Revisiting Growth of Brazilian Economy (1980-2012)*

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Abstract: The objective of the present article is to analyze the causes of growth slowdown of Brazilian economy initiated in the middle of the 1980´s from a Keynesian-Structuralist perspective, according to which long term growth is associated with structural change and capital accumulation. Throughout the article it will be tested the hypothesis that growth slowdown was caused by a huge reduction in the rate of capital accumulation due to a substantial reduction of the investment share in real output that begun in the 1980´s and increased in the 1990´s. The reduction of the investment share was the result of the existing imbalances of macroeconomic prices (mainly overvalued real exchange rate and exchange rate/wage ratio) that caused a premature deindustrialization of Brazilian economy with negative effects over investment opportunities. The period to be analyzed will be from 1980 to 2012. These statistical procedures will allow us to define the list of independent variables of the econometric models to be estimated. Econometric results are compatible with the theoretical hypothesis regarding growth slowdown of Brazilian economy.

Key-Words: structural change; capital accumulation; semi-stagnation; Brazil

JEL Classification: O1, O11, O14

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1. Introduction

Between the 1930s and 1980s the Brazilian economy underwent a profound process of structural change, from a primary export economy to an urban and industrialized economy. During these five decades, real GDP grew at an average rate of 7% per year, while GDP per capita increased at an average rate of 4% per year, causing GDP and GDP per capita to double in size every 10 and 17.5 years, respectively. The 1980s marked the end of the accelerated growth phase of the Brazilian economy, starting a long period in which the growth rate ranged from moderate (2003-2012) to low (1990-2002). This new phase of economic development in Brazil was termed "semi-stagnation" by Bresser-Pereira (2007). In this context, the objective of this article is to analyze the causes of economic growth deceleration in Brazil, based on a Keynesian-Structuralist theoretical framework, according to which economic development consists in the increase in the population's standard of life enabled by the growth of labor productivity, which depends on the structural change or productive sophistication (transfer of labor and other resources from activities with lower added-value per capita to activities with higher added-value) and capital accumulation.

Throughout this article it is shown that the pace of capital accumulation has declined significantly since the late 1980s, and that this reduction was primarily caused by the decrease in the investment rate at current prices. In addition, it is verified that the share of the manufacturing industry in the GDP also presented a clear reduction trend from 1980 on, which is associated to the macroeconomic instability in the second half of that decade and the *overvaluation of real exchange rate* observed from the beginning of the 1990´s and the adoption of the liberal-dependent model of external savings from 1994 onwards. A series of empirical procedures will be presented to allow the estimation of the investment function, the function of technical progress and the function of structural change for the Brazilian economy. The investment function will be estimated with quarterly data for the period 1995/T1 to 2012/ T4, due to lack of data, while the functions of technical progress and structural change will be estimated with annual data for the period 1980-2012.

The estimates carried out in this article show that the rate of growth of labor productivity depends on the dynamics of the manufacturing share in the GDP and the growth rate of the capital stock per worker. The evolution of the manufacturing share in GDP, in turn, depends on the rate of *exchange rate undervaluation* and negatively on the *technological gap*. The estimation of the investment function shows that the investment share is a quadratic function of the exchange rate/wage ratio, a positive function of level of capacity utilization and a negative function of the country risk premium.

Based on the empirical results it is possible to conclude that the deceleration of economic growth since 1980 was due to the combined effects of the reduction of investment rate at current prices and the decrease in the manufacturing share in GDP. The reduction in the investment rate is mainly due to the macroeconomic regime adopted since 1994, which restricted the expansion of aggregate demand, maintaining the capactity utilization at a low level. Another important factor in explaining this phenomenon was the external fragility of the Brazilian economy, which was expressed in currency crisis that were responsible for maintaining a high country risk premium, causing a negative impact on investment. However, the exchange rate overvaluation observed from the beginning of the 1990´s onwards seems to have had a positive impact on the investment rate. The negative effect of the real exchange rate appreciation on growth was due to the dynamics of the manufacturing share in GDP. It will be show that: (i) the reduction of the manufacturing share in the GDP has a strong negative impact on the rate of growth of output per-worker and (ii) the appreciation of the real exchange rate negatively affects the share of manufacturing industry, with a one-year lag. Thus, the trend of exchange overvaluation after 1994 had a negative net impact on growth.

2. Economic Development and Technical Progress Function

Economic development is a process whereby capital accumulation and the systematic incorporation of technical progress allow the persistent increase in labor productivity and population standard of living (Bresser-Pereira, Oreiro and Marconi, 2014). The increase in labor productivity enables the persistent raise in real wages once the so-called "Lewis point" has been overcome; that is, once the labor force employed in the subsistence sector has been fully transferred to the modern sectors (Lewis, 1954). At that point, the unlimited supply of labor, characteristic of Capitalism's Phase I (Kaldor, 1980), is exhausted, causing the continuous increase in the demand for labor, due to the expansion of the activity level, to raise wages at approximately the same pace as labor productivity growth. The growth of wages, in turn, makes it possible to increase the population's standard of living.

Capital accumulation and technical progress are the fundamental sources of growth of labor productivity and population's standard of living. Indeed, technical progress enables, on the one hand, an increase in production efficiency, i.e. that the same goods and services are produced by using a smaller quantity of inputs, in particular labor; on the other hand, technical progress leads to the development of increasingly sophisticated or complex products and services, that is, products that incorporate not only a larger but also more diversified amount of technical and scientific knowledge. These more sophisticated or complex products are produced by highly skilled workers in companies operating at or near the technological frontier; which is why these products have higher added-value per unit of labor employed. Thus, technical progress stems not only from the advancement of the "state of the arts", but also through a process of structural change, in which productive resources and workers are transferred from the activities with lower added-value per worker employed to activities with higher added-value per worker (more complex sectors).

Capital accumulation is an important element in the process of diffusion of technical and scientific knowledge to the whole economy, since a considerable part of this knowledge is incorporated in machines and equipment, making it impossible to separate the increase of the lobour productivity that results from the advance of the "state of the arts" from the one that results from a greater "mechanization" of the workforce. As emphasized by Hidalgo (2015), physical capital is nothing more than technical and scientific knowledge embodied in machines and equipment. The relationship between the growth of labor productivity and the capital accumulation effort was pioneered by Kaldor (1957), and it was called a function of technical progress:

$$\hat{y}_t = \alpha_{0,t} + \beta_0 \hat{k}_t \tag{1}$$

Being $\hat{y}$ the growth rate of the product per worker in period t; $\alpha_{0,t}$ is the autonomous part of the labor productivity growth in period t, that is, that share of productivity gains that is not directly attributable to the greater "mechanization" of the labor force; β_0 is a positive constant that captures the capacity of the economy to transform the increment of technical and scientific knowledge in increase of productivity through investment in machines and equipment e $\hat{k}$ is the rate of capital growth per worker in period t.

The constant term of equation (1) reflects not only that share of the technical progress that is disembodied from machines and equipment (Oreiro, 2016, p. 49); but also the sophistication and complexity of the productive structure of the economy. As the economy undergoes a structural change in which productive resources are transferred from the less complex and sophisticated sectors to more complex sectors, there will be an increase in labor productivity as a result of the increase in the average sophistication / complexity of the economy[1].

The available empirical evidence points to the existence of a positive correlation between the economic complexity index elaborated by Hidalgo (2015) and the per capita income level of a sample of countries[2]. Economic complexity, in turn, seems to be positively associated with the share of the

[1]Hidalgo (2015, pp.145-146) defines the economic complexity as the combination of the diversity and sophistication of productive activities, which originates from the accumulated scientific and technical knowledge.

[2]See Gala (2017) for the methodology behing the construction of the index of economic complexity.

manufacturing industry in GDP. In this context, it is possible to establish a link between the share of the manufacturing industry in GDP and the autonomous part of the function of technical progress; more specifically, we can assume that an increase in the share of the manufacturing industry in GDP, as it is associated with an increase in the level of economic complexity, will result in an increase in labor productivity growth that is autonomous with respect to the capital accumulation effort. If the autonomous part of technical progress depends on structural change and this, in turn, is strongly correlated with the evolution of the share of the manufacturing industry in the GDP, it is possible to write that:

$$\alpha_{0,t} = \delta_0 + \delta_1(h_t - h_{t-1}) \quad (2)$$

Where h_t is the share of industry value added in GDP in t.

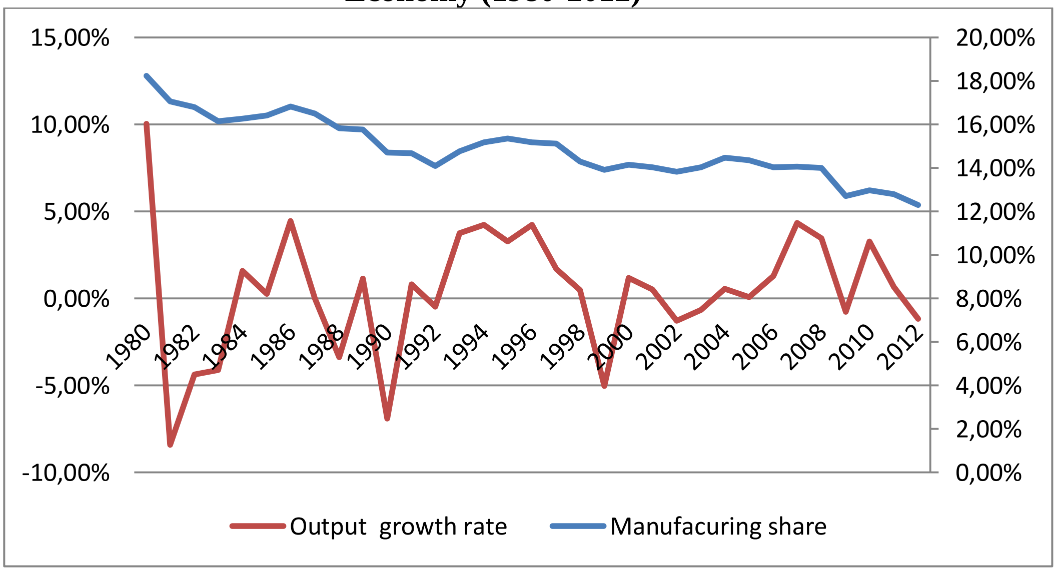
Substituting (2) into (1), we get

$$\hat{y}_t = \delta_0 + \delta_1(h_t - h_{t-1}) + \beta_0\hat{k}_t \quad (3)$$

Equation (3) is the final form of the technical progress function in which the rate of labor productivity growth depends on the growth rate of the stock of capital per worker and the change in the share of the manufacturing industry in GDP. In this context, we can see that productivity growth is affected both by the rate of capital accumulation - and therefore by investment expenditures - and by the evolution of the composition of productive structure.

Turning now to the Brazilian case, we can see in figure 1 bellow that since the beginning of 1980´s manufacturing share as a ratio to GDP is decreasing, so that Brazilian economy faced a process of (premature) deindustrialization[3]. This negative structural change was accompanied by a permanent slowdown in the rate of economic growth.

