes (Road, Air transport and Rail) in Brazil.

**Figure 1.** *Passengers Brazilian Traffic in February 2017 and 2018 in 3 Types of Transport Modes (Road, Air Transport and Rail) in Portuguese Language, Brazil - 2018*




*Source:* CNT 2018, adapted.

Being so, there is the need to identify the demand for the coming years and to come up with solutions for the infrastructure of Uberaba Airport, which leads to finding the consequent benefits in the regional economy by increasing the airport demand.

This paper intends to analyze the demand for air transportation at Mário de Almeida Franco Airport, in Uberaba, Minas Gerais. It seeks to identify which variables influence this passenger demand in domestic flights through an econometric study. In addition, we aim to analyze the economic influences of the airport under study in the region of Triângulo Mineiro, how improvements in operation can increase passenger demand for domestic flights in Uberaba and predicting passenger volume to city-pairs.

## Literature Review

### *Air Transport Economics*

Worldwide air transport moves, over the year, billions of passengers and tons of cargo, being that Europe and North America stand out as users of the service and in Asia, driven by China, Japan, Middle East and the Asian Tigers (Hong Kong, South Korea, Singapore and Taiwan), with aid from parts of Southeast Asia, the growth in the market is also remarkable (IATA, 2017).

In the economy, it is important to evaluate the economic interactions, buying and selling, between nations. To do so, it is indispensable to connect territorial regions of interest and facilitate displacement. The transportation system is the movement of people, goods and services (FALCÃO, 2013) and is directly related to economic and social development (Senna, 2014). Combining the concepts of economy and transport system, it is possible to create a new concept. The economics of transport is responsible for allocating resources for the transportation of people and cargo to different destinations.

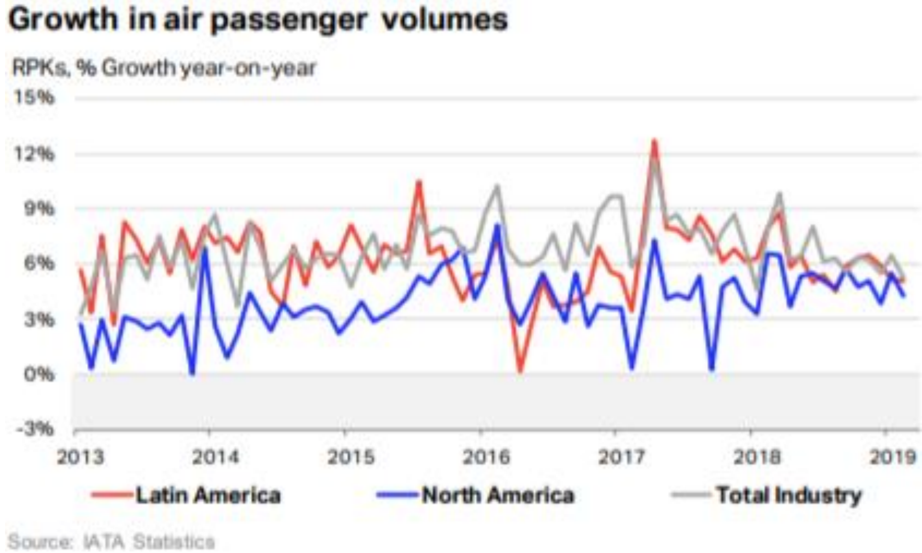
From the Industrial Revolution to globalization, the economic development happened through the greater integration of the regions. Globalization has brought growth in the use of various means of transportation, both for cargo and passengers (Senna, 2014). In addition, logistics and transportation began to play an important role in national trade and production chain (Barat et al., 2007). Yet this mobility from globalization is not symmetrical in all regions. At the same time, promoting economic development requires costs that generate disadvantages (Senna, 2014). Given such fact, it is important to implement public policies, mainly related to transportation planning, infrastructure and operation.

Historically, the transportation system has developed along with the development of the infrastructure. According to Senna (2014), the economy is shaped around a good infrastructure. It is therefore essential to study infrastructure in transport economics. Transport infrastructure can be defined as fixed capital that enables people to move goods and services. In order to identify the investments that must be made in the transportation infrastructure, it is necessary to know the purpose of the transactions carried out. From the identification of this purpose, there is an expansion in the infrastructure, causing greater development in the transportation system.

Investments in transportation infrastructure are transformed into economic growth. In developed countries, that is to say that they present better infrastructures, the transport represents 6% to 12% of the national GDP (Gross Domestic Product). This is because mobility generates greater productivity and competitiveness of goods and services in the macroeconomy (Senna, 2014). In addition, it ensures more availability of resources and markets to more people.

Figure 2 shows the growth in air passenger volumes in Latin and North America (2013 until beginning 2019).

**Figure 2.** *Growth in Air Passenger Volumes – Revenue Passenger Kilometers (RPKs)*



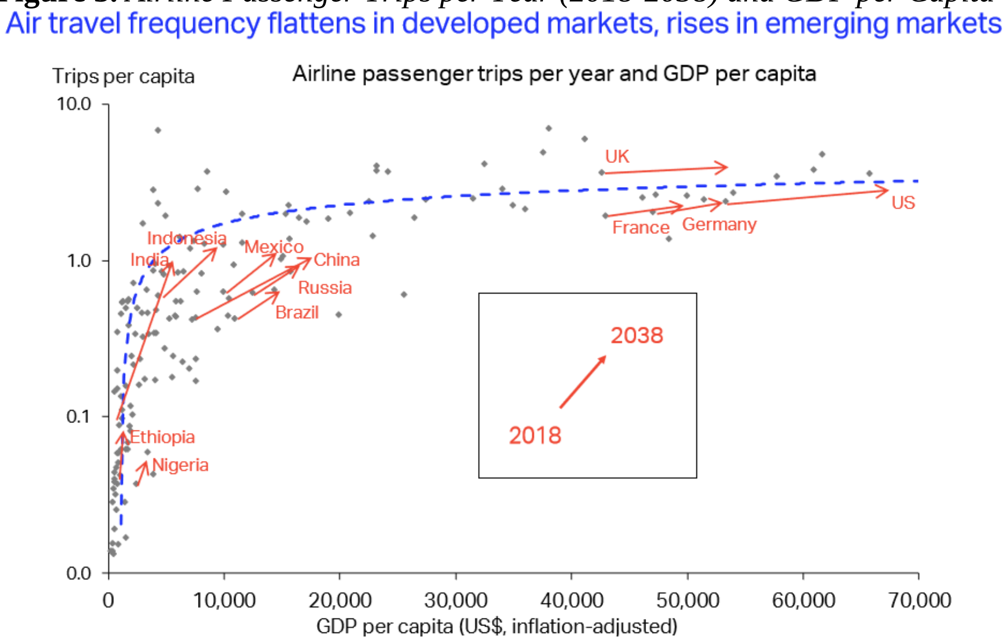
As mentioned above, macroeconomics should be studied in the long term, and this affects the planning of transports directly. Such planning should consider narrowing the gaps in globalization through incentive policies. Thus, it is important to identify that the transport economy is responsible for the movement of people, goods and services, through an efficient management of its scarce resources (Senna, 2014).

