

1st draft: March 28, 2010

Paper to be presented at the Fourth Annual Conference on Development and Change,
Johannesburg, South Africa, April 9-11, 2010

Real Exchange Rate, Capital Accumulation and Growth in Brazil

Nelson Barbosa, Julio Silva, Fabio Goto and Bruno Silva *

Abstract: The impact of the real exchange rate on growth is a controversial topic in developing countries. Depending on the initial conditions and the structural features of the economy under analysis, income growth can either accelerate or decelerate immediately after changes in the real exchange rate. A structuralist theoretical model and the evidence from Brazil (1996-2009) suggest that there exists an optimal-exchange rate level that maximizes growth. If there is also a positive relationship between real exchange rate and inflation, the optimal exchange rate for economic growth might not be compatible with the inflation target desired by the population. The main implication of the results presented in this paper is a defense of moderate exchange-rate fluctuation. This can be achieved through a policy of floating exchange rates in which the government has no compromise with a fixed value of the nominal or the real exchange rate, but it intervenes in the foreign exchange market to avoid an excessive volatility of the real exchange rate.

Keywords: real exchange rate, economic growth, Brazil

JEL code: F41, F43, O54

* Nelson Barbosa is Professor of Macroeconomics at the Federal University of Rio de Janeiro and currently Secretary of Economic Policy at the Brazilian Ministry of Finance. Julio Silva is an analyst at the Central Bank of Brazil and currently Sub-Secretary of Macroeconomic Policy at the Brazilian Ministry of Finance. Fabio Goto and Bruno Rocha are members of the Research Division of the Secretariat of Economic Policy at the Brazilian Ministry of Finance. The views expressed in this work are those of the authors and do not necessarily reflect those of the Brazilian Ministry of Finance. The authors can be contacted through the following e-mail addresses: nhbarbosa@gmail.com or julio.silva@fazenda.gov.br.

The impact of the real exchange rate on growth is a controversial topic in developing countries. On the one hand an appreciation of the domestic currency tends to increase the purchasing power of domestic agents and, in this way, increase domestic absorption and growth in the short run. On the other hand an appreciated currency also has a negative impact on net exports, which pulls income growth down in the short run. The balance between these two effects is not known *a priori*. Depending on the initial conditions and the structural features of the economy under analysis, income growth can either accelerate or decelerate immediately after changes in the real exchange rate. When we look at recent economic history of Latin American, the evidence usually points to a negative impact of depreciation on growth in the short run.¹ The opposite happens after appreciations, which explains the political bias of elected governments to tolerate appreciations and fight depreciations.

When we move to the long run the picture is not so clear because the demand impacts of appreciation and depreciation ceases after the real exchange rate accommodates at a new level. Since in the long run the real exchange rate tends to stabilize, the important question becomes: what is the impact of the level of the real exchange rate on growth? Economic theory does not provide a unique answer to this question. From a purely mainstream growth-accounting perspective, the long-run impact of the real exchange rate on growth depends on how it affects total factor productivity and the investment ratio. From the heterodox perspective of the balance-of-payments constraint on growth, the long-run impact depends on how the income elasticity of exports and imports responds to the level of the real exchange rate. In other heterodox models the real exchange rate can also have a permanent impact on growth through its influence on labor-productivity growth and capital accumulation.

A common feature of heterodox models is the existence of multiple equilibria, that is, the possibility that the real exchange rate and growth can stabilize at more than one equilibrium point. For instance, for the same economy there can be a steady state in which growth is slow and the real exchange rate is low and another steady state in which growth is fast and the real exchange rate is high. In such a situation economic policy can move the economy from a slow-growth to a fast-growth equilibrium or vice versa. The choice of which equilibrium depends not only on the growth rate associated with each steady state, but also on other constraints on economic policy. Growth maximization is a strong candidate to guide economic policy, but this is usually an issue to be considered together with the stability of inflation and the sustainability of the balance-of-payments.

