Forecasting Brazil's Per Capita GDP Growth

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Abstract: Brazil, a country of a massive land areas and a population of 202 million, is endowed with an immense range of diversified natural resources including metallic minerals and oil reserves. For the last decade, Brazil became an attraction for international investors and foreign direct investment initiatives due to rapid industrialization and accelerated rates of growth. In 2012, Brazil's economy was classified by the International Monetary Fund (IMF) as the world's seventh largest economy, both in terms of nominal Gross Domestic Product (GDP) and Purchasing Power Parity (PPP) (IMF Annual Report, 2012). To predict Brazil's potential economic growth, this paper used a regression forecasting model to forecast Brazil's per capita GDP annual percentage growth rate as a function of fixed capital formation growth rate, growth rate of the labor force population, and inflation measured by the annual growth rate of the GDP implicit deflator. The regression model used a growth equation that was derived from a study conducted by the International Monetary Fund to measure economic growth in New Zealand. The data was taken from the World Bank's database of World's Development Indicators during the period between the years 1971-2010. The model's validity test reported that it did not violate any of the classical linear model assumptions for time series regression. Thus, the estimated coefficients are the Best Linear Unbiased Estimators (BLUE) of the population coefficient. The regression forecast of 2010 per capita GDP growth rate approximately equaled 8%. The forecast's 90% confidence interval ranged between a minimum value of 4.7683996, and a maximum value of 11.193217. Brazil's 2010 per capita GDP annual percentage growth rate was also forecasted using an Autoregressive Integrated Moving Average (ARIMA) Model. The dependent variable's time series was transformed by taking the first difference to overcome the problem of non-stationarity. The autocorrelation and the partial autocorrelation functions indicated that the ARIMA model should include one Moving Average (MA) term. The ARIMA 2010 forecast approximately equaled 6% annual growth rate. The forecast's 90% confidence interval ranged between a minimum value of -4.769585, and a maximum value of 7.851028.

Keywords : GDP per capita, Time-Series Analysis, Forecasting Models, ARIMA Forecasts

1. Introduction

Upon outperforming Russia for the first time in terms of economic competitiveness, and rivaling with other BRIC economies like India and China, Brazil was classified as the "top country in upward evolution of competitiveness" by the World Economic Forum in 2009. Brazil competitiveness fundamentals have been significantly boosted since 1990s upon taking serious measures towards fiscal sustainability and economy's liberalization, thus providing a friendly atmosphere for private-sector entrepreneurial initiatives.

Brazil, a country of a massive land areas and a population of 202 million, is endowed with an immense range of diversified natural resources including metallic minerals and oil reserves. It became a leading exporter of automotive products and a major force in civil aircraft production industry. Brazil now operates at the cutting edge of certain technological fields like offshore oil exploration and genomic sequencing (Amann, 2005). For the last decade, Brazil became an attraction for international investors and foreign direct investment initiatives due to rapid industrialization and accelerated rates of growth. In 2012, Brazil's economy was classified by the International Monetary Fund (IMF) as the world's seventh largest economy, both in terms of nominal Gross Domestic Product (GDP) and Purchasing Power Parity (PPP) (IMF Annual Report, 2012).

This paper provides an economic forecasting for Brazil's economic growth. Brazil's per capita GDP annual percentage growth is forecasted as a function of fixed capital formation growth rate, growth rate of labor force population, and inflation rates. The regression model used in this paper is derived from a study conducted by the International Monetary Fund to measure economic growth in New Zealand. The dataset is derived from the World Bank's database of World's Development Indicators during the period between the years 1971-2010. In addition to the single regression equation forecasting method, an MA(1) model is used to conduct ARIMA forecast of per capita GDP annual percentage growth rate for the year 2010. The data were analyzed using STATA software. Both of the models forecasts succeeded the 90% confidence interval. ARIMA forecast were more accurate. But the regression forecast reported a narrower confidence interval.

2. Literature Review

Throughout the economic literature, economic growth has been depicted by a regression equation where the dependent variable is growth rate of GDP per capita, and the independent variables are of a particular importance to the economy under analysis. Inflation rate has frequently been used as an independent variable in forecasting models that predict economic growth.

