Terms of Trade, Real Exchange Rate Over-Valuation and De-industrialization: Theory and Empirical Evidence on Brazilian Case (2003-2015)

José Luis Oreiro
Associate professor of economics at Universidade Federal do Rio de Janeiro
Level IB Researcher at National Scientific Council.

Luciano D´Agostini
Researcher at Instituto de Economia, Universidade Federal do Rio de Janeiro.

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José Luis Oreiro

Associate professor of economics at Universidade Federal do Rio de Janeiro
Level IB Researcher at National Scientific Council.
jose.oreiro@ie.ufrj.br
www.joseluisoreiro.com.br

Luciano D´Agostini

Researcher at Instituto de Economia, Universidade Federal do Rio de Janeiro.
lucianodagostini@yahoo.com.br.

Abstract

The objective of the present paper is to show that the macroeconomic performance of Brazilian economy in the last 12 years was mainly the result of shocks in terms of trade, where the exceptional improvement in the terms of trade occurred from 2006 was a major cause of over-valuation of real exchange rate, but also contributed to maintain inflation rate at low levels, to increase real wages and to reduce unemployment rate to a historically very low level. The exchange rate over-valuation that was caused by the improvement in terms of trade was a driving force in the process of de-industrialization of Brazilian economy from 2006 on, since it induced a substitution of domestic production for imports, which explains the stagnation of industrial output after 2011 in a context of growing domestic absorption. This means that Brazil had very clear symptoms of "Dutch Disease". The recession that started in Brazil in the last quarter of 2014 was mainly the reflection of a negative shock in terms of trade, which resulted in inflation acceleration, decreasing real wages and growing unemployment rate. The positive side of this scenario is that real exchange rate returned to a competitive level in the second semester of 2015, which can give a start in a possible re-industrialization of Brazilian economy.

Key-Words: Real Exchange rate, Dutch Disease, Dependent Economy.

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1   Introduction

From 2003 to 2010 Brazilian economy experienced a period of high growth rates with moderate levels of inflation. Average growth rate of GDP was 4.06% p.y during this period and the average rate of CPI growth was 5.79% p.y. This relatively good macroeconomic performance changed dramatically after 2011. Average growth rate was reduced to 1.59% p.y in the period 2011-2014, a reduction of almost 61% in average growth compared to the previous period. At the same time inflation accelerated to 6.17% p.y. Moreover, for the period 2015-2016 market forecasts for GDP growth showed a contraction of almost 8% in real output, at the same time that average inflation should rose to 7.5% p.y.

This dramatic change in macroeconomic performance was mainly due to the stagnation of industrial output which started at the end of 2010. The combined effects of chronic exchange rate overvaluation - due to improvement in terms of trade - and profit squeeze - due to the wage growth above productivity growth - resulted in a fast reduction of external competitiveness of Brazilian manufacturing sector, inducing a substitution of domestic output for imports. Moreover, the reduction of profit rate in manufacturing sector, due to the reduction in profit margins, resulted in a contraction of investment in new machines and equipment, worsening the productivity problem of Brazilian manufacturing sector.

Federal Government in Brazil tried to solve this problem by the implementation of a new macroeconomic regime, the so-called "nova matriz macroeconômica" (New Macroeconomic Matrix). This macroeconomic regime was characterized by an easing of fiscal and monetary policies in order to increase aggregate demand. From the second semester of 2011 to the first semester of 2013, nominal interest rates were reduced as well as taxes over manufactured products. The result was a very modest increase in growth rate of GDP in 2013 in comparison with 2012, at expense of inflation acceleration and a reduction in the primary surplus of federal government (See Oreiro, 2015). In the second semester of 2013, due to inflationary pressures, Brazilian Central Bank started a process of adjustment in monetary policy, increasing the level of nominal interest rate. This change in monetary policy resulted – combined with the uncertainty generated by the political scandal of corruption inside PETROBRAS – in a growth deceleration in 2014, when Brazilian economy showed a growth rate of only 0.1%. The combined effects of

tax reduction, growth deceleration and increase in interest rates resulted in a huge worsening of fiscal position of public sector. Indeed, the primary surplus of 1.8% of GDP in 2013 was transformed into a primary deficit of almost 0.7%. Moreover the nominal deficit increase to almost 7% of GDP at the end of 2014, starting from a level of 3,26% in November of 2013.

As a result of worsening of fiscal position of public sector, Federal Government, in the beginning of 2015, had to start a fiscal adjustment, designed to stop the continuous increase in the ratio of public debt to GDP. This change in the fiscal policy, combined with a very tight monetary policy had contributed to worsen the growth perspectives of Brazilian economy. After a fall of almost 4% of real GDP in 2015, the consensus among analysts of the financial sector is that Brazilian economy will show a contraction of 3% in 2016.

The objective of the present paper is to show that the macroeconomic performance of Brazilian economy in the last 12 years was mainly the result of shocks in terms of trade, where the exceptional improvement in the terms of trade occurred from 2006 was a major cause of overvaluation of real exchange rate, but also contributed to maintain inflation rate at low levels, to increase real wages and to reduce unemployment rate to a historically very low level. The exchange rate overvaluation that was caused by the improvement in terms of trade was a driving force in the process of de-industrialization of Brazilian economy from 2006 on, since it induced a substitution of domestic production for imports, which explains the stagnation of industrial output after 2011 in a context of growing domestic absorption. This means that Brazil had very clear symptoms of "Dutch Disease". The recession that started in Brazil in the last quarter of 2014 was mainly the reflection of a negative shock in terms of trade, which resulted in inflation acceleration, decreasing real wages and growing unemployment rate. The positive side of this scenario is that real exchange rate returned to a competitive level in the second semester of 2015, which can give a start in a possible re-industrialization of Brazilian economy.

The article is organized in five sections, including the introduction. In Section 2 we present our theoretical framework, which is a three goods version of the Dependent Economy Macroeconomic Model. In Section 3 we made a descriptive analysis of macroeconomic performance of Brazilian economy from 2003 to 2015. In section 4 we made present some empirical evidence regarding the role of terms of trade shocks in the

macroeconomic performance of Brazilian economy through the use of correlation analysis and multivariate time series. In section 5 we present a brief summary of the conclusions.

2 Terms of Trade, Real Exchange Rate and Real Wages in a Dependent Economy Model

In this section we will present a three goods dependent economy macroeconomic model based on Agenor-Montiel (1999) in order to analyze the effects of changes in terms of trade over real exchange rate and real wage of medium-income countries that are rich in natural resources as Brazil. Although the standard macroeconomic model for small open economies is the Mundell-Fleming version of IS-LM, this framework is not suited to discuss the effects of changes in terms or trade since it assumes an economy that specializes in the production of a single (composite) good, which is imperfect substitute for the single (composite) good that produced in the rest of the world (Agenor-Montiel, 1999, p.52). In this setting there is no possible way to distinguish between terms of trade and real exchange rate. In order to do that it is necessary to introduce a three sector economy model with two tradable sectors and one no-tradable sector. Real exchange rate will be defined as the ratio between price of tradable and non-tradable goods, and terms of trade will be the ratio between export and import prices of tradeable goods. Terms of trade will be exogenous to domestic economy, which gives rise to its "dependent" nature.

The model to be presented bellow can solved in order to show a full-employment (classical) or unemployment (Keynesian) equilibrium. Since the qualitative effects of changes of trade over real exchange rate and output composition does not depend on the type of equilibrium, we will focus our analysis only on the full-employment equilibrium.

Let us consider a dependent economy that had three sectors $h = (x, i, n)$: a tradable sector that produces a good that can´t be consumed in domestic markets (primary sector), another tradable sector that produces a good that can be consumed either in domestic or external markets (manufacturing) and a non-tradable sector (services). The output of each sector is supposed to be a function of the quantity of labor employed, which is the only input used in production.

Production technology of each sector is given by:

$$y_h = y_h(n_h) \quad (1)$$

$$Where: y_h^{'}(n_h) > 0; \ y_h^{''}(n_h) < 0$$

Supposing that in all sectors firms operate in conditions of perfect competition and firms to be profit-maximizers, the aggregate labor demand in each sector is given by:

$$n_x^d = n_x^d \left(\frac{\omega}{\theta}\right); \quad \frac{\partial n_x^d}{\partial \left(\frac{\omega}{\theta}\right)} < 0 \quad (2a)$$

$$n_i^d = n_i^d(\omega); \quad \frac{\partial n_i^d}{\partial \omega} < 0 \quad (2b)$$

$$n_n^d = n_n^d \ (z\omega) \ ; \frac{\partial n_n^d}{\partial z\omega} < 0 \quad (2c)$$

Where: $\theta = \frac{p_x}{p_i}$ is the term of trade; $z = \frac{p_i}{p_n}$ is the real exchange rate and $\omega = \frac{W}{p_i}$ is the real wage rate. Prices of primary and manufacturing goods in domestic currency are given by:

$$p_x = E p_x^* \quad (3a)$$

$$p_i = E p_i^* \quad (3a)$$

Where E is the nominal exchange rate defined as the price of foreign currency in terms of domestic currency. Regarding the nominal exchange rate we will suppose the existence of a system of fixed exchange rate. Without loss of generality we can normalize E as equal to one. Price of non-tradable goods is determined domestically.

Domestic demand for manufactured and non-tradeable goods is taken to depend on the relative prices of the two goods, given by the real exchange rate, and on the total domestic absorption measured in terms of manufactured goods, a , given by:

$$a = a_i + \frac{a_n}{z} \quad (4)$$

Let us suppose that the real domestic absorption of both manufactured and non-tradeable goods is given by:

$$a = a(\theta; g) \quad (5)$$

Where: g is the real value of government expenditure and $\frac{\partial a}{\partial \theta} > 0; \frac{\partial a}{\partial g} > 0$

Thus absorption depends positively on the terms of trade as well as on the shift parameter g. From equations (4) and (5) we can see that an increase in government expenditures and/or an improvement in terms of trade will result in an increase in domestic absorption.

Changes in real exchange rate, on the other hand, can displace domestic absorption from manufacturing to service sector and vice-versa, being one of the fundamental determinants of composition of output.

