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GDP and the Unemployment Rate Impact in the Demand for Subway Passengers in São Paulo

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ABSTRACT

The demand for passengers is a leading source of risk for projects related to transportation in subways and railroad. Thus, its measurement and forecasting are essential to the planning and execution of the subway operational activities. This article was based on a descriptive and quantitative research, where the macroeconomic indicators of the GDP and the Unemployment Rate of São Paulo metropolitan area were used as independent variables in order to explain the passengers demand volume of Line 3 - Red Line of the São Paulo Subway. Line 3 (Red Line) was chosen due to its long history of records from 1989 until the present day. The regression model was constructed through the robust OLS – (Ordinary Least Squares), showing that 93.6% of the variations in the passengers demand volume are explained by the GDP and the unemployment rate. The GDP coefficient in the regression model reveals a direct relationship with the demand for passengers. The unemployment rate, in turn, has a negative influence with such demand.

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INTRODUCTION

According to Bonomi and Malvessi (2008), one of the major activities in implementing an enterprise is to know and to size their risks in order to quantify them and establish mitigation instruments. Specifically, for subway-railroad infrastructure projects, one of the main risks is the passengers demand. (Brandão, Bastian-Pinto, Gomes, & Salgado, 2012; Campos & Gomes, 2005; Massa, 2011; Oliveira & Carvalho, 2008).

If on one hand passengers demand is one of the greatest risks for the subway-railroad infrastructure projects, there is a shortage and inefficiency of public transportation in Brazil. This was made evident in the street demonstrations that took place across the country in mid 2013. The survey required by the National Confederation of Transport (CNT) held in 134 Brazilian municipalities in July / 2013 found that 84.3% of respondents approved the street demonstrations, and 30.8% of them related the demonstrations causes with dissatisfaction with the fares and the poor quality of public transportation. (Alegretti & Cardoso, 2013).

Similarly, the research presented by Alvim, Bilt and Darido (2010), carried out by the US Company IBM highlights the main problems of public transportation deficiency in large Brazilian cities. The research has studied the traffic in 20 cities in the world, showing that the city of São Paulo was in the sixth worst condition.

Therefore, the proper sizing of the passenger demand in transportation infrastructure projects is crucial for their economic and financial modeling, thus serving as a criterion for investment decision-making. Davis, Chase and Aquilano (2001, p. 212) argue that the demand forecast is recognized by companies as an important planning tool at all organizational levels since the strategic plan up to the operational level.

This work seeks to understand how passengers demand in subway-railroad infrastructure projects

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can be influenced by the impact of economic indicators. In this context, the research question of this article is: what is the influence of the indicators GDP and Unemployment Rate in the passengers demand of the subway in São Paulo?

The central objective of this work is, through multiple linear regression analysis, to identify a passenger demand forecasting model for the Line 3 – Red Line - of the São Paulo Subway, taking into account the GDP and the Unemployment Rate in the Metropolitan Area of São Paulo.

Initially it was carried out a brief conceptual review of the theoretical axes dealt in this work. Thereafter it was presented: the adopted methodological procedures, the results and discussions, and finally the conclusions and final considerations of the study.

Theoretical reference:

Considering the definition of complexity suggested by Baccarini (1996), the subway-railroad infrastructure projects can be classified as complex projects, given the large number of variables to be controlled, the project size, the technology aggregate level, the long deadlines and the number of experts involved.

The capital costs, the implementation deadlines, and the quantity of stakeholders in this type of venture make it a project of considerable level of uncertainty. Brinco (2012) mentions a maturity of 5 up to 8 years for the construction of a subway-railroad project, at an average cost per kilometer, in the case of São Paulo Subway, around US$ 130 million.

In this context, it is presented hereinafter a conceptual review of the main theoretical axes involved in this work.

