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Effects of overvaluation and exchange rate volatility over industrial investment: Empirical evidence and economic policy proposals for Brazil

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The present article aims to analyze the recent behavior of real exchange rate in Brazil and its effects over investment per worker in Brazilian manufacturing and extractive industry. Preliminary estimates presented in the article shows an over-valuation of 48% of real exchange rate in Brazil. The reaction between the level (and volatility) of real exchange rate and investment (per worker) in Brazil is analyzed by means of a panel data econometric model for 30 sectors of Brazilian manufacturing and extractive industry. The empirical results show that the level and volatility of real exchange rate has a strong effect over investment per worker in Brazilian industry. Finally, we conclude the article presenting a proposal for a new macroeconomic regime that aims to produce an acceleration of economic growth of Brazilian economy and, by that, a catching-up process with developed countries.
Keywords: Real exchange rate, economic development, structuralist development macroeconomics.
JEL Classification: L5, O11, F41

INTRODUCTION.

The general issue formulated for the tenth edition of the Economic Forum of São Paulo concern the strategy required for Brazil double its per-capita income in 15 years. Based on the known "rule of 70", for a country to double its *per-capita* income in 15 years, the rate of growth required for its *per-capita* income double in this period shall equal the 70/15, i.e. 4.66% p.a.. Considering that the Brazilian population is currently growing around 0.6% p.a., for Brazil to double its *per-capita* income in 15 years, GDP would have to grow at rate of 5.26% p.a. during this period. Given that in the last 20 years (1992-2012) the average growth of the Brazilian economy was 2.96% p.a., according IPEADATA, to double Brazil's per capita income, in such a short space of time, would be necessary to increase the rate of GDP growth by almost 100%.

Given that rate unemployment is slightly below 6%, a number considered by some economists to be close to a situation of full employment, an acceleration of this magnitude in real GDP growth rate will only be possible through a significant increase in labor productivity, which requires a significant increase in investment and capital accumulation.

Based on Harrod-Domar growth model, and assuming a capital-output ratio equal to 3 and a rate of depreciation of fixed capital equal to 3.5% p.a., the rate of investment required to double per capita income in 15 years is 26.28% of GDP. An investment rate as a proportion of GDP close to 18%, as observed in recent years, is clearly insufficient to produce an acceleration of this magnitude in real GDP growth rate.

What are the policies that can be adopted to induce a stronger pace of capital accumulation and, therefore, a faster growth of real GDP? In particular, what is the appropriate exchange rate policy for Brazil will be able to double its per capita income in 15 years?

This question is a complete non-sense for liberal economists. For them the relevant variable to explain the growth of *per-capita* income is the Total Factor Productivity (cf. Veloso, Ferreira and Person; 2013). In this

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context, the Brazilian economy is semi-stagnant due to factors like high taxes (cf. Ellery and Teixeira, 2013), low rate of government saving (see Bacha and Bonelli, 2013) or low investment in education (cf. Ferreira and Veloso, 2013). The restrictions on growth of the Brazilian economy came, therefore, from the supply side of the economy, so that changes in exchange rate policy will have little or no effect on growth perspectives of Brazil.

Although the supply side of the economy is relevant to explain the constraints on long-run growth, this paper suggests that the fundamental restriction to growth lies in the demand side of the economy. There are theoretical arguments and lot of empirical evidence in favor of the hypothesis of demand-led growth (Ledesma and Thirwall, 2002; Libanio, 2009; Oreiro et al. 2012). In this context, the restriction on the long-run growth is given by the condition of equilibrium in the balance of payments which gives rise to so-called “Thirlwall Law” according to which the growth rate consistent with equilibrium in the balance of payments is equal the ratio of the income elasticity of exports and income elasticity of imports multiplied by the growth rate of world income. Thus, the domestic growth rate will be equal to the growth rate of exports divided by the income elasticity of imports, what characterizes a growth regime of export-led type. In this context, the occurrence of catching-up requires that the ratio of these elasticities are greater than one; which requires, in turn, a diversified production structure and firms that are operating fairly close to the technological frontier.

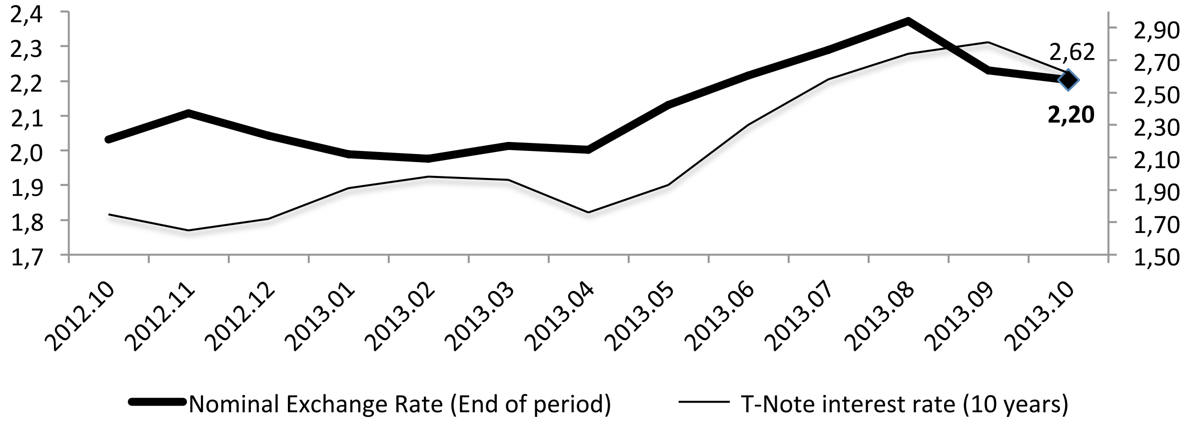
Until recently, the literature of demand-led growth downplayed the existence of a relationship between the income elasticities of imports and exports and the level of real exchange rate. However, economists of the so-called Structuralist Development Macroeconomics has argued for the existence of a relationship between the level of the real exchange rate and the income elasticities of the Thirlwall model. More specifically, it is argued that deviations of real exchange rate with respect to industrial equilibrium level (Bresser-Pereira, Oreiro and Marconi, 2013) result in a reduction in the rate of capital accumulation which leads to perverse changes in the productive structure of a country and therefore in income elasticity of exports and imports, which give rise to a reduction in the growth rate compatible with the balance of payments equilibrium, and therefore can derail the catching-up process.

This article aims to analyze the recent behavior of the real exchange rate in Brazil, emphasizing its state of chronic overvaluation even after recent devaluations of nominal exchange rate. Preliminary estimates presented in this paper point to an overvaluation of about 48% of the real exchange rate in Brazil. The relationship between the level (and volatility) of the real exchange rate and investment (per worker) in Brazil is analyzed using an econometric model with panel data for 30 sectors of manufacturing and extractive industry. The empirical results support the hypothesis that the real exchange rate is a key variable in determining the capital accumulation and long-run growth path. Finally, we conclude this paper by presenting a proposal for a macroeconomic policy framework to enable faster growth of the Brazilian economy and therefore the process of catching-up with respect to developed countries.

THE RECENT BEHAVIOR OF THE EXCHANGE RATE IN BRAZIL: TOWARDS THE INDUSTRIAL EQUILIBRIUM?

Recently, the exchange rate returned to the center of the Brazilian economic debate as a result of nominal devaluation arising from the anticipation of ending or at least reducing of monetary stimulus programs- so-called *Quantitative Easing 3* - by the Federal Reserve, Fed. Indeed, as we see in Figure 1 below, the interest rate of the 10-year T-Notes begin to increase from April 2013 according to the expectation of "normalization" of monetary policy by the Federal Reserve. Simultaneously to this movement, it is observed in Brazil a depreciation of the nominal exchange rate, which increased from R$ 2.00 per dollar in April 2013 for about R$ 2.37 at the end of August of this year, depreciation of 18.52% in four months.

Figure 1 - Nominal exchange rate (US$/RS) and T-Notes interest rate (10 years)



Source: IPEADATA. Prepared by the authors. The values measured on the left vertical axis refers to the nominal exchange rate, while the values measured on the right vertical axis refers to the interest rate of the 10 years T-Notes.