*International*

According to IATA (2017), the most powerful markets in international air transport are domestic flights in the United States, Europe and China. Particularly noteworthy are the companies American Airlines, United Airlines and Delta Airlines, which dominate the global passenger industry. Regarding freight transport, however, as defines IPEA (2010), Federal Express and UPS hold highlighted positions in the market.

According to Figure 3, IATA (2019), air travel markets are reaching maturity in most developed economies (France, Germany, United Kingdom and United States). The rise in the frequency of air travel of the average citizen, which underlies the expected growth in air passenger demand over the next 20 years, will occur mainly in the world's emerging markets (Brazil, China, Ethiopia, India, Indonesia, Mexico, Nigeria and Russia). This is one of the conclusions of the analysis by IATA and Tourism Economics in their latest 20-year air passenger forecast.

**Figure 3.** *Airline Passenger Trips per Year (2018-2038) and GDP per Capita*




*Source:* IATA, 2019.

Since World War II, aviation has strategically been regarded as the greatest potential for the development and integration of a region. Air transport has some peculiarities that make it a strategic model, such as speed of performance and safety. Then there was an accelerated growth of this transport system, mainly due to the technological advances of aviation (Diniz and Diniz, 2006).

*Brazilian Air Transport*

According to ANAC (2017), Brazilian companies carried 98.98 million paying passengers in 2017, including domestic and international flights. Still on this number, almost 91 million passengers were transported (shipments) in the Brazilian domestic market, an increase of 2.2% over the year pf 2016. The occupation of aircrafts for domestic flights was of 81.5% (growth of 1.8% compared to the previous year), surpassing 70%, which is the margin that airlines work to make a flight/route profitable for them.

As aviation causes more agility of connection, there is a competitive differential between the regions, which causes a greater development. However, the greater the economic performance of a region is, the greater the use of this mode of transportation. The growth of air transport, planning, infrastructure and operation depends on federal investments. Thus, the higher the income of a region is, the greater the view of the expansion of the sector (CNT, 2015).

Analyzing the other perspective, the greater the airport infrastructure, the greater the demand for this means of transportation; consequently, the greater the sector's production, employability and availability of credits. All of these are related to better macroeconomic performance, mainly through GDP growth. Therefore, that the air transport system impacts on the economic growth is a cyclical process, depending not only on passenger demand, but on other economic activities linking the two regions.

Another feature of capital-intensive industries is the high fixed cost of operation. The same is true for air travel. Today, Brazil is the third country with the largest domestic air transport market. This reality was only possible because of the gradual increase in demand in the sector and consequently more productivity in the operation of airlines. This causes a reduction on the average costs of tickets, because the higher productivity there is in the sector, the lower are the costs on a large scale. Therefore, from 2000 to 2014, the number of passengers in the sector increased by 210.8% in Brazil (CNT, 2015).

Within the air transport economics, it is possible to analyze two fronts: airports and airlines. In Brazil, airlines form an oligopoly, i.e. the market is concentrated and presents a small number of vendors that compete with each other (MANKIW, 2010). The oligopoly contributes to a concentration in the air network (CNT, 2015) and a reduction in the routes, mainly in regional airports. Analyzing the data for 2017, it has been seen that the market share of domestic flights was concentrated between two airlines, GOL with 36.2% and LATAM with 32.6%. Azul and Avianca participated with 17.8% and 12.9%, respectively, of the total of flights in that year (ANAC, 2017) as shown in Figure 4.

Brazil, in 2015, had seven national airlines, which operated regional domestic flights. Out of the seven companies, four airlines represent more than 90% of the supply (CNT, 2015). That makes it explicit that many routes between large centers are considered monopolies. A monopoly is when a company sells a product without competition (Mankiw, 2010).

**Figure 4.** *Overview of Brazilian Air Transport in 2017, Brazil - 2017*


*Source:* ANAC, 2017.

*Airports*

According to Souza (2010), the airport complex is essential for air transportation, since there is a basic infrastructure of services for passenger mobility and cargo transportation. The installation and expansion of an airport has a direct impact on the quality of life of the region close to it, in addition to impacting the environment around the aerodrome. Besides that, the entire airport tinkers with the economy, society and politics of the city where it is located. The passenger terminal of an airport is already understood to be a commercial venture and no longer only for "exclusive" passenger use.

According to Brida et al. (2016), the satisfaction level of a passenger is a very important performance indicator for the operation and management of airport terminals. The world's major freight and passenger airports are located in major world economies.

<u>Brazilian Airports</u>

Regional aviation is an important catalyst in the process of internationalizing a country. Since Brazil is a country of continental dimensions, the 5th largest in the world, aviation is of extreme importance for the country's operation (CNT, 2015).

There is a program by the National Civil Aviation Bureau to enhance regional aviation in Brazil called Regional Aviation Program, which was launched in December of 2012 with the aim to connect Brazil and bring development and social services to places far from major centers – as is the case of the Amazônia Legal (SAC, 2017).

To do so, the Bureau of Aviation will invest about R$ 7.3 billion in the construction or renovation of 270 airports throughout the national territory. The idea is to leave 96% of the population at least 100 kilometers away from a passenger terminal. Today, 40 million people are farther from an aerodrome than that. The program's investment comes from the National Civil Aviation Fund (FNAC), consisting of aviation fees and grants, and can only be invested back in the sector itself. The contracting companies responsible for studies and works are dealt with directly by the Federal Government and there is no transfer of funds to states and municipalities. The Program is supported by three pillars: airport infrastructure, management and subsidies (ANAC, 2017).

Despite the oligopoly in the sector, airlines have a great financial capacity to expand. In addition, with the incentives from ANAC to dismiss the payment of operation fees, it is possible to predict a greater competitiveness in air transport (McKinsey and Company, 2010).

### Regional Airports

The air transport economics in Brazil has favorable development conditions compared to the world scenario (McKinsey and Company, 2010). Despite infrastructural bottlenecks, the sector has seen an increase in demand over the last year. According to ANAC (2018) in December 2017, the number of passengers compared to 2016 increased 5.6%.

In Macario and Silva's (2009) perspective, regional airports are important catalysts in the process of market integration and globalization. Local industry benefits from reduced transport costs at these airports, increasing its market reach and being more competitive.

### *Gravity Models for Airports*

Understanding the demand is fundamental in the development of transport networks, mainly for aviation. There are many methods to use to analyze the demand, and the conventional methodologies have high costs and time of execution that restrict the frequency of their application (IATA, 2017).