Market-clearing in the non-tradable sector is given by:

$$y_n(z\omega) = a_n(z; a); \ \frac{\partial y_n}{\partial z\omega} < 0 \quad (6)$$

Trade balance measured in units of manufacturing goods is given by:

$$b = \theta y_x\left(\frac{\omega}{\theta}\right) + y_i(\omega) - a_i(z, a) \quad (7)$$

Regarding the labor market, we will suppose that supply of labor is inelastic and equal to $\bar{n}$. This means that full employment condition is given by:

$$\bar{n} = n_x^d\left(\frac{\omega}{\theta}\right) + n_i^d(\omega) + n_n^d\ (z\omega) \quad (8)$$

In order to solve the model, we will suppose that terms of trade are exogenous, being determined in the international markets. Being so, the model has three independent equations [(6)-(8)] with three endogenous variables: z, ω and b. The system of equation is determinate. Putting (5) into (6) and taking the total derivative of the resulting equation we get:

$$dz = -\frac{y_n'z}{y_n'\omega - a_{n,1}}d\omega + \frac{a_{n,2}\left(\partial a/\partial\theta\right)}{y_n'\omega - a_{n,1}}d\theta + \frac{a_{n,2}\left(\partial a/\partial g\right)}{y_n'\omega - a_{n,1}}dg \quad (9)$$

From equation (9) we can derive the slope of NN curve, that is the loci of all combinations of real exchange rate and real wage rate for which there is market for non-tradable goods clears. Taking $d\theta = dg = 0$ in (9) we arrive at:

$$\left[\frac{dz}{d\omega}\right]_{NN} = -\frac{y_n'z}{y_n'\omega - a_{n,1}} < 0 \quad (9a)$$

It is straightforward to see that:

$$\frac{dZ}{d\theta} = \frac{a_{n,2}\left(\partial a/\partial\theta\right)}{y_n'\omega - a_{n,1}} < 0 \quad (9b)$$

That is for a given real wage rate, an improvement in terms of trade will result in an appreciation of real exchange rate. This occurs because an improvement in terms of trade will result in an increase in domestic absorption of both manufacturing goods and services. In order to restore market clearing it is necessary to increase the level of output for non-tradeable goods. Since the real product wage in the non-tradeable sector is given by $z\omega$, then real exchange rate has to appreciate, reducing the real product wage and thereby increasing the profit-maximizing level of employment. This will increase the level of output in the non-tradeable sector, eliminating the excess demand for non-tradable goods. Returning to the full-employment condition, taking the total derivative of equation (8) we get:

$$dz = \left(\frac{1}{\omega n_n^{d'}}\right) d\bar{n} - \frac{1}{\omega n_n^{d'}} \left[\frac{n_x^{d'}}{\theta} + n_i^{d'} + z n_n^{d'}\right] d\omega + \left(\frac{n_x^{d'}}{n_n^{d'}}\frac{1}{\theta^2}\right) d\theta \quad (10)$$

From equation (10) we can derive the slope of LL curve, that is the loci of all combinations of real exchange rate and real wage rate for which full employment condition is met. Taking $d\bar{n} = d\theta$ in (10) we arrive at:

$$\left[\frac{dz}{d\omega}\right]_{NN} = -\frac{1}{\omega n_n^{d'}} \left[\frac{n_x^{d'}}{\theta} + n_i^{d'} + z n_n^{d'}\right] < 0 \quad (10a)^2$$

From (10) it is straightforward to see that:

$$\frac{d\omega}{d\theta} = \left(\frac{n_x^{d'}}{n_n^{d'}}\frac{1}{\theta^2}\right) \cdot \left\{\left(\frac{1}{\omega n_n^{d'}}\right)\left[\left(\frac{n_x^{d'}}{\theta} + n_i^{d'} + z n_n^{d'}\right)\right]\right\}^{-1} > 0 \quad (10b)$$

An improvement in the terms of trade, holding real exchange rate constant, will produce an increase in the level of real wage. Equations (9b) and (10b) show that an improvement in terms of trade is associated with a real exchange appreciation and an increase in the level of real wages, which can be seen in Figure 1.

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[2] It is also possible that the slope of LL curve is steeper than the slope of NN curve (Agenor-Montiel,1999, pp.58-59).

Figure 1: Effects of a Positive Terms-of-Trade-Shock in the Three-Good Dependent Economy Model.
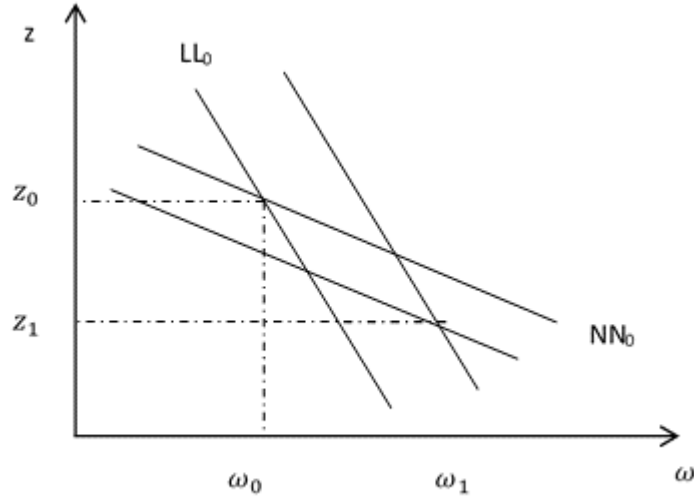

This occurs because an improvement in terms of trade cause a reduction of real product wage in the primary sector, increasing the labor demand and real output of this sector. Since economy is working at full employment, in order to increase output in the primary sector, workers had to be transferred from the manufacturing and service sectors, what will require an increase in the real wage paid in the primary sector. Due to the fact labor is supposed to be a homogenous input and also due to the hypothesis of perfect mobility of labor between sectors, an increase in the real wage in the primary sector will result in an increase of real wage in the manufacturing and service sector as well. Due to the increase in real wages, real output and employment of the manufacturing sector will be reduced, given rise to a classic problem of "Dutch Disease"[3].

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[3] The term "Dutch Disease" arose out of concern about de-industrialization in the Netherlands as a result of real exchange rate appreciation due to North Sea oil discoveries. For a analysis of the origin and effects of Dutch Disease (see Bresser-Pereira, Oreiro and Marconi, 2014).

# 3   Macroeconomic Performance of Brazilian Economy (2003-2015)

This section presents first a descriptive analysis of the temporal variables real exchange rate, terms of trade, real wages, the growth rate of gross domestic product (GDP), share of the gross fixed capital formation on GDP, share industry GDP on GDP, unemployment, inflation, real interest rates, share of the public sector borrowing requirements on GDP, international reserves and external accounts in the period 2003-2015, during the administrations of Presidents Luis Inacio Lula da Silva (Lula I (2003-2006)), (Lula II (2007-2010)) and Dilma Rousself (2011-2015). These variables are depicted in Figure 2 to 5 and commented in the sections 3.1 and 3.2.

Figure 2: Terms of Trade, Real Exchange Rate and Real Wages
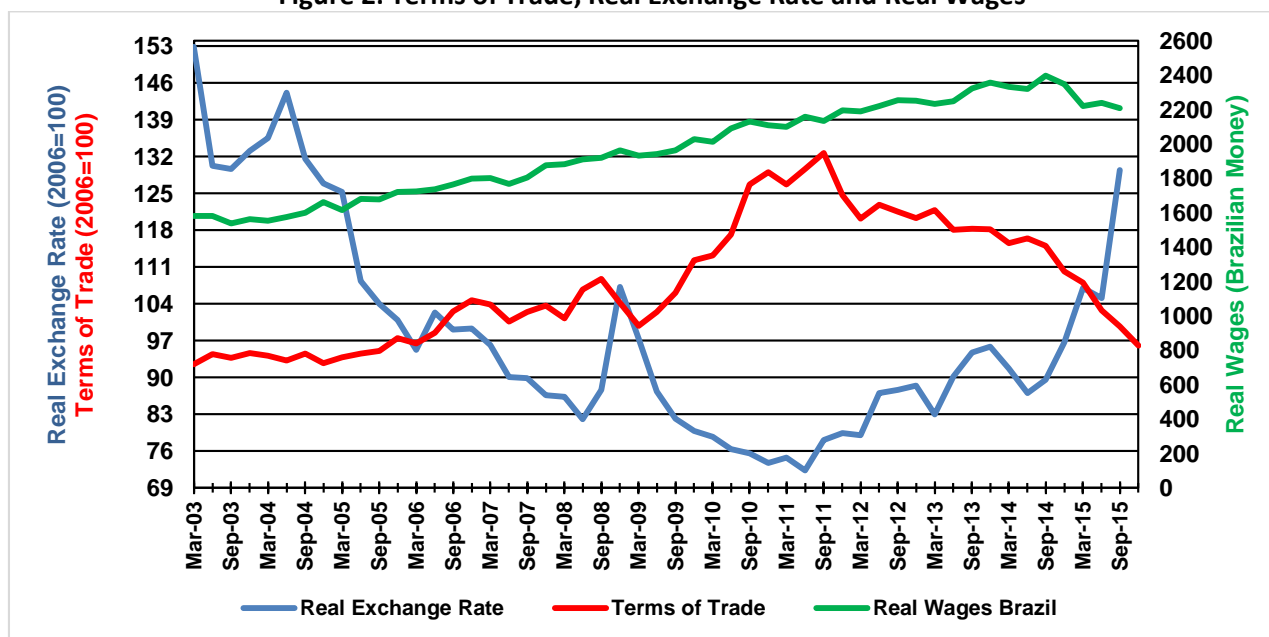
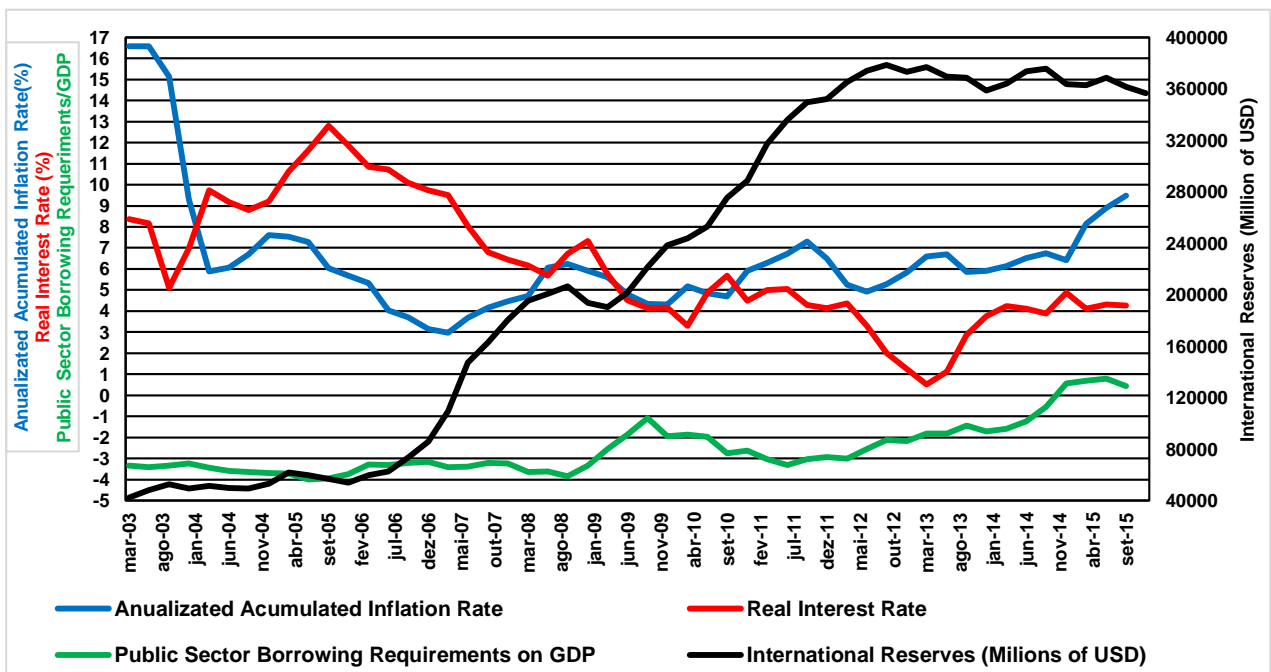Source: Central Bank of Brazil. Authors´ own elaboration.