An IMF study conducted by Dunaway et al (2004) included inflation rate as an independent variable in the regression equation that measures economic growth in New Zealand. The study provides a comparative analysis for the sources of economic growth in some OECD countries compared to New Zealand which experienced an accelerated rate of economic growth for the last decade. Yet, these rates of economic growth were not high enough to put New Zealand per capita GDP up to the level of the top half of the Organization of Economic Cooperation and Development's (OECD) countries. Upon evaluating the importance of some macroeconomic variables as main determinants of GDP per capita growth, Dunaway et al (2004) show that New Zealand geographical isolation is a significant variable in determining its level of economic growth. Dunaway *et el* used a reduced form of growth equation to evaluate the contribution of some macroeconomic policy measures, institutional structural reforms, and the geographical isolation to economic growth. Despite the extensive structural reforms undertaken in New Zealand since the mid-1980s, per capita GDP could not rival with the rest of OECD countries. Thus, New Zealand geographical location turned to be a significant obstacle to economic growth. Besides, the study shows that at low levels of inflation, a small increase in inflation rate has positively impacted growth rates. However, once a certain threshold level of inflation is crossed over, then this effect starts to be negative.

In my study, I will follow the same approach of Dunaway *et el* by estimating a reduced form of growth equation for Brazil's economy represented by the annual percentage growth rate of Brazil's per capita GDP. As described by Edmund Amann, Brazil is "one of the great enigmas of the global economy" (Amann, 2005). In his paper, *Brazil's Economy under Lula,* he addressed the paradox of the Brazilian economy who continued to push below its weight despite the economy's huge endowments of natural resources, human capital and high level of technical expertise, and large entrepreneurial initiatives. He argued that Brazil will have to take a series of reforms to overcome the structural impediments hindering sustainable and equitable growth. He attributed the failure in achieving the ultimate economic potentials to the government's commitment to pursue fiscal and monetary orthodoxy. The former government of President Lula Da Silva has identified the policy measures necessary to face up these challenges; however, it has severely limited the scope for putting these policies into practice. While many studies analyzed the forecasts of two or more macroeconomic variable individually, for instance real GDP growth and inflation rate separately, Sinclair *et al* provided a method for jointly assessing the direction of the change in the projections of these variables (Sinclair, Stekler , & Kitzinger, 2006). Their study attempts to forecast the direction of change in the projected behavior of two correlated variables. Sinclair *et al* developed a methodology to jointly evaluate the accuracy of the forecasts of a single variable to include simultaneously an analysis to the forecasts of other relevant variables. They conclude that such methods provide more accurate forecasts for decision makers than the ones undertaken separately.

2.1 Determinants of Economic Growth – Regression Model

The model employed in this paper is derived from the IMF analysis conducted by Dunaway *et al* of the sources of economic growth in New Zealand (Dunaway, Kronenberg, Ramakrishnan, Salgado, Sanhadji, & Zhang, 2004). A reduced form growth equation which is typically derived from an aggregate production function as follows:

$$Y_t = A_t F(K_t, L_t) \qquad (1)$$

Where Y_t is GDP per capita measured by purchasing power parity (PPP), A_t represents factor productivity, K_t represents capital stock, and L_t represents employment, all in year *t*.

Differentiating equation (1) with respect to time t results in an equation (2) that represents GDP per capita growth on a PPP basis as a function of growth rate of factor productivity, growth rate of capital stock, and growth of employment rate:

$$Y_t = a_t + f(k_t, l_t) \quad (2)$$

In an attempt to forecast Brazil's economic growth, a single regression equation forecasting method is constructed upon the above mentioned equation where the dependent variable, Brazil per capita GDP percentage growth, is regressed on Brazil's fixed capital formation growth rate, growth rate of labor force population, and inflation rates. One of the limitations of this study is that the model developed does not account for the variable that represents the growth of productivity due to the difficulty in approximating this factor.

2.2 Data Source & Description

The dataset used in this paper was taken from the World Bank's database of World's Development Indicators during the period between the years 1971-2010. The variables included in this model are described as follows:

2.2.1 GDP per Capita Growth (annual %):

GDP per capita growth (annual %) measures the annual percentage growth rate of GDP per capita based on constant local currency. GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. It is used as the dependent variable in the regression model to forecast GDP economic growth. Per capita GDP annual percentage growth rate fluctuated between a minimum value of -6.600777 and a maxiumum value of 11.31396 during the priod between the years 1971-2010 with an avergae vlue of 2.258955.