Passengers infrastructure projects:

As claimed by Brandão and Saraiva (2007, p. 1037) infrastructure projects are strongly affected by political and regulatory considerations due to their large amount of funds and maturation deadlines and also because they cover services considered essential to society. Thus, for the private sector to invest in this type of projects, knowledge and mitigation of risks are key tools.

According to Pastori (2007), in order to undertake more investments in infrastructure, Brazilian government has been trying since 2004 through the law of Public-Private Partnership (PPP), to make feasible an investment volume higher than the one which would be possible through traditional funding mechanisms.

It is worth mentioning that recently the first attempt to auction the Line 6 of the subway through the PPP (Public Private Partnership) was a failure. According to Dantas (2013), the problem was the risk that the private sector was running being obliged to bear the costs of expropriations; in a second attempt to auction the Line 6, after the state government bears the risks of expropriation, the auction was successful.

Particularly in the subway-railway infrastructure undertakings, one of the main risks is the demand for passengers, as evidenced by (Brandão *et al*, 2012; Mass., 2011; Oliveira & Carvalho, 2008; Campos & Gomes, 2005; Flyvbjerg, 2007), as the passenger demand is the primary generator factor of operational revenue in this type of venture. Thus, the passenger demand forecast is fundamental for the correct economic and financial modeling of these investments.

Demand forecast:

Davis *et al*. (. 2001, p 213) present a general overview of techniques and the most common models used for the demand forecasting, dividing them into two techniques: i) qualitative; and ii) quantitative. They present as qualitative techniques: i) the Delphi method; ii) the market research; and iii) the historical analogy. As for the quantitative techniques they are subdivided into two groups: i) time-series analysis; and ii) the causal techniques. As time series analysis techniques, the authors present the: i) simple moving average; ii) exponential smoothing; iii) regression analysis; and iv) trend projection. For the causal techniques it is presented: i) regression analysis; ii) the input-output models (the I/O models; and iii) the main indicators.

To Fouto, Angelo, Zwicker and Luppe (2011, p. 3), the demand forecasting techniques are complementary, and the planning areas of the organizations blend different approaches so as to achieve the best results.

Table 1 shows, for some demand forecast methods, the forecast time horizon, the complexity, the accuracy of the model and the amount of data required for such forecast.

Table 1: Comparison of demand forecasting techniques

Forecasting Technique	Method	Accuracy
Qualitative	Delphi	Average or Low
Quantitative	Simple Moving Average	Satisfactory
Quantitative	Exponential Smoothing	Satisfactory
Quantitative	Regression Analysis	High

Source: Adapted from Davis *et al*. (2001, p. 214)

Specifically, on the financial modeling of subway-railway infrastructure projects, it is desired to know the passenger demand at the beginning of the venture commercial operation, where the building takes around 6-8 years.

That is, it is desired to predict the long term demand, therefore, in accordance with Table 1, the indicated methods are: i) Method Delphi; and ii) regression analysis. However, it should be borne in mind that the longer the forecast horizon, the lower the estimates accuracy, since many of the factors that influence the results may change hence a long forecast horizon entails a greater risk. (Reis, 2007, p. 58).

As for the methods for long-term demand forecasts, Davis *et al*. (2001) state that: i) the Delphi Method is an interactive learning process, where a specialized group answers a questionnaire, which is compiled by a mediator, and, based on the responses, another questionnaire is developed and applied again to the group. The process continues until a consensus is reached; ii) in the regression analysis, time series type, the goal is to adjust a sequential line of historical data where the data are usually time-related, being the most common technique the least squares one; and iii) the regression analysis, causal type, which is similar to the regression analysis time series type, however, here there can be multiple variables which affect the forecast.

For the qualitative techniques, which is the case of the Delphi method, Davis *et al*. (2001) state that there is an aspect of subjectivity, since they are based on opinions and that their use takes place when there are no historical data.

The quantitative techniques of time series type are defined by Morettin and Toloi (2006) as any set of observations ordered in the time, in which the data sequence is essential, since the observations present a correlation with each other. As for the quantitative techniques of causal type, Davis *et al*. (2001) state that they seek to identify cause-effect relationships between the variable to be forecasted and other essential factor or factors in the environment, other than time.