Preparing a Destination-to-Destination Matrix search for airports is important as it enables the airport to find out which destinations its customers are most traveling to and from and which aerodrome most passengers choose to use. The results obtained are consistent and help many airlines, together with airport administrations, to calculate new routes or deactivate existing ones.

According to Grosche et al. (2007), in their study, there are a number of models that help determine the estimated future forecast of a source / destination matrix at airports. Examples of these models are the Gravitational Model and ARIMA Models (George Box and Gwilym Jenkins).

In this study, the gravitational model will be studied and put into practice.

Gravitational models originated from the Law of Universal Gravitation enunciated by Isaac Newton in 1686, as follows: "Two material particles attract themselves with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them, being the force directed according to the line that unites them" (Barat et al., 2007).

To study air transport demand, the Dutch economist Jan Tinbergen introduced the gravitational model in this field in 1962 (Olariaga et al., 2018).

According to Fellipi Tomé (2007) in its work of forecasting demand for road transport in the southern region of Brazil, data can be used to calculate areas served by road transport for air transport. The gravitational model can be used to calculate the number of trips between two airports:

$$Tij = (k \times Oi \times Dj)/dij^2 \quad (1)$$

where in Equation 1: Tij = number of trips between airports i and j, k = constant, Oi = number of trips originating from the airport i, Dj = number of trips originating from the airport j, dij = distance between airports i and j.

Through this equation, one must analyze the number of trips required from Uberaba Airport with its main destinations and see if the calculated result is close to what is put into practice.

According to Grosche et al. (2007), in their study, there are two methods that use the gravitational model to estimate the volume of passengers between airports. These models include economic variables, geographic characteristics of cities and air transport variables. They can be applied when the air transport service is decaying between the two routes, when there is a forecast history of demand from the airport studied, or when a new airport will be introduced in the area so that it can, before its construction, make a forecast of demand, concluding whether the airport will be viable or not.

The simple formula of the gravitational model to predict demand between two cities is:

$$Vij = k \times (Ai \times Aj)^{\alpha} \div dij^{\gamma} \quad (2)$$

where in Equation 2: Vij is the volume of passengers between cities i and j, Ai and Aj are attraction factors of cities i and j, respectively. k is a constant, γ and α are parameters of influence on travel demand and control of attraction influence, respectively. Moreover, dij = dji, which is the distance between cities i and j in kilometers.

The first gravitational model developed to estimate passenger volume is called the Basic Gravity Model (BM), which minimizes the effects of competition between destinations, for example, excluding cities that have several airports and serve as a hub for other destinations in the world, like Berlin and London.

The second gravitational model is classified as Extended Gravity Model (EM), which is an extension of the BM, including cities that have several airports and serve as a link to many destinations on the planet.

The BM formula is:

$$Vij = e^{\varepsilon} Pij^{\pi} Cij^{\chi} Bij^{\beta} Gij^{\gamma} Dij^{\delta} Tij^{\tau} \quad (3)$$

where in Equation 3: Vij is the total sales volume between cities i and j, Pij = PiPj (Population), Cij = CiCj (Heritage of destinations) includes areas that already occupy 60 minutes of distance and are considered the considered airport = Catchment, Bij = Bi + Bj which refers to the purchasing power of citizens in the two cities, Dij = geographical distance between cities in kilometers, Tij = Average travel time between two locations without connections and Gij = (GiGj), that classifies the gross domestic product of each country where the airport is located (GDP).

A formula of (EM) is:

$$Vij = e^{\varepsilon} Pij^{\pi} Cij^{\chi} Bij^{\beta} Gij^{\gamma} Dij^{\delta} Tij^{\tau} Nij^{\upsilon} Aij^{\alpha} Wij^{\omega} \quad (4)$$

where in Equation 4, a formula (BM) is added like so: Nij (NiNj) = Number of competing airports, Aij (AiAj) = Average distance between leading airports and Wij (WiWj) = Number of airports where people are weighted.

The methodology and the case study will use the three methods explained above to predict the Origin - Destination in Uberaba Airport. There will be pages to aid the students' study program, and through the aid of the regression, we intend to find a closer transmission of the Matrix Origin - Destination of the Mário de Almeida Franco Regional Airport.

According to Cohen (2016), gravitational models can be used to exemplify international business changes. In aviation, the model can determine the market potential between the two cities.

The Table 1 shows the main references about gravity models in air demand that were used in this study.

**Table 1.** *Gravity Models Main References in this Work*

| **Authors (Year):** | **Title of Work:** | **Objective:** | **Methodology:** | **Conclusions:** |
|---|---|---|---|---|
| Kodana and Verma (2011) | Estimation of Origin-Destination Air Traffic flows from Air Transport Movement Data: Application to Indian Domestic Airport Network System | Study and Estimate Origin-Destination city-pair passenger air traffic based on Director General Civil Aviation airport statistics and scheduled airlines data | Calculation of load factors, distribution of origin traffic to various destinations, test for convergence and then a Correction factor (δj) | The approach that is followed to determine Origin-Destination passenger traffic flows from DGCA and airlines data was helpful to get to an O-D passenger traffic matrix of size 65x65 (airports), for 314 Indian city-pairs |
| Thelle (2017) | Air Competition in Europe | Analyze the development of European airports in competitive constraints in the face of changes in the European aviation market over the last 20 years | Comparing graphics and data | Showed that the European aviation market is extremely dynamic and passengers had more choice of airports in 2011 than in 2002 |
| Grosche et al. (2007) | Gravity models for airline passenger volume estimation | Estimation of air passenger volume between city-pairs | Two Gravity Models include variable describing the | Both Models show a good fit to the observed data and |

| | | | | |
|---|---|---|---|---|
| | | | general economic activity and geographical characteristics of city-pairs instead of variables describing air service characteristics | are statistically tested and validated |
| Cohen (2016) | A Gravity Model for Aviation Forecasting "A fixed effects model for predicting global air passenger city-pair market potential" | Explain global city-pair air travel demand | Build an econometric forecasting model by a Gravity Model | The findings show that income and population are important drivers of air travel demand. Consequently, that excludes all low demand routes, because they are not interesting to forecasters in aviation |
| Çuhadar (2014) | Building proper forecast models for daily air passenger demand: A study of Antalya International Airport | Build a proper model to forecast daily air passenger demand to Antalya International Airport | Using ARIMA, which is also known as Box-Jenkins methodology | The final model was identified as ARIMA (5,1,6). The use of ARIMA model building method for short to medium term forecasting has been long acknowledged for its versality and accuracy |

*Source:* Author, 2019.