With the above view in mind, the objective of this paper is to analyze the impact of the real exchange rate on growth in Brazil since the mid-1990s. The analysis is organized in three sections in addition to this introduction. The first section presents a theoretical model in which the level of the real exchange rate can alter the growth rate of the economy in the long-run. The second section applies the ideas of section one to Brazil. The analysis consists of a series of univariate models in which the dynamics of economic growth are expressed as an error-correction process, and where the long-run value of economic growth is defined as a polynomial of the level of the exchange rate. To complete the analysis, the final section discusses the implications of the results presented in section two for economic policy in Brazil.

1 – Theoretical model

The real exchange rate is a key determinant of economic growth in heterodox models of open economies. The transmission mechanisms vary according to each heterodox

¹ We define the exchange rate as the domestic price of foreign currency, so that depreciation means an increase in the exchange rate.

approach, but we can organize the main models in three groups. First, in models of the balance-of-payments constraint, changes in the real exchange rate have a short-run effect on growth through the price elasticity of exports and imports, whereas the level of the exchange rate may have a long-run effect on growth through its impact on the income elasticity of exports and imports.² Second, in models based on Lewis's dual-economy hypothesis and the Kaldor-Verdoorn laws of productivity growth, the real exchange rate has a short and long-run influence on labor productivity growth through its impact on the allocation of labor between the "advanced" tradable and the "backward" non-tradable sectors of the economy, as well as through the increasing returns in the advanced sector.³ Third, in models that emphasize the conflicting claims on income under a capital constraint, the real exchange is one of the main determinants of income distribution, which in its turn is one of the main determinants of the level of economic activity and the pace of capital accumulation.⁴ These three approaches are not mutually exclusive and can be combined in just one model at the cost of growing complexity. For the applied purpose of this paper we will restrict our analysis to a structuralist model of the conflicting-claims and capital-constraint hypotheses.

The objective of our model is to analyze how the real exchange rate impact on three variables: the functional distribution of income, the rate of capacity utilization and the growth rate of the economy.⁵ Income distribution will be represented by the profit share of income and the rate of capacity utilization will be represented by the income-capital ratio. According to the conflicting-claims hypothesis the real wage tends to grow at the same rate as labor productivity in the long run, but the specific value of profit share at which this happens depends on the level of economic activity and on the other variables that influence the bargaining power of each social group in the distribution of income. In the same vein, according to the capital-constraint hypothesis income and capital tend to growth at the same rate in the long-run, but the specific value of the growth rate at which this happens depends on the investment-GDP ratio, capacity utilization and the rate of capital depreciation. Since both the investment-GDP ratio and the income-capital ratio depend on the real exchange rate, the long-run growth rate of the economy can be modeled as a function of the real exchange rate.

The profit-share of income

The first step of our analysis is to model income distribution. To do this assume that, given the rate of capacity utilization, an increase in the real exchange rate moves the profit share of income up because the prices of both tradable and non-tradable goods rise in relation to the real wage and this is not accompanied by a proportional fall in labor productivity. The basic idea here is that the price of the tradable good is a positive function of the domestic price of imports, whereas the price of the non-tradable product is determined through a markup rule over the total cost of production. In this situation it can be shown that, given the wage rates and the coefficients of production, the markup in the tradable sector and the price of the non-tradable good become a function of the real exchange rate. More important, an increase in the real exchange rate reduces the real wages in both sectors so that, given the labor productivity, the profit share of income goes up.

² For the literature on the Balance-of-Payments constraint, see McCombie and Thirlwall (1994 and 2004). For the case in which the income elasticities change, see Barbosa (2010a and 2010b).

³ For the literature and applied work on Kaldor-Verdoorn laws, see McCombie et al (2003). A recent version of the dual-economy model has been proposed by Rada (2007). The relationship between this approach and other determinants of economic growth can be found in Ocampo et al (2009).

⁴ The main references on the non-mainstream approach to growth and distribution are: Marglin (1984), Dutt (1990), Taylor (1991 and 2004), and Foley and Michl (1999).

⁵ The model presented in this section is based on Barbosa (2010c).