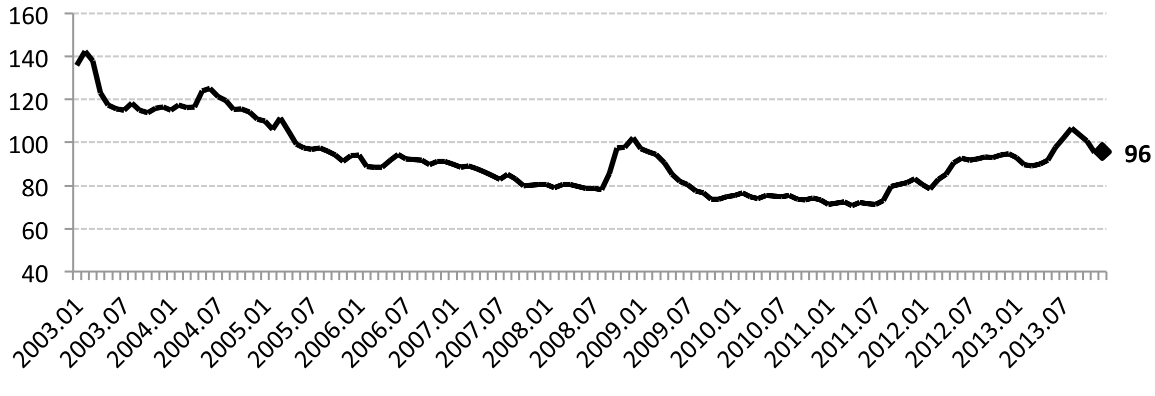
Although the nominal exchange rate has returned to appreciate, standing at around R$ 2,20-2,30; it is unlikely that it will return to the levels prevailing in early 2013. In this context, we should ask what are the likely effects of the devaluation of the nominal exchange rate on the Brazilian economy. In particular, does the current level of exchange rate will allow the recovery of the Brazilian economy's competitiveness to be closer to the so-called industrial equilibrium, leveraging a greater dynamism of the industrial sector and, therefore, a more robust pace of economic growth[1]?

To analyze the impact of the depreciation of the nominal exchange rate on the competitiveness of Brazilian industry we need to look at the effect on the real effective exchange rate for exports of manufactured products[2]. This time series can be viewed in Figure 2 below. As we can see in Figure 2, the real effective exchange rate clear shows a trend to appreciation in the period from January 2003 to June 2008. Due to the impact of the international financial crisis, detonated from the bankruptcy of Lehman Brothers in September 2008, the real effective exchange rate has suffered a rapid depreciation which, however, is reversed at the beginning of 2009. Ended the effects of the international financial crisis on the Brazilian economy observed a tendency towards stability of the real effective exchange rate until August 2011, when it begins a process of depreciation, reaching in August 2013 a plateau near the prevailing in mid-2005.

[1] Regarding the relationship between the exchange rate overvaluation, loss of competitiveness and semi-stagnation of the Brazilian economy, see Oreiro (2013).

[2] This series is calculated by IPEA and is a measure of the competitiveness of Brazilian exports calculated by the weighted-average index of the purchasing power parity of 16 major trading partners of Brazil. The purchasing power parity is defined as the quotient between the nominal exchange rate (R$/unit of foreign currency) and the relationship between the Wholesale Price Index (WPI) of the country concerned and the National Consumer Price Index (INPC/IBGE) from Brazil. The weights used are the contributions of each partner of Brazilian exports of manufactured goods in 2001.

Figure 2 - Real Effective Exchange Rate – Manufactures Exports

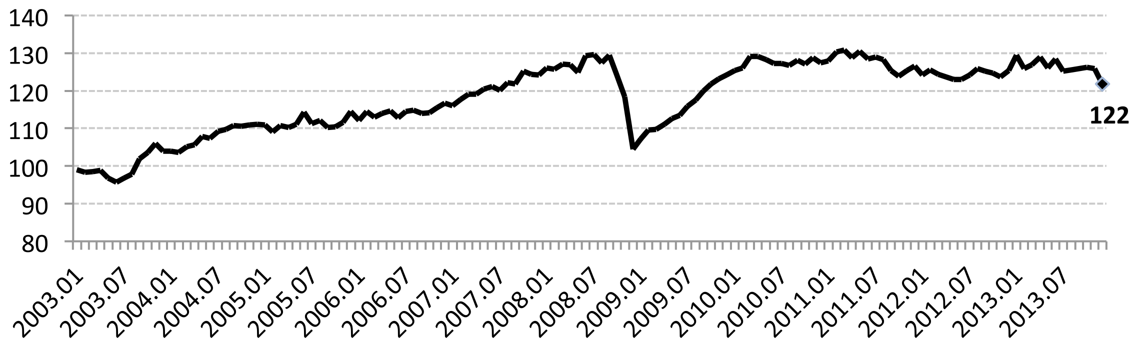


Source: IPEADATA. Prepared by the authors.

The return of the real effective exchange rate to the levels prevailing in mid-2005 means that the Brazilian manufacturing industry will retrieve its dynamism? At first glance the answer would be yes, since in the period in which the real effective exchange rate was more depreciated, the manufacturing industry was more dynamic. In fact, between January 2003 and August 2008, according to data from IPEADATA reproduced in Figure 3 below, the physical production of manufacturing industry grew up 28.71%; whereas in the period between March 2010 and August 2013 the physical production of manufacturing industry was virtually stagnant, showing a slight drop of 2.75%.

A more careful analysis, however, leads us to be more pessimistic about the impact of the recent depreciation of the nominal exchange rate on the prospects of expansion of the production in manufacturing industry. As we can see in Figure 3, the depreciation of the real effective exchange rate, which occurred from January 2012, had no noticeable effect on the trend of the physical production in manufacturing industry, which continues to oscillate around a stationary level. This means that the depreciation of the real exchange rate that has occurred so far has not been large enough to recover the competitiveness of Brazilian industry.

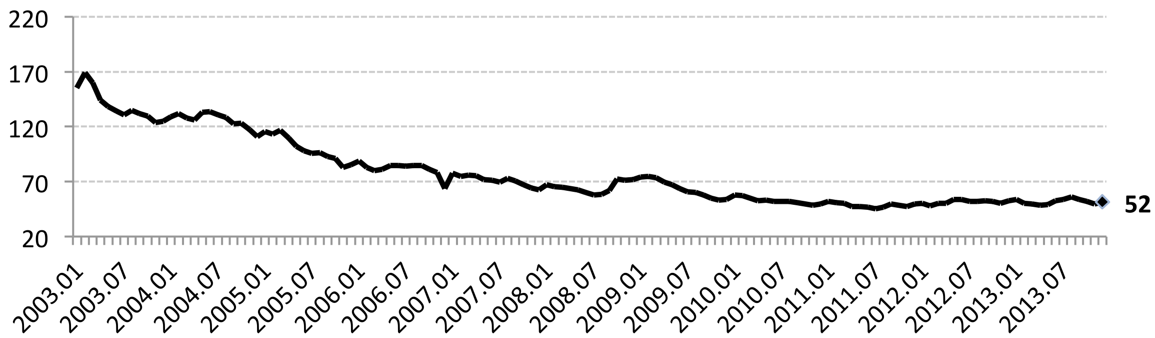
Figure 3 - Physical Production – Manufactory Industry (seasonally adjusted)



Source: IPEADATA. Prepared by the authors.

This observation becomes clearer when we look at the behavior of the relationship between real effective exchange rate/wages[3], shown in Figure 4 below, which is an indicator of the profitability of exports from the manufacturing industry.

Figure 4 - Evolution of the Real Effective Exchange Value / Wages in Brazil



Source: IPEADATA. Prepared by the authors.

As we can see in Figure 4 above, between January 2003 and December 2013 the real effective exchange rate deflated by nominal wage presented an appreciation of incredible 66.78%. This means, first of all, that the recent depreciation of the nominal exchange rate has had no noticeable effect on the relationship under consideration, thereby indicating that the competitiveness of the manufacturing industry remains unchanged. Secondly, but no less important, the loss of competitiveness of the manufacturing industry, not only the trend towards appreciation of the exchange rate recorded since 2003, but also the wage growth at a pace above labor productivity growth that occurred in this period.

What should be the real effective rate exchange rate to reestablish the competitiveness of Brazilian manufacturing industry? To answer that question, let us assume that the ratio between real effective exchange rate/wage prevailing in mid-2005 is appropriate to restore the competitiveness of industry, since, between 2004 and 2007, the physical production of manufacturing industry expanded at rates more robust. In May 2005, the relationship real effective exchange rate/wage was equal to 101.99. In June 2013, the real effective exchange rate and the ratio real effective exchange rate/wage were, respectively, 97.26 and 52.91. Thus, for a simple proportional rule, the real effective exchange rate compatible with the value of the ratio real effective exchange rate/ wage prevailing in May 2005 should be of 187.47, an overvaluation of 48.12%!

This simple exercise points to the fact that the recent depreciation of the nominal exchange rate is much lower than that required to restore the competitiveness of the manufacturing industry, a *sine qua non* condition for obtaining more robust growth rates for real GDP. It follows that while the government does not operate a profound change in macroeconomic matrix, which allows obtaining a more competitive exchange rate in the same time that keeping inflation in low and stable levels, the Brazilian economy will be doomed to get mediocre growth rates. We will return to this issue..