Figure 1 – Manufacturing share in GDP and Growth Rate of Real GDP in Brazilian Economy (1980-2012)

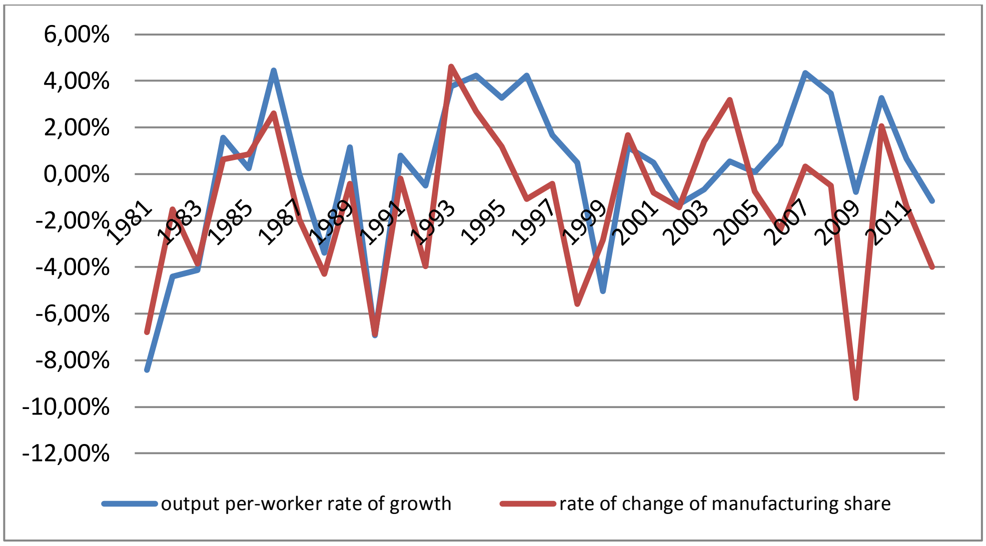


Source: IPEADATA and Marconi and Rocha (2012). Author´s own calculation. Note: (a) left axis (real GDP growth rate); right axis (manufactuting share in GDP); (b) GDP is calculated at 2013 prices; (c) Manufactuing share is calculated at constant prices (See Marconi and Rocha, 2012).

[3] For an anysis of the "premature deindustrialization" see Rodrik (2015).

According to the theory presented so far (equation 3), a reduction of the manufacturing share in GDP will be followed by a reduction in the GDP per-worker growth rate. This relation is clear and strong in the case of the Brazilian economy, as we can see in figure 2 bellow.

Figure 2- GDP per-worker growth rate and rate of change of Manufacturing Share in GDP for Brazilian Economy (1981-2012)



Source: IPEADATA. Author´s own calculation

3. Balanced Growth and Capital Accumulation

Balanced growth trajectories, in which the proportions among economic aggregates are kept constant over time, have historically been the focus of Economic Development Theory. This is because such trajectories have the important property of being sustainable over time, being durable enough to affect the population well-being in a permanent way (Oreiro, 2016). It does not mean that unsustainable growth trajectories are impossible to occur; on the contrary, the historical experience of developed and developing economies is rich in examples of growth trajectories that are unsustainable due to their association with increasing macroeconomic imbalances. Along a balanced growth trajectory, output and capital stock must grow at the same rate in order to keep the product-capital ratio constant over time. To understand why let us consider equation (4):

$$Y = \frac{Y}{\bar{Y}}\frac{\bar{Y}}{K}K = u.\sigma.K \qquad (4)$$

Y is the real output level ; $\bar{Y}$ is the potential output level, i.e. the real value of the production of final goods and services that could be obtained if the firms are operating with a normal degree of utilization of productive capacity; K is the real value of the capital stock of the economy; $u = \mathrm{Y}/\bar{\mathrm{Y}}$; Y is the actual level of capacity utilization; $\sigma = \bar{\mathrm{Y}}/\mathrm{K}$ is the productivity of capital, that is, the maximum output that can be obtained with one unit of capital.

Based on (4) we can see that the output-capital ratio is equal to the level of capacity utilization times the productivity of capital. Thus, for the output-capital ratio to be stable over time, it is necessary that the level of capacity utilization and the productivity of capital do not show a tendency to increase or decrease over time. The level of capacity utilization is variable, due to business cycles, but fluctuates between 70% and 90% over the long term. The behavior of capital productivity depends on the nature of technical progress. According to Harrod (1948), technical progress can be classified in three types: (i) *Capital intensive* when the rate of growth of capital stock is higher than the rate of output growth, causing capital productivity to decline over time; (ii) *Neutral* when the rate of growth of capital stock is equal to the rate of output growth so that the productivity of capital is kept constant over time; (iii) *Capital saving* when the capital stock growth rate is lower than the output growth rate so that capital productivity is growing over time.

Empirical evidence for developed countries has pointed to the stability of capital productivity in the long run (Thirlwall, 2006). That is, for a neutral technical progress in the sense of Harrod; although these estimates may be biased due to the difficulties in defining the concept of capital. From these findings, we can establish that, in the long term, the growth rate of the real output is approximately equal to the growth rate of the capital stock; in order to maintain the output-capital ratio at a stable level. Thus, the growth rate of output is determined by the growth of capital[4]:

$$g_y = g_k \tag{5}$$

Where: g_y is the rate of growth of the real value of the production of final goods and services; g_k is the growth rate of the capital stock.

In turn, the rate of growth of capital stock s given by:

$$g_k = \frac{\Delta K}{K} = \frac{I - \delta K}{K} = \frac{I}{Y}\frac{Y}{K} - \delta = fu\sigma - \delta \tag{6}$$

In which: I is the real value of gross fixed capital formation; δ is the depreciation rate of the capital stock.

The equation $f = I/Y$ is the ratio between gross fixed capital formation (in real terms) and the real value of output of final goods and services, i.e. the investment rate. This, in turn, is expressed by:

$$f = \frac{I}{Y} = \frac{P_I I}{P_Y Y}\frac{P_Y}{P_I} = \frac{INV}{PIB}\frac{1}{\rho} \tag{7}$$

Where: P_I is the capital goods price index; P_Y is the GDP deflator; $P_I I$ is the nominal value of investment expenses; $P_Y Y$ is the nominal GDP; P_I/P_Y is the relative price of investiment[5].

Substituting (7) into (6):

$$g_k = \left(\frac{I}{GDP}\right)\left(\frac{1}{\rho}\right)u\sigma - \delta \tag{8}$$

Based on (8) it is possible to conclude that the growth rate of the capital stock is a direct function of the investment rate, the level of capacity utilization and the productivity of capital; and an inverse function of the relative price of the investment and the rate of depreciation of the capital stock.

4. The Determinants of the Investment Rate: a review of the literature

The previous section has shown that along a balanced growth trajectory, the dynamics of the GDP level heavily depend on the rate of capital accumulation, which directly depends on the share of the real output that is devoted to gross fixed capital formation, that is, depends on the investment rate. But what are the factors that determine the share of real GDP allocated to investment?

One of the most accepted theories about the determinants of investment is the so-called accelerator hypothesis, according to which entrepreneurs invest in order to adjust the size of productive capacity to expected sales growth. Firms, however, had a desired level of idle capacity either as a

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[4]For the Brazilian economy, Bonelli and Bacha (2013) present empirical evidence in order to show that the causal relationship is derived from the growth of the capital stock for real product growth.

[5]Bonelli and Bacha (2013) present an equation for the growth of capital stock similar to equation (8) above, except for the use of the savings rate instead of the investment rate. From the National Accounts point of view, there is no difference between the version used by Bonelli and Bacha (2013) and the version we are using in this article since aggregate investment is, by definition, equal to aggregate savings. There is, however, an important theoretical divergence with regard to causality. In a Keynesian perspective, investment determines savings, so the correct specification of the capital accumulation equation must use the investment rate, not the savings rate, as the explanatory variable. In the neoclassical perspective, as adopted by Bonelli and Bacha (2013), the savings determine the investment, which is why these authors use the savings rate as an explanatory variable. See Carvalho (2015).

defensive strategy against the entry of new competitors or as a mechanism to meet an unexpected increase in sales without losing market share to other competitors (Steindl, 1952). Therefore, the share of investment in GDP will depend on the degree of utilization of productive capacity, the larger the scale, the greater the need for firms to invest in order to restore the desired level of idle capacity. The investment dependence on the degree of utilization of productive capacity is present in Rowthorn (1981), and the investment desired by firms not only depends on the degree of utilization of productive capacity but also on the rate of profit, in line with Kalecki (1971) and Robinson (1962). The investment function of Rowthorn (1981) is given by:

$$\frac{I}{Y} = I(r, u); \quad I_1 \equiv \frac{\partial I}{\partial r} > 0 \,; \; I_2 \equiv \frac{\partial I}{\partial r} > 0 \qquad (9)$$

The rate of profit appears as an explanatory variable in the investment function as a *proxy* for the expected profitability of new investment projects. In conditions of strong uncertainty, economic agents form their expectations based on conventions, particularly on the idea that the current business situation is a good guide for the future, unless they have reasons to expect changes (Keynes, 1936). Thus, the current rate of profit will play a crucial role in shaping expectations about the profitability of new investment projects.

The profit rate is the equal to the share of profits in income times the degree of utilization of productive capacity times the productivity of capital. Taking the productivity of capital as constant (assuming a neutral technical progress in Harrod's sense), then the dynamics of investment will depend on the relationship between the degree of utilization of productive capacity and the share of profits in income. If an increase in this share is associated with an increase in the utilization of productive capacity, then the profit rate will necessarily increase, thus inducing an increase in the share of investment in output. In this case, we say that a profit-led accumulation regime prevails in the economy. On the other hand, if an increase in the share of profits in income is associated with a reduction in the utilization of productive capacity, the profit rate may be reduced due to the redistribution of income from wages to profits. If the reduction of the profit rate is strong, the *I/Y* portion may be reduced, characterizing a wage-led regime. Bhaduri and Marglin (1990), who propose the function below, define the conditions for the existence of accumulation regimes drawn by profits and wages:

$$\frac{I}{Y} = I(m, u); \quad I_1 \equiv \frac{\partial I}{\partial m} > 0 \,; \; I_2 \equiv \frac{\partial I}{\partial u} > 0 \qquad (10)$$

Where m: is the share of profits in income.

Such a specification of the investment function is useful by decomposing the influence of the profit rate over investment into its two components: the share of profits in income and the degree of capacity utilization. It is still possible to verify separately the role of the functional distribution of income and the degree of utilization on the share of investment in output. When the sensitivity of *I/Y* to a varying profit share in income is relatively high and/or the sensitivity of *I/Y* to variations in the degree of utilization of productive capacity is relatively low, then the economy will be more likely to have a *profit-led accumulation regime*. Otherwise, it will be prone to a *wage-led regime*.

On the other hand, the incorporation of financial variables into the investment function was done, among others, by Taylor and O'Conell (1985), who developed a model that formalizes aspects of Minsky's (1982) financial instability hypothesis. Based on this model, the I/Y plot can be presented by:

$$\frac{I}{Y} = \beta_1 + \beta_2 \,(r + \xi - i); \quad \beta_1 > 0 \,; \; \beta_2 > 0 \qquad (11)$$

Being β_1 is autonomous propensity to invest; β_2 is the coefficient of sensitivity; r: rate of profit; ξ: confidence of the entrepreneurs and i: interest rate.

Based on (11), the share of investment in output is negatively influenced by the interest rate, which represents the opportunity cost of investment in fixed capital. An increase in this rate reduces investment as the present value of the expected cash flow of new investment projects decreases, thus reducing the demand price of capital equipment.