Now assume that the real exchange rate is constant and consider the relationship between capacity utilization and income distribution. Depending on the initial conditions an increase in the income-capital ratio can either raise or lower the real wage in terms of labor productivity. If the economy is at a low level of capacity utilization, an increase in the income-capital ratio is likely to be accompanied by an increase in the profit share because labor productivity grows temporarily faster than wages. In contrast, if the economy is at a high level of economic activity, an additional increase in the rate of capacity utilization tends to reduce the profit share of income because the real wage grows temporarily faster than labor productivity. The whole process is based on Marx's reserve-army assumption, that is, the bargaining power of workers is low at a low rate of capacity utilization and high when the opposite happens.⁶

In mathematical terms the two assumptions outlined above can be represented by defining the profit share as a linear function of the real exchange rate and a quadratic function of capacity utilization, that is:

$$\pi = \pi_0 + \pi_1 \varepsilon + \pi_2 u + \pi_3 u^2, \quad (1)$$

where π represents the profit share of income, ε the real exchange rate, and u the ratio of income to private capital.⁷ According to the assumptions presented above $\pi_1 > 0$ and $\pi_3 < 0$, so that according to the partial derivatives the profit share of income is a positive function of the real exchange rate and a concave-down function of the level of economic activity.

In economic terms equation (1) means that there is one income-capital ratio that maximizes the profit share of income for a given value of the real exchange rate. If the economy is below such a point, an increase in the level of economic activity increases labor productivity more than the real wage, which in its turns shifts the functional distribution of income in favor of profits. By analogy, the opposite happens if the economy is above the income-capital ratio that maximizes the profit share of income, as shown in figure 1.1 below.⁸

FIGURE 1.1

The rate of profit

The next step of our model is to define the rate of profit in terms of the level of economic activity. By definition the rate of profit on fixed capital can be defined as

$$r = \pi u = (\pi_0 + \pi_1 \varepsilon + \pi_2 u + \pi_3 u^2)u. \quad (2)$$

In words, the rate of profit is also a function of the real exchange rate and the income-capital ratio. Since the profit share was specified as a quadratic function of the level of economic activity, the rate of profit becomes a cubic function of the same variable. In economic terms this means that the response of the rate of profit to changes in capacity utilization depends on the initial conditions, that is, r can go up or down in face of change in u . To illustrate this figure 1.2 shows the graphic representation of (2) for a given real exchange rate. It should be noted that the rate of profit is zero either when the income-capital ratio is zero or when the profit share of income is zero, that is, the two non-zero roots of the equation $\pi = 0$ are the same

⁶ The dynamics of income distribution and economic activity can also be modeled as a predator-prey system, in which the wage share of income "chases" capacity utilization (Barbosa and Taylor, 2006). For the purpose of this paper we will concentrate the analysis on the steady state positions.

⁷ We define u in terms of private capital because we will introduce the government sector later into the model.

⁸ In the jargon of structuralist macroeconomics, the economy is said to be "Kaldorian" when an increase in the income-capital ratio raises the profit share, and "Marxian" when the opposite happens.

non-zero roots of the equation $r = 0$. It should also be noted that the concave-up segment of (2) tends to happen at a very low rate of capacity utilization. In economic terms this means that the rate of profit can be described as a concave-down function of the income-capital ratio for the relevant interval in which the economy operates.

FIGURE 1.2

The rate of capacity utilization

The third step of our model is to determine the income-capital ratio. To do this assume that the rate of profit on fixed capital is given from economic policy, that is, the rate of profit required by investors is a function of the real interest rate set by monetary policy. The basic idea here is that the real rate of return on public bonds functions as a low-risk reference for the rate of profit on private fixed capital. To keep the model as simple as possible, let us represent this assumption idea simply as

$$r = r_L + \sigma, \quad (3)$$

where r_L is the low-risk rate of return on public bonds and σ is the risk-premium wanted by investors to hold fixed capital. For simplicity we will assume that these two variables are constant in the rest of this section.⁹

The income-capital ratio consistent with the required rate of profit can be obtained by substituting (3) in (2). The resulting function is a third-degree polynomial of the income-capital ratio in which we have three possible mathematical solutions.¹⁰ However, when we move back to economics we have only two possible solutions because the lowest root of $r = r_f + \sigma$ is a negative income-capital ratio. Figure 1.3 shows the economically reasonable solutions consistent with the required rate of profit. The existence of two solutions means that, at least in theory, the same rate of profit can be obtained at a low or at a high rate of capacity utilization.