2.2.2 Gross Fixed Capital Formation Growth (% of GDP):

Gross fixed capital formation (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. It is used as an independent variable in the regression model to capture the growth rate of fixed capital stock as a percentage of GDP. This variable is expected to positively affect per capita GDP annual growth. Fixed capital purchases, whether by the public or private sector, is expected to boost the economy, to create job opportunities, to boost consumption, and to positively affect the standards of living. The percentage of gross fixed capital formation to GDP fluctuated between the minimum value of -16.09837 and the maximum value of 22.98004 during the period between the years 1971-2010 with an average value of 4.091361.

2.2.3 Population, Total:

Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The values shown are midyear estimates.

2.2.4 Population, Age 15-64 (% of total):

The population between the ages of 15 and 64 as a percentage of the total population. Both of the above mentioned variables were used to create the variable employed in the regression model as an independent variable to capture the growth in the labor force. This variable attempts to approximate the growth in total employment due to the fact that there is no access for data on employment rates and labor force participation in Brazil in the period between the years 1971-2010. The following equations was used to calculate the variable:

Total Population 15-64 = Total Population* Population 15-64 Percentage of Total Population

Percentage Growth Rate of Population between 15-64 =

$$\frac{(Tot\ Pop\ 15-64)_t - (Tot\ Pop\ 15-64)_{t-1}}{(Tot\ Pop\ 15-64)_{t-1}}$$

Though total population growth is expected to negatively affect per capita GDP growth, the growth in labor force population, represented by growth in population between the ages of 15 and 64 as a percentage of the total population, is expected to have a positive effect on per capita GDP especially when it is accompanied by growth in fixed capital formation and job opportunities. The percentage growth rate of the population between the ages of 15 and 64 flucautaed between the minimum value of .0129066 and the maximum value of .0318539 during the period between the years 1971-2010 with an average value of .023307.

2.2.5 Inflation, GDP Deflator (annual %):

Inflation measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency.

The economic theory implies that the increased rates of inflation may negatively affect economic growth. Thus high rates of inflation are expected to negatively affect the growth of GDP per capita. Recent research that examined relationship between inflation and economic growth indicated that at low levels of inflation, a modest increase in inflation may positively impact growth. However, inflation starts to hurt growth once a certain threshold level of inflation has been crossed. Inflation measured by the annual growth rate of the GDP implicit deflator fluctuated between the minimum value of 4.235904 and the maximum value of 2735.488 during the periods between the years 1971-2010 with an average value of307.0091.This variable recorded its highest values during the preiod between the years 1980-1995 with high degree of variation. Then it recoreded decreases in later years.

Table 1 shows the summary statistics of each above mentioned variables.

Table 1 Summary Statistics

The variables are measured in percentages.

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP_Per_Ca~r	40	2.258955	4.002771	-6.600777	11.31396
Gross_Fixe~r	40	4.091361	9.514693	-16.09837	22.98004
LFPopGr	39	.023307	.0058416	.0129066	.0318539
Inf_GDP_Def	40	307.0091	668.3922	4.235904	2735.488

Estimates – Regression Results

Table 2 summarizes the regression results:

Table 2 Regression Results

Depdent Variable GDP_Per_Capita_Gr

Independent Variables	Estimated Coefficient	Standard Error
Gross_Fixed_K	0.3612893	0.0291172
LFPopGr	95.87149	46.92367
Inf_GDP_Def	(0.0008883)	0.0004079
Constant	(-1.233255)	1.138595
Number of Obesrvations	39	
$\boldsymbol{R^2}$	0.8288	
Adusted $\boldsymbol{R^2}$	0.8141	
RMSE	1.6893	

2.2.6 Interpretation of the Estimated Coefficients:

Gross_Fixed_K: This variable represents growth of fixed capital stock as a percentage of GDP. The variable's estimated coefficient has a positive sign. Everything else equal, a one percent increase in gross fixed capital growth as a percentage of GDP contemporaneously increases the annual percentage growth rate of GDP per capita by 0.36. The coefficient's sign is consistent with the economic theory. The coefficient's t-statistic is larger than the critical values at both 5% and 10% significance levels and 35 degrees of freedom. So the null hypothesis that estimate is statistically insignificant is rejected.