## Methodology

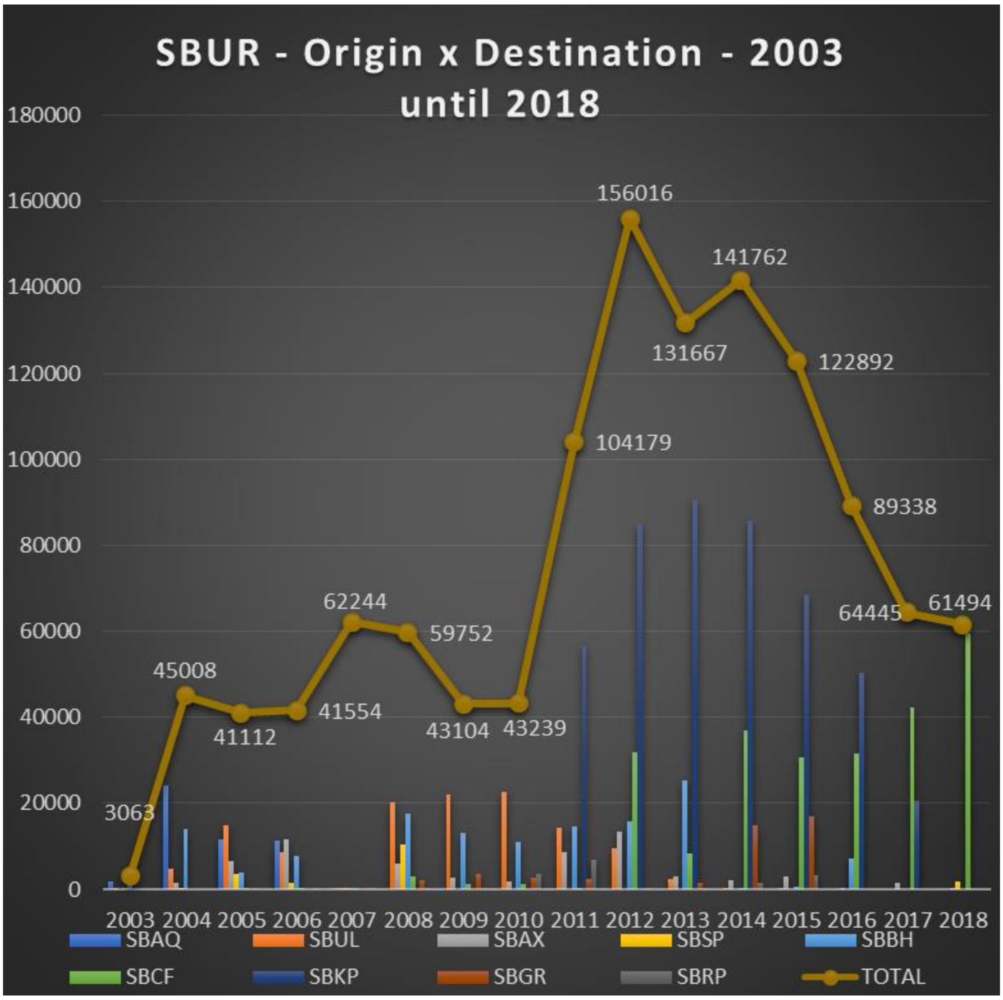
The present study is an estimation research that will be applied with a quantitative approach. It has experimental descriptive objectives regarding Mário de Almeida Franco Airport, in Uberaba. The study will be carried out according to the research steps presented below.

### *Research Steps*

Based on a questionnaire (attached) developed for the Decola Uberaba Project to understand the demand of Mário de Almeida Franco Airport, we learned the main routes and airports that users of this terminal used more frequently in the year of 2018.

INFRAERO provided passenger data for the airport from 2003 to 2018 and, with Figure 5, the graphic depicting the period was obtained, consisting of the airports that have the most connections with Uberaba and a table based on the principles of Grosche et al. (2007) study. They were used to make the Gravitational Model of this paper with the help of the GRETL Software. GRETL is an open-source statistical package, mainly for econometrics. The name is an acronym for Gnu Regression, Econometrics and Time-series Library (Cottrell and Lucchetti, 2019).

**Figure 5.** *Movement of Passengers in Uberaba Airport (ICAO-SBUR) – Mário de Almeida Franco (2003-2018) to City-Pairs (Origin x Destination). INFRAERO Data. Brazil - 2019*




*Source:* Author, 2019.

For the definition of the econometric model in GRETL, annual data were used from 2003 to 2018. The topics considered were: Airport and city where the terminal is located, year (2003-2018), city population in each year, city GDP every year in (R$) thousands, duration of the journey by car: Uberaba to Airport (Hours), duration of the journey by bus: Uberaba to the cities (Hours), distance between Uberaba and the cities, and the flow of passengers between two cities (number of people).

City-pairs with Airports are: Pampulha and Confins in Belo Horizonte – MG, Congonhas in São Paulo – SP, Guarulhos-SP, Viracopos in Campinas-SP, Brasília-DF, Santos Dumont and Galeão in Rio de Janeiro-RJ.

## Findings/Results and Discussion

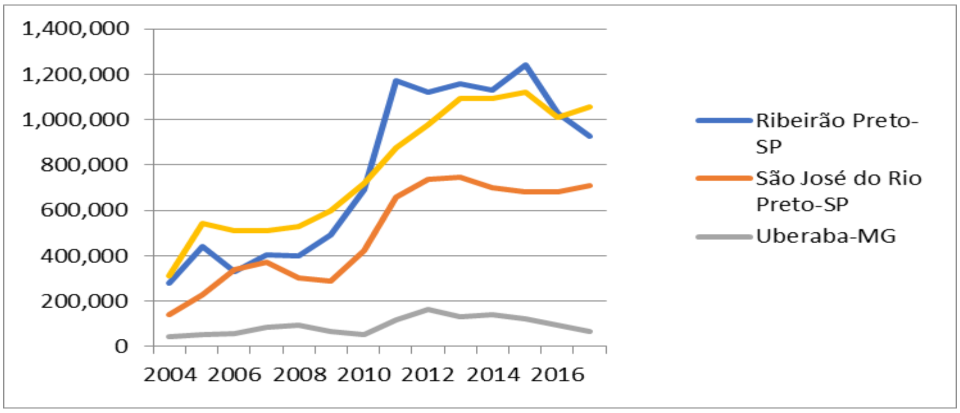
With the increase in the flow of passengers in air transport, regional airports become strategic to consolidate this model. Thus, it is necessary to assess the demand for regional airports to ensure a faster and safer connection to other locations and their integration through aviation (ABAETAR, 2011).

It is thus important to analyze the recent growth in passenger demand at regional airports and their direct influence on the economy. Uberaba is a city located in the Triângulo Mineiro Region, which is a strategic region, within a radius of 500 km from the main capitals of the southeast and mid-west regions and the Federal District (Gomes, 2016). Therefore, it is worth mentioning that the study of the demand for air transportation in Mário de Almeida Franco Airport can generate more investments, and consequently an improvement in the economy.