Regression analisis:

Fávero, Belfiore, Chan and Silva (2009) present the regression analysis as a modeling technique where a set of variables (known as independent, explanatory or predictive) can influence one or more variables (known as dependent or explained) representing the phenomenon which will be studied. This technique allows the creation of forecasting models, that is, getting into the model with the explanatory variables one gets as output the forecast of the explained variables.

Due to the type of curve (functional form) that the dependent variable assumes in relation to the explanatory variable, the regression analysis is classified into: i) linear regression, where the functional form of the curve is linear; or ii) non-linear regression for all other possible functional forms (exponential, quadratic, etc.).

Another classification takes place in relation to the amount of explanatory variables, thus, the regression analysis can be divided into: i) simple regression where there is only one explanatory variable; and ii) multiple regression, where there are more than one explanatory variable, this being an analysis of multivariate type.

So, to use this technique it is necessary to determine what the best model of functional form to use. Favero *et al*. (. 2009, p 365) present as decision criteria: i) the choice of the specification that meets the assumptions; and ii) the biggest adjustment coefficient (R^2).

The R^2 adjustment coefficient is a measure that shows how much the independent variables performance explains the dependent variables variation. Its value can range from 0 to 1, and the closer to the unit, the better the explanation of the dependent variable performance. (Favero *et al*., 2009).

Economic indicators:

According to Guerra (2012), the conceptualization of the metric indicator is a difficult and complex task, and trough the understanding compilation of several authors, he defines indicator as "instruments that enable to identify and measure aspects related to a particular concept, phenomenon problem or result of an intervention in the reality" (p. 10).

Jannuzzi (2001, cited by Guerra (2012, pp. 10-11) proposes taxonomy where the indicators are related in four classifying groups, namely:

i) by the thematic area of reference, such as health, education, among others;

ii) by the complexity, as follows: 1) the objective indicators, which are built through statistical data, and refer to the reality data, such as unemployment rate, among others; and 2) the subjective indicators, which are based on the perception of a particular social group concerning a proposed topic, such as the opinion polls;

iii) by the extent intended to be measured, as follows: 1) the analytical indicators used in the analysis of specific issues, such as the infant mortality rate; and 2) the synthetic indicators that propose the observation of the social reality as of the combination of a set of measures into a single indicator, such as the Human Development Index (HDI);

iv) by the flow implementation management, as follows: 1) input indicators, which measure the funds allocation in the social policies implementation; 2) process indicators, which reflect the effort expended in running a public program; 3) outcome indicators, which are used for the purpose of measuring the effectiveness in the fulfillment of the program goals;

and
v) impact indicators that seek to measure the effects resulting from the public programs implementation.

The Brazilian Institute of Geography and Statistics (IBGE), the body that coordinates the Brazilian statistical system, consolidates the indicators of some of its major publications, classifying them in: i) economic; ii) social; and iii) environmental. (Brazil, 2010, p. 28)

Baumohl (2012) defines the economic indicators as statistical measures of the market economic conditions or a specific sector of the economy, and states that they are produced to support the economic analysis as a representation of the economical performance in a specific sector at a certain time.

The economic indicator Gross Domestic Product (GDP) is the global production of goods and services of a country. In this calculation it is discounted the expenses with the inputs used in the production process during the fiscal year. This production is measured by the sum of the overall gross added value generated by all the country's economic activities which covers the sectors: agribusiness, industrial and services. The GDP is measured by IBGE in accordance with the methodology proposed by the United Nations (UN). (Ribeiro, Teleginski, Souza, & Gugelmin, 2010).