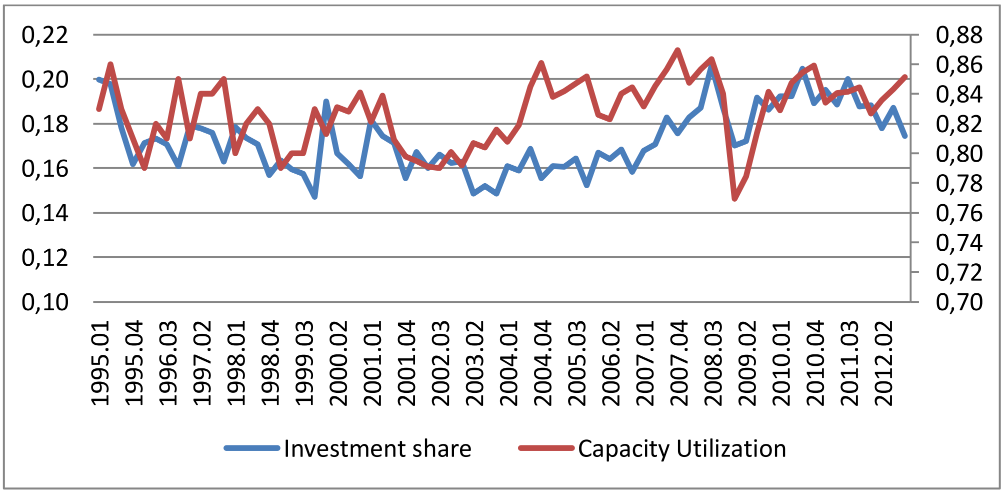
More recently, literature that seeks to explore the possible relations between the real exchange rate and investment decision has been developed, such as Oreiro and Araújo (2013). For these authors, the real exchange rate presents a non-linear relation with the investment desired by the entrepreneurs, similar to an inverted U. The authors justify this relationship with the following argument: for low levels of the real exchange rate, currency depreciation stimulates investment; since it allows an increase in the market power of domestic firms and therefore an increase in profit margins and in the share of profits in income. The increase in profit margins, in turn, will lead to a higher rate of capital accumulation. As a share of the demand for capital is met through imports, however, a very high exchange rate could discourage investment decisions. This is because raising the profit margins of domestic firms may not be enough to offset rising costs of imported capital goods. A very high exchange rate can thus cause the supply price of capital goods to exceed its demand price, discouraging investment. The specification of the investment function based on Oreiro and Araújo (2013) is:

$$\frac{I}{Y} = \alpha_0 + \alpha_1 . h + \alpha_2 . u + \alpha_3 . \theta - \alpha_4 . \theta^2 - \alpha_5 . i \qquad (12)$$

Where θ is the real exchange rate and i is the real interest rate.

In figure 3 we can see the behavior of investment rate and capacity utilization in Brazil in the period 1995-2012[6]. From the first quarter of 1995 to the first quarter of 2003, investment rate fluctuates between 16% to 18% of GDP. In the same period, capacity utilization fluctuated around 82% of full capacity. From 2003 on, we can observe *a clear increase in the average level of capacity utilization* and also an increase in investment share. Indeed, from 2003 to 2012, investment share fluctuated between 18% to 20% and capacity utilization fluctuated between 82% to 85% of full capacity. So there is some empirical basis for the validity of accelerator effect in Brazilian economy.

Figure 3 – Investment Share and Capacity Utilization in the Brazilian Economy, Quarterly Data (1995.01-2012.04)



Source: IPEADATA. Author´s own elaboration

[6] There are no available data for capacity utilization before 1995; that is why the analysis of the behavior of investment share and capacity utilization begins in 1995, instead of 1980.

5. Structural Change, Exchange Rate and Technological Gap: explaining the deindustrialization of Brazilian Economy.

In section 2 it is shown that the evolution of the manufacturing industry share in GDP is a determinant of the labor productivity growth rate and, therefore, of the rate of economic growth. In this context, industrialization, understood as a sustained increase in the share of manufacturing industry in GDP, is the engine of long-term growth (Thirlwall, 2002).

The emphasis on industrialization as the engine of growth is in agreement with the Kaldorian and structuralist literature, which emphasizes the fundamental role of industry as the locus of increasing returns and dynamic economies of scale. The dynamics of the share of the manufacturing industry is influenced for by price and ono-price factors. With regard to price competitiveness, an overvalued exchange rate, that is, below the level that makes the industries operating with world-class technology competitive on the international market, leads to a progressive reduction of manufacturuing share in GDP, since this situation induces an increasing transfer of productive activities abroad, leading to the substitution of domestic production for imports. We will call this level of *industrial equilibrium real exchange rate* (Bresser-Pereira, Oreiro and Marconi, 2014). Thus, a situation of exchange rate overvaluation is associated with a negative structural change in the economy, which may be termed *premature deindustrialization*. An undervalued exchange rate, that is, above the level of industrial equilibrium, would have the opposite effect, would induce a transfer of productive activities from abroad to the domestic economy, increasing the manufacturing share.

Turning now the attention to non-price competitiveness, a key feature of developing countries is that they are far from the technological frontier, and therefore their firms cannot operate with technology in the world's state of the art. This *technological gap* has a negative effect over the non-price competitiveness of developing countries' manufacturing industries, since they produce manufactured goods that are of inferior quality and/or of less technological intensity when compared to manufactured goods in developed countries (Verspagen, 1993). It follows that the existence of this gap is a key factor for reducing the competitiveness of the manufacturing industry in developing countries, thereby contributing to a reduction in its share in GDP. From this discussion, we will assume that the dynamics of the share of the manufacturing industry in the GDP in the case of developing countries is given by:

$$h_t = h_{t-1} + \beta_3(\theta - \theta^i)_{t-1} - \beta_4(G_{t-1} - 1) \qquad (13)$$

Where: θ is the real exchange rate; θ^i is the exchange rate of industrial equilibrium; G is the technological gap; $0 < \beta_3 < 1$ is a parameter that represents the discretionary policies that directly affect the development of the industrial sector (for example, the level of import tariffs); β_4 is a coefficient that captures the sensitivity of the productive structure to the technological gap.

It can be seen from equation (13) that for those economies operating at the technological frontier, the level of the real exchange rate for which the manufacturing share is constant over time is equal to the industrial equilibrium level[7]. However, if the economy is far from the technological frontier, the share of the manufacturing industry in GDP can only increase over time if the real exchange rate is above the industrial equilibrium level. Substituting (13) into (3) we obtain the final format of the technical progress function:

$$\hat{y}_t = \delta_0 + \delta_1\left[\beta_3(\theta - \theta^i)_{t-1} - \beta_4(G_{t-1} - 1)\right] + \beta_0\hat{k}_t \quad (14)$$

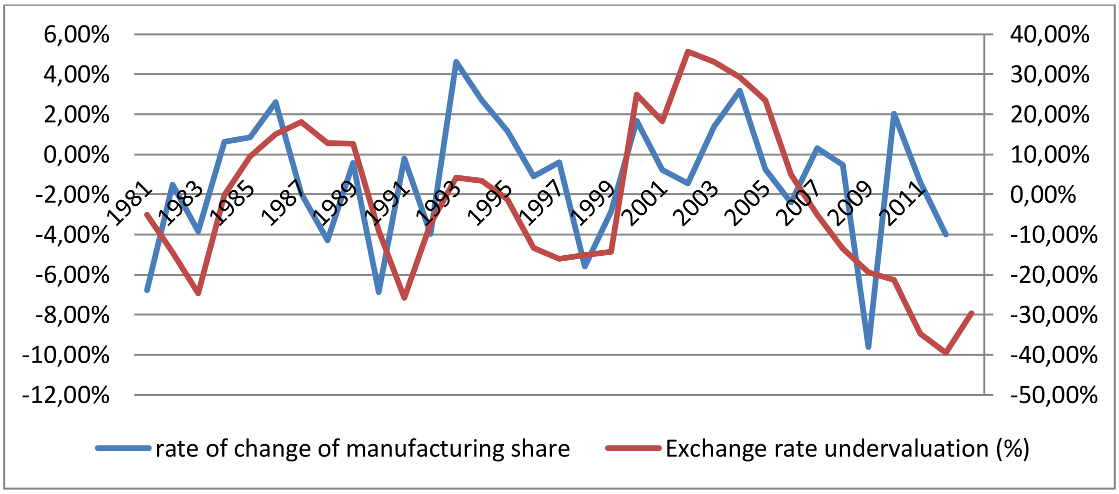
Thus, the growth rate of labor productivity in a developing economy depends on the rate of capital accumulation per worker, the level of exchange undervaluation - measured by the difference between the real exchange rate and the level of industrial equilibrium - and the technological gap.

Figure 4 below presents the relation between the rate of change in manufacturing share in GDP and the rate of exchange rate undervaluation for the Brazilian economy between 1981 and 2012. As predicted by the theory presented so far – see equation (13) – increases in manufacturing share in GDP

[7]If we do $h_t = h_{t-1}$ in equation (13), the following expression will be obtained: $\theta = \theta^i + (\beta_4/\beta_3)(G - 1)$, with G = 1 (assuming that the technological frontier does not move), we have $\theta = \theta^i$, so that the level of the share of manufacturing in GDP is constant.

are, in general, associated with an undervalued exchange rate, except for the period 1993-1996; and decreases in manufacturing share are associated with over-valued exchange rate.

Figure 4 – Rate of Change of Manufacturing Share in GDP and Exchange Rate Undervaluation (%) for Brazilian Economy (1981-2012)

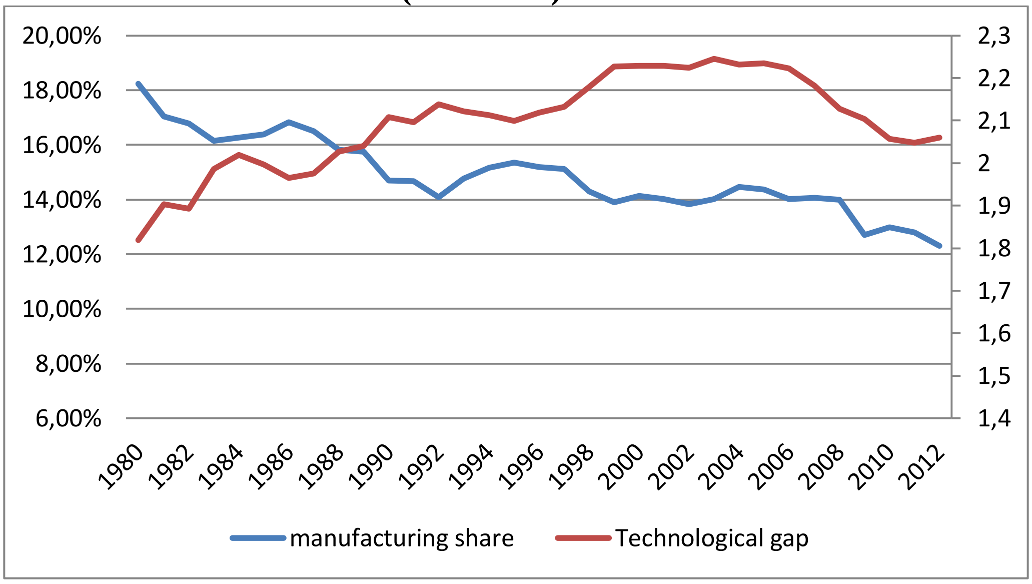


Source: IPEADATA and Marconi and Rocha (2012). Note: (a) Real exchange rate Undervaluation (%) is defined as the difference between the log of real exchange rate for year t *minus* the log of industrial equilibrium exchange rate; (b) Industrial equilibrium exchange rate is assumed to be equal to the average of real exchange rate for period 1980-2012.

Regarding the role of non-price competitiveness factors – proxied by technological gap – over the deindustrialization process of Brazilian economy, figure 5 shows that deindustrialization observed from 1980 on was followed by a huge increase in technological gap until 2004. The moderate acceleration of GDP growth after 2004 (see Table I) was responsible for a modest reduction of techonological gap until 2012.