INTERNATIONAL EVIDENCE ON THE VOLATILITY OF THE EXCHANGE RATE AND ITS EFFECT ON INVESTMENT (1995-2013)

The hypothesis that not only the level of the real exchange rate, but also the volatility of the nominal exchange rate affects investment decisions was empirically supported by Darby et al. (1999). Thus, there would be two related channels acting on agent's investment decisions. The first, the traditional, which relates

[3] Index calculated from the average wages nominal (FIESP), real exchange rate (R$) / US dollar (US$) - monthly average - sale (Central Bank of Brazil), Exchange rates for 16 selected countries / US dollar (US$) - monthly average (IMF) and the weighting of 16 selected countries of Brazilian exports (Secex).

the real exchange rate to external competitiveness and economic activity: "*The exchange rate is one of most important macroeconomic variables in the emerging and transition countries. It affects inflation, exports, imports and economic activity*" (Edwards, 2006, p. 28). The second effect, relates the nominal exchange rate volatility to investment. Is was argued that the flow of new information on the market, in an environment of uncertainty, asymmetric information and incomplete markets, can both reduce the volatility but also increase it. This means that the relationship between volatility and increased uncertainty is not linear. This statement also does not mean that the elimination of exchange rate volatility automatically eliminates the uncertainty and therefore stimulates investment but yes, from certain level of volatility, uncertainty is so large that the agents simply choose to postpone their investment decisions. Thus, the effect of volatility on the economy, in particular on industry, should not be homogeneous, being more significant for those with less monopoly power and lower technological intensity, i.e., for those industries more susceptible to price fluctuations.

Considering the data of the nominal bilateral exchange rate with the US dollar of the countries of G20[4], in the period from 01.02.1995 to 09.10.2013, totaling 4,877 observations, and the monthly real effective exchange rate calculated by BIS (Bank for International Settlements), from December 1994 to July 2013, with 224 observations, we proceed with the analysis between the relationship of exchange rate variation with average economic growth.

The results are consistent with the empirical evidence cited by literature, so that exchange rate volatility is negatively correlated with economic growth, according to Figures 5 and 6 below.

Figure 5 – Relationship between daily variation of the nominal exchange rate and average economic growth between 1995 and 2013

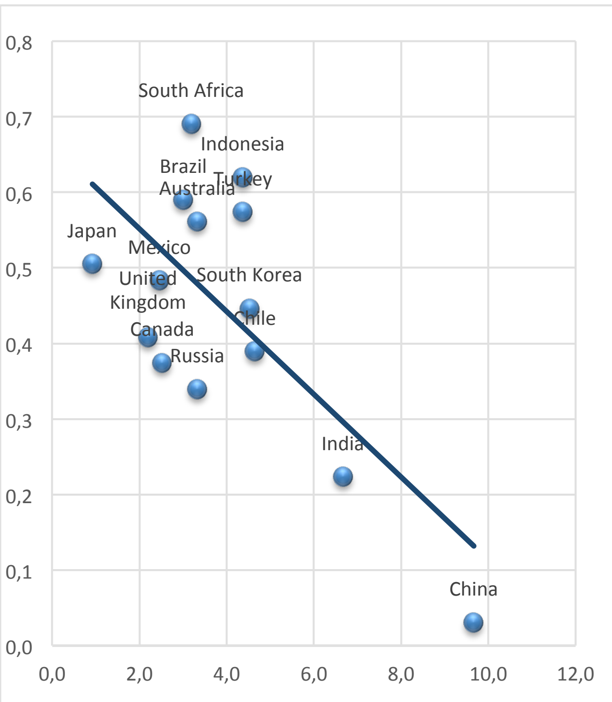
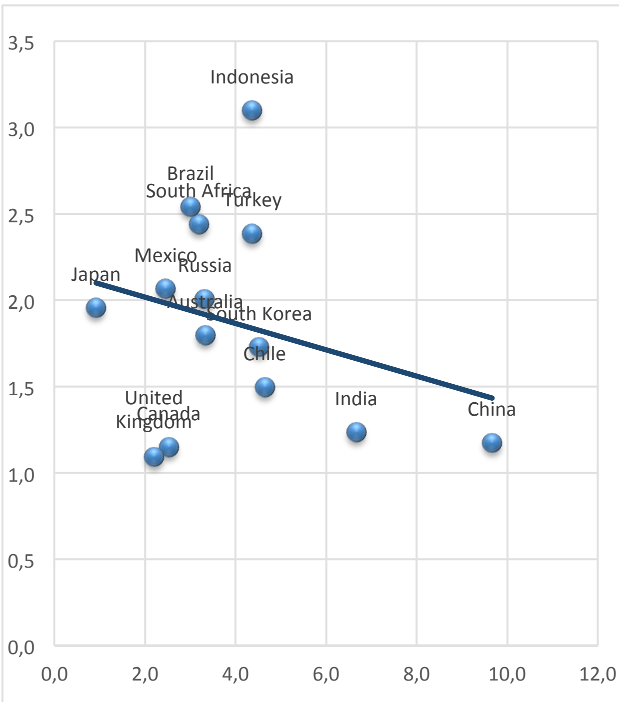


Figure 6 – Relationship between monthly variation of real effective exchange rate and average economic growth between 1995 and 2013



Source: BIS, Bloomberg. Prepared by the authors.

[4] Argentina was excluded from the analysis due to lack of credibility of the exchange rate data. As we all know, there is a huge difference between the value of official exchange rate and the one practiced in the real spot market. Instead, it was considered the Chile which, although not part of the G20, is an important country in Latin America.

Table 1 - Correlation between variations of exchange rates (nominal and real) and average growth of countries between 1995 and 2013

		Daily Nominal Exchange Rate				Montly Real Exchange Rate			
Country	Average Growth Rate	Mean	Std. Deviation	non-parametric VaR (95%)	non-parametric VaR (99%)	Mean	Std. Deviation	non-parametric VaR (95%)	non-parametric VaR (99%)
South Africa	3,2	0,69	0,77	2,12	3,38	2,44	2,41	6,56	14,79
Australia	3,3	0,56	0,58	1,58	2,61	1,80	1,56	4,25	6,09
Brazil	3,0	0,59	0,80	2,02	3,76	2,54	3,14	7,63	21,81
Canada	2,5	0,37	0,37	1,10	1,81	1,15	1,04	2,66	5,44
Chile	4,6	0,39	0,42	1,16	1,90	1,50	1,34	4,04	6,23
China	9,7	0,03	0,06	0,15	0,27	1,18	0,91	2,87	4,22
South Korea	4,5	0,45	0,85	1,36	3,58	1,73	3,01	5,81	13,38
India	6,7	0,22	0,32	0,81	1,51	1,24	1,06	3,48	5,20
Indonesia	4,4	0,62	1,43	2,39	6,15	3,10	6,48	13,11	31,04
Japan	0,9	0,50	0,49	1,37	2,33	1,96	1,70	5,45	8,54
Mexico	2,5	0,48	0,68	1,40	3,06	2,07	3,20	5,42	14,42
United Kingdom	2,2	0,41	0,37	1,12	1,71	1,09	1,03	3,00	5,72
Turkey	4,4	0,57	0,95	1,73	3,66	2,39	2,61	9,36	12,62
Russia	3,3	0,34	1,11	1,09	2,65	2,01	4,06	5,47	15,32
Correlation		**-0,68**	**-0,30**	**-0,53**	**-0,34**	**-0,27**	**-0,15**	**-0,12**	**-0,19**

Source: BIS, Bloomberg. Prepared by the authors.

For calculating the volatility, in addition to the usual statistics measures, we used the VaR (Value at Risk) approach, derived from the probability distribution of asset, $f(w)$. The choice of this measure stems from the international banking regulations established by Basel and followed by major central banks in the world. The risk associated of fluctuation of the exchange rate is part of the menu of concerns of regulatory requirements, so that the higher the risk exposure, the greater the capital requirements by banks and thus lower the capacity of lending and leverage.

In this context, given the level of confidence, c, it is estimated the worst possible realization, W^*, such that the probability of exceeding this value of trust is given by:

$$c = \int_{W^*}^{\infty} f(w)dw$$

Alternatively, the probability that a value smaller than w^*occurs, with $p = P(w \leq W^*)$, is $1 - c$:

$$1 - c = \int_{-\infty}^{W^*} f(w)dw = P(w \leq W^*) = p$$

Assuming the data of daily variations (for nominal exchange rate) and monthly variations (for the real effective exchange rate) are independent and identically distributed, the VaR indicates at the level of confidence 95% and 99%, the largest daily or monthly expected loss, as the case. Tables 1, 2 and 3 and Figure 7 (Tables 2 and 3 and Figure 7 are in the last pages) summarize the results of calculation for both, parametric and no-parametric approach.