LFPopGr: This variable represents the percentage growth rate of the population between 15-64 years old. The variable's coefficient has a positive sign. Everything else equal, a one percent increase in the labor force population growth contemporaneously increases the annual percentage growth rate of GDP per capita by 96.87. The coefficient's sign is consistent with the economic theory. The coefficient's t-statistic is larger than the critical values at 10% significance level and 35 degrees of freedom, and slightly higher than the critical value at 5% significance level. So the null hypothesis that estimate is statistically insignificant is rejected at 10% significance level. However, the coefficient is barely significant at 5% significance level.

Inf_GDP_Def: This variable represents inflation measured by the annual growth rate of the GDP implicit deflator. The variable's coefficient has a negative sign. Everything else equal, a one percent increase in inflation rate measured by annual growth rate of GDP implicit deflator contemporaneously decreases the annual percentage growth rate of GDP per capita by 0.000888. The coefficient's sign is consistent with the economic theory. The coefficient's t-statistic is larger (in its absolute value) than the critical values at both 5% and 10% significance levels and 35 degrees of freedom. So the null hypothesis that estimate is statistically insignificant is rejected.

2.2.7 The Model's Goodness of Fit Characteristics:

The model reported high values of R-squared and adjusted R-squared measures of goodness of fit. The model's R-squared reports that 82.88 % of the variation in the dependent variable is explained by the variation in the independent variables. The model's adjusted R-squared reports that 81.41% of the variation in the dependent variable is explained by the variation in the independent variables upon adjusting for the degrees of freedom.

The Root Mean Squared Error (RMSE) value is 1.6893, reflects the variation in the dependent variable which is not explained by the independent variables. Upon comparing the value of RMSE to the mean value of the dependent variable, the annual percentage growth rate of GDP per capita that equals 2.2589, the value of RMSE is not sufficiently low, the thing that may cast some doubts on the model's goodness of fit characteristics.

2.2.8 Testing the Model's Validity:

The following tests were conducted to examine the model's validity. The model was examined for the existence of a multi-collinearity problem, a serial correlation problem, and a heterskedasticity problem. Besides, a test to examine whether the model is misspecified or any significant variable is omitted was also conducted. The tests reported that none of the above mentioned problems was traced in the model. The regression model does not violate any of the classical linear model assumptions for time series regression (Wooldridge, 2009). Thus, the model's estimated coefficients are the Best Linear Unbiased Estimators (BLUE) for the population's coefficients.

2.2.9 Testing for Multi-collinearity:

Upon applying the Variance Inflation Factor (VIF) test (Wooldridge, 2009), each of the coefficient's VIF and the Mean VIF, which is 1.01, are lower than 10. Besides, as the model's estimated coefficients are all statistically significant and their signs are consistent with the economic theory, there are no symptoms of a multi-collinearity problem in the regression model (as shown below).

Variable	VIF	1/VIF
Inf_GDP_Def	1.01	0.989400
Gross_Fixe~K	1.01	0.989793
LFPopGr	1.00	0.999504
Mean VIF	1.01	

2.2.10 Testing for Serial Correlation:

Upon applying both the Durbin's Alternative and the Breusch-Godfrey tests for serial correlation (Wooldridge, 2009), both tests reported remarkably high p-values of 0.3587, and 0.3316 respectively. Thus, the null hypothesis of no serial correlation is not rejected. The regression model does not suffer from any autocorrelation problem.

Durbin's alternative test for autocorrelation

lags(p)	chi2	df	Prob > chi2
1	0.842	1	0.3587

H0: no serial correlation

Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob > chi2
1	0.943	1	0.3316

H0: no serial correlation

2.2.11 Testing for Heteroskedasticity:

Upon applying Breush-Pagan test for Heteroskadasticity (Wooldridge, 2009), the test reported a remarkably high p-value of 0.3653.Thus, the null hypothesis of homoscedasticity is not rejected and the regression model does not suffer from heteroskedasticity problem.

. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of GDP_Per_Capita_Gr

chi2(1) = 0.82

Prob > chi2 = 0.3653

2.2.12 Misspecification Test:

By applying the Ramsey's Regression Specification Error (RESET) test for model misspecification (Wooldridge, 2009), the test reported a high p-value of 0.4083. Thus, the null hypothesis that the model has no omitted variable is not rejected.