Figure 3: Industrial GDP/GDP, GFCF/GDP, GDP and Unemployment
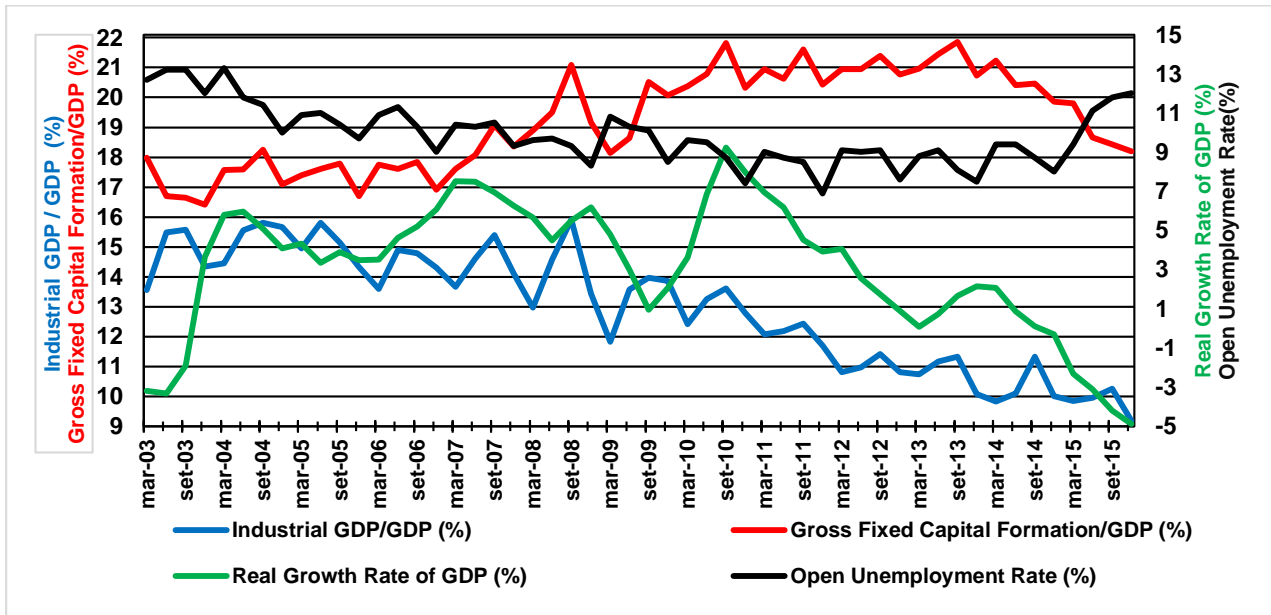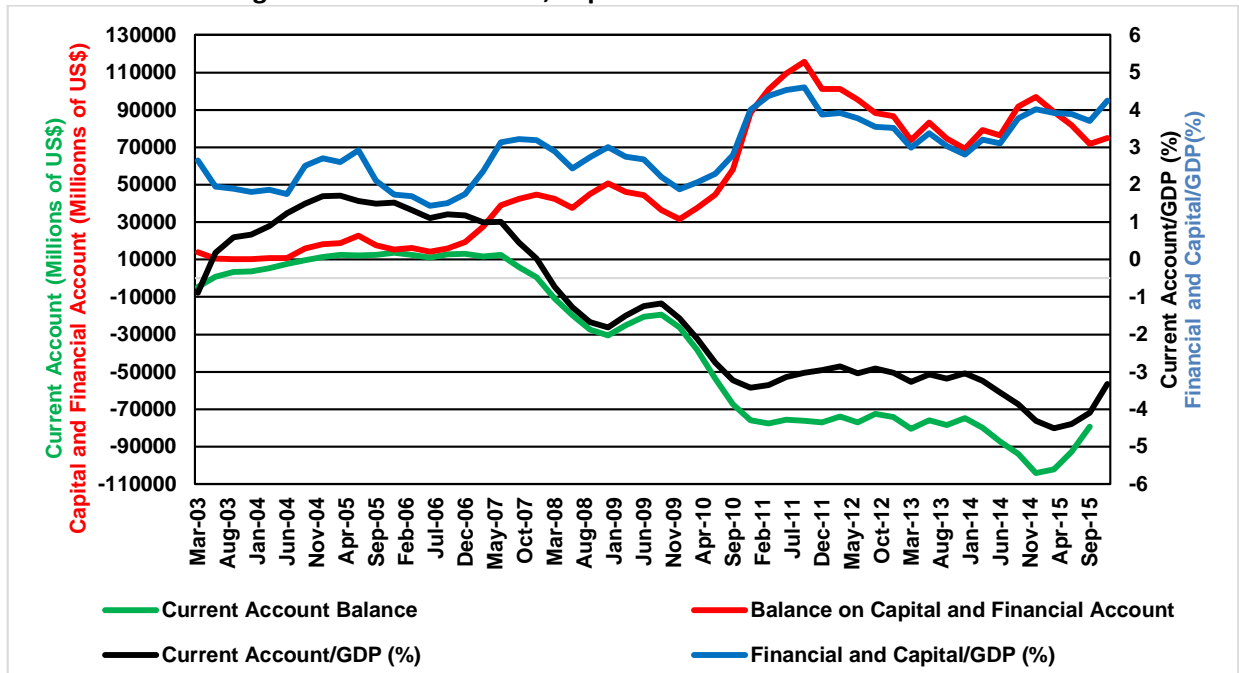

Source: Central Bank and Brazilian Institute of Geography and Statistics. Authors´ own elaboration.

Figure 4: Inflation, Real Interest Rate, Public Sector Deficit on GDP

Source: Central Bank and Brazilian Institute of Geography and Statistics. Authors´ own elaboration.

Figure 5: Current Account, Capital and Financial Account

Source: Central Bank of Brazil. Authors´ own elaboration.

3.1   Real Exchange Rate Over-Valuation under Lula Government, 2003-2010

From the first quarter of 2003 to the last quarter of 2005, real exchange rate presented an appreciation of 33.98% (see Figure 2). According to some studies about exchange rate misalignment, as the one of Oreiro, Punzo and Araujo (2012), real exchange rate in Brazil started to become overvalued in second quarter of 2004, reaching a level of 18% of overvaluation in the last quarter of 2007.

In 2006, Central Bank of Brazil begun to make sterilized interventions in exchange rate market by means of buying an enormous quantity of international reserves and sterilizing its effects over high powered money by selling Treasury bonds in Repurchase Agreements (Repo) operations. The consequence were the international reserves had grown at a rate of 50.7% in 2006 and 97.98% in 2007, reaching more than US$ 206 Billion in September of 2008 (see Figure 4); while Repo increased from 1.7% of GDP in 2005 to 10.4% of GDP in 2008.

This huge accumulation of international reserves meant that the free floating exchange rate regime was substituted by a *de facto* managed exchange rate regime, although

without an explicit or even an implicit target for nominal exchange rate. The objective of the new exchange rate regime seemed to be to reduce and eventually stop the process of real exchange rate appreciation[4]. Indeed, the pace of exchange rate appreciation was greatly reduced after 2006. Between 2003.Q1 to 2005.Q4, real exchange rate depreciated 33.98%, this rhythm of appreciation was reduced to just 8.06% in the period 2006.Q1 to 2008.Q3.

It is also important to notice that export performance of Brazilian economy until 2005.Q3 was not due to an improvement in the *Terms of Trade*. As we can see in Figure 2, from the first 2003.Q1 until 2005.Q3, the index of terms of trade remained almost constant around a level of 95. A modest improvement of 12.79% in terms of trade would only begin in the 2006.Q1, when the index of terms of trade increased from 96.45 to 108.75 at the end of the period[5].

The export performance of Brazilian Economy from first quarter of 2003 to last quarter of 2005 was mostly due to the level of real exchange rate, that remained under-valued at least the end of 2004 (See Oreiro, Punzo and Araujo, 2012, p. 926), and the strong growth of world economy during this period.

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[4] At this point a theoretical discussion is needed. According to the policy trilemma of Robert Mundell it is impossible to have at the same time capital mobility, autonomous monetary policy and managed exchange rate. Since Brazil had an open capital account and an inflation targeting regime, then a managed exchange rate was not a policy option. In this setting making sterilized interventions in exchange rate markets could only be ineffective over the level of nominal exchange rate (See Garcia, 2011). The first problem with this trilemma is that it does not consider the possibility of some sort of compromise between these options. For instance, a country may decide to impose some capital controls in order to have an autonomous monetary policy with a managed exchange rate (Bresser-Pereira, Oreiro and Marconi, 2014, p. 152). Besides that, emerging countries like Brazil are very far to have perfect capital mobility in Mundell´s sense. Capital account in Brazil is better characterized by imperfect capital mobility, due to the remaining capital controls (for instance, domestic currency, the REAL, is not convertible) and imperfect substitution between domestic and foreign bonds. Under these circumstances it is perfectly possible for the Central Bank to control the quantity of money (or interest rate) and nominal exchange rate at the same time (See Montiel, 2011, chapters 6-8).

[5] It is noteworthy to see in figure 2 that until the 2005.Q3, real exchange rate appreciation can´t be the result of the improvement in the *terms of trade*. As a matter of fact, during this period terms of trade remained practically constant, but real exchange rate appreciated almost 38%. Exchange rate appreciation is mainly due to the strong reduction in country risk premium occurred in this period (around 1200 b.p. to around 250 b.p.).

Another important element for explaining macroeconomic performance is *wage policy*, more precisely, the policy for minimum wage. Between January of 1999 and February of 2006, minimum wage had an increase of 30.87% in real terms or an average real increase of 4.44% during this period. From March of 2006 to February of 2008, however, minimum wage had a real increase of 16.82%, i.e. a real increase of 8.4% p.y. during the entire period, almost twice of the increase observed in the last period. This acceleration of the rate of increase in minimum wage was due to a wage rule that President Lula negotiated with Labor Unions in 2007. According to this rule, the rate of increase in minimum wage from one year to the other will be equal to the rate of inflation observed in the last year plus the growth rate of real GDP observed two years before. The minimum wage policy also helped the increase in real wages (see Figure 2).

The implicit objective of such a rule was to induce an increase in the wage share, due to the fact that real wages are expected to increase at rate higher than labor productivity. This should produce an improvement in income distribution and also boost effective demand through the effect of increasing wage share over consumption expenditures. The increased consumption expenditures should induce capital accumulation by private sector due to the traditional accelerator effect. The final result should be an increase in investment rate (See Figure 3) and hence an increase of growth rate of potential output. Indeed, flexible tripod should achieve also a higher rate of growth, stability of real exchange rate and a higher wage share (See Figure 2 and 3).

Minsky once stated that "stability is destabilizing". In the case of Brazilian economy, however, may be it is more precise to say that "growth is destabilizing". As a matter of fact, during the period 2003-2008 the growth acceleration in Brazil was followed by a huge appreciation of real exchange rate (see Figures 2 and 3).

The growth performance of Brazilian economy in this period – called "growth spectacle" by President Lula – allowed a remarkable reduction in open unemployment rate (Figure 2). Indeed, President Lula first term had started with an unemployment rate around 13%. After reaching a peak of 13,8%% of labor force in the 2004.1, open unemployment rate begin to fall, around 8,7% of labor force in 2008.4.