From the data presented in Tables 2 and 3, it is noted that the relative VaR exposure to foreign exchange rate in Brazil is quite high, which means high intensity in the exchange rate volatility and therefore high probability of maximum expected loss in portfolio of agents, particularly banks. However, the Brazilian data are in line with the values obtained by the major emerging countries of the G20, with the exception of Indonesia, whose daily VaR reached the amazing mark 26.99% (parametric) and 37.65% (non-parametric).

DETERMINANTS OF INVESTMENT IN BRAZILIAN INDUSTRY (1996-2007)

Taking as starting point the econometric model of Darby et al. (1999), we estimate the determinants of investment in Brazilian extraction and manufacturing industry taking into consideration not only the traditional purposes of capital cost and mark-up, but also on positive elements related to business opportunities, and negative related to uncertainties of investment decisions.

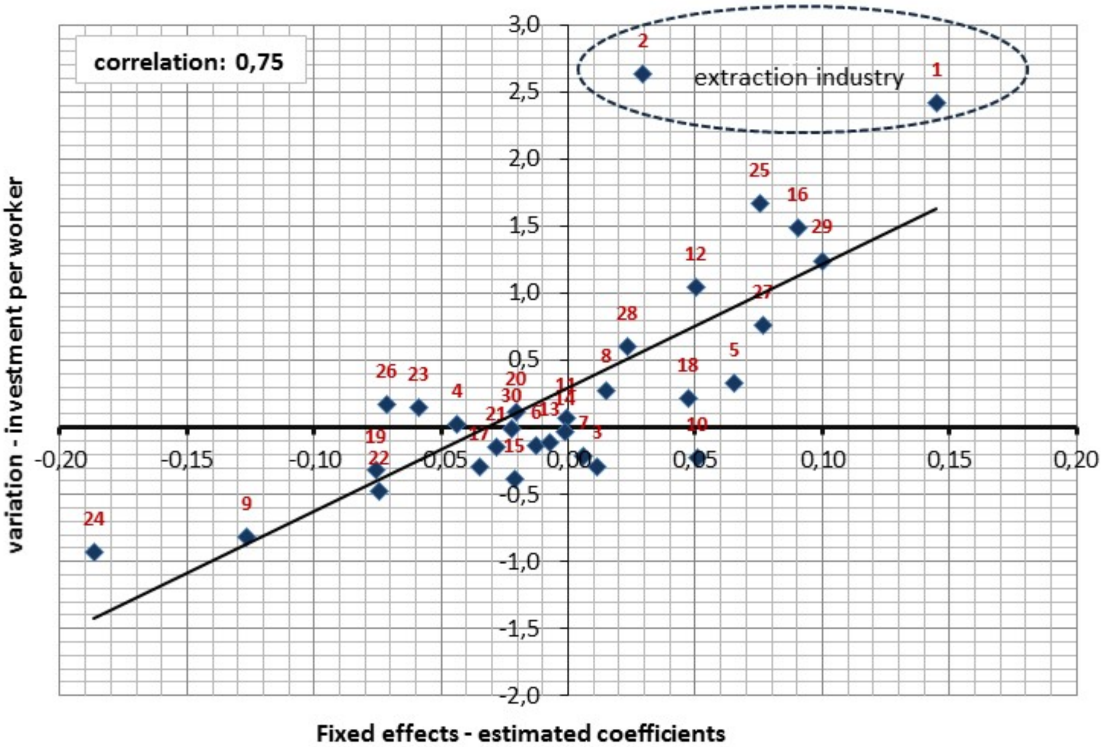
Given that investment per worker is the relevant variable in terms of output growth in the long run, we develop an econometric analysis based on six models with panel data for 30 industrial sectors of the Brazilian national accounts system (SCN-econometric analysis 42) in the period between 1996 and 2007. In this sense, the estimation method chosen allows different analysis of those proposals in Darby et al. (1999) model, because our model takes into consideration the sectorial heterogeneities, as suggested by the authors in the original model. Furthermore, the analysis developed not only checks the effects of real exchange rate on investment per worker, but also the effects of exchange rate volatility (uncertainty effect) causes in investment decisions. Additionally, we analyze the effects of investment opportunities through the traditional channel of Tobin's Q[5] and also about the mark-up effects on investment decisions. As a proxy of the latter variable, we use the relative price of industrial sector i on the economy general price level. As a robustness test, we have replaced the relative price for traditional variables such as the unit labor cost and labor productivity. Furthermore, we tested the effects of Harrodian accelerator on investment decisions. Finally, we replaced the volatility of the real exchange rate by the volatility of nominal exchange in order to verify the robustness of the empirical results.

1. Description of model variables and main results

Investment per worker: calculated at constant prices of 1995, from the system of national accounts of IBGE.

5 See Tobin (1969).

Figure 8 - Relationship between investment per worker and fixed effects coefficient of econometric[6] model (baseline model)



Real Effective Exchange Rate-REER: The real exchange rate (or effective rate) is the nominal rate deflated by a similarly weighted average of foreign price or cost. In particularly, the calculation of the real effective exchange rate is made from BIS data. To this end, we consider a basket of currencies consisting of 61 countries, so that the nominal exchange rate is weighted by the bilateral price on trading partners. In addition, the weighting system, itself, is based on Turner and Van ´t dack (1993) and takes into account the manufacturing transactions flows between countries. Algebraically, the methodology is expressed by:

Weight of imports: $w_i^m = \frac{m_j^i}{m_j}$

Weight of exports: $w_i^x = \left(\frac{x_j^i}{x_j}\right)\left(\frac{y_i}{y_i+\sum_h x_h^i}\right) + \sum_{k\neq i}\left(\frac{x_j^k}{x_j}\right)\left(\frac{x_i^k}{y_k+\sum_h x_h^k}\right)$

Average weight: $w_i = \left(\frac{m_j}{x_j+m_j}\right)w_i^m + \left(\frac{x_j}{x_j+m_j}\right)w_i^x$

Where: $x_j^i(m_j^i)$ is the export of the economy j for the economy i.

$x_j(m_j)$ is the total export of the economy j

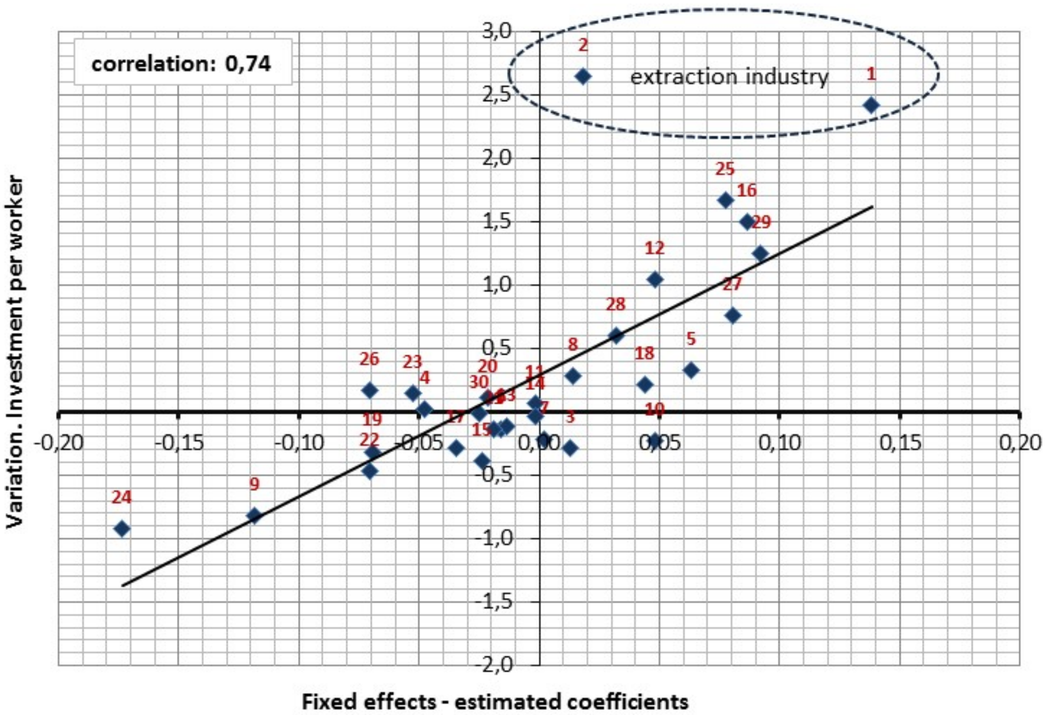
y_i is the total domestic supply of manufactured goods in the economyi

$\sum_h x_h^i$ is the export of h (excluding j) for i

[6] In the graph above, we compare the percentage change in the period of 1996-2007 of the real value of the investment, calculated from the System of National Accounts IBGE, with the estimated coefficients for each cross-section unit of the econometric model (M1) - benchmark. In this sense, considering that the higher the coefficient (constant) model, higher is the investment per worker, it is suggested that the estimates calculated for each sector are consistent with empirical evidence. Particularly, the greatest divergence occurs with the extractive industry. When we compare the estimated value with the actual real value reported, we found greater investment per worker than the result expected by the model. However, when considering that the extractive industry sector are companies such as Vale do Rio Doce and Petrobras, is justified by higher variation in investment per worker than predicted by the econometric model.