Ramsey RESET test using powers of the fitted values of GDP_Per_Capita_Gr

Ho: model has no omitted variables

F(3, 32) = 0.99

Prob > F = 0.4083

2.2.13 Regression Forecast and Confidence Interval:

In order to forecast per capita GDP annual percentage growth rate for the year 2010, the regression model was rerun after excluding the year 2010 and resulted the following regression equation (3):

GDP_Per_Capi_Gr = -0.9643674 + 0.3682839 Gross_Fixed_K+ 84.88602 LFPopGr - 0.0009008 Inf_GDP_Def + e_t (3)

The forecast of per capita GDP annual percentage growth rate for the year 2010 equals 7.9808084, that approximately equals 8% annual growth rate. It is calculated via inserting the values of the indepedent variables for the year 2010 in equation (3).

GDP_Per_Capi_Gr = -0.9643674 +(0.3682839*21.3340731364)+(84.88602*0.01290663)-(0.0009008*8.2285350577) + e_t

2.2.14 Confidence Interval Calculations:

The following equation (4) is used to calculate the confidence interval at α significance level (Wooldridge, 2009):

$y_{t-1} \pm t_\alpha * s_f$ (4)

Where:

y_{t-1} : Is the point forecast.

t_α : The critical *t* value at α significance level.

s_f : The forecast's standard error.

The 90% confidence interval where *t* = 1.690 at 35 degrees of freedom is:

7.9808084 ± (1.690*1.9008336) → [4.7683996, 11.193217]

The regression model's forecast succeed the 90% confidence interval as actual value of GDP per capita annual growth rate in the year 2010 is 6.59596271689. The actual value falls within the confidence interval's range.

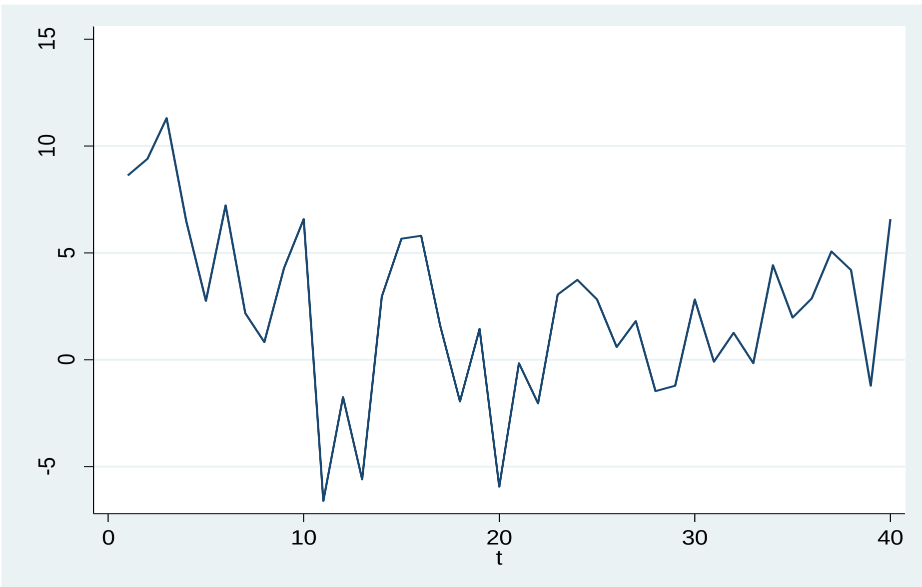
2.2.15 Autoregressive Integrated Moving Average (ARIMA) Model:

The other method used to forecast 2010 per capita GDP annual growth rate is an Autoregressive Integrated Moving Average (ARIMA) Model (Wooldridge, 2009). In order to decide the optimal number of Autoregressive (AR) and/or moving average (MA) terms used in the model, the time series dataset was first tested for stationarity. To examine whether the dataset is stationary or not, the time series was represented by a graph to capture the pattern that the dependent variable follows over time. Besides, a Dickey-Fuller test for unit root was also conducted (Wooldridge, 2009). As the time series was found to be a highly persistent one, it is transformed by taking the first difference to overcome the problem of non-stationarity. The transformed time series dataset was also tested for stationarity, and the transformed form of the time series turned to be weakly dependent. Then both the autocorrelation and the partial autocorrelation correlograms of the transformed form was examined to decide on an MA(1) ARIMA model.

2.2.16 Testing the Time Series for Stationarity:

Figure 1 represents the pattern that the dependent variable, GDP per capita annual growth rate, takes over time. The figure shows that the time series neither has a constant mean nor a constant variance with time progress. Thus, the time series turned to be a highly persistent one.