Based on data for manufacturing share, rate of exchange rate undervaluation and technological gap we can infer that deindustrialization process of Brazilian economy from 1980 on was the combined result of the trend for exchange rate over-valuation and technological backwardeness of Brazilian manufacturing industry. Since techonological backwardeness is a key feature of all developing countries; deindustrialization could only be avoided by means of an undervalued exchange rate and/or controls over imports. The Import Substitution Industrialization (ISI) Development Model adopted in Brazil from 1930-1980 was heavily based on high import tariffs, export subsides and other types of import controls to induce industrialization of the economy. However, this development model was exhausted at the end of 1970´s due to the very low level of trade openness of Brazilian economy. A change for an export-led growth industrialization was required in the beginning of the 1980´s, which could only be implemented by means of an exchange rate policy designed to produce an undervalued real exchange rate. The concern with inflation stabilization, however, not only prevented the adoption of such a policy; but also make policy makers prone to use an exchange rate anchor in the beginning of the 1990´s in order to figh inflation. High inflation regime disappeared after 1995; but the result was a trend for exchange rate overvaluation that accelerated the deindustrialization process of Brazilian economy.

Figure 5 – Manufaturing Share in Output and Technological Gap of Brazilian Economy (1980-2012)



Source: IPEADATA. Notes: (a) Manufacturing share is measured on left axis and technological gap is measured on right axis; (b) Tecnnological gap is calculated as the log of the ratio between output per-worker in the United States and output per-worker in Brazil.

6. Dynamics of Capital Accumulation in Brazil (1980-2012)

There is a consensus among Brazilian economists that the high growth phase that Brazil experienced since the post-Second World War ended in the early 1980s, which was called "the lost decade". The collapse in the pace of economic growth persisted even after price stabilization in 1994. For the whole period 1980-2012, Brazilian economy showed an average growth of real GDP of 2.73% p.y, characterizing a semi-stagnation growth regime. In the period 1980-1994, previous to inflation stabilization done with "Plano Real", real GDP growth was only 2,32% p.y. After inflation stabilization, in the period 1995-2012, growth accelerated to 3,04%. The end of high inflation in Brazil was not followed by a return to high growth rates observed until the end of 1970´s.

Table I – Real GDP Growth of Brazilian Economy (1980-2012)

Period	Real GDP Growth
1980-1984	1,51%
1985-1989	4,26%
1990-1994	1,17%
1995-1999	2,01%
2000-2004	2,97%
2005-2009	3,52%
2010-2012	3,66%
1980-2012	**2,73%**

Source: IPEADATA. Authors´ own elaboration. GDP calculated at 2013 prices.

In section 3 we have seen that along a balanced growth path, real GDP and capital stock should grow at the same rate. These results are consistent with those of Bonelli and Bacha (2013) for the period 1947-2010. Thus, the pace of growth of the Brazilian economy seems to be determined by the pace of capital accumulation[8]. In this context we use equation (8) presented in section 3 to calculate the growth rate of the capital stock of the Brazilian economy in the period 1980-2012. The rate of investment at constant prices, f, was obtained using data on gross fixed capital formation and GDP at current prices, together with the variable "relative price of investment", obtained from the IPEADATA database. The relative price of the investment, ρ, was calculated as the ratio between the implicit capital goods deflator and the GDP deflator, both obtained on the IPEADATA basis. Capital productivity, σ, was calculated as the ratio between GDP and the capital stock of the economy split by the degree of utilization of productive capacity in order to separate the variations in the product-capital ratio that result from fluctuations in the level of economic activity from those arising from technical progress. In the construction of this variable for the period 1980-2007, we used the series calculated by Alvim et al. (2008); whereas for 2008-2012 the calculation was done using the method used by Bonelli and Bacha (2013), based on Morandi and Reis (2004). The depreciation rate of capital stock, δ, was assumed 3.9% per year based on Bonelli and Bacha (2013). The series of the utilization of productive capacity, u, was obtained from the FGV database. The evolution of the capital growth rate, the investment rate, the relative price of investment and the productivity of capital for 1980-2012 can be seen in Table II below:

Table II - Dynamics of Capital Accumulation in Brazil (1980-2012)[9]

Period	Growth Rate of Capital Stock	Investment Rate at Current Prices	Relative Price of the Investment	Capital Productivity
1980-1984	7.68%	21.26%	1.11	0.72
1985-1989	6.93%	22.93%	1.30	0.63
1990-1994	4.28%	20.35%	1.33	0.63
1995-1999	3.43%	17.19%	1.08	0.57
2000-2004	2.62%	17.04%	1.17	0.57
2005-2009	3.34%	17.81%	1.17	0.58
2010-2012	4.33%	19.13%	1.10	N.A
Δ % 1980-2012	**-43.53%**	**-10.42%**	**+1.53%**	**-19.93%**

Source: elaboration of the authors. Note: (*) $P_I I / P_Y Y$.

According to the data above, we can see the occurrence of a very strong reduction of the growth rate of capital stock in the Brazilian economy since the beginning of the 1990s. In the 1980s, capital stock grew at an average rate of 7.30% per year; in the 1990s the growth rate of the capital stock decreases to 3.85% per year; a reduction of 47.22% in the pace of capital accumulation. In the 2000s, the slowdown in the pace of capital accumulation continued, with the average growth rate of capital stock dropping to 2.98% per year, a reduction of 22.59% compared to the average recorded in the previous decade. Only in the period 2010-2012, the pace of capital accumulation accelerates again, increasing to 4.33% per year. The data in Table II also allow us to understand the most immediate reasons for the decline in the pace of capital accumulation. In the period 1980-2012 we saw a strong reduction of the investment rate accompanied by a very significant reduction of capital productivity. The relative price of investment remained stable in the period, with little influence on the path of capital accumulation. The investment rate fell from 22.09% per year in the period 1980-1989 to 18.77% per year in the period 1990-1999. The reduction of the investment rate continues in 2000-2009, when it reaches an average value of 17.81% per year.

[8] For an empirical analysis of this hypothesis for the Brazilian economy in the period 19802012, see Annex I.

[9] The degree of utilization of productive capacity increased by 9.53% in the accumulated period of the period 1980-2012, acting as an attenuating force of the movement to reduce the pace of capital accumulation in the Brazilian economy.

7. Empirical determinants of the Investment Share, Labor Productivity Growth and Share of the Manufacturing Industry

This section estimates the equations for investment share (equation 12), the rate of growth of labor productivity (equation 3) and the share of the manufacturing industry in output (equation 13). In order to estimate the determinants of the investment share in the Brazilian economy, we used 72 quarterly observations, beginning in the first quarter of 1995 to the fourth quarter of 2012, due to the lack of some data from 1980 to 1995. To estimate the determinants of the share of the manufacturing industry in output and of the rate of growth of labor productivity we used 33 annual observations from 1980 to 2012. Table III describes the set of variables used and the data source.

Table III - Variables and Data Sources

Variables used to calculate the Investment Rate at Current Prices			
	Comments	**Format**	**Source**
I/Y	Investment Share of GDP at current prices	%	IPEADATA, own elaboration
u	Level of capacity utilization of manufacturing industry - average.	%	FGV, Economic Review
θ	Effective Real Exchange Rate -INPC- imports - index (1995 T1=100), quarterly index calculated by the average of the component months.	Index	IPEADATA
R	Real interest rate of the economy, end of the last month of the considered quarter, calculated using the SELIC nominal interest rate and observed IPCA inflation rate.	%	Central Bank of Brazil, own elaboration
i	SELIC nominal interest rate, value of the last month of each quarter	%	Central Bank of Brazil
π	Inflation rate, IPCA, accumulated in 12 months, average value of the quarter	%	IBGE,own elaboration
θ/w	Exchange rate/wage ratio-index (average 2010= 100), average value of the quarter	Index	IPEADATA
λ	EMBI+ Brazil-Risk - quarterly average, constructed from daily observation of the quarter considered.	Points	JP Morgan, own elaboration
Variables to estimating the rate of growth of labor productivity			
y	Annual rate of growth of the output per worker, named rate of growth of labor productivity. Calculated using the GDP growth rate and the growth rate of the employed population. Calculations in log.	%	IPEADATA, Penn World Table and own elaboration
h	Share of value added in manufacturing industry in GDP.	%	IPEADATA, own elaboration
h_{t-1}	Share of the value added in manufacturing industry in GDP, lagged one period.	%	IPEADATA, own elaboration
k	Annual growth rate of capital stock per worker. Calculated using the capital stock growth rate and the growth rate of the employed population. Calculations in log.	%	IPEADATA, Penn World Table, own elaboration
Variables to estimation of the share of the manufacturing industry in product			
h	Share of value added in manufacturing industry in GDP.	%	IPEADATA, own elaboration
h_{t-1}	Share of value added in manufacturing industry in GDP, lagged one period.	%	IPEADATA, own elaboration
θ	Real Effective Exchange Rate - IPA-OG-IT-exports-manufactured-index (average 2010=100).The annual observation was calculated by month average .	Index	IPEADATA, own elaboration
θ^i	Industrial Equilibrium Real Exchange Rate, being calculated by the series of long-term trend of the real exchange rate, θ, estimated by the Hodrick-Prescott Filter.	Index	own elaboration
G_{t-1}	Technological gap lagged a period. Calculated using the ratio between the US per capita income log and the per capita income log of Brazil.	%	Central Bank of Brazil, own elaboration

Source: Elaboration of the authors.

We adopted some statistical and econometric procedures in order to specify the econometric models to be run, more specifically we calculated the (i) Correlation Matrix Analysis between variables; (ii) Stationary series test; (iii) Principal Components Analysis; (iv) Estimations of the parameters; (v) Diagnostic Tests on the coefficients, residuals and stability.

7.1. Multivariate Analysis - The Correlation Matrix

From the analysis of the correlation, we chose the candidate variables that have relevant correlation with the share of investment on output and/or with the share of the manufacturing industry in output and/or the rate of growth of labor productivity to compose the possible set of explanatory variables in each statistical model. The matrix of the coefficients of product-moment correlation of

Pearson, $Corr(X)$, between each of the random variables of the random vector $X' = [X_1 \quad X_2 \cdots X_n]$is the decomposition matrix of the covariance matrix, Σ , written as:

$$Corr(X) = \left(diag(\Sigma)\right)^{-\frac{1}{2}} \underbrace{\begin{bmatrix} COV(X_1, X_1) & \cdots & COV(X_1, X_n) \\ \vdots & \ddots & \vdots \\ COV(X_n, X_1) & \cdots & COV(X_n, X_n) \end{bmatrix}}_{\Sigma} \left(diag(\Sigma)\right)^{-\frac{1}{2}} = \begin{bmatrix} r_{x_1x_1} & \cdots & r_{x_1x_n} \\ \vdots & \ddots & \vdots \\ r_{x_nx_1} & \cdots & r_{x_nx_n} \end{bmatrix}$$

Where $\left(diag(\Sigma)\right)^{-\frac{1}{2}}$ is the triangular matrix of diagonal elements of Σ. The result shows the Pearson correlation coefficients, $r_{x_nx_n}$, between each variable and others at the same time. According to the Cauchy-Schwarz corollary, we adopted numerical criteria to differentiate the degree of correlation and linear dependence between variables (strong, moderate or weak), according to Table IV.

Table IV - Degree of correlation between variables

Correlation coefficient value	Grade Correlation	Candidate variables?
$0.7 \leq r_{xy} \leq 1$	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 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: Elaboration of the authors.

We chose to make three different correlation matrices: for the estimation of the share of investment on output; for the estimation of the share of the manufacturing industry in output and for the estimatation of the rate of growth of labor productivity. The results of the correlation between the variable share of investment and other candidate variables in level, first difference, Δ, in growth rate, %, and in lags, are shown in Table V. Likewise, in Table VI and VII, we present the correlation results for the rate of growth of labor productivity and the share of the manufacturing industry in output with the candidate variables to compose the specification of the equation. The p-value in up to 10% indicates significant correlations between variables.