However, the BIS methodology calculated the real exchange rate is in terms of the currency of the country of origin. This means that the interpretation of the exchange rate is how much foreign currency can be purchased with a unit of the domestic currency. In other words, "with a one real buy how many dollars is possible to buy".

Figure 9 - Relationship between investment per worker and fixed effects coefficient of econometric model (average of models) [7]



To invert the logic, we proceed with the following algebraic calculus:

$$real\ exchange\ rate - notation\ Brazil = 1/(1 + exchange\ rate\ variation - BIS\ notation)$$

Real Effective Exchange Rate Volatility: calculated on the basis of the monthly volatility of the real effective exchange rate.

Tobin Q: calculated from the ratio of the market value of companies listed on BMF Bovespa for its respective book value. The aggregate index is calculated from the weighting of individual values by asset of the company.

Cost of Capital: Brazilian average annual long-term interest rate (TJLP).

Relative price: industrial mark-up proxy, calculated from the ratio of the sectoral price index by the General index of the economy, both calculated from the SCN (system of national accounts) of the IBGE.

Unit labor cost: using the labor productivity data and wages per worker at constant prices of 1995, it is estimated the unit cost of labor by each industrial sector.

Gross value added: obtained from the SNA, and supply and uses tables, calculated at constant price of 1995.

Relative Labor Productivity: ratio between the average labor productivity of labor in industrial sector i by average labor productivity of the total economy.

Nominal Exchange Rate Volatility: calculated from daily data of nominal exchange rate real/dollar

[7] For the analysis, the averages were calculated from estimated coefficients in econometric models M2 to M6, for each sector, and compared with the values of actual observed variation of investment per worker. Again, there is significant correlation between the estimated coefficients for each cross-section unit of the model with the actual data observed.

aggregated on an annual basis.

2. Empirical analysis

From the econometric models (1) to (6) shown in Table 4 (at the end of the paper), it is evident that the level of the exchange rate affects investment per worker, so that the exchange rate depreciation has positive effects on industrial investment decisions. In this sense, the result obtained corroborates the thesis of structuralist development macroeconomics that more depreciated exchange rate levels stimulate investment decisions by industrial sector.

The exchange rate volatility, by involving important elements related to uncertainty about the future behavior of the exchange rate, was highly significant in all estimated models. In addition, the exchange rate volatility appears to affect investment decisions in a higher intensity than related to the level of the exchange rate. Apparently, the stability of the exchange rate by reducing the levels of volatility and uncertainty has beneficial effects on investment decisions, which provides support to a regime of exchange rate administration.

The cost of capital, measured by TJLP, was highly significant, corroborating the need for industrial policies for the long-term investment and pointing to the need to reduce the value of the real interest rate in Brazil as a way to stimulate invest decisions and long-run economic growth.

Investment opportunities, estimated from Tobin's Q, were highly significant in all analyzes. This result brings an important component of the Keynesian theory of investment and signals the importance of using, in the future, this indicator for predicting the behavior of investment, since it is a leading indicator, prior lagged to investment decision itself.

The industrial mark-up was an important industrial component of investment decisions and highly significant in all tests developed.

To test the robustness of the model through the replacement of the mark-up by the unit cost of labor and later by relative productivity, high stability of the estimated coefficients for the other explanatory variables, corroborating the importance of the result found in relation to the Exchange and its volatility.

Using the classification of technological intensity of the OECD, it was not possible to check, *a priori*, any distinction in relation to the investment behavior of sectors with greater technological intensity in comparison with the sectors of low technological intensity. The estimated data show that all sectors are sensitive to the level of real exchange rate, as well as the volatility of the exchange rate and the interest rate. However, the estimated coefficients for each cross-section unit (Sectors of the CNAE-IBGE) showed no differentiated behavior in virtue of technological intensity of the sector. I.e., the estimated data of the coefficients, which measure the individual characteristic of the sector in the analysis in panel, showed no distinct behavior in relation to the macroeconomic variables with regard to the technological intensity. This result is particularly important, because it does not confirm the thesis that the sectors of high technological intensity are less sensitive to the effects of the exchange rate, at least in the sample in question. For example, the sector 9 (Manufacture of electronic material and equipment), classified in high technological intensity, is more sensitive to exchange rate effects than low technological intensity, such as sector 29 (Other food products and beverages) or even the sector 12 (Sawmills and manufacture of woods products and furniture).

However, notably the industrial sectors linked to the extraction of commodities (Cme) showed strong dynamism related to investment, since in this sector include two of the largest Brazilian companies, namely: Petrobras and Vale do Rio Doce.

THE MANAGEMENT OF REAL EXCHANGE RATE

Neo-liberal economists argue that management of real exchange rate is impossible because the only thing that the monetary authority can do is determine the nominal exchange rate, not the real rate. This is because the variations of the nominal exchange rate generate exactly proportional variations in domestic price level in the long-term, thus leaving the real exchange rate outside the scope of action of the monetary authority. Moreover, it is also argued that the administration of the nominal exchange rate would only be possible in a context of financial openness to the outside, if the Central Bank failed to conduct monetary policy in order to meet domestic objectives (e.g., control inflation and/or stabilization of the level of output and employment). As democratic societies seem to demand the adoption of counter-cyclical policies by their respective Governments, in order to mitigate the effects of business cycles on the level of employment and welfare; it follows that the fixed exchange rate regime or managed regime is politically impracticable, and it should be, therefore, adopt floating exchange regime.

It is not true that the Central Bank can't manage the real exchange rate with the instruments it has at its disposal, so it also is not true that the adoption of a system of fixed or managed exchange rates requires abandoning autonomous monetary policy, i.e., a policy geared to meet domestic objectives. In an economy in which the goods produced domestically are imperfect substitutes of goods produced abroad and where domestic assets are equally imperfect substitutes of assets denominated in foreign currency; not only the real exchange rate is a variable that, under certain conditions, can be administered by the Monetary Authority, as even this administration is done without loss of autonomy in the conduct of monetary policy.

To demonstrate the validity of this assertion let us consider a small open economy that operates with a fixed exchange rate regime or with a managed regime8. Let S to be the nominal exchange rate, settled by the monetary authority, $A_p(.)$ Is the absorption of domestic private sector, Y is domestic income, $\emptyset(.)$ the fraction of domestic absorption that is intended for the purchase of domestic goods, G is the expense of government in real terms, $X(.)$ is the quantity of domestic goods demanded by non-residents, r is the real rate of interest, T is a proxy of tax collections by the Government, $Y^*$is the international income and P * is the international price level. The condition of equilibrium in the market goods is given by:

$$\mathrm{Y} = \emptyset\left(\frac{SP^*}{P}\right) A_p[Y - T, r] + G + X\left[\frac{SP^*}{P}; Y^*\right] \quad (1)$$

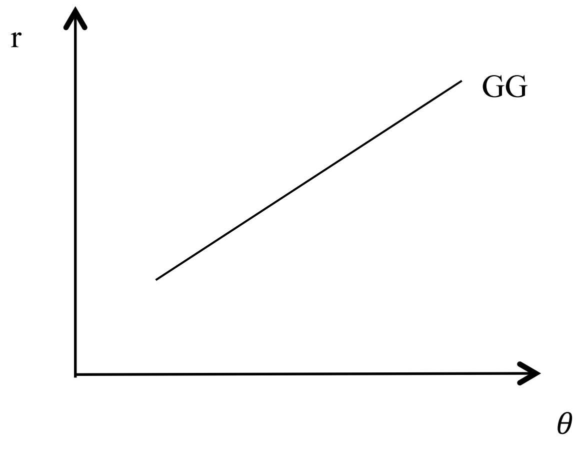
We will assume that: (i) the economy operates at full-capacity, i.e., with a level of output equal to potential output, Y_p; (ii) behavioral functions presented in (1) are homogeneous of degree one with respect to the capital stock, so that variations in the stock of aggregate capital does not alter the values of the endogenous variables.

That said, the equilibrium condition in the goods market is given by:

$$Y_p = \emptyset\left(\frac{SP^*}{P}\right) A_p\left[Y_p - T, r\right] + G + X\left[\frac{SP^*}{P}; Y^*\right] \quad (2)$$

In equation (2) the endogenous variables are: G, T, S, Y* e P*. By setting the real exchange rate as $\theta = \frac{SP^*}{P}$, equation (2) will define the locus of combinations between real interest rate and real exchange rate for which the goods market is in equilibrium. Making the usual assumptions about the values of the partial derivatives with respect to behavioral functions r and θ, we obtain the curve GG presented in Figure 10:

Figure 10 – Lócus GG



[8] The present model is based on Montiel (2011).