Up to Q3.2008, real exchange rate appreciation did not seem to produce any serious harm to the performance of Brazilian manufacturing sector. The share of industrial GDP on

GDP (Figure 3) increased from 12.34% in the 2002.Q4 to 14.09% in the 2008.Q3. Compared to the 2005.Q3, industrial GDP on GDP had fallen almost 1.0%, from 15.09% to 14.09%. It is noteworthy that this decreasing in the manufacturing share occurred almost at the same time of the reversion in the current account from surplus to deficit and the growth acceleration in period 2006-2008 (see Figure 5). These are clear signs that manufacturing sector was losing its dynamism due to the behavior of real exchange rate.

Facing a fall of almost 30% of industrial output and 14% in GDP occurred in the 2008.4, Brazilian government reacted by means of a *strong fiscal expansion*[6], followed some months after by a considerable easing of monetary policy. At the same time, public banks (*Banco do Brasil* and *Caixa Econômica Federal*) made a considerable increase in their credit lines in order to solve the credit crunch appeared after the collapse of international financial markets in September 2008.

The world financial crisis has a modest and temporary effect over Brazilian macroeconomic performance. From 2008.Q4 to 2009.Q3 real GDP growth was reduced, causing an increase in unemployment rate above 11.6% of labor force (Figure 3). The combined effects of fiscal, monetary and credit expansion allowed Brazilian economy to recover quickly from 2008 crisis, exhibiting a real growth rate of 9,22% of GDP in the 2010.Q4 (Figure 3). Labor market reacted also very fast to aggregate demand stimulus, making unemployment rate to fall back at the level in the 2008.Q4.

Just after the bankruptcy of Lehman Brothers, nominal exchange rate in Brazil had suffered a huge depreciation due to the precautionary demand for foreign currency by domestic residents in order to fulfill their commitments in future and derivative markets (See Oreiro-Basilio, 2011). This movement of nominal exchange rate produced a temporary reversal of the tendency for exchange rate over-valuation observed in the period 2003-2008 (see Figure 2). In the 2009.Q3, however, real exchange rate started again to appreciate. As matter of fact, from 2009.Q3 to 2011.Q4 real exchange rate had an appreciation of 19%, reaching its lowest level since 2003.

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[6] According to data of National Treasury, between 2008 and 2009, primary expenditures of federal government increased R$ 74.28 billion, an increase of 14.91% in nominal terms.

In the period 2003.Q1 to 2008.Q9 the appreciation of real exchange rate in Brazil was due to the combined effects of reduction in sovereign risk premium (up to the 2005.Q4) and improvements in terms of trade (from the beginning of 2006 on). Now the real exchange rate appreciation appeared to be mainly the result of improvement in terms of trade. As we can see in Figure 2, terms of trade increased 24% between the 2009.Q3 to 2011.Q4.

In order to face the real exchange rate appreciation problem, Central Bank of Brazil continued its policy of *intervention* in exchange markets buying additional quantity of international reserves (Figure 4). The international reserves increased at an average rate of 22.01% p.y in the period 2009-2011, reaching a value of US$ 352 billion at the end of 2011, an increase of almost 82% between 2008 and 2011. These interventions on foreign exchange market, however, are not fully sterilized. As we can see in Table I, the stock of Repo in R$ million and as a share of GDP had increased in 2009, but decreased strongly in 2010, showing that Central Bank of Brazil had increased the stock of high powered money to finance the acquisition of international reserves.

Table I – Evolution of Repo operations (2009-2011)

Year	Repo (in R$ millions)	Repo as % of GDP
2009	427800	12,85%
2010	259200	6,67%
2011	311900	7,13%

Source: Central Bank of Brazil. Authors´ own elaboration.

These developments were possible because the world financial crisis induced an easing of monetary policy in Brazil that resulted in a sharp decrease of nominal short-term interest rate. The combined effects of improvement in terms of trade and reserve accumulation allowed Brazilian economy to maintain a good average performance in the external fragility indicators between 2008.Q4 to 2011.Q4 (external debt as a ratio of GDP, 12,36%, external debt on exports, 122.31%, reserves on external debt, 112.22%, and current account on GDP, -2.41%), clearly indicating a situation of solvency of external accounts despite the over-valuation of real exchange rate. International reserves were larger than external debt, indicating that Brazilian economy had also a very comfortable liquidity position.

The behavior of current account/GDP ratio (see Figure 5) indicated a clear and growing over-valuation or real exchange rate. In only two years, from 2008.Q4 to 2010.Q4, current account/GDP deficit almost double, increasing from 1.81% of GDP to 3.43% of GDP. Since the increase in current account deficit (see Figure 5) was followed by a huge improvement in terms of trade (see Figure 2), this could only be the result of substitution of domestic production for imports in the manufacturing sector. The first symptoms of *Dutch Disease* were beginning to appear in Brazilian economy.

But, without questioning the conduction of economic policy, comparing 2003 with 2010, the Lula government was able to reduce the real interest rate, the nominal interest rate, inflation and unemployment. Brazil grew on average more than in the 90s and increased real income of the worker, the rate of investment on GDP and achieved investment grade by agencies of sovereign risk rating. There was a strong decline in public debt as a proportion of GDP.

This exceptionally good macroeconomic performance allowed the election of Dilma Rouseff from Labor Party (Partido dos Trabalhadores) as President of Brazil in 2010.Q4, as successor of Lula.

3.2 Stagnation and Recession under Dilma Government, 2011-2015

The substitution of domestic production for imports in Brazilian manufacturing industry caused a stagnation of manufacturing output from the beginning of 2011 on. After a quickly recover of the effects of world financial crisis, output of manufacturing industry remained roughly constant at the beginning of 2011, despite Brazilian economy was still growing at a higher, although declining. Manufacturing industry was clearly loosing dynamism due to over-valuation of real exchange rate. Dutch disease was becoming to cause a negative structural change in Brazilian economy, reducing the industrial GDP on GDP (see Figure 3). A second wave of de-industrialization had begun[7]. The strength of de-industrialization of Brazilian economy could be seen. From 2008.Q4 to 2011.Q4 manufacturing share in GDP had fallen from 13.92% to 11.8%, a decrease of 15.23% in the manufacturing share in only three years.

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[7] See Oreiro and Feijó (2010) for an account of de-industrialization of Brazilian economy.

From the 2011.Q4 until the 2013.Q3, Brazilian economy had experienced a strong growth deceleration. As we can see in Figure 6, the 12 month moving average of real GDP growth fallen from 5.39% p.y in the 2011, Q4 to 0.84% p.y in the 2013.Q3. Moreover, the 12 month moving average of output in manufacturing industry had fallen 1.55% during this period. After a quick recover of 2008 financial crisis, production of manufacturing industry in Brazil stagnated, and this situation was slowing down GDP growth. The slowdown in economic growth was not due to a *cyclical downturn* caused by a Keynesian problem of insufficiency of aggregate demand. During this period the *output gap* was positive, showing that Brazilian economy was growing above its *potential* or *natural growth rate*. The problem seemed to be a structural one: the potential growth rate was being reduced.

Figure 6: Real GDP Growth and Manufacturing Industry Output (2011.Q4-2013.Q3)
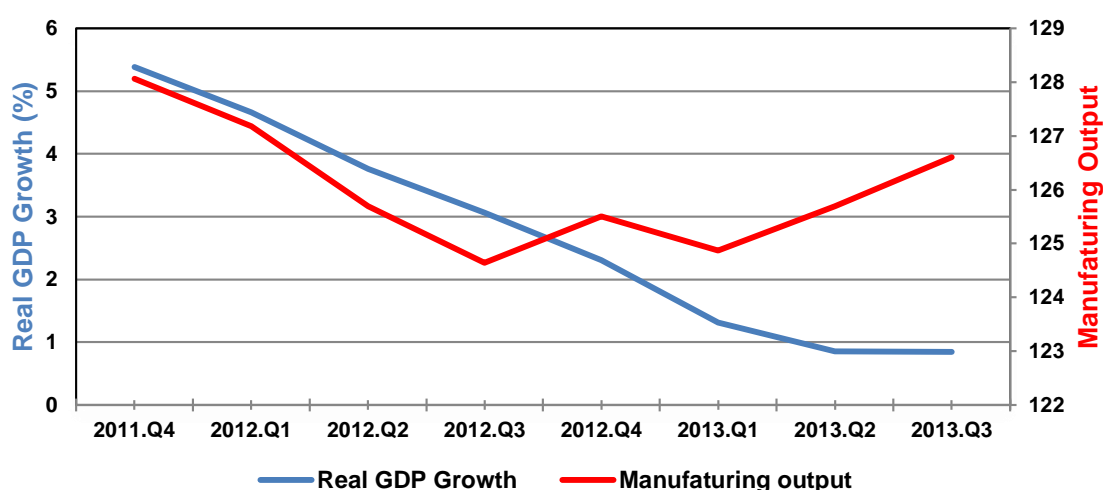
Source: IPEADATA. Authors´ own elaboration.

Another way to see that growth deceleration was not due to a fall of aggregate demand is to compare the behavior of sales in the commercial sector with the behavior of manufacturing industry output. As we can see in Figure 7, although manufacturing output was declining up to the end of 2012, sales in the commercial sector were growing at a robust average rate of 5.62% p.y in real terms. Thus the problem did not seem to be *insufficiency of aggregate demand*, but the revealed incapacity of Brazilian industrial firms *to had access to effective demand*. This means that stagnation of Brazilian economy was more likely to be the effect of real exchange rate appreciation (Figure 2) over

competitiveness of Brazilian manufacturing industry both in external and domestic markets (See Bresser-Pereira, Oreiro and Marconi, 2014, chapter 6).

Figure 8: Evolution of Real Effective Exchange Rate-Wage Ratio (2003.1-2014.12)
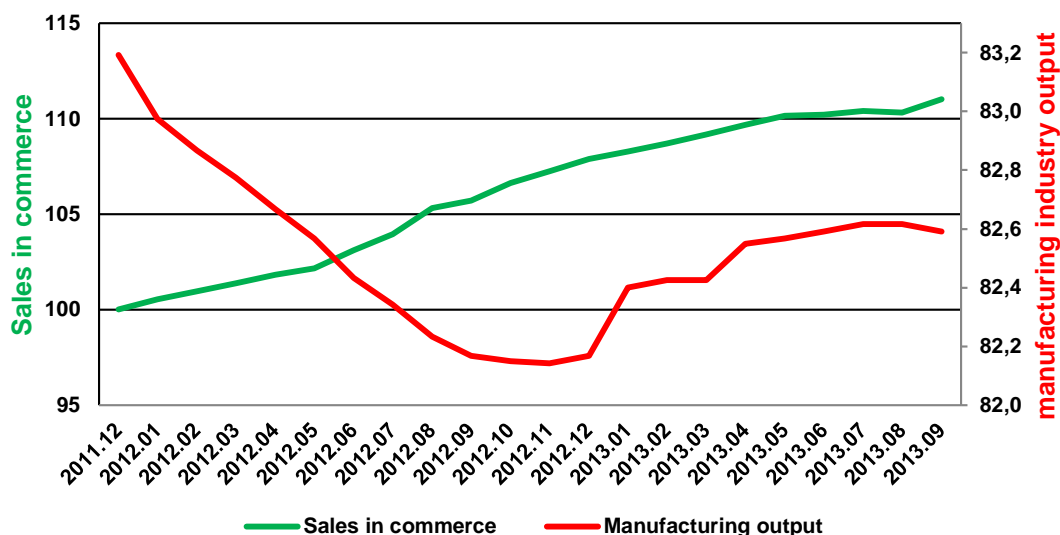
Source: IPEADATA. Authors´ own elaboration.