FIGURE 1.3

The remaining question is to define the value of the income-capital ratio to which the economy converges. In this issue it is reasonable to assume that the growth rate of investment accelerates when the effective rate of profit is higher than the required rate of profit. The logic comes from Keynes's General Theory, according to which the asset demand for fixed capital rises when its corresponding real rate of return is high in relation to other assets. Since an increase in investment usually raises income faster than it raises capital, the income-capital ratio tends to move up when the effective rate of profit is higher than the required rate of profit. In the terms of figure 1.3 this means that the first equilibrium point is unstable, whereas the second equilibrium point is stable. Based on this result and assuming that the income-capital ratio never falls below its unstable steady state, we will assume that the long-run equilibrium between the growth rate of income and capital occurs at the higher level of economic activity shown in figure 1.3.

Effects of a change in the real exchange rate

⁹ Both variables can be modeled as a function of the rate of inflation, as shown in Barbosa (2010c).

¹⁰ In mathematical terms we can have just one solution in the set of real numbers. We assume three solutions in real numbers because the required rate of profit is a policy variable. If the central bank set r too high, the result is an economic depression that makes the central bank change its decision.

To link the income-capital ratio to the real exchange rate, note that the roots of $r = r_f + \sigma$ are functions of ε . The specific algebraic solutions can be obtained by factoring the third-degree polynomial, but the direction of change can be understood directly from the analysis of figures (1.1) and (1.2). First, an increase in the real exchange rate moves the quadratic function in (1.2) up, since for the same level of income-capital ratio we obtain a higher profit share. Second, since the rate of profit is zero when the profit share of income is zero, the increase in the real exchange rate widens the difference between the roots of second-degree polynomial $\pi = 0$, which in its turn widens the difference between the non-zero roots of the third-degree polynomial $r = 0$. The result is a counter-clockwise rotation of the effective rate of profit in figure 1.3, so that the stable long-run value of the income capital ratio goes up, as shown in figure 1.4.

FIGURE 1.4

Given a change in the real exchange rate, the adjustment of the rate of profit is usually faster than the adjustment of the income-capital ratio. In terms of our model this means that process shown in figure 1.4 can be described in two sequential moves. First, an increase in the real exchange rate pushes the profit share of income up and puts the effective rate of profit above the required rate of profit. Second, the economy responds to the higher rate of profit by increasing investment and raising the income-capital ratio. The increase in the level of economic activity reduces the profit share of income until the equality between the effective and the required rates of profit is reestablished. At the new equilibrium the income-capital ratio is higher than at the initial point, the rate of profit is the same and, therefore, the profit-share of income is lower than at the initial point.¹¹

To simplify the analysis, take a linear approximation of the highest root of equation $r = r_f + \sigma$ and define the higher equilibrium value of the income-capital ratio simply as

$$u = u_0 + u_1 \varepsilon, \quad (4)$$

where $u_1 > 0$.

Economic growth

The fourth and final step of our model is to determine the long-run value of income growth from the stability of the income-capital ratio. By definition the growth rate of private capital is given by

$$k = su - \delta, \quad (5)$$

where s is the ratio of investment to income and δ is the rate of capital depreciation. We already saw that under reasonable assumptions we can expect that an increase in the real exchange rate pushes the income-capital ratio up, as modeled in (4). Assuming that the rate of capital depreciation is constant, we have to check how the real exchange rate influences the investment ratio.