In addition, according to INFRAERO (2019), Uberaba is one of the regional airports with the greatest potential for growth. In 2009 the number of passengers at Mário Almeida Franco Airport was 43104, and the forecast in 5 years was 370315 passengers. However, in 2014, Uberaba had a demand of 141762 passengers, failing to meet growth expectations for the same year. In 2017, demand fell to 64445 passengers (INFRAERO, 2019). It is believed that the decrease of passengers occurred due to the political-economic crisis and the low number of routes found in Mario de Almeida Franco Airport.

In Figure 6, the Uberaba airport was always constant when compared his flow of passengers to its main competing terminals. It is inferred that, while Mário de Almeida Franco Airport remained constant and in last place, its competitors grew up.

**Figure 6.** *Movement of Passengers in Ribeirão Preto Airport (IATA-RAO), São José do Rio Preto Airport (IATA-SJP), Uberaba Airport (IATA-UBA), Uberlândia Airport (IATA-UDI). (2004-2017). Competitive Airports. INFRAERO Data. Brazil – 2019*




*Source:* Author and Decola Uberaba, 2019

Uberaba is worldly known as the capital of Zebu (a bovine breed). It is also the largest agricultural producer in the state of Minas Gerais. This locality has three industrial districts of great economic importance. In the municipality, there are factories of furniture, food, footwear and chemicals. According to an IBGE study, in 2018, the city had a population of 330400, being the 8th most populated municipality in the state, and data for 2016 indicated a GDP/city of R$ 13.5 billion as well as a GDP per capita of R$ 41.4 thousand (IBGE, 2019).

According to INFRAERO (2019), the technical characteristics of Uberaba Airport (IATA / ICAO: UBA / SBUR) are a runway with dimensions of 1759 meters x 45 meters, 2030m² of passenger terminal area, parking for 20 small aircrafts (e.g. ATR - 42, ATR - 72), parking for 63 cars, capacity of 1.7 million passengers per year, aircraft yard of 13450 m², and the airport site has 1182 million m². INFRAERO Airports, which is a Brazilian federal company linked to the Bureau of Infrastructure, operates this terminal.

The database for the study will be presented in this section first, then discussions on the models analyzed and a presentation of the best model that describes the prediction of passenger volume from Mário de Almeida Franco to city-pairs. Finally, the results of the study will be presented.

In the econometric study, Ordinary Least Squares are grouped and Weighted Least Squares are in a single type of model (Logarithm-Logarithm), in which the dependent and independent variables are in the logarithmic form, through regression.

In the first analysis, the model was applied to all variables chosen, as presented in Table 2. The variables with the highest significance for the model are those with the highest T-Reason value and those with the lowest P-Value.

**Table 2**. *Model 1: MQO (Minimum Quantity Order-Ordinary Least Squares) Grouped, using 69 Observations, including Eight Cross-sectional Units. Length of Time Series: Minimum 4, Maximum 12. Dependent Variable: l_Flow_of_ Passengers*

| **Variable** | **Coefficient** | **Standard Error** | **T-Reason** | **P-Value** | **Importance of Variable (*):** |
|---|---|---|---|---|---|
| const | -4262.98 | 2490.72 | -1.725 | 0.0895 | * |
| l_Airport | -2.90456 | 1.78324 | -1.629 | 0.1085 | - |
| l_Year | 561.565 | 325.584 | 1.725 | 0.0896 | * |
| l_Population | 0.418420 | 2.57783 | 0.1623 | 0.8716 | - |
| l_City_GDP | -0.745755 | 1.94774 | -0.3829 | 0.7031 | - |
| l_Time_car_Hour | 3.11353 | 17.3931 | 0.1790 | 0.8585 | - |
| l_Time_bus_Hour | -14.0277 | 17.7980 | -0.7882 | 0.4337 | - |
| l_Distance_KM | 5.75962 | 7.43406 | 0.7748 | 0.4414 | - |
| **Other Values:** | **Sum of the squares of the residuals:** 234.0034 | **D.P. dependent variable:** 2.701175 | **E.P. of Regression:** 1.958602 | **Hannan-Quinn:** 303.1691 | **Schwarz:** 313.9512 |
| **P (Rho):** -0.327245 | **R² (R squared):** 0.528363 | **P-Value (F)**: 4.29e-08 | **Akaike**: 296.0783 | **F(7, 61)**: 9.762400 | **Durbin-Watson**: 1.733722 |
| **Dependent variable (Flow of Passengers) average**: 7.356454 | **Logarithm of likelihood**: -140.0392 | **Adjusted R²**: 0.474241 | | | |

*Source:* Author with Gretl, 2019.

The VIF (Variance Inflation Factor) Test, Table 3, needs to be done to check for any collinearity problems in Model 1.

**Table 3**. *Variance Inflation Factor (VIF) Test, Minimum Possible Value = 1.0, Values> 10.0 may Indicate a Collinearity Problem*

| | |
|---|---|
| l_Airport | 8.193 |
| l_Year | 2.514 |
| l_Population | 9.602 |
| l_City_GDP | 9.675 |
| l_Time_car_Hour | 318.815 |
| l_Time_bus_Hour | 191.995 |
| l_Distance_KM | 51.243 |

*Source:* Author with Gretl, 2019.

From Table 3, it is possible to study the Variance Inflation Factor that verifies the multicollinearity of the variables, which can interfere in the best model. The variance inflation factor (VIF) has a VIF = 1.00 value when there is an absence of multicollinearity, and when VIF> 10, it indicates multicollinearity problems, which may interfere with the model. It is possible to notice that the variables *l_time_car_Hour* and *l_time_bus_hour* have the highest VIF.

According to Falcão and Caixeta Silva (2018), multicollinearity generates a problem in the econometric model when the regressors are correlated. So is the case with time by a car trip (hours) and time by a bus trip (hours). This happens because they are time series. To correct multicollinearity, Model 2 was applied as depicted in Table 4 by the WLS (Weighted Least Squares) method.

VIF (j) = 1 / (1 – R (j) ^ 2), where R (j) is the coefficient of correlation between the variable j and the other independent variable.