The stagnation of manufacturing industry output combined with a strong expansion of domestic demand resulted in the continuation of de-industrialization of Brazilian economy, measured by the industrial GDP on GDP (Figure 3). Due to the fact that manufacturing industry is the source of increasing returns, this structural change resulted in a reduction of potential growth rate. The de-industrialization of Brazilian economy must not be under-estimated. From 2008.Q4 to 2014.Q4, the 12-month moving average of industrial GDP on GDP had fallen 32.13%, from 14.75% to 10.01% [8].

Facing deceleration of GDP growth and a stagnation of industrial output since 2011, Brazilian government answered in the same way it done in 2008, by means of a new round

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[8] The re-primarization of exports signaled for a clear reduction in the growth rate that is compatible with the equilibrium in the balance of payments (Thirwall, 2002). This was another channel by which over-valuation of real exchange rate was reducing the potential or natural growth rate of Brazilian For an empirical analysis of the impact of real exchange rate over income elasticities of exports and imports see Marconi, Araujo and Oreiro (2015).

of easing monetary and fiscal policy, trying to boost aggregate demand. One of the objectives of easing monetary policy was to induce a depreciation of nominal exchange rate in order to reduce or even eliminate the over-valuation of real exchange rate. This means that monetary policy in Brazil clearly incorporated as one of its objectives to stabilize the real exchange rate, but without an explicit commitment with a target for nominal or real level of exchange rate.

In order to avoid a conflict between the stabilization of real exchange rate and inflation targeting, Central Bank of Brazil choose to make an informal spreading of the convergence period from one year to the "relevant period for monetary policy to operate", which means, in practice, that monetary authority has no commitment with any definite period for inflation to converge for the center of the target (4.5% p.y), although annual inflation must be lower than the ceiling defined by CMN (6.5% p.y). This means that in order to make possible an adjustment of real exchange rate, Central Bank of Brazil would tolerate a higher inflation rate, between 5.0% and 5.5% p.y, instead of 4.5% p.y. A higher real exchange rate was been traded for a higher inflation rate.

Along with easing of monetary policy, Brazilian Central Bank tried to continue its intervention in foreign exchange markets by means of buying international reserves (see Figure 4). From 2011 to 2012, Central Bank continued to increase international reserves at a rate of almost 20% p.y as it was done in previous years (after 2006). From 2012 on, however, the rate of reserve accumulation slowed down and then reversed in 2014. Clearly, the policy of reserve accumulation was now reaching its limits. From 2011 to 2012, reserve accumulation required a large increase in REPO operations as we can see in Table I in order to avoid a decrease in short term interest rate greater than the one desired by Brazilian Central Bank. At the end of 2013, REPO operations were near 10% of GDP, representing almost 20% of gross public debt. The large size of international reserves together with the size and cost of REPO operations were making the continuation of reserve accumulation a very costly policy for Brazilian Government. Due to the increasing fiscal difficulties that National Treasury started to face after 2013, the

intervention in foreign exchange market by means of reserve accumulation would be stopped in 2014[9].

Regarding the fiscal policy, Ministry of Finance decided that a reduction of the primary surplus/GDP was both possible and required. The reduction of real interest rate due to easing of monetary policy had reduced the primary surplus/GDP that was required to stabilize (net) public debt as a ratio to GDP[10]. This means that *fiscal space* was created, allowing an easing of fiscal policy. Besides that, growth deceleration observed after 2011 signaled a weakness of aggregate demand that would demand some fiscal stimulus. The issue was not if a fiscal stimulus was needed, but what form the fiscal stimulus must have. The decision of the Minister of Finance, Guido Mantega, was to use the fiscal space to promote a semi-permanent round of tax reduction for both productive sector (mainly automobile industry) and consumers instead of an increase in Public Investment, as it was defended by the Vice-Minister, Nelson Barbosa. The impact of this decision over the path of primary surplus were negative. The declared objective of the new macroeconomic regime according to the Finance Minister Guido Mantega[11] was to produce a change in the combination of interest rate and exchange rate towards a lower nominal and real interest rate and a more competitive real exchange rate in order to (i) boost capital accumulation and economic growth in the medium term; (ii) stimulate manufacturing industry and revert the de-industrialization of Brazilian economy.

Which was the result of the so-called New Macroeconomic Matrix? Growth almost stagnated, reaching an average of only 1.73% p.y. Despite growth deceleration, output gap was positive on average during this period, indicating that Brazilian economy was growing above potential and also that growth potential was reduced. Regarding the situation of manufacturing industry, output increased in 2013 compared to 2012, but it

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[9] Another problem was the resilience of inflation near 6% p.y in the period 2011-2013. If average inflation was 5.15% in the second term of President Lula, in the period of 2011 to 2013, average inflation rose to 6.08% p.y. After the popular protests of 2013, the political conditions in Brazil made impossible for the government to tolerate greater inflation acceleration, making Central Bank to give up the attempt of adjusting real exchange rate to a more competitive level.

[10] This combination was called as New Macroeconomic Matrix. For financial markets and many economists this was the official announcement of the end of Macroeconomic Tripod, even in its more flexible version that arose after 2006.

[11] See http://jornalggn.com.br/blog/luisnassif/o-primeiro-ano-da-nova-matriz-economica-por-mantega

did not returned to the average observed at the end of 2011 (see Figure 7). As a consequence, de-industrialization continued its course with manufacturing share reaching 10.29% in the 2014.Q1 (see Figure 7).

The failure of *new macroeconomic matrix* can be partially explained by the behavior of real exchange rate (see Figure 2). The real exchange rate depreciated but this movement was not enough to restore real exchange rate at the level observed in the 2006.Q1, when it looked to be at a very comfortable level for both manufacturing industry and current account. Compared to the level 2006.Q1, real exchange rate remained with an over-valuation of 12.23% in the 2013.Q4. The surprising feature of the period was the revealed incapacity of a remarkable low level for real short-term interest rate to stimulate economic growth. Thus Brazilian economy was experiencing a classical situation of *profit squeeze* (see Table II) which had clear and strong negative effects over the rate of capital accumulation and moderate effect on the gross fixed capital formation on GDP (GFCF/GDP).

Table II – Evolution of ROE, Selic/Over, Rate of capital Accumulation and GFCF/GDP (2010-2014)

Year	ROE (1)	Nominal Interest Rate (2)	Rate of capital Accumulation (3)	GFCF/GDP
2010	16,5%	9,8%	35%	20,65%
2011	12,5%	11,7%	12%	20,64%
2012	7,2%	8,5%	-4,4%	20,47%
2013	7,0%	8,2%	7,5%	20,43%
2014	4,3%	10,9%	0%	19,55%

Source: Rocca (2015). Authors´ own elaboration. Note: (1) and (2) are Average. (3) and (4) are end of period.

From the first quarter of 2011 until last quarter of 2012, the moving average of the growth rate of investment decreased, reaching *minus* 4.4% p.y at the end of this period. During 2013 investment growth experienced a temporary recover may be due to the lagged effects of monetary and fiscal policy easing, but it started again to fall in the beginning of 2014.

Another important element for explaining why exchange rate over-valuation did not cause a worsening in the external fragility indicators was the behavior of terms of trade. In the period 2011-2013 (see Figure 2) the terms of trade remained stable at very high levels,

sustaining the value of exports, despite the exchange rate over-valuation. At the end of 2013, however, terms of trade became to deteriorate, signaling clearly the end of commodity boom that begun in 2006. This would have a very strong and negative effect in Brazilian economy in 2014 and 2015, helping to transform a situation of economic stagnation in a depression of economic activity. We observe strong sharp decline in the the following variables (see Figures 3 and 4): growth rate of GDP, the investment rate, the share of investment to GDP, the share of industrial GDP on GDP and public sector borrowing requirements on GDP. Open unemployment rose from 6.9% to 13% in less than two years. From 2012 on, terms of trade became to deteriorate, but remained at a higher level until the beginning of 2014. At the end of this year, terms of trade started a new decline, returning to the level prevalent at 2006. The deterioration of the terms of trade induced a sharp depreciation of real exchange rate (see Figure 2)[12]. Due to the increase in the price of tradeable goods caused by exchange rate depreciation, real income per-worker started to decline from 2014.Q3 (R$ 2422,00 to R$2209,00 in the 2015.Q3).

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[12] The depreciation of real exchange rate occurred from 2005.Q2 on seemed to be more the result of the political crisis that erupted in Brazil after the beginning of President Dilma second term and the downgrade of Brazil by Rating Agencies in the second semester of 2015.

4 The effects on macroeconomic variables after shock in the Terms of Trade

This section is dedicated to analyze the reaction functions in several macroeconomic variables of Brazilian economy, following a positive exogenous shock in terms of trade. The period of sample observations is 2003 to 2015, during the mandates of Presidents Lula (2003-2010) and Dilma (2011-2015). Before the presentation of the results of the reactions functions, we adopted some statistical and econometric procedures, usually used when working with time series[13], in order:

a) **Correlation analysis between variables (see 4.1 topic)**: Based on section 2, for emerging economies, several macroeconomic variables of the Brazilian economy were selected as candidates to compose the set of variables of the dynamic statistical model. From the analysis of correlation between variables in level, their first differences and their accumulated growth rates, we choose the ones that have, over the period considered, a considerable correlation (moderate or strong, positive or negative signal).

b) **Use of Temporal Multivariate Series (see 4.2 topic):** Vector Auto Regressive models (VAR), with finite lag orders, were specified, estimated, analyzed and used to generate graphs of reaction function.

4.1 Multiple-Variable Analysis – Correlation Matrix

Since we are interested in the relationship between two variables, more precisely, since we want to know how variation of one affects the other, by a shock with a commanded mechanism transmission in a model where there variable multipath by impulse function response of a multivariate model, we start from the bivariate correlation analysis to choose the variables to be inserted in the VAR. The correlation study allowed us to determine the type of dependence or relationship between the variables (linear or not) and the intensity of this relationship (correlation measure) at same time. To multiple times

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[13] We use the R and J-MULTI softwares.

series the familiar measure of dependence is the Pearson product-moment correlation coefficients between each of the random variables X_i in the vector $X' = [X_1 \quad X_2 \cdots X_n]$, $Corr(X)$, is the matrix decomposition of the covariance matrix, Σ, which can be written:

$$Corr(X) = \left(diag(\Sigma)\right)^{-\frac{1}{2}}.\Sigma.\left(diag(\Sigma)\right)^{-\frac{1}{2}} = \begin{bmatrix} r_{x_1 x_1} & \cdots & r_{x_1 x_n} \\ \vdots & \ddots & \vdots \\ r_{x_n x_1} & \cdots & r_{x_n x_n} \end{bmatrix} (11)$$

When Σ is the covariance matrix of random variables, $X_1, X_2, ..., X_n$:

$$\sum_{X_n, X_n} = \begin{bmatrix} COV(X_1, X_1) & \cdots & COV(X_1, X_n) \\ \vdots & \ddots & \vdots \\ COV(X_n, X_1) & \cdots & COV(X_n, X_n) \end{bmatrix} (12)$$

And $\left(diag(\Sigma)\right)^{-\frac{1}{2}}$ is the matrix triangular of the diagonal elements of Σ. The result of the $Corr(X)$ show the correlation coefficients, $r_{x_n x_n}$, between each variable and the others at same time. Each element on the principal diagonal is the correlation of a random variable with itself, which always equals 1. We have adopted numerical criteria to differentiate the degree of correlation between variables (strong, moderate or weak), according to Table III.