Table V - Correlations between the share of investment on output with other possible variables to be included in the statistical model

Correlation	I/Y	p-value	Correlation	I/Y	p-value	Correlation	I/Y	p-value
$(\mathbf{I/Y})_{-1}$	0,66	0,00	$\boldsymbol{r}$	-0,39	0,00	$\boldsymbol{\theta}$	-0,66	0,00
$\%(\boldsymbol{I}/\mathbf{Y})$	0,42	0,00	$\boldsymbol{r}_{-1}$	-0,40	0,00	$\boldsymbol{\Delta\theta}$	0,02	0,89
$\boldsymbol{\Delta}(\mathbf{I/Y})$	0,41	0,00	$\boldsymbol{r}_{-2}$	-0,45	0,00	$\%\boldsymbol{\theta}$	-0,01	0,97
$\boldsymbol{u}$	0,35	0,00	$\%\boldsymbol{r}$	-0,08	0,51	$\boldsymbol{\theta}^2$	-0,62	0,00
$\boldsymbol{u}_{-1}$	0,44	0,00	$\boldsymbol{\Delta r}$	0,01	0,98	$\boldsymbol{\theta}^2_{-1}$	-0,63	0,00
$\boldsymbol{u}_{-2}$	0,24	0,14	$\boldsymbol{i}$	-0,52	0,00	$\boldsymbol{\Delta\theta}^2$	0,04	0,77
$\boldsymbol{\Delta u}$	-0,09	0,45	$\boldsymbol{i}_{-1}$	-0,54	0,00	$\%\boldsymbol{\theta}^2$	0,01	0,97
$\%\boldsymbol{u}$	-0,07	0,48	$\%\boldsymbol{i}$	0,08	0,51	$\boldsymbol{\theta}_{-1}$	-0,66	0,00
$\boldsymbol{\pi}$	-0,31	0,00	$\boldsymbol{\Delta i}$	0,04	0,77	$(\boldsymbol{\theta}/\mathbf{w})$	-0,70	0,00
$\boldsymbol{\pi}_{-1}$	-0,31	0,00	λ	-0,50	0,00	$(\boldsymbol{\theta}/\mathbf{w})_{-1}$	-0,72	0,00
$\%\boldsymbol{\pi}$	0,05	0,71	$\boldsymbol{\lambda}_{-1}$	-0,56	0,00	$\%(\boldsymbol{\theta}/\mathbf{w})$	0,09	0,47
$\boldsymbol{\Delta\pi}$	0,06	0,63	Δλ	0,12	0,34	$\boldsymbol{\Delta}(\boldsymbol{\theta}/\mathbf{w})$	0,12	0,36

Source: Elaboration of the authors.

According to Table V there is: (i) a moderate positive correlation between the share of investment on output, I/Y, and the share of investment on output with a lag, $(I/Y)_{-1}$, the growth rate of the share of investment on output, %(I/Y), the change in the share of investment on output Δ(I/Y), the degree of capacity utilization at a level and with a lag (u e u_{-1}); (ii) moderate negative correlation of the share of investment on output with the inflation rate, π, the nominal interest rate, i, the real interest rate, r, the real exchange rate, θ, the real rate exchange squared, θ^2, the measure of risk, λ, both level and with a lag; (iii) strong negative correlation of the share of investment on output with the real exchange rate ratio with respect to the wage level and with a lag, (θ/w)e$(\theta/\mathrm{w})_{-1}$; (iv) absence and/or there is no significant linear correlation between candidate variables in first differences and in growth rate, with the share of investment on output .

Table VI - Correlations between the share of the manufacturing industry in output with other possible variables to be included in the statistical model

Correlation	h	p-valor	Correlation	h	p-valor
h_{t-1}	0,93	0	$(\theta - \theta^i)$	-0,07	0,72
h_{t-2}	0,87	0	θ_{t-1}	0,53	0
θ	0,58	0	$(\theta - \theta^i)_{t-1}$	0,09	0,62
θ^i	0,84	0	$(G_{t-1} - 1)$	-0,57	0

Source: Elaboration of the authors.

According to Table VI, there is: (i) a strong positive correlation between the share of the manufacturing industry in output, itself (lagged in one and two periods), and the industrial equilibrium real exchange rate, which is not lagged; (ii) moderate negative correlation between the share of the manufacturing industry in output with the technological gap variable lagged one period minus one; (iii) a moderate positive correlation between the share of the manufacturing industry in output with the effective real exchange rate variable, not lagged and deferred over a period; (iv) absence and/or there is no significant linear correlation between the share of the manufacturing industry in output with the difference between the real effective exchange rate and the industrial equilibrium real exchange rate, without lag and with a lag;

Table VII - Correlations between the labor productivity growth rate and other possible variables to be included in the statistical model

Correlation	y	p-valor	Correlation	y	p-valor
y_{t-1}	0.01	0.94	k	0.35	0.047
h	-0.17	0.34	k_{t-1}	-0.48	0.00
Δh	0.72	0.00	k_{t-2}	-0.24	0.19

Source: Elaboration of the authors.

According to Table VII there is: (i) a strong positive correlation between the labor productivity growth rate and the change in the share of the manufacturing industry in output; (ii) moderate positive correlation between labor productivity growth rate and the growth rate of capital stock per worker; (iii) a moderate negative correlation between the labor productivity growth rate and the growth rate of capital stock per worker, which lags behind in a period; (iv) absence and/or there is no significant linear correlation between the rate of growth of labor productivity, itself lagged in one period, with the growth rate of capital stock per worker, lagged in two periods and with the share of manufacturing industry in output, it is not lagging behind. In order to compose the econometric model, in each function specification, variables that have, over the period considered, moderate or strong (positive or negative sign) correlation were chosen.

7.2–Estationary Test

The next step was to determine the order of integration of the candidate series to be stationary. Under null hypothesis, H_0, the time series tested has a unit root. The test used for this proposal was the Dickey-Fuller Aumentaded (ADF), proposed by Dickey-Fuller (1979,1981) and Said-Dickey (1984)[10]. The results of the ADF test, using the modified Schwarz criterion (MSIC), are shown in Table VII.

[10] The general equation of the ADF test is: $\Delta y_t = \alpha + \beta . t + \gamma . y_{t-1} + \sum_{i=1}^{p-1} \delta_i . \Delta_{t-i} + \varepsilon_i$. There is sensitivity to the presence of deterministic regressors, such as an intercept term, α, or a deterministic time trend, β. Strategically we elaborate stationarity tests, without trend and intercept, with trend and intercept and only intercept. We started the test with the variables in level and, being non-stationary in level, we performed the test in first differences. The tables containing the critical values can be found in Mackinnon (1991) and Fuller (1976).

Table VIII - Results of the Unitary Root Test, ADF

Function of the Investment share in output									
Variables	**Equation**	**Lags**	**T**	**1%**	**5%**	**10%**	**Prob.**	H_0	**Integration**
$(\mathbf{I/Y})$	I	4	-2.61	-3.53	-2.91	-2.59	0.09	R	I(0)
$(\mathbf{I/Y})_{-1}$	S T/I	5	-1.62	-2.60	-1.95	-1.61	0.10	R	I(0)
$\%(\mathbf{I/Y})$	S T/I	0	-12.72	-2.60	-1.95	-1.61	0	R	I(0)
$\Delta(\mathbf{I/Y})$	S T/I	0	-12.52	-2.60	-1.95	-1.61	0	R	I(0)
u	I/T	0	-4.51	-4.09	-3.47	-3.16	0	R	I(0)
u_{-1}	I/T	0	-4.49	-4.09	-3.47	-3.16	0	R	I(0)
$\%u$	S T/I	0	-10.68	-2.60	-1.95	-1.61	0	R	I(0)
θ	I	2	-1.43	-3.53	-2.91	-2.59	0.58	NR	I(1)
θ_{-1}	S T/I	2	-0.38	-2.60	-1.95	-1.61	0.54	NR	I(1)
$\Delta\theta$	S T/I	0	-6.83	-2.60	-1.95	-1.61	0	R	I(0)
$\%\theta$	S T/I	0	-7.03	-2.60	-1.95	-1.61	0	R	I(0)
θ^2	I	2	-1.43	-3.53	-2.91	-2.59	0.56	NR	I(1)
θ^2_{-1}	S T/I	2	-0.64	-2.60	-1.95	-1.61	0.44	NR	I(1)
$\Delta\theta^2$	S T/I	0	-6.61	-2.60	-1.95	-1.61	0	R	I(0)
$\%\theta^2$	S T/I	0	-7.03	-2.60	-1.95	-1.61	0	R	I(0)
π	T/I	0	-6.23	-4.09	-3.47	-3.16	0	R	I(0)
π_{-1}	T/I	0	-6.23	-4.09	-3.47	-3.16	0	R	I(0)
$\%\pi$	S T/I	0	-10.14	-4.09	-3.47	-3.16	0	R	I(0)
R	T/I	1	-5.79	-4.09	-3.47	-3.16	0	R	I(0)
R_{-1}	T/I	1	-4.03	-4.09	-3.47	-3.16	0	R	I(0)
$\%R$	S T/I	0	-9.33	-2.60	-1.95	-1.61	0	R	I(0)
i	T/I	0	-4.60	-4.09	-3.47	-3.16	0	R	I(0)
i_{-1}	T/I	0	-3.57	-4.09	-3.47	-3.16	0.04	R	I(0)
$\%i$	S T/I	0	-9.70	-2.60	-1.95	-1.61	0	R	I(0)
θ/w	T/I	4	-4.21	-4.09	-3.47	-3.16	0	R	I(0)
$(\theta/w)_{-1}$	T/I	4	-4.24	-4.09	-3.47	-3.16	0	R	I(0)
$\Delta(\theta/\mathbf{w})$	S T/I	0	-7.04	-2.60	-1.95	-1.61	0	R	I(0)
$\%(\theta/\mathbf{w})$	S T/I	1	-1.92	-2.60	-1.95	-1.61	0.04	R	I(0)
Λ	S T/I	0	-1.79	-2.60	-1.95	-1.61	0.07	R	I(0)
λ_{-1}	S T/I	0	-1.59	-2.60	-1.95	-1.61	0.09	R	I(0)
$\%\lambda$	S T/I	0	-6.85	-2.60	-1.95	-1.61	0	R	I(0)
Function of Manufactuing Share in GDP									
Variables	**Eq.**	**Lags**	**T**	**1%**	**5%**	**10%**	**Prob.**	H_0	**Integration**
h	S T/I	7	-2.37	-3.53	-2.91	-2.59	0.02	R	I(0)
h_{t-1}	S T/I	7	-2.21	-2.60	-1.95	-1.61	0.03	R	I(0)
h_{t-2}	S T/I	0	-12.72	-2.60	-1.95	-1.61	0	R	I(0)
θ	I	3	-2.60	-3.53	-2.91	-2.59	0.10	R	I(0)
θ^i	I	2	-2.69	-3.53	-2.91	-2.59	0.09	R	I(0)
θ_{t-1}	S T/I	10	-1.67	-2.60	-1.95	-1.61	0.09	R	I(0)
$\theta^i{}_{t-1}$	T/I	10	-0.89	-2.60	-1.95	-1.61	0.09	R	I(0)
$(\theta - \theta^i)$	S T/I	10 M	-3.44	-2.60	-1.95	-1.61	0	R	I(0)
$(\theta - \theta^i)_{t-1}$	S T/I	10	-3.29	-2.60	-1.95	-1,61	0	R	I(0)
$(G_{t-1} - 1)$	I/T	10	-3.51	-4.28	-3.56	-3,21	0,04	R	I(0)
Function of the growth rate of the output per worker									
Variables	**Eq.**	**Lags**	**T**	**1%**	**5%**	**10%**	**Prob.**	H_0	**Integration**
y	S T/I	8	-2.73	-2.60	-1.95	-1.61	0.00	R	I(0)
y_{t-1}	S T/I	8	-2.74	-2.60	-1.95	-1.61	0.00	R	I(0)
h	S T/I	7	-2.37	-3.53	-2.91	-2.59	0.02	R	I(0)
h_{t-1}	S T/I	7	-2.21	-2.60	-1.95	-1.61	0.03	R	I(0)
Δh	S T/I	7	-5.39	-2.60	-1.95	-1.61	0.03	R	I(0)
k	S T/I	6	-1.68	-2.60	-1.95	-1.61	0.09	R	I(0)
k_{t-1}	S T/I	6	-1.69	-2.60	-1.95	-1.61	0.09	R	I(0)
k_{t-2}	S T/I	7	-1.69	-2.60	-1.95	-1.61	0.09	R	I(0)

Source: Elaboration of the authors.