From the usual decomposition of income we have

$$s = 1 - c - g - x + m, \quad (6)$$

¹¹ The fall in the profit-share can also be obtained from figure 1.1. To do this, note that a constant rate of profit can be represented by a fixed downward-sloping asymptote curve on the profit share x capacity utilization plane.

where c , g , x and m are the ratios of private consumption, government expenditures, exports and imports to income, respectively.¹² To move to aggregate demand, assume that c is a negative function of the profit share of income. In heterodox models with two social classes this assumption is usually based on the proposition that the propensity to consume of workers is higher than the propensity to consume of capitalists, so that a redistribution of income in favor of profits lowers the average propensity to consume of the economy. However, since in modern economies households earn both labor and capital income, and government taxes and transfers change income distribution substantially, the class-based distinction between the propensities to save becomes blurred. An alternative way to the same logical result is to assume that, despite taxes, transfers and the eventual local investment club, most of the disposable income of households still comes from wages in modern economies. In this situation a redistribution of income in favor of profits reduces the ratio of consumption to GDP even if the households' average propensity to consume out of disposable income stays the same. The reason is that the ratio of households' disposable income to GDP becomes a negative function of the profit share of GDP. With these ideas in mind, let us assume for simplicity that the relationship between c and π is linear, that is:

$$c = c_0 + c_1\pi = c_0 + c_1(\pi_0 + \pi_1\varepsilon + \pi_2u + \pi_3u^2), \quad (7)$$

where $c_1 < 0$.

Now focus on the long-run value of the income-capital ratio. After we substitute (4) in (7) the average propensity to consume becomes a function of only one variable: the real exchange rate. We already assumed that that an increase in the real exchange rate pushes the profit share of income down after the adjustment presented in figure 1.4 is completed. In terms of (7) this means that an increase in the real exchange rate reduces the average propensity to consume in the short run, but increases it in the long run. The reason is that the profit share of income first moves up and then moves down in figure 1.4.

Moving to government expenditures, assume for simplicity that both government consumption and investment are fixed in terms of income because of the targets that must be met by fiscal policy. The basic ideas here are that the government has a target for its primary surplus and that its total tax revenue net of current transfers is stable in terms of GDP.¹³ In this situation the target for the primary surplus of the public sector implies a constant ratio of government consumption and investment to GDP. In the real world fiscal policy tends to respond strongly to changes in the real exchange rate, especially when the government is either deep into external debt or has a large volume of international reserves. Despite this stylized fact, we will continue under the assumption that g is constant in (6) to show how the exchange rate may impact growth even when it has no impact on public finance.

In the case of trade flows, assume that the share of exports and imports in GDP can also be specified as linear functions of the real exchange rate. The idea here is that, given the value of the real exchange rate, imports can be modeled as a constant share of domestic income, and exports as a constant share of the income in the rest of the world. In this situation a change in the real exchange rate has a permanent impact on the ratios of exports and imports to GDP, but only a temporary impact on the growth rates of exports and imports.¹⁴ In the long run exports grow at the same rate as the world economy, whereas imports grow in line with the local GDP. If the growth rate of the domestic economy is

¹² Note that g includes both consumption and investment expenditures because we specified u as the ratio of income to private capital.

¹³ The primary surplus is the total surplus minus net interest payments.

¹⁴ More formally, the income elasticity of exports and imports is equal to one.

substantially different than the growth rate of the rest of the world, there will be a growing trade imbalance, which may trigger currency problems. For the purpose of this paper the capital-constraint hypothesis means that the balance-of-payments constraint is not the main determinant of economic growth.¹⁵

The linear representations of our assumptions for the trade ratios are simply

$$x = x_0 + x_1 \varepsilon \quad (8)$$

and

$$m = m_0 + m_1 \varepsilon, \quad (9)$$

where $x_1 > 0$ and $m_1 < 0$. With these two final assumptions, we can obtain the impact the real exchange rate on the long-run growth rate of income from the derivative of k in relation to ε . Formally:

$$\frac{\partial y}{\partial \varepsilon} = (1 - c - x + m) \frac{\partial u}{\partial \varepsilon} - \left[\left(\frac{\partial c}{\partial \varepsilon} \right) + \left(\frac{\partial x}{\partial \varepsilon} - \frac{\partial m}{\partial \varepsilon} \right) \right] u. \quad (10)$$

The first term on the right-hand side of (10) is positive because a higher real exchange rate raises the long-run value of the income-capital ratio in order to make the effective rate of profit converge to the required rate of profit, as shown in figure 1.4. The sign of the second term is negative because the reduction in the profit share of income pushes the average propensity to consume up and the ratio of net exports to income also rises after an increase in the real exchange rate.