Domestic residents may allocate their financial wealth, W_p, between money (M), domestic government securities (B), and foreign government bonds (B^*). We suppose that domestic and foreign bonds are imperfect substitutes[9] for each other so that, in equilibrium, their rates of return may be different. No-residents can also buy domestic bonds, such that the economy has a financially open account. The monetary authority may or may not impose restrictions on the purchase of domestic securities by foreigners or the purchase of foreign securities by domestic residents. If these controls are imposed, the demand for domestic bonds by non-residents will be a fraction λ demand with absence of such restrictions[10].

Let R to be the nominal domestic interest rate, R^* the nominal international interest rate, *b(.)* the fraction of non-monetary wealth that domestic residents allocate for the purchase of domestic bonds, b^*(.) the fraction of wealth measured in foreign currency that non-residents allocate for buying international bonds, L(.) the actual demand for domestic money balances, L^*(.) the real money demand for non-residents e W_F the financial wealth of non-residents measured in the currency of their own country. We have then that the demand for residents and non-residents for domestic bonds is given by:

$$B^d = \mathrm{b}(R-R^*)\left[W_p - PL(R,Y_p)\right] + \lambda\,\mathrm{Sb}^*(R-R^*)[W_F - P^*L^*(R,Y^*)] \quad (3)$$

Assuming that the stock of domestic bonds is given by B and the central bank retains B_c of these securities in portfolio, the equilibrium in the domestic bond market is given by:

$$B - B_c = \mathrm{b}(R-R^*)\left[W_p - PL(R,Y_p)\right] + \lambda\,\mathrm{Sb}^*(R-R^*)[W_F - P^*L^*(R,Y^*)] \quad (4)$$

The aggregate financial wealth of the country is given by the sum between the wealth of the private sector, W_p, the wealth of the government, W_G , and the wealth of the Central Bank, W_c. In This way, we have that:

$$W_p + W_G + W_c = \left(M + B_p + SF_p^*\right) - B + (SF_c^* + B_c - M) = S\left(F_c^* + F_p^*\right) - B_F \quad (5)$$

Where: B_p represents the domestic bonds owned by the private sector, F_c^* represents the value in foreign currency of international bonds owned by the Central Bank (international reserves), F_p^* is the foreign currency value of international securities owned by private domestic sector, M is the monetary base and B_F represents value in terms of domestic currency owned by non-residents.

From equation (5) we can see that the aggregate wealth is equal to financial claims against the rest of the world, except the financial rights of the rest of the world against domestic economy. We will call this resulting as net foreign assets, IIP. This value refers to the net investment position of the domestic economy measured in terms of their own currency. The net foreign assets measured in foreign currency is: $IIP^* = \frac{IIP}{S}$.

Assuming that $W_c = 0$ and taking into account that $W_G = -B$, we have that $S\,IIP^* = W_p - B$, i.e.:

$$W_p = S\,IIP^* + B \quad (6)$$

A similar relation applies to the rest of the world, so that:

$$W_F^* = -IIP^* + F^* (7)$$

Suppose that π is the expected inflation rate and $\hat{S}$ is the expected rate of depreciation of the nominal exchange rate. Consider, also, that the expected rate of inflation in the rest of the world, π^* is equal to zero. Then, in equilibrium, the domestic bond market can be presented by:

$$B - B_c = \left[b\left(r+\pi-\hat{S}-r^*\right) - \lambda\, b^*\left(r+\pi-\hat{S}-r^*\right)\right]SIIP^* + b\left(r+\pi-\hat{S}-r^*\right)\left[B - PL\left(r+\pi;Y_p\right)\right] + S\lambda\, b^*\left(r+\pi-\hat{S}-r^*\right)(F^* - P^*L^*) \quad (8)$$

Assuming that $\hat{S} = \pi$, i.e., that the public expects that Central Bank devalues the nominal exchange rate by the same rate of (expected) of inflation in order to maintain the real exchange rate stable over time, and without loss of generality, suppose $P^* = 1$, we have, after dividing the expression (8) for S, that:

$$\frac{B-B_c}{S} = [b(r-r^*) - \lambda\, b^*(r-r^*)]IIP^* + b(r-r^*)\left[\frac{B}{S} - \frac{L\left(r+\pi;Y_p\right)}{\theta}\right] + \lambda\, b^*(r-r^*)(F^* - P^*L^*) \quad (9)$$

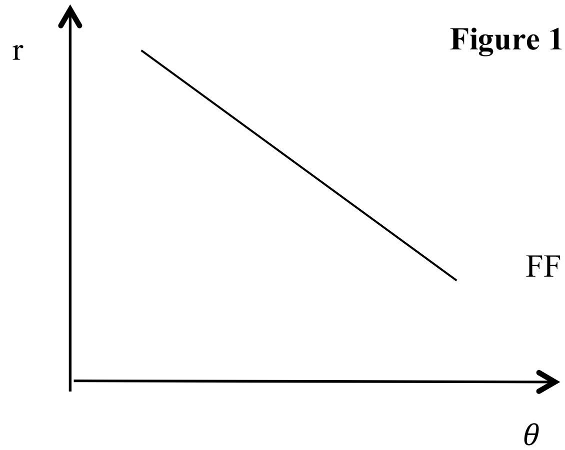
---

[9] This means that the domestic and foreign bonds have different risk characteristics.

[10] The variable λ can be seen as a proxy of the intensity of capital controls on the economy. If $\lambda = 1$ then the capital controls are non-existent, if $\lambda = 0$ then the economy is closed to the outside in terms of capital flows.

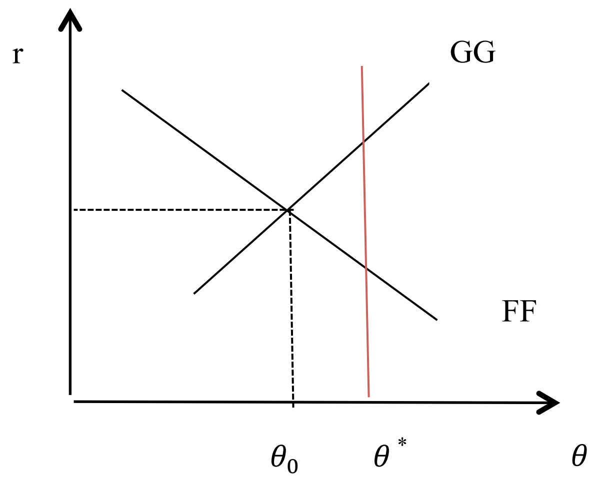
The equation (9) shows the locus of combinations between real interest rate and real exchange rate for which the bond market is in equilibrium. This locus, as shown in Figure 11 below, have a negative slope. That's because a depreciation of the real exchange rate, kept constant the nominal exchange rate, can only be obtained by a fall of the domestic price level. However, in this case, money demand is reduced, thereby increasing non-monetary wealth available to be allocated between domestic and foreign bonds. For a given level of real interest rate, there will be an increased demand for bonds, thus producing an excess of demand in bond market. The only way to restore the balance is through a reduction in the real rate of interest, so as to induce a substitution of domestic securities by foreign securities and currencies in the portfolio of domestic residents.

Figure 11



The determination of the real interest rate and the domestic real exchange rate will be at the intersection between the locus GG and FF as seen in Figure 12 below. We will assume that due to the existence of *Dutch disease* and also because the purchases of domestic bonds by non-residents, the real exchange rate is appreciated with respect to the level of industrial equilibrium.

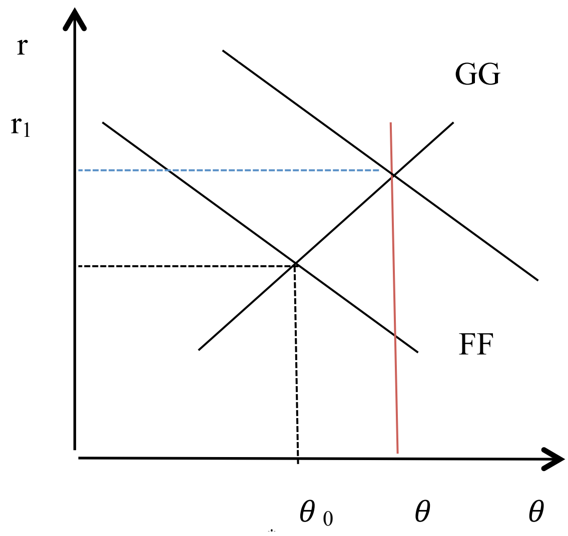
Figure 12



What are the options that the Monetary Authority and the Treasury have at their disposal to produce a depreciation of the real exchange rate in order to achieve the industrial equilibrium? A first option is to increase the level of capital controls, which implies a reduction of the value of λ in equation (9). In this case, there will be a reduction in demand of non-residents by domestic bonds[11]. Given the amount of bonds issued by the Treasury and the amount of the same type of bonds in the Central Bank's portfolio, this will result in an oversupply in bond market. To restore equilibrium in the bond market is necessary an increase in domestic interest rates, which will shift the FF curve up and to the right as seen in Figure 13 below. Everything else constant, there will be an increase in the real rate of interest and a depreciation of the domestic real exchange rate. If the reduction in the demand of domestic bonds by non-residents due to the increase of capital controls is strong enough, then the actual rate of exchange may adjust to the level compatible with the industrial equilibrium.