The Unemployment Rate Indicator is also measured by IBGE through the Monthly Employment Survey (PME). The data are obtained from a probabilistic sample in the Metropolitan Areas of Recife, Salvador, Belo Horizonte, Rio de Janeiro, Sao Paulo and Porto Alegre. The Unemployment Rate is the ratio between the number of unemployed persons (looking for a job) and the number of economically active persons in a particular reference period. (IBGE, 2013).

Methodology:

Due to the general objective of this study, it was used the descriptive research, according to the classification carried out by Gil (2002, p. 42), where the goal is the description of the characteristics of a specific population or phenomenon or also the establishment of relationships among variables. The author also notes that, generally, this type of research takes, as a technical procedure (strategy / method), the form of a survey.

The survey technical procedure involves obtaining information from a large group, about the studied problem, followed by quantitative analysis, reaching the conclusions corresponding to the data collected. (Gil, 2002, p. 50). In this paper it was used the survey as a technical procedure.

The central objective of this work is, through multiple linear regression analysis, to identify a passenger demand forecasting model for the Line 3 – Red - of the São Paulo Subway, depending on the Brazilian Gross Domestic Product and the Unemployment Rate of the Metropolitan Area of São Paulo.

It was used the following indicators: Brazilian GDP and Unemployment Rate in the Metropolitan Area of São Paulo (RMSP) as explanatory variables in a passenger demand growth forecast model, which is the dependent variable through a regression analysis . As historical passenger demand data, it was used an annual database of passenger entries in the Line 3 - Red – São Paulo Subway in the period 1989 up to 2012.

Line 3 – red – sao paulo subway:

The "Companhia do Metropolitano de Sao Paulo" - Sao Paulo Subway commercially operates the subway system in the city of São Paulo since 1974. Currently four lines are operated, carrying about 4.5 million passengers / day.

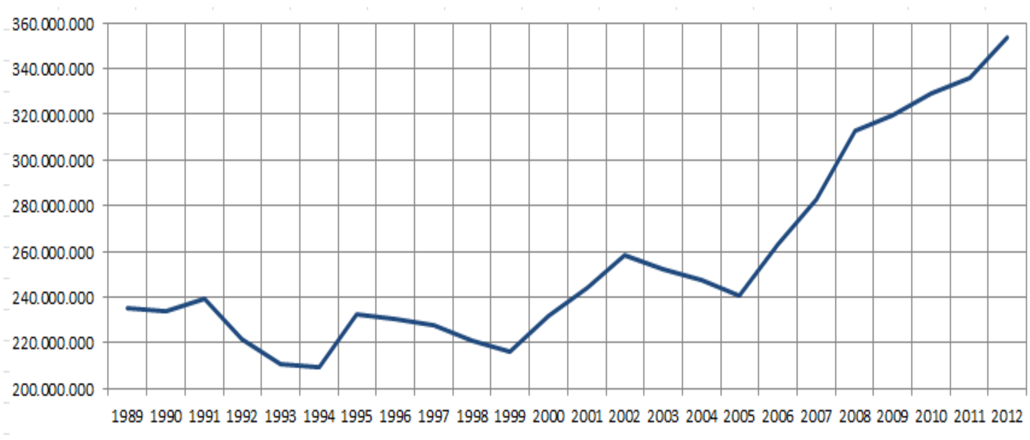
Line 3 - Red connects the neighborhoods of Barra Funda up to Itaquera connecting the West and the East zones of the city, in a length of 22 km and 18 stations. During peak hours, this line operates with 40 trains (240 cars) and a minimum break between trains (*headway*) of 104 seconds.

The start of commercial operation of this line occurred in 1979; however, it was only at the end of 1988, with the openings of Itaquera (Oct/1988) and Barra Funda (Dec/1988) stations that the line reached the current configuration. It is the busiest line of the São Paulo Subway, and in 2012 the average demand on weekdays, was 1.191 million passengers.

Taking into account the capability of the trains to transport about 2,100 passengers with a *headway* of 104 seconds, during one hour, it follows that the capacity of this line is of around 72,692 passengers per hour.