**Table 4.** *Model 2: WLS (Weighted Least Squares), using 69 Observations, including Seven Cross-sectional Units, Corrects the Multicollinearity. Weights based on Error Variances per Unit. Dependent Variable: l_Flow_of_Passengers*

| **Variable** | **Coefficient** | **Standard Error** | **T-Reason** | **P-Value** | **Importance of Variable (*):** |
|---|---|---|---|---|---|
| const | -5089.93 | 2515.41 | -2.024 | 0.0474 | ** |
| l_Airport | -2.33891 | 1.77604 | -1.317 | 0.1928 | - |
| l_Year | 617.465 | 331.310 | 2.027 | 0.0471 | ** |
| l_Population | 1.67013 | 2.59570 | 0.6434 | 0.5224 | - |
| l_City_GDP | -1.78365 | 1.95299 | -0.9133 | 0.3647 | * |
| l_Time_car_Hour | 2.67147 | 18.7390 | 0.1426 | 0.8871 | - |
| l_Time_bus_Hour | -11.5223 | 18.2284 | -0.6321 | 0.5297 | - |
| l_Distance_KM | 3.48566 | 7.08365 | 0.4921 | 0.6244 | - |
| **Statistic based on weighted data**: | **Sum of the squares of the residuals**: 67.16483 | **$R^2$ (R squared)**: 0.662684 | **P-Value (F)**: 2.66e-12 | **Akaike**: 209.9535 | **Hannan-Quinn**: 217.0443 |
| | **Schwarz**: 227.8264 | **F(7, 61)**: 17.11990 | **Logarithm of** | **E.P. of Regression**: | **Adjusted $R^2$**: |

| | | | | | |
|---|---|---|---|---|---|
| | | | **likelihood**: -96.97675 | 1.049315 | 0.623975 |
| **Statistic based on original data:** | **Dependent variable (Movement of Passengers) average**: 7.356454 | **D.P. dependent variable**: 2.701175 | **E.P. of Regression**: 1.973455 | **Sum of the squares of the residuals:** 237.5661 | |

*Source:* Author with Gretl, 2019.

The R-square represents how much the model adheres to the variables, so the closer to 1.00, the more adjusted the model is. The adjusted R-squared is the measure of the degree of variation of the model setting. In the models presented, they all have a reasonable fit to the model. However, the one with the highest value of $R^2$ is Model 2, with a value of 0.662684 and the adjusted $R^2$ of 0.623975.

**Table 5.** *Model 3: WLS (Weighted Least Squares), using 69 Observations, including Seven Cross-sectional Units. Removing the Variable l_Time_bus_Hour of Model 2. Weights based on Error Variances per Unit. Dependent Variable: l_Flow_of_Passengers*

| **Variable** | **Coefficient** | **Standard Error** | **T-Reason** | **P-Value** | **Importance of Variable (*):** |
|---|---|---|---|---|---|
| const | -6205.96 | 1871.01 | -3.317 | 0.0015 | *** |
| l_Airport | -1.37575 | 1.00082 | -1.375 | 0.1742 | - |
| l_Year | 816.843 | 248.857 | 3.282 | 0.0017 | *** |
| l_Population | 2.92472 | 1.78227 | 1.641 | 0.1059 | - |
| l_City_GDP | -2.68237 | 1.40234 | -1.913 | 0.0604 | * |
| l_Time_car_Hour | -8.43615 | 5.39090 | -1.565 | 0.1227 | - |
| l_Distance_KM | 3.73238 | 6.96171 | 0.5361 | 0.5938 | - |
| **Statistic based on weighted data:** | **Sum of the squares of the residuals**: 67.03406 | **$R^2$ (R squared):** 0.656752 | **P-Value (F):** 9.45e-13 | **Akaike**: 207.8190 | **Hannan-Quinn**: 214.0234 |
| | **Schwarz**: 223.4578 | **F(6, 62):** 19.77123 | **Logarithm of likelihood**: -96.90951 | **E.P. of Regression**: 1.039805 | **Adjusted $R^2$:** 0.623534 |
| | | | | | |
| **Statistic based on original data:** | **Dependent variable (Flow of Passengers) average:** 7.356454 | **D.P. dependent variable:** 2.701175 | **E.P. of Regression**: 1.964892 | **Sum of the squares of the residuals:** 239.3695 | |

*Source:* Author with Gretl, 2019.

In Table 6 (Model 4), the variable *l_distance_KM* is removed because it had the highest P-Value in Table 5.

**Table 6.** *Model 4: WLS (Weighted Least Squares), using 69 Observations, including Seven Cross-sectional Units. Removing the Variable l_distance_KM. Weights based on Error Variances per Unit. Dependent Variable: l_Flow_of_ Passengers*

| Variable | Coefficient | Standard Error | T-Reason | P-Value | Importance of Variable (*): |
|---|---|---|---|---|---|
| const | -6926.82 | 1404.07 | -4.933 | <0.0001 | *** |
| l_Airport | -0.900402 | 0.480051 | -1.876 | 0.0653 | * |
| l_Year | 913.820 | 184.687 | 4.948 | <0.0001 | *** |
| l_Population | 3.68213 | 1.12786 | 3.265 | 0.0018 | *** |
| l_City_GDP | -3.25459 | 0.922382 | -3.528 | 0.0008 | *** |
| l_Time_car_Hour | -5.65004 | 1.53187 | -3.688 | 0.0005 | *** |
| **Statistic based on weighted data:** | **Sum of the squares of the residuals**: 66.39490 | **$R^2$ (R squared):** 0.648008 | **P-Value (F):** 3.92e-13 | **Akaike**: 205.1580 | **Hannan-Quinn**: 210.4760 |
| | **Schwarz**: 218.5626 | **F(5, 63):** 23.19624 | **Logarithm of likelihood:** -96.57898 | **E.P. of Regression**: 1.026590 | **Adjusted $R^2$:** 0.620072 |
| **Statistic based on original data:** | **Dependent variable (Movement of Passengers) average:** 7.356454 | **D.P. dependent variable**: 2.701175 | **E.P. of Regression**: 1.960577 | **Sum of the squares of the residuals:** 242.1634 | |

*Source:* Author with Gretl, 2019.

In Model 4 (Table 6), which is the method that best fits the reality data because of its low p-value in the variables, the values of $R^2$, which is 0.648008, and adjusted $R^2$, which is 0.620072, are not as close to 1.00, because, to achieve that, we would need a broader data collection and more observations (more variables, more years), as can be seen in other works in this area.

Among the models, represented in the study tables, the model with the lowest p-value is Model 4, the most significant models being the distance-between-cities and time-by-bus variables. Among the variables with greater significance in model four are the *Constant, Year, City GDP, Population and time by a car journey*. The significance of *City GDP* in the model is justified because the increase of the population's income in the cities also increases the flow of passengers in air transport and hence its attractiveness. The duration of the journey, time by a car trip, also reflects on the increase in demand, because the longer it takes to get to a destination by car, the greater the chance that users will opt for air transport instead.