Note: NR=No Reject, R=Reject, H_0 = null hypothesis, I/T = Intercept and Trend, I=Intercept, SI/T= No Intercept and Trend

In the quarterly series, the null hypothesis of unit root (not stationary) for the variables (at level) real exchange rate and real exchange rate squared, at level and with a lag, with statistical significance of 1%. Differentiating these series once, or in growth rate, these series become stationary. The capacity utilization, investment share on output, inflation rate, real interest rate, nominal interest rate, exchange rate/wage ratio and sovereign risk measure, in the level, in the growth rate or with a lag are stationary, between 1 to 10% significance. In the annual series, either level, with a lag or differentiating, are stationary, between 1 to 10% of significance.

7.3– Principal Components Analysis

With the candidate variables defined in the correlation matrix and with the results of the stationarity test, in order to reduce the number of explanatory variables, we applied the principal component variance analysis method. The method shows the main variables that explain most of the original variability (variance) using a relatively small number of k components, among the total set of p components to describe the behavior of the dependent variable. The principal components of a set of variables are obtained by calculating the *eigenvalue* decomposition of the observed covariance matrix[11].

Above limit 1, the ordered eigenvalues[12] from largest to smallest identify candidate variables and that can be inserted into the model. Using the correlations, the summary of Principal Component Analysis ordered by *eigenvalues*, with the individual proportion explained and accumulated for the rate of investment on the product, the share of the manufacturing industry in the product, and the rate of productivity growth are presented in Annex 2, Tables IX, X and XI.

Of the fifty-eitgh candidate variables to explain the variance of the investment share on output, in first difference, in lagged and in growth rate, only ten of the variables have *eingenvalues* above 1. To explain the variance of the share of the manufacturing industry in output, of the nine candidate variables, in the level, difference and lagged, only four are with *eigenvalues* above one. And to explain the variance of rate of growth of labor productivity, of the seven candidate variables, in the level, difference and lagged, only three of the seven eingenvalues are above one.

Looking at Table X, of the total variance of the investment share we have that (i) 28.23% is explained by the investment share on output itself; (ii) 17.51% is explained by the share of investment on output, which lags behind in a period; (iii) 10.67% is explained by the degree of capacity utilization; (iv) 9.23% is explained by the degree of capacity utilization, lagged in one period; (v) 7% is explained by sovereign risk (Embi+); (vi) 5.45% is explained by sovereign risk, lagged in one period; (vii) 4.71% is explained by the exchange rate/wage ratio; (Viii) 3.69% is explained by the exchange rate/wage ratio, squared; (ix) 3.1% is explained by the real interest rate; (X) 1.85% is explained by the real interest rate, lagged in one period. Added to the proportions of the sample variance of each main component, we conclude that 10 components, explain 91.44% of the sample variance of the investment rate on the product.

Also, on the sample variance of the investment rate on the product we have: (i) 65.64% of the variation of (I/Y), is explained by variables originating from the statistical sample of the share of investment on output (45.74%), and the degree of capacity utilization (19.9%), both variables in level and with a lag; (ii) 12.45% is explained by the sovereign risk variable at the level (7%), and with a lag (5.45%); (iii) 8.40% is explained by the variable exchange rate/wage level (4.71%) and squared (3.10%) and (iv) 4.95% of the sample variance of the share of investment on output is explained by the variable real interest rate at level (4.71%) and lagged for a period (1.85%). Thus, from the correlation matrix, the stationarity test and the principal component analysis, it is suggested to reduce the number of components to explain the behavior of the share of investment on output. In particular, the variable share

[11] To mathematical details of the method, see Johnson-Wichern (2002, chapter 8).

[12] Autovalues or characterisc vector of the a linear transformation is a vector no null that no modify your direction when this linear transformation is applied, $T(\boldsymbol{v}) = \lambda.\boldsymbol{v}$. Where λ is the scalar, with name´s autovalues or *eingenvalue*, characterisc vector or characterisc root associatedin the autovector$\boldsymbol{v}$.

of investment on output, the degree of capacity utilization, the risk premium measure, the exchange rate/wage ratio and the real interest rate are the principal components to explain the variability of the share of investment on output.

Moreover, although it belongs to the set of non-disposable principal components, the exchange rate/wage relation and the real interest rate has a very small proportion (less than 5% per component) to explain the behavior of the share of investment on output.

Looking at Table XI, of the total variance of the share manufacturing industry in output we have that (i) 37.38% is explained by the own share of the manufacturing industry in output; (ii) 23.31% is explained by the share of the manufacturing industry in output, lagged over a period; (iii) 13% is explained by the technological gap lagged one period minus one; (iv) 11.56% is explained by the real exchange rate, lagged in one period; (v) 4.44% is explained by the industrial equilibrium real exchange rate. Added to the proportions of the sample variance of each principal component, it can be concluded that four components explain 90.11% of the share of the manufacturing industry in the output, *h*. From the correlation matrix, stationarity test and principal component analysis, it is suggested to reduce the number of components to explain the behavior of the manufacturing industry's share in output. The share of the manufacturing industry in output, the technological gap lagged a period less one and the real exchange rate, all lagged in a period are major components to explain the variability of the share of the manufacturing industry in output. In addition, although it belongs to the set of non-disposable main components, insert in the specification the industrial equilibrium exchange rate, θ^i or; The difference between the real exchange rate and the industrial equilibrium exchange rate, $(\theta - \theta^i)$; or the real exchange rate non-lagged, θ, has a very small proportion (less than 5% per component) to explain the behavior of the manufacturing share in output.

Looking at Table XI, of the labor productivity growth rate total variance, we have that (i) 39.63% is explained by the change in the share of the manufacturing industry in output; (ii) 20.82% is explained by the rate of growth of capital per worker, without lag; (iii) 14.82% is explained by the growth rate of capital per worker, which lags behind in one period. Added to the proportions of the sample variance of each principal component, we conclude that three components explain 75.27% of the rate of growth of labour productivity. Therefore, from the correlation matrix, the stationarity test and the principal components analysis, it is suggested to reduce the number of components to explain the behavior of the rate growth of the labor productivity, using only the variation of the share of the manufacturing industry and the rate of growth of the capital per worker, with or without lag, or a combination of both.

7.4 – The estimation of the investment equation, the rate of growth of labor productivity and the share of the manufacturing industry in output.

As a strategy, we used several combinations of candidate variables to estimate the role of investment rate on output, the rate of growth of output per worker and the share of manufacturing industry in output. In order to estimate the parameters of the functions, we used the method of Ordinary Least Squares (OLS), conjugated hybridly with Auto Regressive processes (AR), moving average (MA), Auto Regressive Average Moving Average (ARMA) (ARIMA) with maximum likelihood estimator for the residuals by the external product of the gradients (OPG) and the algorithm optimization by Berndt-Hall-Hall-Hausman (BHHH)[13].

Since lagged and non-lagged variables were combined to explain the behavior of the investment share, the share of the manufacturing industry in output, and the labor productivity growth rate, the roots of the polynomial characteristic were verified and the condition of invertibility of the ARMA process, as

[13] It is important to notice that in order to estimate the determinants of the investment share in the Brazilian economy, we used 72 quarterly observations, beginning in the first quarter of 1995 to the fourth quarter of 2012. To estimate the determinants of the share of the manufacturing industry in output and of the rate of growth of labor productivity we used 33 annual observations from 1980 to 2012. In this case, the VAR method and Impulse Response is not applied because the times series are diferents.

criterion of stability of the model. In addition, for the process to approximate the theoretical model of covariance-stationary (see Hamilton, chapter 3), we observe whether the variance of the residuals is constant over time, through the Breusch-Pagan-Godfrey heteroscedasticity tests (1979), Harvey (1976) and Glejser (1969). We also decided to elaborate the outliers test by the Grubbs criterion and, in this way, we set up a set of dummies variables, in certain quarters, in the case of the function of the investment share, and in certain years, in the case of the equation for the rate of growth of labor productivity and of the share of the manufacturing industry in output. From convergent iterations, with the dependent variables being the share of investment on output, the growth rate of output per worker and the share of the manufacturing industry in output, we find the following econometrically interesting functions:

$$\widehat{(I/Y)}_t = 0{,}669797.(I/Y)_{t-1} + 0{,}090142.u_t - 0{,}000151.(\theta/w)_{t-1} + 0{,}000000309.(\theta/w)_t^2 - 0{,}00000423.\lambda_{t-1} + 0{,}028596.\text{D94} - 0{,}497374.\varepsilon_{t-1} \quad (15)$$

$$\hat{y}_t = 5{,}1163.\Delta h + 0{,}545852.k_t + 0{,}4635.\varepsilon_{t-1} \quad (16)$$

$$\hat{h}_t = 0{,}86236.h_{t-1} + 0{,}000068.\theta_{t-1} - 0.08999(G_{t-1} - 1) + \varepsilon_t \quad (17)$$

The results of the estimated coefficients, the standard error, the Student statistic, the p-value, the coefficient of determination, the adjusted coefficient of determination and the Durbin-Watson statistic are found in Table XII for the share of investment on output; in Table XIII, for the rate of growth of output per worker and; in Table XIV, for the share of the manufacturing industry in output. The test of individual parameters with *, ** and *** are significant at 1%, 5% and 10% respectively.

Table XII – Estimated model for the share of investment on output

Variable	Coefficient	Standard error	t	Prob.	I.C. 95%		I.C.99%	
					Bottom	Upper	Bottom	Upper
$(I/Y)_{t-1}$	0.669797	0.074659	8.97	0.00*	0.521	0.819	0.471	0.868
u_t	0.090142	0.018548	4.86	0.00*	0.053	0.127	0.040	0.139
$(\theta/w)_{t-1}$	-0.000151	4.54E-05	-3.32	0.00*	-0.0002	-6.00E-05	-0.0002	-3.0E-05
$(\theta/w)_t^2$	3.09E-07	1.26E-07	2.45	0.02**	5.7E-08	5.60E-07	-2.5E-08	6.4E-07
λ_{t-1}	-4.23E-06	2.46E-06	-1.72	0.09***	-9.1E-06	6.85E-07	-1.1E-05	2.3E-06
D94	0.028596	0.007338	3.89	0.00*	0.014	0.043264	0.009	0.048
MA(1)	-0.497374	0.135106	-3.68	0.00*	-0.76	-0.227	-0.856	-0.138
SIGMASQ	6.22E-05	1.22E-05	5.095	0.00*	3.7E-05	8.66E-05	2.9E-05	9.4E-05

Source: Elaboration of the authors.

Notes: $R^2 = 0{,}69, \bar{R}^2 = 0{,}65$, Durbin-Watson: 1.99; Root of the inverted moving average equal to 0.497, statistic F=79.13; Prob (statistic F)= 0.00; I.C. is the confidence interval. Statistics based on a sample of 79 observations (70 adjusted observations).