Figure 1 – GDP Per Capita Annual Percentage Growth**:**



However, the Dickey-Fuller test for unit root that tests the null hypothesis of non-stationarity reported a p-value of 0.0007 and a test statistic of -4.169 which is statistically different that zero and less than the critical value of -2.961. Thus the null hypothesis that the data is highly persistent is rejected. The Dickey-Fuller test showed that the time series data is weakly dependent. This result contradicts the information extracted from the above Figure 1.

. dfuller GDP_Per_Capita_Gr, lags(0)

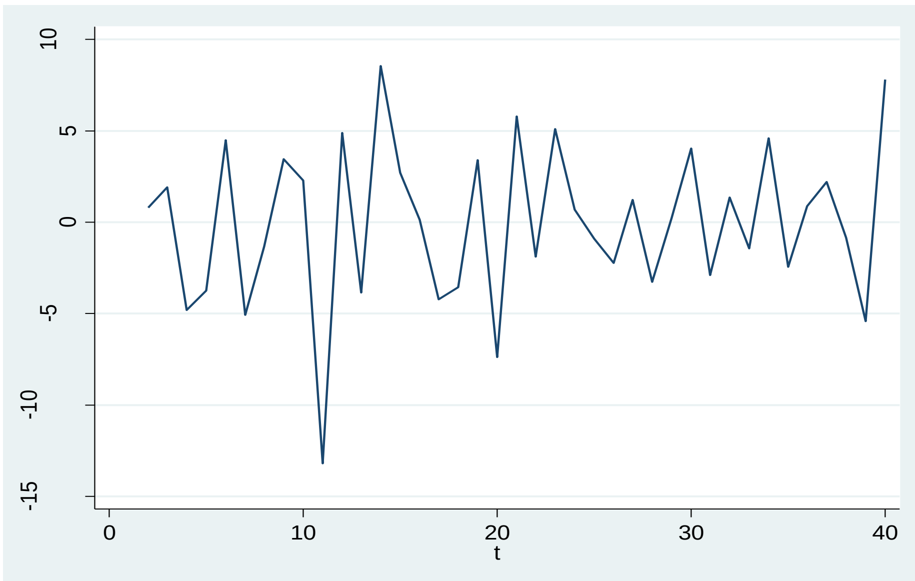
Dickey-Fuller test for unit root Number of obs = 39

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		---------- Interpolated Dickey-Fuller ---------		
Z(t)	-4.169	-3.655	-2.961	-2.613

MacKinnon approximate p-value for Z(t) = 0.0007

The time series was transformed by taking the first difference to overcome the problem of non-stationarity. The transformed form of the time series is presented in Figure 2 which shows the pattern that the transformed form of the time series follows over time. The figure shows some outliers, but a better behavior of the economic variable towards a constant mean and a constant variance.

Figure 2 – Transformed Time Series – First Difference – GDP Per Capita Annual Percentage Growth



The Dickey-Fuller test for unit root that tests the null hypothesis of non-stationarity reported a p-value of 0.0000 and a test statistic of -9.307 which is statistically different that zero and is less than the critical value of -2.964. Thus the null hypothesis that the data is highly persistent is rejected. Thus, the transformed form of the time series data is weakly dependent.

. dfuller d.GDP_Per_Capita_Gr, lags(0)

Dickey-Fuller test for unit root Number of obs = 38

	---------- Interpolated Dickey-Fuller ---------			
	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-9.307	-3.662	-2.964	-2.614

MacKinnon approximate p-value for Z(t) = 0.0000

2.2.17 Autocorrelation and Partial Autocorrelation Functions:

Both the autocorrelation and the partial autocorrelation functions of the transformed form of the time series were examined to decide the number of autoregressive and/or moving average terms that need to be included in the ARIMA model.

Table 3 shows a rapidly declining the autocorrelation histogram where the autocorrelation coefficient declines to zero at the second lag. It also shows a rapidly declining partial autocorrelation histogram where the partial autocorrelation coefficient also declines to zero at the second lag.

A one high autocorrelation coefficient followed by an autocorrelation coefficient near zero indicates that the ARIMA model should include a moving average term, meanwhile no autoregressive term should be included (Oppenheim, 1978).