**Table 7.** *Model 5: MQO (Minimum Quantity Order-Ordinary Least Squares) Grouped, using 69 Observations, including Seven Cross-sectional Units. Removing the Variable l_distance_KM and l_Time_bus_Hour from Model 1. Length of Time Series: Minimum 5, Maximum 12. Dependent Variable: l_Flow_of_Passengers*

| Variable | Coefficient | Standard Error | T-Reason | P-Value | Importance of Variable (*): |
|---|---|---|---|---|---|
| const | -6128.30 | 1767.73 | -3.467 | 0.0010 | *** |
| l_Airport | -1.06449 | 0.506662 | -2.101 | 0.0397 | ** |
| l_Year | 808.687 | 232.474 | 3.479 | 0.0009 | *** |
| l_Population | 2.71262 | 1.46675 | 1.849 | 0.0691 | * |
| l_City_GDP | -2.38452 | 1.23369 | -1.933 | 0.0578 | * |
| l_Time_car_Hour | -5.70852 | 1.43799 | -3.970 | 0.0002 | *** |
| **Other Values**: | **Sum of the squares of the residuals:** 238.6612 | **D.P. dependent variable:** 2.701175 | **E.P. of Regression:** 1.946348 | **Hannan-Quinn:** 303.1691 | **Schwarz**: 306.8429 |
| **P (Rho):** 0.351410 | **$R^2$ (R squared):** 0.518975 | **P-Value (F):** 5.35e-09 | **Akaike**: 293.4383 | **F(5, 63):** 13.59408 | **Durbin-Watson**: 1.039303 |
| **Dependent variable (Flow of Passengers) average:** 7.356454 | **Logarithm of likelihood**: -140.7191 | **Adjusted $R^2$:** 0.480799 | | | |

*Source:* Author with Gretl, 2019.

The models represented in the study tables (2, 4, 5, 6, and 7); the one with the lowest p-value is Model 4, the most significant models being the distance-between-cities and time-by-bus variables. Among the variables with greater significance in Model 4 are the *Constant, Year, City GDP, Population and Time by a Car Trip.*

Table 8 represents the predicting volume of the regional airport Mário de Almeida Franco to city-pairs by Ordinary Least Squares. This table compares the prediction based on the gravity model proposed in this work with the flow of passengers observed in the Uberaba Airport during the period from 2003 to 2018.

**Table 8.** *Predicting Volume of the Regional Airport Mário De Almeida Franco to City-Pairs by MQO (Minimum Quantity Order-Ordinary Least Squares) Grouped, using 69 Observations, including Eight Cross-Sectional Units. The Research Ranged from 2003 to 2018, but, to Summarize it in the Study, we Present the Results of the Years in which there were More Intense Flows in Figures 5 and 6, and Last Year's (2018) Flow in Figure 5. Figure 5 was used to compare the Flow of Passengers. Length of Time Series: Minimum 4, Maximum 12. Dependent Variable: L_Flow_of_Passengers*

| **Airports** | **Flow of passengers in Natural Logarithmic scale (e) on 2007** | **Flow of passengers in Natural Logarithmic scale (e) on 2012** | **Flow of passengers in Natural Logarithmic scale (e) on 2018** | **Prediction in Logarithm scale (e) (2007;2012;2018)** | **Standard Error (2007;2012;2018)** | **Confidence Interval 95% (2007);(2012);(2018) t (63, 0.025)=1.998** |
|---|---|---|---|---|---|---|
| Pampulha-BH | 9.14228 | 9.66644 | 0 | (8.32;9.00;0) | (2.00;2.02;0) | (4.31,12.33)<br>(4.97,13.04)<br>0 |
| Confins-BH | 8.64206 | 10.3663 | 10.9960 | (7.18;7.86;9.98) | (1.98;1.98;2.07) | (3.21,11.14)<br>(3.91,11.80)<br>(5.85,14.12) |
| Congonhas-SP | 9.33176 | 0 | 0 | (7.30;0;0) | (2.09;0;0) | (3.12,11.48)<br>0<br>0 |
| Guarulhos-SP | 7.27725 | 3.58352 | 0 | (6.95;7.65;0) | (2.02;1.98;0) | (2.92,10.98)<br>(3.69,11.61)<br>0 |
| Viracopos-SP | 4.11087 | 11.3505 | 5.02388 | (7.86;8.52;10.70) | (2.05;2.02;2.09) | (3.75,11.97)<br>(4.49,12.56)<br>(6.53,14.88) |
| Brasília-DF | 5.78383 | 5.27300 | 0 | (4.55;5.49;0) | (2.02;2.03;0) | (0.51,8.59)<br>(1.43,9.55)<br>0 |
| Galeão-RJ | 0 | 0 | 0 | (0;0;0) | (0;0;0) | 0<br>0<br>0 |
| Santos Dumont-RJ | 4.18965 | 0 | 0 | (3.21;0;0) | (2.10;0;0) | (-0.98,7.40)<br>0<br>0 |

*Source:* Author with Gretl, 2019.

Analyzing Table 8, it was sought to choose the years of greatest flow according to Figures 5 and 6 and the year of 2018 in Figure 5 too. When comparing the values found in Table 8 with figure 5 and the questionnaire (attached), we notice that the cities that are most sought after by the users of Mário de Almeida Franco Airport are Belo Horizonte and Viracopos, which, despite being in Campinas, receives passengers bound for other places (Azul Linhas Aéreas hub) and users who go to São Paulo, as they are localities nearby.

Looking further at Table 8, these figures from Belo Horizonte (Pampulha and Confins) and Viracopos show that the volume forecast for these airports is related to the only companies that operate in Uberaba, which are Azul Linhas Aéreas to Belo Horizonte and Viracopos, and Passaredo Linhas Aéreas to

Pampulha-Belo Horizonte. In light of these facts, it can be seen that the airlines have great importance for the forecast of Table 8.

## Conclusions

With the increasing preference for the use of air transport when it comes to passengers, the researches and studies in this area have grown. Regional aviation has become a broad theme in those studies, especially considering the potential for growth and the influences it can generate in the local and national economy. This study aimed to forecast the passenger volume of the regional airport Mário de Almeida Franco (Uberaba-MG) for city-pairs. In order to analyze the estimated passenger volume, we considered some variables based on bibliographic reviews that were cited in this study.

Analyzing the gravity model, it was possible to identify that *City GDP* has great significance in the analysis for its low p-value (below 5%, null hypothesis), showing that the economic growth of a city generates positive impacts in regional air transport. Uberaba is in a strategic location for the economic development of the country, since it lies within a radius of approximately 600 kilometers from the main cities in Brazil, such as Campinas, Uberlândia, São José dos Campos, Ribeirão Preto, Brasília, Belo Horizonte, São Paulo and Goiânia. This strategic location creates more connections and economic development.

The coefficient of the variable *City GDP* was expected to be positive together with the coefficient of the variable *Population* in the Model 4 that was considered better to explain the passenger flow between Uberaba-MG and city-pairs, however, the coefficient of the *City GDP* was negative and the coefficient of the *Population* gave positive. It can be inferred from this fact that the main competing airports of Uberaba Airport may be attracting this volume of passengers, with factors that were not considered in this Model 4 such as fare price, flight time, existing routes, airlines operating at these airports, among others.