This policy, however, has the side effect of an increase in real domestic interest rate, which discourages investment in fixed capital. Therefore, it is necessary to combine the introduction and/or increase of capital controls with a policy of fiscal contraction, which will allow a reduction in the real rate of interest without prejudice to the attainment of the goal of real exchange rate.

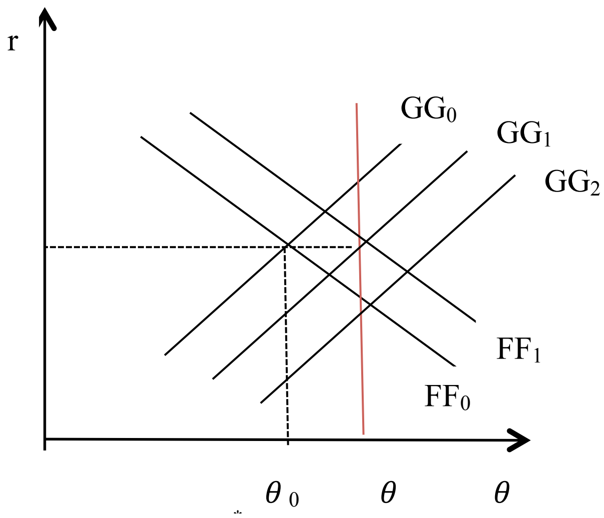
Figure 13



As seen in Figure 14 below the combination between capital controls and fiscal contraction allows that the real exchange rate to be devalued until reaching the level given by industrial equilibrium without any negative impact on the real rate of interest.

[11] A similar effect is obtained in case of an increase in international interest rates.

Figure 14



An important observation regarding the Figure 14 is that it shows us that the combination between capital controls and fiscal adjustment may be politically more palatable to society in order to control the real exchange rate than only the fiscal adjustment. In fact, if the only instrument available to the policy makers is the fiscal policy, the fiscal adjustment required to produce a devaluation of the real exchange rate to the level industrial equilibrium will be much greater than the required in the case that the fiscal adjustment is combined with an increase of capital controls intensity. Indeed, keeping unaltered the level of capital controls, the GG curve needs to move up to GG2 to which the real exchange rate reaches the industrial equilibrium, while combining the fiscal contraction with an increase of capital controls intensity the GG curve only needs to move up to GG1.

In the exercise performed above the nominal exchange rate was assumed constant during the entire experiment. This means that real exchange rate depreciation was achieved through a reduction in the domestic price level or, in the case of a model in which prices grow at a sustained rate over time, through a disinflation.

Finally, it should be noted that the management of the real exchange rate do not led the Central Bank to lose control of the monetary policy instrument, which, in the model considered here, is the amount of domestic credit B_c It. follows that the control of the exchange rate does not preclude the conduct of monetary policy in order to obtaining domestic goals.

CONCLUSION: A PROPOSAL FOR A MACROECONOMIC FRAMEWORK FOR BRAZILIAN CATCHING-UP

The empirical evidence presented in the previous sections have pointed to the fact that both the level and volatility of the real exchange rate in Brazil adversely affects the industrial investment decisions, which prevents, therefore, a more robust expansion of productive capacity and labor productivity without which it is impossible to accelerate sustained growth of the Brazilian economy. In addition, preliminary calculations on the level of the real exchange rate that would recover the level of competitiveness of Brazilian industry show that the real effective exchange rate is overvalued, probably around 48%. This is a significant overvaluation.

As we have seen in the fifth section, the correction of an overvalued exchange rate can be performed through the combination of an increase in the level of capital controls with a fiscal adjustment. As the international scenario in the next years must be characterized by a gradual adjustment in monetary liquidity conditions in developed countries, thus imposing an increase in international interest rates, which has similar effects to an increase in the level of capital controls, it follows that a tightening controls on the entry of foreign capitals can be discarded. Thus, the implementation of a fiscal contraction will be essential for obtaining a more competitive exchange rate.

This fiscal adjustment should be performed in the context of a reform of the fiscal regime in Brazil. Currently the fiscal regime is characterized by achieving a primary surplus target, which has been sufficient to stabilize the public debt/GDP ratio, but has not allowed a substantial increase in public savings, thus contributing to maintain low governments investments. In this way, we suggest the implementation of a tax regime based on the goal of government current account surplus (see Oreiro, 2014). The implementation of this regime, necessarily requires the control of pace of growth of government expenses in consumption, thus enabling the fiscal adjustment required to obtain a more competitive exchange rate without deleterious effects on the level of the real interest rate.

It is clear that the adjustment of the exchange rate may not be done once-for-all, at one shot, under the risk of being politically unfeasible, given the notorious effects that the nominal exchange rate depreciation has on inflation and, therefore, on the real wage. In this way, a gradual adjustment of the exchange rate towards the industrial equilibrium is necessary. To avoid speculative movements in the foreign exchange market, which can lead to an over-shooting of exchange rate, we suggest the adoption of a crawling-peg regime in which the Central Bank fixed the exchange rate depreciation of the nominal exchange rate. This system should be combined with temporary capital outflow controls to facilitate the pace of nominal exchange rate devaluation by the Central Bank.

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Figure 7 – Daily Volatility of the nominal exchange rate

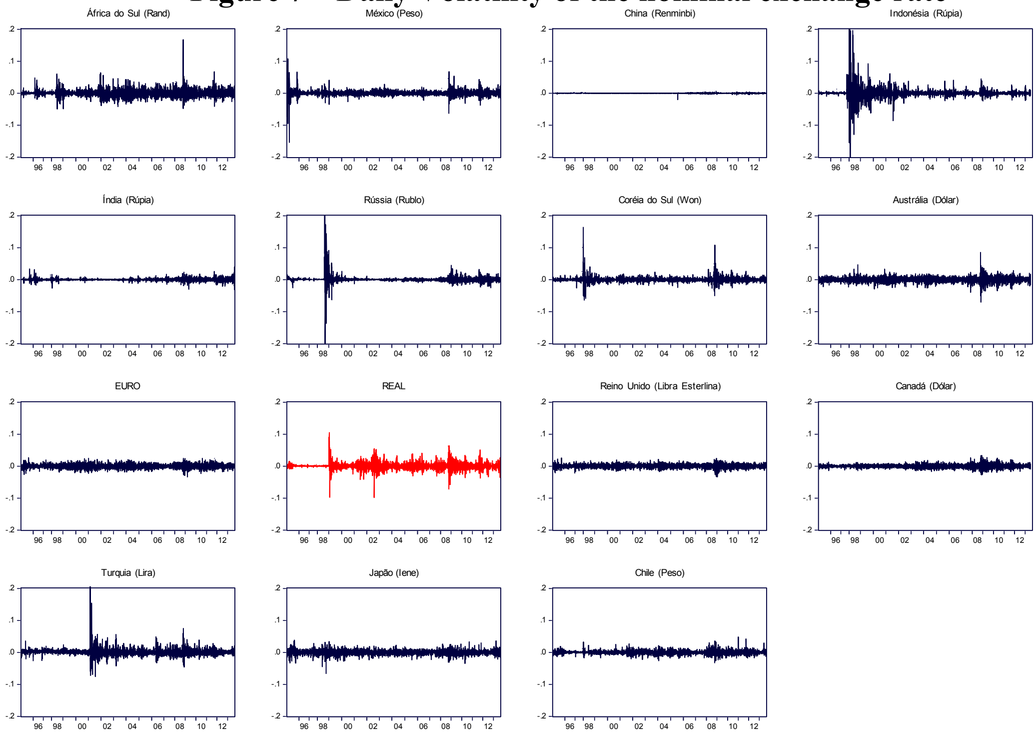

Table 2 – Analysis of Volatility of the Nominal Exchange Rate (daily)