The passengers demand:

Passengers demand is the amount of people who use the subway system. In this work, as the focus is on passengers demand data for economic and financial modeling, what matters is the total amount of users thus it was acquired the annual data of Line 3 passenger entry between the years 1989 to 2012, i.e. soon after the line reaches the current setting. This period totaled 24 measurements presented graphically in Graph 1.



Graph 1: Passengers entry on Line 3 - Red - São Paulo Subway. Frequency: Annual from 1989 to 2012.

Source: Operation Management - São Paulo Subway. Unit: Passengers.

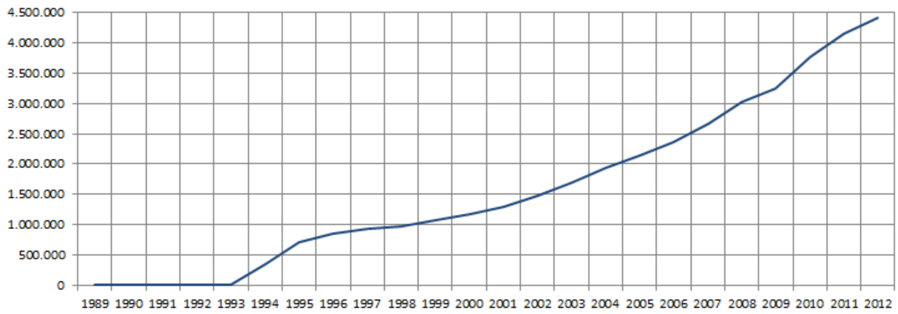
Source: Database of the São Paulo Subway, adapted by the authors

Graph 1 presents the annual passengers data entries, the demand seasonality in the months of January and July; vacation characteristics, typical in these months of the year, becomes transparent in this analysis.

In many demand forecasting studies, binary variables (dummy type) are used for treating the seasonality phenomenon, however, as the focus of this work is the long-term forecast, seasonality will not be addressed here, since what matters is to know the total amount of users in the year for the project's cash flow construction.

Indicators gdp and performance rate:

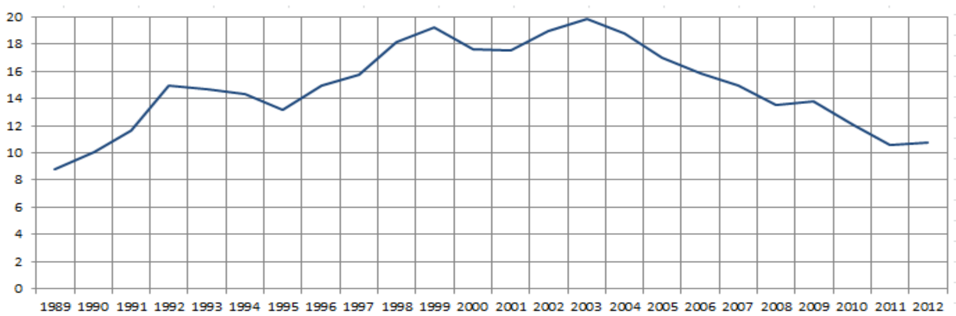
The indicators of Brazilian Gross Domestic Product and Unemployment Rate in the Metropolitan Area of São Paulo were acquired from the Applied Economic Research Institute (IPEA) and are presented in Graphs 2 and 3



Graph 2: Gross Domestic Product. Frequency: Annual from 1989 up to 2012. Source: Brazil Central Bank, Bulletin, Section Economic Activity (BCB Bulletin / Economic Activity). Unit: R$ (million).

Comment: Frame: National Accounts. Obs.: Central Bank estimate. Updated: Nov. 01, 2013.

Source: IPEA data, adapted by the authors.