In terms of the dynamics of the capital stock described in (7), the long-run impact of a depreciation of the real exchange rate is to reduce the investment-ratio (s) and increase the rate of capacity utilization (u). The net impact on growth depends on which of these two effects is stronger, that is, we cannot know how the growth rate of capital will behave a priori. What we do know is that when the investment-ratio and the income-capital ratio move in opposite directions after a change in the real exchange rate, the long-run growth rate of a capital-constrained economy is a concave-down function of the real exchange rate. As shown in figure 1.5, this result means that there is an optimal value of the real exchange rate that maximizes economic growth in the long run. More important, if we take such “optimal” point as a reference, appreciation accelerates growth when the initial real exchange is too high, but decelerates it if the initial exchange rate is too low. By analogy, depreciation accelerates economic growth if the initial real exchange rate is too low, but decelerates it if the initial exchange rate is too high. As we shall see in the next section, this situation is a good representation of the recent Brazilian experience.

FIGURE 1.5

2 - Evidence from Brazil

This section analyses the statistical relationship between the real exchange and economic growth in Brazil in 1996-2009. The period under analysis reflects the recent revision of the quarterly GDP series for Brazil, which starts only in 1996. The period under analysis also

¹⁵ When growth is determined from the balance-of-payments, the long-run growth rates of income and capital are given by the growth rate of the rest of the world, multiplied by the ratio of the income elasticity of exports to the income elasticity of imports. In this case the ratios of private consumption and government expenditures to income become the adjusting variables to make capital grow at the balance-of-payments constrained rate.

excludes the years of the Brazilian high inflation, in the 1980s and early 1990s, during which fluctuations in economic growth were more associated with the government's stabilization attempts rather than with the change in the real exchange rate. The real exchange rate corresponds to the nominal exchange rate multiplied by the ratio of consumer prices abroad and in Brazil, in which the weight of each foreign economy corresponds to its participation in Brazilian foreign trade (exports plus imports).¹⁶ The growth rates of GDP and real exchange rate will be represented by the first difference of the natural logarithm of the respective series.¹⁷

The modeling strategy is to specify the dynamics of the dependent variable as an error-correction process, that is, a process in which the change in the dependent variable is specified as a function of a long-run trend, and where this long-run trend is defined as a function of the variables of interest. Our main variable of interest is the real exchange rate and, based on the ideas presented in the previous sections, this section has two main objectives: (i) analyze the impact of the level of the real exchange rate on the long-run trend of growth; and (ii) check whether this impact varies according to the initial conditions, that is, according to the starting level of the exchange rate.

Table 2.1 presents a summary of six error-correction models. In all of them the dependent variable is the change in GDP growth, measured by the second difference of the natural log of GDP. The basic idea of all models is to estimate the acceleration of GDP growth as a function of its long-run trend, which in its turn is a function of the real exchange rate. The independent variables are the change and the level of the real exchange rate, as well as dummy variables to capture exogenous shocks not directly related to the exchange rate. In the sample considered we have two shocks of this kind: (i) the 2001 blackout, when Brazilian economic growth was compromised by a sudden reduction of energy supply due to low investment and climatic reasons and (ii) the 2008 international financial crash, when growth in Brazil was compromised by a sudden stop in domestic and international credit supply.

TABLE 2.1

The main results of the error-correction models can be summarized as follows:

- i. The simplest model (Model 1), in which the GDP growth rate converges to a constant, can explain approximately 45% of the acceleration and deceleration of growth in the period. In other words, 45% of the sample variance reflects the GDP growth adjustment to its long-run trend.
- ii. The introduction of dummies for the 2001 blackout and 2008 financial crash (Model 2) increases the explanatory power of the model in 13 percentage points (pp).

¹⁶ The reference for this series is Jun/94 (Jun/94=100), the last month before the Brazilian "real" plan, which introduced a new currency, the real. The results with a real exchange rate based on wholesale price indexes are not statistically significant. All series used in the analysis can be obtained from the authors' upon the reader's request.