Statistic	South Africa	Australia	Brazil	Canada	Chile	China	South Korea	Euro	India	Indonesia	Japan	Mexico	United Kingdom	Turkey	Russia
Mean	0,70%	0,56%	0,60%	0,38%	0,39%	0,03%	0,41%	0,47%	0,22%	0,59%	0,51%	0,48%	0,41%	0,58%	0,34%
Median	0,48%	0,43%	0,34%	0,28%	0,27%	0,00%	0,25%	0,36%	0,11%	0,22%	0,39%	0,31%	0,31%	0,37%	0,12%
Standard Deviation	0,78%	0,54%	0,81%	0,36%	0,41%	0,06%	0,66%	0,41%	0,32%	1,39%	0,48%	0,68%	0,37%	0,99%	1,14%
Coefficient of variation	111%	97%	134%	97%	104%	216%	159%	88%	143%	234%	94%	141%	90%	170%	335%
Rank	9	11	8	12	10	3	5	15	6	2	13	7	14	4	1
Non parametric VaR (95%)	2,14%	1,54%	2,02%	1,09%	1,17%	0,15%	1,26%	1,28%	0,82%	2,21%	1,35%	1,39%	1,11%	1,75%	1,09%
Rank	2	5	3	13	10	15	9	8	14	1	7	6	11	4	12
Non parametric VaR (99%)	3,40%	2,44%	3,76%	1,74%	1,80%	0,26%	2,72%	1,83%	1,51%	5,85%	2,28%	2,99%	1,70%	3,69%	3,02%
Rank	4	8	2	12	11	15	7	10	14	1	9	6	13	3	5
Parametric VaR (99%)	3,47%			1,74%	1,82%		2,67%	1,85%				2,90%	1,69%		
Selected Probability Distribution	Wakeby		do not fit	Wakeby	Wakeby	do not fit	Wakeby	Wakeby	do not fit	do not fit	do not fit	Wakeby	Wakeby	do not fit	do not fit
Anderson Darling Statisctis	0,9797			0,41211	0,58179		1,4344	0,22772				0,5152	0,24192		

Table 3 - Analysis of Volatility of Real Effective Exchange Rate (monthly)

Statistic	South Africa	Australia	Brazil	Canada	Chile	China	South Korea	Euro	India	Indonesia	Japan	Mexico	United Kingdom	Turkey	Russia
Mean	2,56%	1,88%	2,54%	1,27%	1,49%	1,27%	1,74%	1,19%	1,26%	3,15%	2,12%	2,15%	1,11%	2,74%	2,45%
Median	1,81%	1,53%	1,63%	0,92%	1,17%	1,03%	1,17%	1,05%	1,04%	1,20%	1,42%	1,38%	0,76%	1,58%	1,25%
Standard Deviation	2,87%	1,99%	3,17%	2,06%	1,35%	1,62%	3,04%	0,92%	1,11%	6,60%	2,92%	3,32%	1,18%	5,75%	7,47%
Coefficient of variation	112%	106%	125%	162%	90%	127%	175%	77%	88%	209%	138%	155%	106%	210%	305%
Rank	10	12	9	5	13	8	4	15	14	3	7	6	11	2	1
Non parametric VaR (95%)	6,60%	4,26%	7,23%	2,67%	3,85%	2,93%	5,62%	2,99%	3,38%	13,43%	5,55%	5,55%	2,96%	9,55%	5,53%
Rank	4	9	3	15	10	14	5	12	11	1	7	6	13	2	8
Non parametric VaR (99%)	15,00%	6,10%	14,13%	5,52%	5,92%	4,24%	10,04%	3,67%	5,45%	26,99%	8,62%	14,06%	5,73%	12,70%	15,69%
Rank	3	9	4	12	10	14	7	15	13	1	8	5	11	6	2
Parametric VaR (99%)	12,91%	7,56%	13,96%	4,28%	6,27%	5,74%	11,18%	4,35%	5,40%	37,65%	10,40%	11,93%	4,99%	20,22%	14,09%
Selected Probability Distribution	Burr	Dagum	Wakeby	Wakeby	Johnson SB	Wakeby	Wakeby	Phased Bi-Weibull	Dagum	Dagum	Burr	Wakeby	Wakeby	Wakeby	Wakeby
Anderson Darling Statisctis	0,38324	0,31931	0,11173	0,20854	0,94284	0,22046	0,35902	0,21153	0,18848	0,25771	0,45106	0,21817	0,45081	0,15634	0,19904
Rank	5	9	4	15	10	11	7	14	12	1	8	6	13	2	3

Note: For the calculation of Var, 65 were tested parametric probability distributions, among which: Beta, Burr, Cauchy, Dagum, Error, Exponential, Fatique resistance, Frechet, Gamma, Ge. Extreme Value, Gen. Gamma, Gen. Logistic, Gen, Pareto, Max Gumbel, Hypersecant, Inv. Gaussian, Johnson Su, Kumaraswamy, Laplace, Levy, Log-logistic, Logistic, Lognormal, Normal, Pareto, Person, Bi-Phased Weibull, Rayleigh, Rice, Uniform, Wakeby, Chi-Squared, etc.

Table 4 – Empirical results

Dependent variable: $\Delta\, log\ (investment\ per\ worker)$						
Variable / Model	(1)	(2)	(3)	(4)	(5)	(6)
$constant$	-0,04242 (0,013639) [0,0019]	-0,044612 (0,016101) [0,0060]	-0,049950 (0,013845) [0,0004]	-0,03541 (0,012970) [0,0069]	-0,036822 (0,012801) [0,0043]	-0,036458 (0,012663) [0,0043]
Δ log $(REER\ volatility)$	0,122901 (0,055918) [0,0288]	0,127981 (0,067630) [0,0595]	0,126815 (0,060045) [0,0356]	0,102141 (0,055647) [0,0676]	0,112913 (0,053711) [0,0365]	0,098529 (0,056136) [0,0804]
Δ log $(real\ excgange\ rate\ volatility(-1))$	-0,034525 (0,014058) [0,0147]	-0,037043 (0,016013) [0,0215]	-0,031579 (0,014817) [0,0340]	-0,036790 (0,008219) [0,0000]	-0,039394 (0,010173) [0,0001]	-
Δ log $(Tobin's\ Q(-1))$	0,009993 (0,001783) [0,0000}	0,011037 (0,002533) [0,0000]	0,009112 (0,001669) [0,0000]	0,010012 (0,001531) [0,0000]	0,10139 (0,001545) [0,0000]	0,011270 (0,001510) [0,0000]
Δ log $(TJLP -$ $long\ term\ interest\ rate\ (-1))$	-0,375520 (0,032879) [0,0000]	-0,363435 (0,046135) [0,0000]	-0,405572 (0,040092) [0,0000]	-0,353268 (0,021083) [0,0000]	-0,368002 (0,017448 [0,0000]	-0,342589 (0,026648) [0,0000]
Δ log $(relative\ price\ (-1))$	0,171480 (0,072408) [0,0186]	-	0,167191 (0,074742) [0,0261]	-	-	0,183334 (0,069713) [0,0090]
Δ log $(unit\ labor\ cost\ (-1))$	-	-0,246907 (0,119453) [0,0397]	-	-	-	-
Δ log $(gross\ value\ added)$	-	-	0,308105 (0,253269) [0,2249]	-	-	-
Δ log $(labor\ productivity(-1))$	-	-	-	0,323720 (0,200390) [0,1074]	-	-
Δ log $(labor\ rel. productivity. (-1))$	-	-	-	-	0,306238 (0,205652) [0,1376]	-
Δ log $(NER\ volatitlity(-1))$	-	-	-	-	-	-0,039362 (0,008607) [0,0000]
Observations:	Cross-sections included: 30. Periods included: 10 years - 1998-2007. Total panel (balanced) observations: 300					
Redundant fixed effects (likelihood ratio)	0,326785 gl. (29,265)	0,313718 gl. (29,265)	0,200379 gl. (29,264)	0,266450 gl. (29,265)	0,268253 gl. (29,265)	0,330388 gl. (29,265)
Normality test: Jarque-Bera	1,453363 [0,483511]	1,818856 [0,402755]	1,706006 [0,426133]	1,404904 [0,495369]	1,353664 0,508224	1,397585 0,497185
Method	Panel EGLS (cross-section weights). Linear estimation after one-step weighting matrix. White cross-section standard errors & covariance (d.f. corrected).					
Weighted Statistics						
R2	0,163952	0,169393	0,158093	0,169274	0,168097	0,172352
Adjusted – R2	0,056686	0,062825	0,046477	0,062690	0,061363	0,066164
F - Statistic	1,528456 [0,035894]	1,589524 [0,024419]	1,416395 [0,067923]	1,588175 [0,024631]	1,574909 [0,026811]	1,623075 [0,019648]
Unweighted Statistics						
R2	0,101540	0,106688	0,113629	0,083488	0,084023	0,100710

Note: standard deviations in parentheses, and probability values between brackets.