Graph 2: Unemployment rate in the Metropolitan Area of São Paulo (RMSP). Frequency: Annual from 1989 up to 2012. Source: Foundation State System of Data Analysis, Employment and Unemployment Survey (Seade / PED). Unit: (%). Comment: Frame: Unemployment rates, by type - Metropolitan Area of São Paulo, São

Paulo and other municipalities of the Metropolitan Area of São Paulo. In: http://www.seade.gov.br. Obs.: Metropolitan Area of São Paulo (RMSP). It includes hidden unemployment (precarious jobs and unemployment by discouragement) and open unemployment. Updated: Oct. 31, 2013. **Source:** IPEA data, adapted by the authors.

All these data were processed quantitatively, aided by multivariate analysis of causal multiple linear regression - *stepwise* procedure in order to foresee the passengers demand and their causal relationships.

For predicting the passengers demand in the Line 3 – Red - after the year 2012 it were collected the GDP forecast data and the Unemployment Rate. The *long-term baseline projections* Report, No. 9, of the Organization for Economic Cooperation and Development (OECD) presents projections of these indicators up to the year 2060. (OECD, 2013).

Table 2 presents the projections for the period 2013-2020, according to the report of the OECD (2013), and the years 2013 to 2015, have been updated based on the latest forecasts of the OECD.

Table 2: Brazilian GDP and Unemployment Rate projections

	2013	2014	2015	2016	2017	2018	2019	2020
GDP (%)	2,5	2,2	2,5	4,21	4,03	3,88	3,77	3,70
UR (%)	7,60	7,50	7,41	7,33	7,26	7,19	7,14	7,09

Source: Report (OECD, 2013), adapted by the authors

Results:

Initially it was carried out a descriptive analysis of the studied variables, Table 3 presents the values: Mean, Standard Deviation, Minimum and Maximum, being the number of samples (N) equal to 24.

Table 3: Descriptive statistics of the studied variables.

Variables	Mean	Standard Deviation	Minimum Value	Maximum Value
Annual entries of Passengers in L3-Red [Passengers]	256.180.022	42.661.404	209.374.806	353.508.563
Unemployment rate in the RMSP [%]	14,88	3,16	8,83	19,88
Brazilian GDP [R$ (million)]	1.594.302	1.367.171	0,426	4.402.537

Source: Output Report of the SPSS (Statistical Package for the Social Sciences), adapted by the authors.

Table 4 presents the correlation matrix of the studied variables with the Pearson correlation coefficients (r), in parentheses, and their respective statistical significance (P-value).

Table 4: Matrix of correlations and statistical significance of the studied variables

	Passengers Entry	Unemployment Rate	Gross Domestic Product
Passengers Entry	(1,000) ------	(-0,393) 0,029	(0,925) 0,000
Unemployment Rate	(-0,393) 0,029	(1,000) ------	(-0,108) 0,307
Gross Domestic Product	(0,925) 0,000	(-0,108) 0,307	(1,000) ------

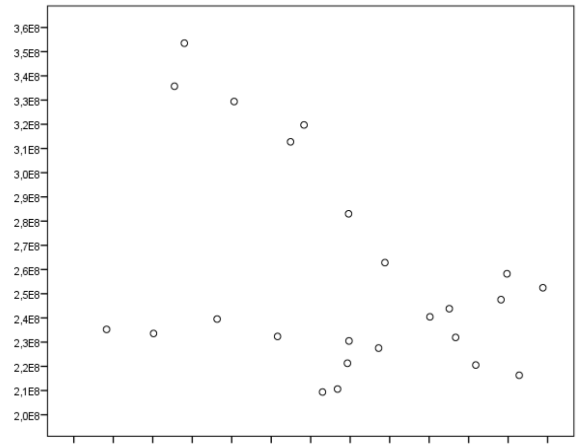
Source: Output Report of the SPSS (Statistical Package for the Social Sciences), adapted by the authors.

Analyzing the results in Table 4, and adopting the classification proposed by Franzblau (1958) for the correlation coefficients, it follows that:

i) Among the variables: Demand for Passengers and Unemployment Rate, there is a weak negative correlation, significant to the significance level $\alpha = 0.05$. Where: The Pearson correlation coefficient equal to (r) = - 0.393. Thus, as the Unemployment Rate decreases, the Passengers Demand increases, indicating the existence of a significant relationship between these variables.