Table XIII - Estimated model for Growth Rate of Output Per-Worker

Variable	Coefficient	Standard error	t	Prob.	I.C. 95%		I.C.99%	
					Bottom	Upper	Bottom	Upper
Δh	5.116300	0.548422	9.32	0.0000	3.9929	6.2397	3.6000	6.6317
k_t	0.545852	0.145753	3.75	0.0008*	0.2472	0.8444	0.1430	0.9486
MA(1)	0.463500	0.209954	2.21	0.0356**	0.0334	0.8935	-0.1166	1.04365
SIGMASQ	0.000295	8.31E-0.5	3.55	0.0014*	124.5E-5	465.1E-5	23.4E-5	172.7E-5

Source: Elaboration of the authors.

Notes: $R^2 = 0.71, \bar{R}^2 = 0.68$, Durbin-Watson: 1.77; Root of the inverted moving average equal to ±0.46i; I.C. is the confidence interval. Statistics based on a sample of 33 adjusted observations.

Table XIV– Estimated model of the Manufacturing Share

Variable	Coefficient	Standard error	t	Prob.	I.C. 95%		I.C.99%	
					Bottom	Upper	Bottom	Upper
h_{t-1}	0,86236	0.039289	21.90	0.00*	0.782003	0.942713	0.75406	0.97062
θ_{t-1}	6.80E-05	2.95E-05	2.30	0.029**	7.54E-06	0.000128	-1.35E-05	0.00012
$(G_{t-1}-1)$	-0.08999	0.041443	2.17	0.038**	-0.175235	-0.005225	-0.20523	0.02425

Source: Elaboration of the authors.

Notes: $R^2 = 0.89, \bar{R}^2 = 0.89$, Durbin-Watson: 2.07; F statistic =82.53; Prob (F-statistic) = 0.00; I.C. is the confidence interval. Statistics based on a sample of 32 adjusted observations.

Table XII shows that the empirical model of the investment share in output is well adjusted. The coefficients of the exchange rate/wage ratio, $(\theta/w)_{t-1}$, sovereign risk, λ_{t-1}, and the moving average process, MA(1), with a lag, have negative signals. The investment share with one lag, $(I/Y)_{t-1}$, the square of the exchange rate/wage ratio, $(\theta/w)_t^2$, the level of capacity utilization and the dummy variable 1999.Q4, said D94, showed positive signs. It should be noted that the sovereign risk and the exchange rate/wage presented coefficients close to zero, even though they are not insignificant main components and with moderate negative correlation (-0.56) and strong (-0.72) correlation.

Table XIII shows that the empirical model of labor productivity growth rate, y_t, is relatively well adjusted. The coefficients of the change in the manufacturing share in output, Δh, of the growth rate of capital per worker, k_t, and the moving average process, MA(1), with a lag, show positive signs. It is emphasized here that the correlation between Δh and $y_t$is 0.71, and between k_t and $y_t$is 0.35. Also, in the analysis of principal components, of the total variance of the growth rate of output per worker, 60.45% is explained by the sum of the variability of the change in the share of the manufacturing industry and the growth rate of capital per worker.

The Table XIV shows that the empirical model of the share of the manufacturing industry on the product is also relatively well adjusted. The coefficients of the share of the manufacturing industry on output, the real exchange rate and the technological gap minus one, all with a lag, h_{t-1}, θ_{t-1} and $(G_{t-1}-1)$, have the expected signs. It should be noted that the real exchange rate, θ_{t-1}, even though the main component is not negligible, explaining 11.56% of the total variance of the manufacturing industry share in output and even having a moderate positive correlation (0.53). With h_t, is presented, in the estimation, with coefficient very close to zero.

As for the stability of the functions, the inverse root of the polynomial of the MA process in the function investment share on output and in the function of the rate of growth of labor productivity, with values of 0.497 and ± 0.46i, in module, are presented within the unit circle (root outside the circle). Therefore, the coefficients of the lagged variables are not explosive, the MA process is invertible and the functions have desirable properties when lagged time series is used.

Turning to the analysis of the residues of the estimated functions, the Jarque-Bera test indicates the non-rejection of the normality hypothesis of the residues in all the estimated functions, since the calculated values and p-value of the residues of the functions $\widehat{(I/Y)}_t$, $\hat{y}_t$ e $\hat{h}_t$are the respective pairs (0.84; 0.65), (1.21; 0.54) and (1.47; 0.48). Finally, it is important to note the homoscedasticity of the residues. In order to do this, we developed the Breusch-Pagan-Godfrey tests (see Breusch-Pagan, 1979, and Godfrey, 1978), the Glejser test (1969) and the Harvey test (1976), both under null hypothesis of non-heteroscedasticity against Hypothesis of heteroscedasticity. The results show that in all the estimated functions the null hypothesis of non-heterocedasticiade is not rejected.

8. Final Remarks.

The purpose of this article was to analyze the causes of the deceleration of the growth of the Brazilian economy from the beginning of the 1980s on the basis of a Keynesian-Structuralist theoretical framework according to which the growth of labor productivity depends basically on structural change or productive sophistication (Transfer of labor and resources from activities with lower per-capita added value to activities with higher per-capita added value) and capital accumulation. In this context, we find that the pace of capital accumulation declined significantly since the late 1980s, and that this reduction was primarily caused by the reduction of the investment rate at current prices. In the sequence, a series of empirical procedures were presented to allow the estimation of the investment function, the technical progress function and the structural change function for the Brazilian economy. The investment function was estimated with quarterly data for the period 1995/Q1 to 2012/Q4. The technical progress and structural change functions were estimated with annual data for the period 1980-2012.

In order to make these estimates, a series of tests for the selection of explanatory variables was performed, namely: analysis of correlation matrix between variables, stationarity test and principal components analysis. In the estimation of the parameters of the functions, the hybrid method was used with time series processes Auto Regressive (AR) and/or moving average (MA) and/or Auto Regressive of Average Average (ARMA) and/or Integrated Auto-Regressive Average of Mobile (ARIMA).

Also, depending on the equation, dummy variables were selected. Diagnostic tests on the coefficients, on the residues and stability in the estimated functions were implemented. From the statistical point of view, the signs presented by the estimation of the parameters of the functions of the investment rate, the rate of growth of labor productivity and the share of the value added of the manufacturing industry on the product were the same as expected based on the theoretical reference employed, as well as the functions were validated by diagnostic tests on the coefficients, on the residues and stability of each function.

Estimates have shown that the rate of growth of labor productivity in Brazil depended on the dynamics of the share of manufacturing industry in GDP as well as the growth rate of capital stock per worker. The evolution of the share of manufacturing industry in GDP, in turn, depended on the level of the real exchange rate and negatively on the technological gap.

Finally, the estimation of the investment equation showed that the investment rate is a quadratic function of the exchange rate-wage ratio, positive of the degree of productive capacity utilization and negative of the country risk premium.

Based on the results of the econometric tests, one can conjecture that the deceleration of the growth of the Brazilian economy since 1980 was due to the combined effects of the reduction of the investment rate at current prices and the reduction of the share of the manufacturing industry in the GDP. The reduction in the investment rate is mainly due to the macroeconomic regime adopted since 1994 (and relaxed since 2006), which has restricted the expansion of aggregate demand, keeping the level of utilization of productive capacity at a low level (See Oreiro and D´Agostini, 2017). Another important factor was the external fragility of the Brazilian economy, which was expressed in two currency crises (1999 and 2002), which was responsible for maintaining the country risk premium at a high level, which had a negative impact on the investment rate. The appreciation of the real exchange rate observed since 1994 seems to have had a positive impact on the investment rate.

The negative effect of the appreciation of the real exchange rate on growth was due to the dynamics of the share of the manufacturing industry in GDP. Since 1980 there was a significant reduction in the share of manufacturing industry in GDP, which fell from 18.24% in 1980 to 12.3% in 2012. On the basis of the estimates made in this article, that (i) the reduction of the share of the manufacturing industry in the GDP has a strong negative impact on the labor productivity growth rate and (ii) the appreciation of the real exchange rate negatively affects, with a one-year lag, the share of manufacturing industry. Thus, the appreciation of the exchange rate, verified in Brazil mainly after 1994, had a negative net impact on the growth of the Brazilian economy.

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Annex I - Granger Causation Test for the Relationship between Capital Accumulation and GDP Growth (1980-2012)

Correlation does not necessarily imply causality among random variables. In macroeconomics there are variables with moderate or strong positive or negative correlations, but which are simply false or meaningless. The Granger (1969) approach to the question of whether x causes y refers to verifying how much of the current value of y can be explained by past values of this variable to then test whether the addition of lagged values of the variable x may improve the explanation. The variable y is said to be Granger caused by x, if x aids in the prediction of y, or equivalently, if the lagged coefficients of x are statistically significant. It is possible to test the two meanings of causality, that is, if x causes Granger in y and if y causes Granger in x. It should be noted that the statement "x Granger causes y" does not imply that y is the effect or the result of x. Granger's causality measures the content of precedence and information, but by itself does not indicate the causality in the most common use of the term. The Granger Causality test regresses the following equations for the pairs, (x, y):

$$y_t = \alpha_o + \sum_{i=1}^{l} \alpha_i . y_{t-l} + \sum_{i=1}^{l} \beta_i . x_{t-l} + \varepsilon_t$$

$$x_t = \alpha_o + \sum_{i=1}^{l} \alpha_i . y_{t-l} + \sum_{i=1}^{l} \beta_i . y_{t-l} + \varepsilon_t$$

The values of the Fischer-Snedecor continuous distribution are presented, the critical values being used to formalize the Wald test for the joint hypothesis on the coefficients β_i in each equation: $\beta_1 = \beta_2 = \cdots = \beta_l = 0$. The null hypothesis is that x does not cause Granger at y in the first regression and that y does not cause Granger at x in the second regression. The pairs results GDP growth rate, GRRATEGDP, and capital stock growth rate, G, with annual observations from 1980 to 2012 are in Table XIV.

Table XV-Granger Causality Test: relationship between capital accumulation and GDP growth (1980-2012)

Lag	null hypothesis	sample	F	Prob.
1	GRRATEGDP does not Granger Cause G does not Granger Cause GRRATEGDP	32	0.01394 6.59523	0.9068 0.0156
2	GRRATEGDP does not Granger Cause G G does not Granger Cause GRRATEGDP	31	0.79042 1.25924	0.4643 0.3006
3	GRRATEGDP does not Granger Cause G G does not Granger Cause GRRATEGDP	30	1.22627 0.87483	0.3228 0.4685
4	GRRATEGDP does not Granger Cause G G does not Granger Cause GRRATEGDP	29	1.83708 0.32662	0.1613 0.8568
5	GRRATEGDP does not Granger Cause G G does not Granger Cause GRRATEGDP	28	3.70987 0.83637	0.0188 0.5419

Source:Elaboration of the authors.

For a lag, we can not reject the null hypothesis that the GDP growth rate does not cause Granger in the capital stock growth rate, but we can reject the null hypothesis that the capital stock growth rate does not cause Granger to Rate of GDP growth. Therefore, in the one-off test, Granger's causality provides the unidirectional result of the capital stock growth rate for the GDP growth rate, not the other way round, from GDP to the stock growth rate of capital. For 2, 3 and 4 lags, we can reject both the null hypothesis that the growth rate of GDP does not cause Granger the growth rate of the capital stock; But we can also reject the null hypothesis that the growth rate of capital stock does not cause Granger to GDP growth rate. For 5 lags, we can not reject the null hypothesis that the growth rate of the capital stock does not cause the GDP growth rate but we can reject the null hypothesis that in the GDP growth rate Granger does not cause the rate of growth. Growth of capital stock. Therefore, for the 5-lagged model, Granger's causality occurs unidirectionally from the GDP growth rate to the capital stock growth rate, not the other way round.