Another independent variable that has high significance is the car journey time, since, besides the car being a mode of transportation competing with air transportation, this variable is related to the distance in kilometers between city-pairs and the travel time between cities by bus, which is another competitor to air travel. The relationship between them was observed when the VIF test was used and were the only ones that remained above 10.00, indicating collinearity.

Therefore, it can be concluded that the study of predicting the volume of the regional airport Mário de Almeida Franco to city-pairs showed that the independent variables *City GDP, Population and Time by a Car Trip* in a proposed gravitational model are important to this calculation. However, in order to get more complex and accurate results, we would need more variables and more observations on those variables.

## References


ABAETAR. Brazilian Association of Regional Air Transport Companies. *Study for the adequacy of Airport Infrastructure in Regions of Tourist Interest.* Brasília, DF: 2011. Brazil.

Barat, J. et al. (Org.) (2007) *Logistics and Transportation in the process of globalization: Opportunities for Brazil.* São Paulo: Unesp Publishing Foundation. 2000-2007. Brazil.

Brida, J.G.; Moreno-Izquierdo. L, Zapata-Aguirre, S. (2016) *Customer perception of service quality: The role of Information and Communication Technologies (ICTs) at airport functional areas*. Tourism Management Perspectives 20 (2016) 209-216.

CNT (2015) National Confederation of Transport. *Transport and economy: air passenger transport.* Brasília, 2015. Brazil.

CNT (2018) National Confederation of Transport. *Statistical Report Card.* Feb. 2018. Brasília, 2018. Brazil.

Cohen, S. (2016) *A Gravity Model for Aviation Forecasting "A fixed effects model for predicting global air passenger city-pair market potential"*. Faculty of Economics and Business Administration. Department of spatial Economics. University Amsterdam. Amsterdam-Netherlands.

Cottrell, A; Lucchetti, R. (2019) *Gretl User´s Guide "Gnu Regression, Econometrics and Time-series Library".* Department of Economics and Dipartimento di Economia. Wake Forest University and Università Politecnica delle Marche.

Çuhadar, M. (2014) *Bulding proper forecast model for daily air passenger demand: A study of Antalya International Airport*. Antalya. Turkey.

Diniz, A.M.A; Diniz, L.C.A. (2006) *Analysis of the main air flows of Belo Horizonte airports and their recent transformations.* Redalyc, Uberlandia, v. 34, n. 18, p. 31-43. 2006. Brazil. DOI=http://www.redalyc.org/html/3213/321327188003/.

Falcão, V.A. (2013) *Airport demand of Manaus and its influence for the tourism sector of the region.* Journal of Transport Literature, v.7, n. 1, p.127-146. 2013. Brazil.

Falcão, V.A. and Caixeta Silva, A.L. (2018) *Uberaba Airport demand and its influence for regional economy.* XVII Sitraer. São Paulo. Brazil.

Fellipi Tomé, P.T. (2007) *Demand Forecasting Models: An Application for Interstate Road Transportation of Passengers by Bus in the South of Brazil.* Federal University of Santa Catarina. Florianópolis. Brazil.

Gomes, M.T.S. (2016) *Economic dynamics and medium cities: an analysis of the city of Uberaba in the Triângulo Mineiro region.* Geousp - Space and Time (Online), v.19, n. 3, p. 516-534. ISSN 2179-0892. Uberaba. Brazil.

Grosche, T; Rothlauf, F and Heinzl, A. (2007) *Gravity models for airlines passenger volume estimation*. Journal of Air Transport Management 13: 175-183.

IBGE cities. *Statistic Data*. DOI=https://cidades.ibge.gov.br/brasil/mg/uberaba/panorama.

INFRAERO Airports. *Statistics*. 2018. Brazil.

INFRAERO Airports. *Uberaba Airport Mário de Almeida Franco*. Available at: DOI=https://www4.infraero.gov.br/aeroportos/aeroporto-de-uberaba-mario-de-almeida-franco/.

International Air Transport Association (IATA) ANNUAL REVIEW 2017. *Statistic data*. DOI=https://www.iata.org/publications/Documents/iata-annual-review-2017.pdf.

International Air Transport Association (IATA). *State of the region: The Americas.* DOI= https://www.iata.org/publications/economics/Reports/regional-reports/Americas-Apr19.pdf.

International Air Transport Association (IATA). *IATA Economics Chart of the Week*. DOI=file:///C:/Users/mathe/Downloads/TCC/Chart-of-the-week-26-Apr-19%20iata.pdf.

IPEA 2010. *Overview and Perspectives for Air Transport in Brazil and worldwide.* Institute of Applied Economic Research, Brasília. 2010 Brazil.

Kodanda B. and Verma A. (2011) *Estimation of Origin-Destination air traffic flows from air transport movement data: An application to Indian domestic airport network system.* World Conference of Air Transport Research Society (ATRS 2011), Sydney, Australia, June 29 - July 2, 2011.

Macário, R and Silva, J. (2009) *Regional Airports and local development: "The challenging balance between sustainability and economic growth"*. International Conference on Prospects for Research in Transport and Logistics on a Regional – Global Perspective. Dogus University Publications. Istanbul – Turkey.

Mankiw, N.G. (2001) *Introduction to economics: Principles of Micro and Macroeconomics.* 2. ed. Rio de Janeiro: Elsevier, Brazil.

Mckinsey and Company (2010) *Study of the Brazilian Air Transport Sector: Consolidated Report*. National Bank for Economic and Social Development. Rio de Janeiro, Brazil.

MOST MOVED AIRPORTS IN THE WORLD IN 2017. *Curiosities*. DOI=https://www.gqportugal.pt/sabe-qual-aeroporto-movimentado-do-mundo.

NATIONAL CIVIL AVIATION AGENCY (ANAC). Statistic data. DOI=http://www.anac.gov.br/noticias/company-travel-transportation-98-9-civil-payments-in-2017.

NATIONAL SECRETARY OF CIVIL AVIATION (SAC). Statistic data. DOI=http://transportes.gov.br/aviacaoem20anos.html.

NATIONAL SECRETARY OF CIVIL AVIATION (SAC). Statistic data 2017. DOI=http://transportes.gov.br/rede-aeroportos.html.

Olariaga, O.D; Bolívar, N; Gutiérrez, R.M. and Galeana, O.R. (2018) *Gravitational analysis of the Colombian air transport network. Application to the case of Colombia.* Transportation Research Procedia 33: 51-58.

Senna, L.A.S. (2014) *Economy and Transportation Planning.* Rio de Janeiro: Elsevier. Brazil.

Souza, A.L.L. (2010) *Comparative analysis of airports worldwide using DEA concepts.* (2010). 94 f. Dissertation (Master in Production Engineering). Alberto Luiz Coimbra Institute for Graduate Studies and Engineering Research. Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.

Thelle H.M. (2017) *Airport Competition in Europe.* Journal of Air Transport Management. Copenhagen.