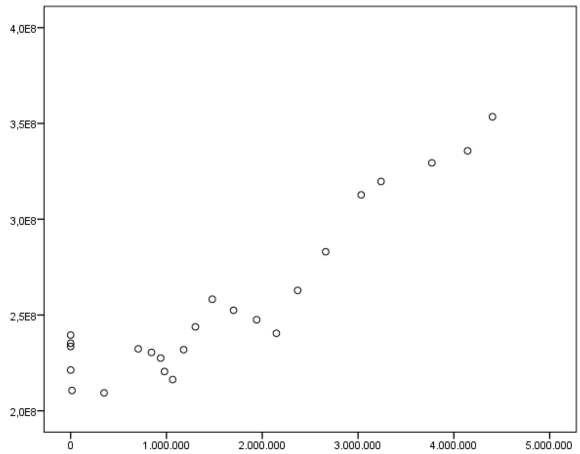
ii) Among the variables: Passengers Entry and Gross Domestic Product, there is a strong positive correlation, significant to the significance level $\alpha = 0.05$. The Pearson correlation coefficient (r) = + 0.925. As the Gross Domestic Product increases the passenger demand follows the same trend, indicating a strong relationship between the variables.

iii) Among the independent variables: Gross Domestic Product and Unemployment Rate, there is no significant correlation at a significance level $\alpha = 0.05$, indicating that the variable Gross Domestic Product affects very little the variable Unemployment Rate and therefore it does not incur in the problem of multicollinearity in the multiple regression models.



Graph 4: Dispersion of the independent variable Unemployment Rate (%) in the RMSP according to the number of Passengers Entry in the Line 3 São Paulo Subway.

Source: Output Report of the SPSS, adapted by the authors.
Fonte: Relatório de saída do SPSS, adaptado pelos autores.



Graph 5: Dispersion of the independent variable Gross Domestic Product according to the number of Passengers Entry in the Line 3 São Paulo Subway.

Source: Output Report of the SPSS, adapted by the authors.

Graphs 4 and 5 present the relationship of the two independent variables: i) Unemployment Rate% in the RMSP; and ii) Brazilian GDP depending on the dependent variable - Passengers Entry.

It is noticed that in Graph 4, two characteristics of the passengers demand of Line 3 according to the

Unemployment Rate in the RMSP:

i) when the Passengers Entry is around the 220 million passengers/year, that is, close to the initial demand of this line (1989 - Graph 1), the demand is uncoupled from the Unemployment Rate, that is, its value does not tend to vary according to the Unemployment Rate;

ii) from the time that the demand is out of the initial demand level, there is an inversely proportional relationship with the Unemployment Rate, so that when the latter decreases, the passenger demand increases.

As for the Graph 5, it is observed that the Demand for Passengers is directly related to the Brazilian GDP.

Table 5 presents the results of multiple linear regression, using the *stepwise* procedure and the robust minimum squares ordinary procedure in order to overcome the problems of Heterocedasticity and autocorrelation of the residuals. The independent variables are the GDP and the Unemployment Rate and the dependent variable is represented by the Passengers Demand Line 3 - Red – São Paulo Subway.

Table 5: Results of Multiple Linear Regression - procedure *stepwise*

	Coefficients	t-Test	Sig	Beta Standard	Confidence Interval of 95% for B		Statistics of Colinearity	
					Inferior	Superior	Tolerance	VIF
Constant	271.367.416,0	23,645	0,000	------	247.499.998	295.234.834	------	------
Gross Domestic Product	27,9	16,832	0,000	0,893	24,4	31,3	0,988	1,012
Unemployment Rate	- 4.004.648,6	- 5,586	0,000	- 0,296	- 5.495.622	- 2.513.675	0,988	1,012

Source: Output Report of the SPSS, adapted by the authors.