¹⁷ The GDP series has quarterly frequency and the real-exchange-rate series has a monthly frequency. The monthly series was converted to a quarterly series using the quarterly average.

- iii. The depreciation of the real exchange rate impacts negatively GDP growth, but it is not possible to reject the null hypothesis that the corresponding coefficient is zero at a 5% significance level (Model 3).
- iv. Introducing the level of the real exchange rate as an independent variable does not increase the statistical fit of the model substantially (Model 4).
- v. Adding the level of the exchange rate and the level of the real exchange rate squared increases the fit of the model substantially (Model 5). The two corresponding coefficients are statistically significant at 1% and the adjusted R-Squared statistic increases in 5 pp when compared to the model without the level of the real exchange rate (Model 3).
- vi. When we omit the dummy variables from the regression, the estimated coefficients for the real exchange rate level and the real exchange rate squared are no longer statistically different than zero at 5% significant level (Model 6).

It should be noted that when we run the regression for the sample up to the quarter immediately before the 2008 financial crash, both coefficients for the real exchange rate in model 6 are statistically significant at 5%. Then, as we add new observations, the statistical significance of the coefficients first goes down, and then goes up. This indicates that the coefficients for the level of the real exchange rate in model 6 tend to become statistically significant at 5% as we add more observations, that is, the statistical effect of the 2008 financial crash on the results is temporary.

In economic terms the results presented in table 2.2 confirm the theoretical hypothesis presented earlier, that is, Brazilian GDP growth can be represented by a non-linear function of the real exchange rate. The results also indicate that Brazilian GDP growth can be represented by a quadratic concave-down function of the real exchange rate, that is, either appreciation from a “high” real exchange rate or depreciation from a “low” real exchange rate has a positive impact on growth. In terms of the theoretical model presented in section one, excessive appreciation and excessive depreciation are not good for growth and there is one optimal value for the real exchange rate at which growth is maximized. Based on the coefficients estimated in model 5, the highest growth rate corresponds to a real exchange rate of 101.6 during the period under analysis. As shown in figure 2.1, the maximum annual growth rate at this optimal real exchange rate is 5% so that, either a depreciation or an appreciation of the real exchange rate from 101.6 tended to decelerate long-run economic growth during the period under analysis.

FIGURE 2.1

The main conclusion from Figure 2.1 is that the impact of the real exchange rate on growth depends on the initial conditions. In terms of current policy debate in Brazil, if the starting point of the real exchange rate is above 101.6, appreciation tends to increase growth rate, as suggested by Pastore (2010). If the starting point is below 101.6, depreciation tends to increase GDP growth, as proposed by Bresser-Pereira (2010). The next natural question is what is the current situation? To answer this and put the current situation in historical

perspective, figure 2.2 shows the evolution of the Brazilian real exchange rate since the late 1980s. Focusing just on the recent period figure 2.2 shows that the exchange-rate appreciation of 2003-04 had a positive impact on long-run growth because it started from a very high real exchange rate. Appreciation started to be excessive only at the end of 2005, when real exchange rate fell below its optimum-growth level. As a result, the exchange-rate appreciation that took place in 2006-07 had a negative impact on long-run growth, whereas the depreciation brought by the 2008 crash had a positive impact on long-run growth. Finally, at the end of the sample, the real exchange rate was again below its optimal level for long-run growth. So, if the parameters of the economy remain the same, an additional appreciation of the real exchange from the value verified at the end of 2009 would tend to decelerate Brazilian economic growth in the long run, as proposed by Bresser-Pereira (2010).

FIGURE 2.2

3 – Implications for Economic Policy

The long-run relationship presented in the previous section suggests that there exists an optimal-exchange rate level that maximizes growth in Brazil. The next obvious question is: should economic policy intervene in the foreign-exchange market and keep the real exchange rate at such a level? The answer to this question depends on the analysis of the relationship between real exchange rate and inflation, since the optimal exchange rate for economic growth might not be compatible with the inflation target desired by the population. To analyze this point, let us assume that there is a positive relationship between the level of the real exchange rate and the rate of inflation.¹⁸ The source of this relationship comes from the fact that a depreciated (high) real exchange rate protects domestic production from foreign competition, which in its turn results in a higher inflation rate at the steady state because domestic firms tend to pass cost increases to prices more easily.¹⁹ In this situation the combination of inflation targeting with managed float generates nine possible logical situations, as shown in table 3.1. Each situation is defined by the position of the real exchange rate in relation to its optimal level for growth, and the position of inflation in relation to the government's target. To facilitate the analysis we will consider each column of table 3.1 separately.