Table III –Degree of correlation between variables

Correlation Coeficient Value	Degree of correlation	Variables enter in VAR?
$0.7 \leq r_{xy} \leq 1$	strong positive correlation	Yes, except if $r_{xy} = 1$
$0.3 \leq r_{xy} < 0.7$	moderate positive correlation	Yes
$-0.3 < r_{xy} < 0.3$	weak correlation or correlation absence	No
$-0.7 < r_{xy} \leq -0.3$	moderate negative correlation	Yes
$-0.7 \leq r_{xy} \leq -1$	strong negative correlation	Yes, except if $r_{xy} = -1$

Source: Authors´ own elaboration..

By Cauchy–Schwarz corollary, each off-diagonal element is between 1 and –1, inclusive. The correlation is +1 in the case of a perfect direct (increasing) linear relationship (correlation), −1 in the case of a perfect decreasing (inverse) linear relationship (anticorrelation), and some value between −1 and 1 in all other cases, indicating the

degree of linear dependence between the variables. As it approaches zero there is less of a relationship (closer to uncorrelated).

Correlations were calculated on 32 samples of President Lula (2003-2010), 19 samples of President Dilma (2011-2015) and 51 samples in the full period (2003-2015). All collected samples are quarterly order. Only the risk variable Brazil, measured by the EMBI+, disclosed on a daily basis, was converted to quarterly data. Each new quarterly report was obtained by the simple average of daily samples within each quarter in question. Also in this context, some variables had to be calculated or even handled in such a way to adjust the database, namely the output gap, the domestic absorption, real interest rate and the real growth rate of deflated product IPCA.

The usual definition of the output gap is the difference between the product (GDP) logaritm, y_t, and the product potential (potential GDP) logaritm, y_t^*. In practical, the gap output is obtained by trend extraction methods. We use the HP filter (see Hodrick-Prescott 1997) and were calculated as the difference between the product and its trend:

$$x_t = y_t - y_t^* \therefore x_t = C_t + \theta_t \quad (13)$$

The series x_t is made up of a trend component, denoted by θ and a cyclical component, denoted by C such that in econometrics with disturb, $x_t = C_t + \theta_t + \epsilon_t$.

GDP is the main information on the level of activity economic and the output gap product is a central concept in macroeconomic discussion, since it allowed us to make inferences about the state of the economy. For example, a positive value for the gap product can indicate the need raise the interest rate for contain demand pressures in the economy.

The HP filter is used to remove the cyclical component of a time series from raw data. It is used to obtain a smoothed-curve representation of a time series, one that is more sensitive to long-term than to short-term fluctuations. The adjustment of the sensitivity of the trend to short-term fluctuations is achieved by modifying a multiplier λ. The reasoning for the methodology uses ideas related to the decomposition of time series. Let x_t for t = 1, 2, …, T, denote the logarithms of a time series variable. The adjusted values of the x_t are the estimated potential products and ϵ_t are the gaps of product. Given an adequately

positive chosen of the smoothing[14] parameter multiplier, λ, positive there is a trend component that will solve minimizing the loss functions:

$$L = \min_{\theta} \left(\sum_{t=1}^{T} \left(\underbrace{x_t - \theta_t}_{d_t} \right)^2 + \lambda . \sum_{t=2}^{T-1} [(\theta_{t+1} - \theta_t) - (\theta_t - \theta_{t-1})]^2 \right) \quad (14)$$

The first term of the equation is the sum of the squared deviations, $d_t = x_t - \theta_t$, which penalizes the cyclical component. The second term is a multiple λ of the sum of the squares of the trend component's second differences. This second term penalizes variations in the growth rate of the trend component. The larger the value of λ the higher is the penalty. Hodrick-Prescott (1997) suggest λ =1600 as a value for quarterly data. And still T is the sample size. Once $y_t^* = \theta_t$ was calculated using the HP filter, we obtain the output gap from equation $x_t = y_t - y_t^* \therefore x_t = C_t + \theta_t$.

The variable domestic absorption, AD, was calculated as the difference between the gross domestic product at market price, GDP at market prices, and the net balance of exports of goods and services, NX:

$$AD = PIBpm - NX \quad (15)$$

We also calculate the real interest rate, r, of the Brazilian economy for the entire period using the following function:

$$r_t = 100 * \{((i_t - \pi_t).(1 + \pi_t)^{-1}) - 1\} \quad (16)$$

Where: i_t is the nominal interest rate and π_t is the inflation rate. For the nominal interest rate we use the basic rate of accumulated SELIC interest in annualized month, based on 252 working days, and the rate of inflation we use the inflation rate as measured by the Broad Consumer Price Index (IPCA) accumulated in 12 months since this indicator is used by governments on the inflation targeting regime, as target measured variable of the monetary policy rule.

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[14] The parameter λ is a number positive that penalizes the variability of potential output growth.

The variable real growth rate of gross domestic product accumulated in the last twelve months, $\%PIBr12m_t$, was calculated by deflating in terms of the accumulated IPCA in twelve months, π_t, as follows:

$$\%PIBr12m_t = 100 * \{(\%PIB12m_t - \pi_t).(1 + \pi_t)^{-1}) - 1\} \quad (17)$$

We divided the correlation analysis into three parts: (i) government of President Lula (2003-2010); (ii) government of President Dilma (2011-2015) and full period (2003-2015). The results are shown in Table IV. Based on the correlations we choose the endogenous variables inserted in the terms of trade model (TT) to dependence economy, where the shock will be given in terms of trade. The variables are: terms of trade (TT), Country risk premium (EMBIBR), Real Exchange Rate (TRC), Real Interest Rate (TRJ), gross fixed capital formation/GDP (GFCGGDP), Industrial GDP on GDP (GDPindGDP), Domestic absorption(DA), Output gap (GAP), Public Sector Borrowing Requirement on GDP (PSBRGDP), Real Labor Income(W), Unemployment(U), Inflation(IPCA). This is the starting order of the variables into VAR, chosen after the presentation of dependent economy model (see Section 2).

Table IV – Correlations between terms of trade (TT) with other macroeconomic variables

President	Lula	Dilma	All
Period	2003-2010	2011-2015	2003-2015
Quarter Samples	32	19	51
Correlation	TT	TT	TT
Terms of Trade	1,00	1,00	1,00
Real Exchange Rate	-0,83	-0,85	-0,78
Interest Rate	-0,77	-0,33	-0,71
Inflation	-0,56	-0,54	-0,32
Real Interest Rate	-0,52	0,03	-0,71
Public Sector Borrowing Requirement on GDP	-0,40	-0,89	-0,42
Acumullated GDP	0,46	-0,90	0,70
%GDP in 12 months	-0,56	0,78	-0,11
% real GDP in 12 months	0,32	0,80	0,14
Industrial GDP	0,90	-0,33	0,79
Market Price GDP	0,91	-0,64	0,71
GDPind/GDPpm (%)	-0,30	0,64	-0,61
Gross Fixed Capital Formation	0,90	-0,45	0,77
Gross Fixed Capital Formation on GDP	0,74	0,73	0,74
Net Exports (NX)	-0,42	0,33	-0,65
Domestic Absorption (AD)	0,91	-0,64	0,71
Unemployement (U)	-0,81	-0,38	-0,86
Real Wage (W)	0,89	-0,34	0,80
Open Unemploymet Rate - T.DA-RM	-0,76	-0,65	-0,79
OUTPUT GAP%	-0,26	0,42	0,32
Δ Terms of Trade	-0,09	0,49	0,05
% Terms of Trade in 12 months	0,47	0,59	0,18
Δ Domestic Absorption	0,44	0,27	0,26
%Domestic Absorption - Quarterly	0,27	0,32	0,06
% Domestic Absorption in 12 months	0,26	0,54	0,07
Δ Real Wage	0,38	0,30	0,15
%Real Wage - Quarterly	0,34	0,30	0,12
%Real Wage in 12 months	0,41	0,63	0,28
Δ Industrial GDP	0,17	0,10	0,01
%Industrial GDP - Quarterly	0,08	0,10	-0,06
% Industrial GDP in 12 months	0,11	0,22	-0,15
%Real Industrial GDP in 12 months	0,14	0,03	0,02
Premium Risk - EMBI-BR	-0,59	-0,81	-0,65

Legend:	Positive Strong Correlation	Moderate Positive Correlation	Low Correlation or not existent	Moderate Negative Correlation	Negative Strong Correlation

Source: Author´s own elaboration.

4.2 Use of Temporal Multivariate Series

Once the variables are chosen, we will use the methodology VAR to generate momentum (impulse or shocks) in terms of trade to observe the responses in the variables Brazil´s country risk premium (EMBIBR), Real Exchange Rate (TRC), Real Interest Rate (TRJ), Gross fixed capital formation/GDP (FBKFPIB), manufacturing share of GDP

(GDPindGDP), Output gap (gap), Public Sector Borrowing Requirement on GDP (PSBRGPP), Real Labor Income (W), Unemployment (U) and Inflation (IPCA).

For the empirical analysis we adopted the following in order[15]: (i) specify the VAR models following Sims-Stock-Watson(1990), i.e., with several variables in level, first differences or combinations of both, (ii) choose to lag optimal VAR(p) the criteria of Akaike (AIC), Final Prediction Error (FPE), Hannan-Quinn (HQ) and Schwarz (SC); (iii) estimate VAR models by Estimated Generalized Least Squares (EGLS) intercept, trend, restriction in coefficients via Top/Down method chosen by Akaike criteria; (iv) analyze the stability of VAR by eingelvalues polynomial reverse feature; (v) make the structural break point from Chow Forecast Test; (vi) make Cusum on each residual equation of the VAR, as Brown et al (1975); (vii) analyzing the autocorrelation of residuals through the auto-correlation function and partial auto-correlation, Portmanteau tests and Breusch (1978) and Godfrey (1978); (vii) analyze the normality of the residual from function Kernel type Gaussian with multivariate Jarque-Bera, Lütkepohl (1993) and Doornik-Hansen (1994) tests (ix) Generate impulse (shock) in the variable terms of trade and analyze the responses of the variables entered in the systems.

The basic vector autoregressive model (VAR) has the form:

$$y_t = A_1.y_{t-1} + \cdots + A_p.y_{t-p} + B_o.x_t + \cdots + B_q.x_{t-q} + C.D_t + \mu_t \quad (18)$$

Where $y_t = (y_{1t}, y_{2t}, \ldots, y_{Kt})'$ is a vector of K observable endogenous variables; $x_t = (x_{1t}, x_{2t}, \ldots, x_{Mt})'$ is a vector of M observable exogenous or unmodelled variables, D_t contains all deterministic variables which may consist of a constant, a linear trend, seasonal dummy variables as well as user specified other dummy variables, and μ_t is a K dimensional unobservable zero mean white noise process with positive definite covariance matrix $E(u_t, u_t') = \sum_u$. The A_i, B_j and C are parameter matrices of suitable dimension. In the $VAR(p)$ process, theoretically, it is assumed that: (i) E(μ_t)=0; (ii) E($\mu_t\mu_t'$)=$\sum_u$; (iii)E($\mu_t\mu_s'$)=0 for $s \neq t$; (iv) the covariance matrix, $\sum_u$ is singular. Said properties are desirable in a $VAR(p)$ stable and consistent.