Analyzing the results of Table 5, it follows that: There is a statistically significant relationship between the GDP and the Unemployment Rate with the Demand for Passengers of Line 3 - Red - São Paulo Subway showing 95% of confidence. The model does not present Colinearity problems, since the resulting statistical VIF (*Variance Inflation Factor*) is less than 5 (VIF = 1.012 $\leq$ 5) according to Favero *et al*. (2009).

Table 6 presents a summary of the results obtained through the multiple linear regression model.

Table 6: Summary of the Multiple Linear Regression Model, procedure *stepwise*.

R	R²	R² Adjusted	Standard Error of the Estimate	Durbin-Watson
0,970	0,942	0,936	10.785.893,85	0,985

Source: Output Report of the SPSS, adapted by the authors.

It can be stated that 93.6% of The Demand for Passengers is influenced by the GDP and the Unemployment Rate. This high value of R squared reinforces the use of this model for predicting the Demand for Passengers on an annual basis. The Durbin-Watson test was of 0.985. According to Favero *et al*. (2009, p. 397), so that there is no self-correction of the residue, this statistic must stay close to the value 2 (two). Thus, the model in question may present the problem of the residue autocorrelation. As there was the use of the method of ordinary least squares, there is no need for adjustments in the model variables in order to reduce the harmful effects of the residue autocorrelation and heteroscedasticity.

The difference between the actual dependent variable and its estimated value is known as residue. Table 7 presents the obtained residue statistics.

Table 1: Residue Statistics

	Minimum	Maximum	Mean	Standard Deviation
Predicted Value	211.595.872,00	350.738.400,00	256.180.022,63	41.397.777,616
Residues	-22.566.832,00	21.681.578,00	0,000	10.306.278,44
Predicted Value Standard	-1,077	2,284	0,000	1,000
Standard Residue	-2,092	2,010	0,000	0,956

Source: Output Report of the SPSS, adapted by the authors.

The residues analysis investigates the regression model suitability based on the residues that should have an approximately normal distribution. The Jarque-Bera test presented a P-value of 0.4567, indicating that the residues follow a normal distribution with 95% of confidence.

Conclusions:

This study aimed to verify whether the Gross Domestic Product and the Unemployment Rate significantly influences the Passengers Demand in subway and railway infrastructure projects. To that end, it was studied the influence of the Brazilian GDP and the Unemployment Rate in the São Paulo Metropolitan Area in the Passengers Demand of Line 3 - Red - of São Paulo Subway in the 1989-2012 period.

The research was descriptive, establishing relationships between the variables Passengers Demand, GDP and Unemployment Rate. As a technical procedure, the survey was used, which involved obtaining 24 annual historical data of the variables involved, from January 1989 up to 2012. The estimation window covers a long period in order to bring robustness to the estimated parameters.

The regression model used the method of robust ordinary least squares in order to avoid the harmful effects on the estimation of the residues autocorrelation parameters and the heteroscedasticity.

Evidence shows that the Demand for Passenger of the Line 3 - Red – of the São Paulo Subway can be satisfactorily explained by the variations in the GDP and in the Unemployment Rate with 95% of confidence. The R squared of the model was of 93.6%, indicating that the resulting model equation can be efficiently applied for prediction purposes in an annual database.

As contributions of this work it stands out the possibility of passenger demand forecast depending on economic indicators, since for these indicators there are already several forecast models by the traditional economic theory. With this in hand, it is possible to develop a cash flow modeling of subway-railway infrastructure projects and thereby define its economic feasibility by the Internal Rate of Return or Net Present Value.

As limitations of the study there is the fact that it was only used historical data of a single subway line, which can compromise the use of the model in other lines. In this regard, as suggestions for future researches, it is suggested the application of the forecasting model proposed in this work in other lines of subway and rail systems, as well as using the time series techniques and neural networks for comparative purposes.

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