Table 3 Autocorrelation & Partial Autocorrelation Functions

```
. corrgram d.GDP_Per_Capita_Gr

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1      -0.4183  -0.4584   7.3641  0.0067       ---|              ---|
2       0.0760  -0.1247   7.6138  0.0222          |                 |
3      -0.1390  -0.1939    8.472  0.0372         -|                -|
4       0.0588  -0.1120   8.6302  0.0710          |                 |
5      -0.2033  -0.3349   10.574  0.0605         -|               --|
6       0.1227  -0.1884   11.303  0.0794          |                -|
7       0.1472   0.1271   12.386  0.0886          |-                |-
8      -0.1474  -0.1456   13.507  0.0955         -|                -|
9       0.2102   0.1452   15.861  0.0698          |-                |-
10     -0.1991  -0.0025   18.046  0.0542         -|                 |
11      0.1492   0.0467   19.317  0.0556          |-                |
12     -0.2103  -0.1200   21.936  0.0382         -|                 |
13      0.2066   0.1726    24.56  0.0264          |-                |-
14     -0.1699   0.1307   26.407  0.0230         -|                 |-
15      0.1500   0.3584   27.905  0.0222          |-                |--
16     -0.0889   0.0788   28.455  0.0279          |                 |
17      0.0167   0.1998   28.475  0.0397          |                 |-
```

The following MA(1) ARIMA model is used to forecast the 2010 per capita GDP annual percentage growth rate, where the time series were transformed by taking the first difference. The moving average term has a z-statistic of -4.41 and a p-value of 0.0000. Thus, the null hypothesis that the moving average term is insignificant is rejected. The model reported a 3.7339 RMSE. The ARIMA forecasting model is represented by equation (5).

$$GDP\_Per\_Capita\_Gr = \underset{(0.2514771)}{-0.1275} + \underset{(0.1482611)}{0.6544}e_{t-1} + e_t \qquad (5)$$

ARIMA regression

Sample: 2 - 40 Number of obs = 39

Wald chi2(1) = 19.48

Log likelihood = -106.9992 Prob > chi2 = 0.0000

D. GDP_Per_Capita_Gr	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf. Interval]	
GDP_Per_Capita_Gr						
_cons	-.1275337	.2514771	-0.51	0.612	-.6204198	.3653525
ARMA						
ma						
L1.	-.6544435	.1482611	-4.41	0.000	-.9450299	-.3638571
/sigma	3.733909	.4462901	8.37	0.000	2.859197	4.608622

Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.

2.2.18 ARIMA Forecast and Confidence Interval:

ARIMA forecast of 2010 per capita GDP annual percentage growth rate calculated using STATA is 6.3103065. That approximately equals 6% annual growth rate.

2.2.19 Confidence Interval Calculations:

Equation (4) is also used to calculate the confidence interval at α significance level (Wooldridge, 2009):

The 90% confidence interval where t = 1.690 at 37 degrees of freedom is:

6.3103065 ± (1.690*3.7339092) ⟹ [-4.769585, 7.851028]

The ARIMA model's forecast succeed the 90% confidence interval as actual value of GDP per capita annual growth rate in the year 2010 is 6.59596271689. The actual value falls within the confidence interval's range.

3. Conclusion

Brazil's per capita GDP annual percentage growth rate was forecasted using both a single regression equation forecasting model and ARIMA forecasting model. The ARIMA model predicted more accurate forecast in the sense that it is closer to the actual value of GDP per capita growth rate recorded on 2010. But the ARIMA 90% confidence interval has a remarkably wide range. Meanwhile, the regression forecasting model over-predicted the value to a little extent, but reported a narrower 90% confidence interval.

The regression model reported few shortcomings. The model is derived from the growth equation employed in the literature, so should include a variable that approximate the growth in economic productivity. Though the Ramsey mis-specification test reported that the regression model has no omitted variable, the model lacks the productivity growth variable. Besides, the labor force growth was calculated via using population growth variables due to the fact that there is no access for labor force participation growth rates for the period between the years 1971-2010. Another limitation is that the model reported high values of both R-squared and adjusted R-squared. However, the RMSE value was not sufficiently low when compared to the mean value of the dependent variable, the thing that casts some doubts on the model's goodness of fit characteristics.

As for the ARIMA model, the dependent variable's time series data was found weakly dependent using the Dickey-Fuller test. However, depicting the dependent variable's pattern over time via a graph showed that the time series needs to be transformed by taking the first difference in order to construct a proper ARIMA forecasting model.

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