The VAR order *p* may be chosen with the help of model selection criteria. The optimal lag order is chosen by minimizing one of the following information criteria for a range of lag orders n: Akaike (AIC), Final Prediction Error (FPE), Hannan-Quinn (HQ) e Schwarz (SC).

With samples of the 2003.Q1 to 2015.Q3, the results of the SC, AIC, FPE and HQ tests, including exogenous variables as intercept, trend and seasonal dummyes were calculated, always searched for one to ten lag. We will consider in this analysis the strategy of: (i) compare the order suggested by different criteria; (ii) use the order of selection indicated by most criteria; (iii) if the criteria indicate different orders, we will use, for thrift, the smallest gap; (iv) if half of the selection criteria point to a lag and the other half points to another delay, once again, we will use sparingly. Also, we execute analyzes with different orders of VAR. In Table V we can see the optimal criterion for lag selection for terms of trade model (TT model) is using the order of 3, 1 and 2 lags.

Table V – Optimal endogenous lags from information criteria

SPECIFICATION	LAG USED INTO VAR	OPTIMAL LAG ORDER				EXOGENOUS VARIABLES
		AIC	FPE	HQ	SC	
TT MODEL	1	2	3	1	1	intercept, trend and seasonal dummyes

Source: Authors´ own elaboration.

The next step is to estimate the coefficients of the specifications proposed in TT Model, according with the optimal lags obtained, in this case 1 lag, but too 2 or 3 are used to convenience. To decrease the number of estimated parameters, we adopt the VAR with restrictions on the coefficients, said VAR* by Estimator Generalized Least Squares (EGLS) method and Top-Down procedure (TD), that chosen by Akaike criteria.

After, we evaluate the stability of residues of each equation in the VAR. In theory the residuals must meet the white noise condition. In practice, according Lutkepohl (2005, p.157) if the model order is chosen by economic theory (our case) to generate momentum in a variable (shock) and observed responses in the other system variables is necessary investigate the properties of the residuals. For strategy, began by analyzing the Kernel probability density function on residuals. Subsequently, apply the Portmanteau Test and Lagrange Multipliers Tests, including the LM test Breusch-Godfrey.

Let $(\mu_1, \mu_2, ..., \mu_n)$ in each equation into VAR be an independent and identically distributed sample drawn from some distribution with an unknown density f. We are

interested in estimating the shape of this function f. The calculus of Kernel density estimator on residuals, $K(\mu)$, is:

$$\hat{f}_h(\mu) \therefore K(\mu) = nh^{-1} . \sum_{i=1}^{n} \{K(*) . [(\mu - \mu_i) . h^{-1}]\} \quad (19)$$

Where the h is called the scaled Kernel, $K(*)$ is a function tha define a kernel distribution. Data that residuals VAR should theoretically be independent and identically distributed use here the partial $K(*)$ that generates the Gaussian aspect of the distribution function estimated Kernel probability. The $K(*)$ is:

$$K = \left(\sqrt{2.\pi}\right)^{-1} . exp^{-(2^{-1}.\mu^2)} \quad (20)$$

Where K is a non-negative function that integrates to one and has mean zero, and $h > 0$ is a smoothing parameter called the bandwidth.

To illustrate the residual analysis in Terms of Trade Model, we take a simulated random sample from the standard normal distribution in the Kernel density, using a bandwidth h=0.05 at h=2. The kernel density with a bandwidth of h=0.182 is considered to be optimally smoothed. The Figure 9 insert too the bandwidth h to each residuals of estimated VAR.

Figure 9: Residual Kernel Density Estimaton – Terms of Trade Model
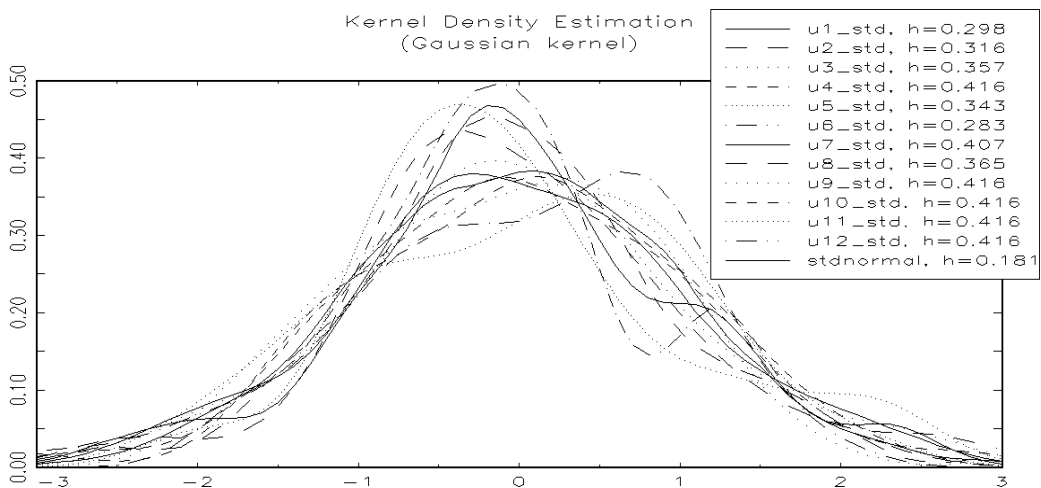
Source: Authors´ own elaboration.

In the terms of trade model, as the skewness and kurtosis, we observed that the estimated residuals of the VAR equations have similarities with the normal distribution (zero

skewness and tree kurtosis). Some residues exhibit leptokurtic curves and others exhibit mesokurtics curves. Yet all residues exhibit some form of symmetry about zero. Apparently, the residuals are very similar to the normal distribution in scale, as manner.

The next step is to perform multivariate normality test JB, Jarque-Bera (1987), Lütkepohl (1993) and Doornik-Hansen (1994). The JB test is based on the third and fourth central moments of the standard normal distribution, respectively skewness and kurtosis. The nonnormality residuals test proposed by Lutkepohl (1991) is an extension of JB test. The test focuses on the method of calculating the factorization matrix, which is the inverse of the lower triangular Cholesky matrix with positive elements on the diagonal orthogonal obtained by factorization of the residual covariance matrix. As the input order of the variables is defined by the Cholesky decomposition, so the results of the non-normality test residuals also depend on variable VAR in the input order. The Doornik-Hansen test does not vary by sorting and the range of the variable VAR, such as in Lutkepohl test. The test of the inverse of the square root of the residual correlation matrix. The Lütkepohl tests and Doornik-Hansen show small systematic deviations of skewness and kurtosis observed by viewing the Gaussian kernel in some residual, but do not reject the null hypothesis of multivariate normality of the residuals of the terms of trade model. As for the JB test, the results do not reject the null hypothesis of normality residual.

One of the most important tests in the VAR model, when it incorporates stationary variables and non-stationary, mixed way comments the article Sims Stock-Watson (1990), is to see if the set of equations of VAR has stability and consistent. The joint distribution of equations into VAR process is uniquely determined by the distributions μ_t process. The first and second time of VAR process, ie, the mean and covariance[16], are independent of time, therefore stationary and stable. The VAR process is stable if the reverse characteristic polynomial has no roots inside the unit circle and the circle unit complex. Formally, this condition is given by:

$$det(I_{Kp} - A.z) \neq 0 \; \therefore \; det(I_K - A_1.z - A_2.z^2 - \cdots - A_p.z^p) \neq 0 \quad (20)$$

Where I_K is the identity matrix, A is the set of matrix coefficients and z is modulus of the eigenvalues of the reverse characteristic polynomial. So strategically in practice, we can

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[16] The proof is in Luktepohl (2005, p.689).

filter VAR models eliminating those that have at least one value in module of eigenvalues of polynomial lower reverse feature that unit. The Table VI shows the results of modulus of the eigenvalues of the reverse characteristic polynomial, z, to Terms of Trade model, being stable VAR and, therefore, the covariance matrix, $\sum_u$, is not singular.

Table VI – Results of modulus of the eigenvalues of the reverse characteristic polynomial, z.

SPECIFICATION	MODULUS OF THE EIGENVALUES OF THE REVERSE CHARACTERISTIC POLYNOMIAL
"TT" MODEL	|z| = (1.7334, 1.7334, 4.1724, 4.1724, 1.5069, 1.5069, 1.0144, 1.0144, 1.4876, 1.4876, 1.2124, 2.0138)

Source: Authors´ own elaboration.

Finally, to check if VAR processes is stable we need to check the residual autocorrelation, as in theory $E(\mu_t\mu_s')=0$ for $s \neq t$. In practice it is almost inevitable when there are several variables in the VAR system. However the use of optimum lag assists order to improve the problem of residual autocorrelation. Tests such as Portmanteau and Lagrange Multiplier Breusch-Godfrey Test[17], help to determine whether, in general, there is residual autocorrelation in the VAR models. A Portmanteau Test for residual autocorrelation may be applied if a pure VAR process possibly with subset restrictions but without exogenous variables has been fitted. The test checks the null hypothesis. The Portmanteau test and Lagrange Multipliers Test Breusch-Godfrey has the null hypothesis not residual autocorrelation, $H_0 = E\mu_t\mu_{t-i}'=0$, with $s = t - i$ and $i = 1,2,...,h$. The alternative hypothesis test is that at least one auto-covariance, and thus a self-correlation is not zero, showing auto-correlation. Using the Chi-Square distribution in both tests, with 5 % significance, both the Portmanteau test and Breusch- Godfrey test does not reject the null hypothesis of no residual autocorrelation in the Terms of Trade model.

Another concern is the parameter constancy throughout the sample period is a key assumption in VAR econometric models. In this sense residual CUSUM tests and parameters constancy Chow tests were used to verify the parameter constancy. To test this, the Figure 10 presents the Chow test results[18] for structural break in the last years of multivariate temporal series into VAR model. The dotted line show the p-values with 5% and 10% of significance. Chow Forecast Test has the null hypothesis against an

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[17] See Breusch (1978), Godfrey (1978), with modification Godfrey (1988).

[18] See the test in the Candelon-Lütkepohl (2000).

alternative that all coefficients, including the residual covariance matrix,$\sum_u$, may be exchanged. The null hypothesis of constant parameters is rejected between 2012 and 2013 and strongly in 2015, during the second year of government mandate of Dilma (see the section 2 to details of this moment).