Annex II - Principal Component Analysis

Table IX - Pricipal components of the investment rate on the product

Importance	Variable	Eingenvalues	Difference	Individual Proportion	Value Accumulated	Proportion Accumulated
1	(Y/I)	16.37	6.22	28.23%	16.37	28.23%
2	$(Y/I)_{-1}$	10.16	3.97	17.51%	26.53	45.74%
3	u	6.19	0.84	10.67%	32.72	56.41%
4	u_{-1}	5.35	1.29	9.23%	38.07	65.64%
5	Λ	4.06	0.90	7.00%	42.13	72.64%
6	λ_{-1}	3.16	0.43	5.45%	45.29	78.09%
7	θ/w	2.73	0.59	4.71%	48.02	82.80%
8	$(\theta/w)^2$	2.14	0.34	3.69%	50.16	86.49%
9	r	1.80	0.72	3.10%	51.96	89.58%
10	r_{-1}	1.08	0.10	1.85%	53.03	91.44%
11	Θ	0.98	0.18	1.68%	54.01	93.12%
12	$(\theta)^2$	0.79	0.06	1.36%	54.80	94.48%
13	θ_{-1}	0.73	0.21	1.27%	55.54	95.75%
14	$(\theta)^2{}_{-1}$	0.52	0.14	0.90%	56.06	96.65%
15	i_f	0.38	0.02	0.65%	56.44	97.30%
16	π_m	0.36	0.10	0.61%	56.79	97.92%
17	π_f	0.25	0.04	0.44%	57.05	98.36%
18	i_m	0.21	0.05	0.36%	57.26	98.72%
19	i_{f-1}	0.16	0.03	0.27%	57.41	98.99%
20	i_{m-1}	0.13	0.02	0.22%	57.54	99.21%
21	θ/w	0.11	0.03	0.18%	57.65	99.39%
22	$(\theta/w)_{f-1}$	0.08	0.01	0.14%	57.73	99.53%
23	π_{f-1}	0.07	0.02	0.13%	57.80	99.66%
24	π_{m-1}	0.05	0.02	0.09%	57.86	99.75%
25	$(\theta/w)_{m-1}$	0.04	0.01	0.06%	57.89	99.82%
26	$\Delta\theta$	0.03	0.00	0.05%	57.92	99.86%
27	$\Delta(\theta)^2$	0.03	0.01	0.04%	57.95	99.91%
28	Δi_f	0.01	0.00	0.02%	57.96	99.93%
29	Δi_m	0.01	0.00	0.02%	57.97	99.95%
30	$\%u$	0.01	0.00	0.02%	57.98	99.97%
31	$\%(\theta)^2$	0.00	0.00	0.01%	57.99	99.98%
32	$\%\theta$	0.00	0.00	0.01%	57.99	99.98%

33	$\%i_m$	0.00	0.00	0.01%	57.99	99.99%
34	$\%i_f$	0.00	0.00	0.00%	58.00	99.99%
35	$\%r$	0.00	0.00	0.00%	58.00	99.99%
36	$\%(\theta/w)_m$	0.00	0.00	0.00%	58.00	100.00%
37	$\%(Y/I)$	0.00	0.00	0.00%	58.00	100.00%
38	$\%\pi_m$	0.00	0.00	0.00%	58.00	100.00%
39	$\%\pi_f$	0.00	0.00	0.00%	58.00	100.00%
40	$\%(\theta/w)_f$	0.00	0.00	0.00%	58.00	100.00%
41	$\%\lambda$	0.00	0.00	0.00%	58.00	100.00%
42	$\%r$	0.00	0.00	0.00%	58.00	100.00%
43	$\%r(Y/I)$	0.00	0.00	0.00%	58.00	100.00%
44	$\Delta\pi_m$	0.00	0.00	0.00%	58.00	100.00%
45	$\Delta\pi_f$	0.00	0.00	0.00%	58.00	100.00%
46	$\Delta(\theta/w)_f$	0.00	0.00	0.00%	58.00	100.00%
47	$\Delta\ \lambda$	0.00	0.00	0.00%	58.00	100.00%
48	$\Delta(\theta/w)_m$	0.00	0.00	0.00%	58.00	100.00%
49	Δr	0.00	0.00	0.00%	58.00	100.00%
50	Δr_m	0.00	0.00	0.00%	58.00	100.00%
51	Δu	0.00	0.00	0.00%	58.00	100.00%
52	r_{-2}	0.00	0.00	0.01%	58.00	100.00%
53	r_m	0.00	0.00	0.02%	58.00	100.00%
54	θ_{-2}	0.00	0.00	0.03%	58.00	100.00%
55	$(\theta)^2{}_{-2}$	0.00	0.00	0.04%	58.00	100.00%
56	u_{-2}	0.00	0.00	0.05%	58.00	100.00%
57	r_{m-2}	0.00	0.00	0.06%	58.00	100.00%
58	r_{m-1}	0.00	---	0.07%	58.00	100.00%

Source: Elaboration of the authors.
Legend: Principal Components; do not discard or disposable frontier and disposable.

Table X- Principal components of the share of manufacturing industry in output

Importance	Variable	Eingenvalues	Difference	Individual Proportion	Value Accumulated	Proportion Accumulated
1	$\boldsymbol{h}$	3.4	1.3	37.78%	3.4	37.78%
2	$\boldsymbol{h_{t-1}}$	2.1	0.93	23.33%	5.5	61.11%
3	$\boldsymbol{(G_{t-1}-1)}$	1.17	0.13	13.00%	6.67	74.11%
4	$\boldsymbol{\theta_{t-1}}$	1.04	0.64	11.56%	7.71	85.67%
5	$\boldsymbol{\theta^i}$	0.4	0.1	4.44%	8.11	90.11%
6	$\boldsymbol{(\theta-\theta^i)}$	0.3	0	3.33%	8.41	93.44%
7	$\boldsymbol{\theta}$	0.3	0.1	3.33%	8.71	96.78%
8	$\boldsymbol{\theta^i{}_{t-1}}$	0.2	0.11	2.22%	8.91	99.00%
9	$\boldsymbol{h_{t-2}}$	0.09	---	1.00%	9	100.00%

Source: Elaboration of the authors.
Legend: Principal Components; do not discard or disposable frontier and disposable.

Table XI –Principal components of the growth rate of labor productivity

Importance	Variable	Eingenvalues	Difference	Individual Proportion	Value Accumulated	Proportion Accumulated
1	Δh	2.77	1.32	39.63%	2.77	39.63%
2	k	1.46	0.42	20.82%	4.23	60.45%
3	k_{t-1}	1.03	0.31	14.82%	5.27	75.27%
4	k_{t-2}	0.73	0.06	10.36%	5.99	85.63%
5	y_{t-1}	0.66	0.32	9.47%	6.66	95.10%
6	h	0.34	0.34	4.90%	6.99	100%
7	h_{t-1}	-4.17E-16	---	0.00	7.00	100%

Source: Elaboration of the authors.

Legend: ● Principal Components; ● do not discard or disposable frontier and ● disposable.

Annex IV – Data Base

Year	Manufacturing share	GDP (R$ Million)	Employed Population	GDP per worker	Growth rate of GDP per worker
1980	18,24%	2135978,99	49,7253685	42955,52	
1981	17,04%	2045199,88	51,78702927	39492,51	-8,41%
1982	16,79%	2062175,04	54,56090927	37795,83	-4,39%
1983	16,16%	2001753,31	55,19734955	36265,39	-4,13%
1984	16,26%	2109847,99	57,27428818	36837,61	1,57%
1985	16,40%	2275471,06	61,61935043	36927,87	0,24%
1986	16,83%	2445903,84	63,34943771	38609,72	4,45%
1987	16,50%	2532244,25	65,58335114	38611,08	0,00%
1988	15,81%	2530724,90	67,79129791	37331,12	-3,37%
1989	15,75%	2610695,81	69,13825226	37760,51	1,14%
1990	14,70%	2497130,54	70,86920166	35235,77	-6,92%
1991	14,67%	2522888,05	71,02437592	35521,44	0,81%
1992	14,10%	2511108,31	71,04246521	35346,58	-0,49%
1993	14,76%	2628255,30	71,61356354	36700,52	3,76%
1994	15,17%	2768455,90	72,31313324	38284,28	4,22%
1995	15,35%	2890733,94	73,06744385	39562,54	3,28%
1996	15,18%	2952899,14	71,55144501	41269,59	4,22%
1997	15,12%	3052568,29	72,7330246	41969,49	1,68%
1998	14,30%	3053647,24	72,40484619	42174,63	0,49%
1999	13,90%	3061405,90	76,33848572	40103,05	-5,04%
2000	14,13%	3193235,75	78,7113266	40568,95	1,16%
2001	14,02%	3235166,73	79,342659	40774,62	0,51%
2002	13,82%	3321160,51	82,50563812	40253,74	-1,29%
2003	14,02%	3359241,59	84,00519562	39988,50	-0,66%
2004	14,47%	3551131,29	88,31071472	40211,78	0,56%
2005	14,36%	3663335,45	91,03479767	40241,05	0,07%
2006	14,02%	3808294,92	93,41861725	40765,91	1,30%
2007	14,07%	4040273,80	94,89915466	42574,39	4,34%
2008	14,00%	4249220,50	96,41851044	44070,59	3,45%
2009	12,71%	4235209,66	96,8421402	43733,13	-0,77%
2010	12,98%	4554277,15	100,7918243	45184,99	3,27%
2011	12,80%	4678736,67	102,8767319	45479,06	0,65%
2012	12,30%	4726976,10	105,1605453	44950,09	-1,17%

Source: IPEADATA and Marconi and Rocha (2012).

Year	Real Exchange Rate	Real Exchange Rate (1980=100)	Underval(%)	Tech. Gap
1980	134,5639	100	-0,05	1,0621
1981	122,4726	91,01	-0,14	1,0712
1982	110,5481	82,15	-0,25	1,0699
1983	141,2364	104,96	0,00	1,0795
1984	155,4569	115,53	0,09	1,0824
1985	164,4800	122,23	0,15	1,0797
1986	169,4859	125,95	0,18	1,0765
1987	160,8254	119,52	0,13	1,0774
1988	160,5518	119,31	0,13	1,0828
1989	129,1237	95,96	-0,09	1,0840
1990	109,3558	81,27	-0,26	1,0919
1991	131,5231	97,74	-0,07	1,0915
1992	147,6436	109,72	0,04	1,0965
1993	146,3206	108,74	0,03	1,0946
1994	139,7429	103,85	-0,01	1,0928
1995	123,6836	91,91	-0,13	1,0917
1996	120,4525	89,51	-0,16	1,0936
1997	121,5865	90,36	-0,15	1,0948
1998	122,5526	91,07	-0,14	1,0993
1999	181,4274	134,83	0,25	1,1039
2000	169,8697	126,24	0,18	1,1037
2001	201,9648	150,09	0,36	1,1039
2002	197,0135	146,41	0,33	1,1029
2003	189,6675	140,95	0,29	1,1051
2004	178,9301	132,97	0,23	1,1033
2005	148,6291	110,45	0,05	1,1037
2006	134,4009	99,88	-0,05	1,1024
2007	123,5357	91,80	-0,14	1,0979
2008	116,5039	86,58	-0,19	1,0924
2009	114,2551	84,91	-0,21	1,0900
2010	100,0000	74,31	-0,35	1,0847
2011	95,2089	70,75	-0,40	1,0824
2012	105,2221	78,19	-0,30	1,0829

Source: IPEADATA and Marconi and Rocha (2012).