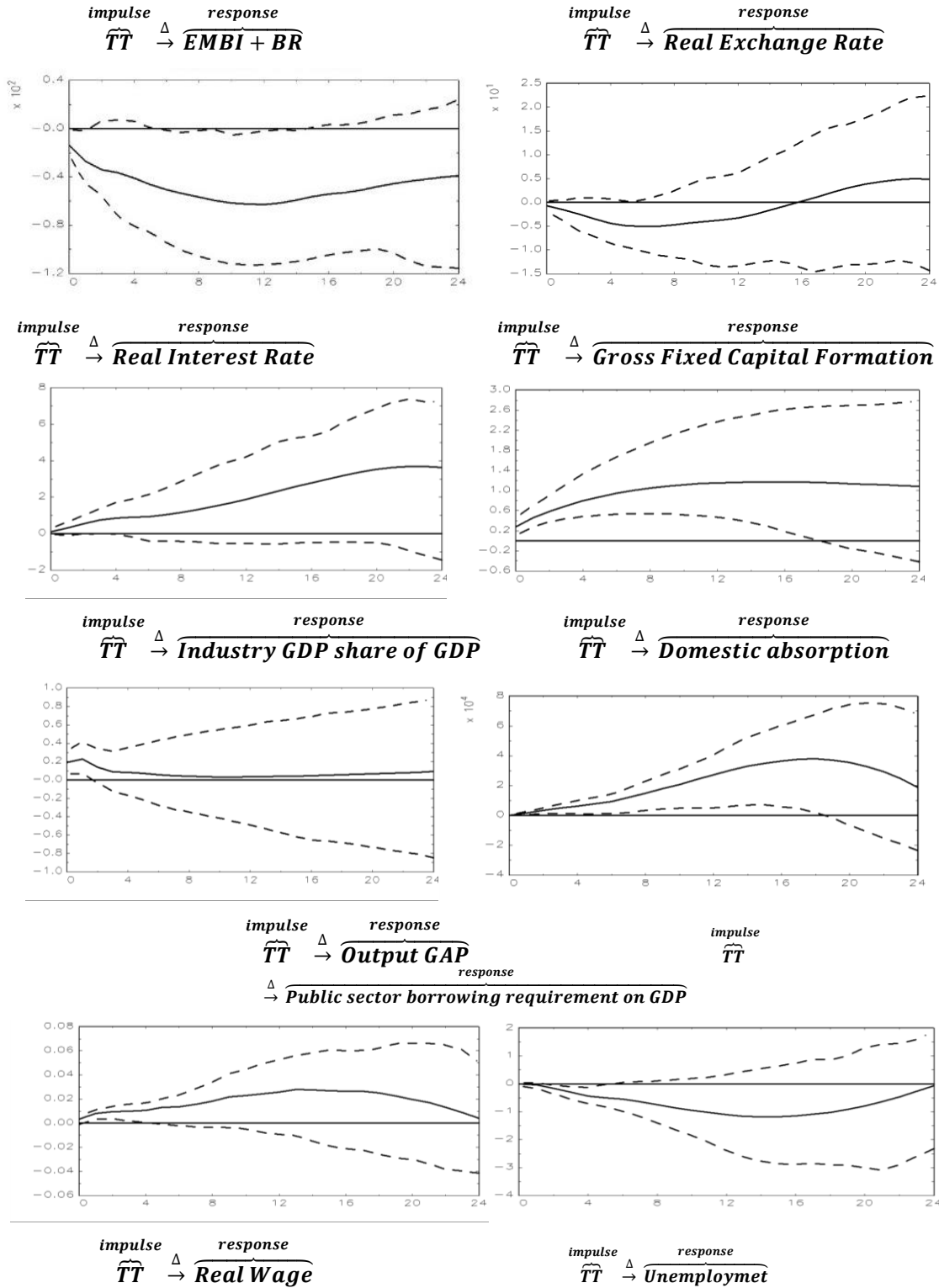**Figure 10: Structural Break: Chow Forecast Test Results 2009-2015.**
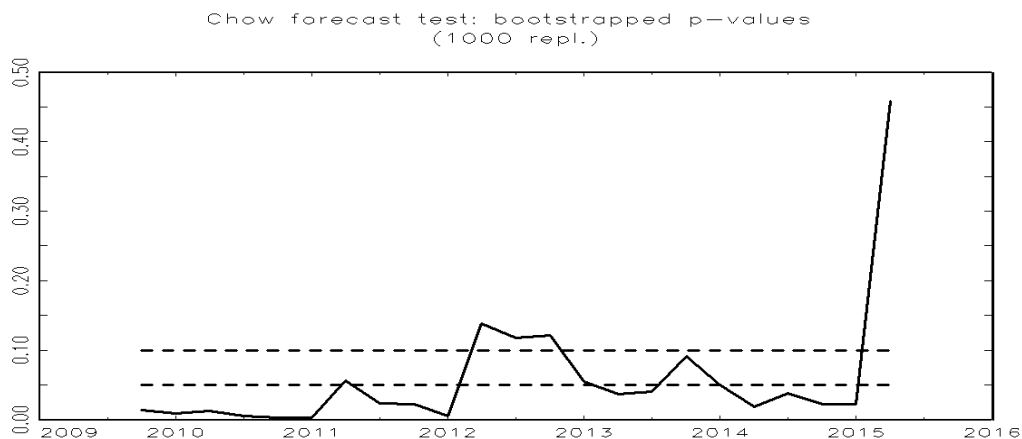
Source: Authors´ own elaboration.

Replicating CUSUM stability test on residuals proposed by Brown et al (1975)[19] in the terms of trade model, over the past years (2009-2015), the results observed indicate stability on VAR process, with 5% significance.

To analyze the dynamic interactions between the endogenous variables the last part of this section show the responses of the variables inserted in the $VAR(p)$, when it generates a shock in terms of trade. The total cumulative effects of impulses in the residuals, u_t's, were obtained by addition of appropriate coefficients of Impulse Response Function (IRF). Too the impulse responses are computed from the estimated VAR coefficients and Hall bootstrap percentile method with 95% confidence interval (see Hall,1992). We created orthogonalized impulse responses based on an innovation of size one standard deviation in the transformed model as well as forecast error variance impulse responses based on a unit innovation in the original model. The responses, which generate a shock in terms of trade, can be observed in the Figure 11, left and right side, respectively.

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[19] See the test in Brown et al (1975).

Figure 11: Brazil: Accumulated Responses in the macroeconomic variables after VAR Orthogonal Impulse in the terms of trade (TT)

$$\overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{EMBI + BR}} \qquad\qquad \overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Real\ Exchange\ Rate}}$$

$$\overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Real\ Interest\ Rate}} \qquad\qquad \overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Gross\ Fixed\ Capital\ Formation}}$$

$$\overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Industry\ GDP\ share\ of\ GDP}} \qquad\qquad \overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Domestic\ absorption}}$$

$$\overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Output\ GAP}} \qquad\qquad \overset{impulse}{\overbrace{\widetilde{TT}}}$$
$$\overset{\Delta}{\to} \overset{response}{\overbrace{Public\ sector\ borrowing\ requirement\ on\ GDP}}$$

$$\overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Real\ Wage}} \qquad\qquad \overset{impulse}{\overbrace{\widetilde{TT}}} \overset{\Delta}{\to} \overset{response}{\overbrace{Unemploymet}}$$

$$\underbrace{\widetilde{TT}}_{impulse} \xrightarrow{\Delta} \underbrace{\widetilde{INFLATION}}_{response}$$

Source: Author´s own elaboration.

As we can see a positive shock in Terms of Trade is associated with a permanent decrease in the sovereign risk premium measures by EMBI+, in the investment rate, industrial GDP on GDP, unemployment rate and inflation. Real exchange rate appreciates in first instance, and then depreciates after 16 quarters. A positive shock in terms of trade is also associated with a permanent increase in the real income per worker and in output gap.

The change from a good to a poor macroeconomic performance in Brazil after 2013 can be partially explained by the combined effects of a negative shock in terms of trade and a positive shock in domestic absorption due to the trend increase in primary expenditures to GDP. But these factors do not seem to be enough to explain the magnitude of the fall in GDP occurred in 2015. As we saw in figure 10 there is econometric evidence of structural break in the econometric model in 2012, 2013 and, more strongly, in 2015. This structural break may be caused by the increased in the perception of uncertainty due to the recent Brazilian political crisis and the empirical evidence on Brazilian case about terms of trade, real exchange rate over-valuation and de-industrialization.

5   Final Remarks

What factors explain this collapse of Brazilian macroeconomic performance after 2014? We had that due to exchange rate over-valuation caused by the improvement in Terms of Trade, Brazilian economy had experienced some structural negative changes like de-industrialization and re-primarization of exports that reduced its long-run growth potential. These structural changes were sufficient to explain a situation of near stagnation that Brazil experienced in the period 2011-2013; but are incapable for its own to produce a deep recession as the one seen in 2015. A recession is always and elsewhere caused by insufficient effective demand, so in order to explain why Brazil entered in a deep recession we have to understand what factors caused a fall of aggregate demand at the end of 2014 and beginning of 2015.

The first cause of the contraction of aggregate demand was the reduction of investment rate. As we can see in figure 3 below, investment had fallen from 20.92% of GDP in the first quarter of 2014 to 18.12% of GDP in the third quarter of 2015, a fall of 2.80% of GDP in less than two years. This contraction of investment demand is for sure the result of ROE falling below the safe rate of interest after 2012 as we had seen in last section, i.e. a result of a profit squeeze. Besides that, the public scandal originated by police investigations of corruption (the so-called "operação lava-jato") at PETROBRAS had provoked a major political crisis with a serious threat of impeachment of President Dilma Rouseff. This crisis had also a clear and negative (but until now not quantified) effect over investment expenditures of private sector since it increased the perceived uncertainty in economic environment. Finally, the deterioration in terms of trade had also a negative effect over profitability of investment projects of the mining industry (oil and iron ore), which become increasing important in Brazil during the commodity boom.

The second cause was the huge contraction of real income per-worker since the beginning of 2015. As we can see in figure 2, in the first semester of 2015 real income per-worker started to fall at a very fast rate, with the expected effects over consumption expenditures. The fall in real income per-worker was the result of inflation acceleration occurred in 2015 combined with the increasing in the rate of unemployment (Figure 3). To sum-up, a combination of change in international economic environment, delayed effects of errors in the conduction of economic policy, profit squeeze and a major political crisis had created the scenario of a *perfect storm,* generating a huge contraction of aggregate

demand that reduced growth below potential. Since potential growth was reduced due to negative structural changes that Brazilian economy faced as a consequence of exchange rate over-valuation, the result was a deep recession, probably the deepest that occurred in Brazil since the end of Second World War.

The positive side of this scenario is that real exchange rate seemed to return to a competitive level in the second semester of 2015. Indeed, nominal exchange rate had experienced a huge depreciation due to the combined effects of deterioration of terms of trade and uncertainty created by the political crisis in Brazil. From July of 2014 to July of 2015, nominal exchange rate had devaluated in 49,7%, reaching a value near R$ 3,40 in the beginning of august. If we consider the industrial equilibrium exchange rate (see Bresser-Pereira, Oreiro and Marconi, 2014) as the adequate measure for a competitive exchange rate, then we obtain a value of R$ 3,39 per dollar as the adequate level for nominal exchange rate[20]. This means that exchange rate adjustment is done, which can give a start in a possible re-industrialization of Brazilian economy.

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[20] See Marconi (2012) for the methodology of estimating the level of industrial equilibrium exchange rate. Our estimates for industrial equilibrium exchange rate are based on Marconi´s estimates for 2011, updating it according to the inflation differential between Brazil and United States from 2012 to 2015.

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