TABLE 3.1

In the first column of table 3.1 the rate of inflation is below target and, therefore, managed float does not conflict with inflation targeting. More specifically: (i) when the initial exchange rate is appreciated, a depreciation does not conflict with the inflation targeting

¹⁸ If there is a negative relationship between inflation and the level of the real exchange rate, there would be little conflict between inflation targeting and exchange-rate targeting. The econometric results presented in Barbosa et al (2010) indicate that inflation was indeed a positive function of the real exchange rate in Brazil in 1996-2009.

¹⁹ The basic idea here is that a high real exchange rate increases the inertial coefficient of inflation, which raises its steady-state value. Alternatively, the rate of inflation at the steady-state can be modeled as a negative function of the effective rate of profit (Barbosa 2010c), which would make it a positive function of the real exchange rate for both "low" and "high" initial values of the real exchange rate.

because inflation can move up and still remain below target;²⁰ (ii) when the real exchange rate is already at its optimal level for growth, exchange-rate stability keeps inflation below target; and (iii) when the real exchange rate is depreciated, appreciation pushes inflation further below target. Assuming that society accepts inflation below its target if this does not result in slower growth, in all three cases in the first column of table 3.1 the government can adopt a managed float without risking excessive inflation.

Next, consider the cases in which inflation is on target. In the second column of table 3.1 there is no conflict between managed float and inflation targeting, provided that the real exchange rate is not appreciated. More specifically, if the real exchange rate is above its optimal level, appreciation pushes inflation below target without hurting growth. If the real exchange rate is already at its optimal level, exchange-rate stability does not impact on inflation. However, if the real exchange rate is appreciated, depreciation tends to increase inflation above the target. In face of this conflict, the government has to choose one objective, as we will see later in this section.

Finally, consider the cases in which inflation is above target, as shown in the third column of table 3.1. In this situation a managed float to maximize growth is consistent with inflation targeting only if the exchange rate is depreciated. This happens because exchange-rate appreciation helps in decelerating inflation and accelerating growth. In the other two alternatives inflation targeting conflicts with managing the real exchange rate to maximize growth, that is: (i) when the real exchange rate is appreciated, depreciation pushes inflation further up above target; and (ii) when the real exchange rate is at its optimal level, exchange rate stability does not contribute to reduce inflation. The bottom line is that managed float and inflation targeting are not usually compatible when inflation is high. One objective must take precedence, which is the next issue we have to consider.

The choice between maximizing growth and controlling inflation depends obviously on the preferences of society. In theory it would be possible to have a stable situation with maximum growth and a stable competitive real exchange rate, provided that the inflation rate at such steady state is also stable. When we consider the recent economic history of countries like Brazil, the evidence shows that inflation tends to become unstable at high rates. The reason is that a persistently high rate of inflation tends to get built into the markets' expectations, which in its turn leads to generalized indexation and makes inflation rigid downwards. In the jargon of structuralist macroeconomics, the higher the inflation rate the higher the inertial inflation. At some point the inertial component may become unstable, pushing the economy from high inflation to hyperinflation. Because of this instability, accepting a high inflation target to pursue growth maximization through managed float is too risky. The choice of economic policy should be to control inflation over managing the real exchange rate to maximize growth whenever these two policies conflict.

What if the two policies do not conflict? The next issue we have to consider is the macroeconomics of managed float in an economy that does not issue an international reserve currency. Assuming that the managed float is consistent with inflation targeting, figure 3.1

²⁰ Note that if depreciation puts inflation on or above target, we move to the second and third columns of table 3.1, respectively.

presents a possible illustration of this case. In the top graph we have the long-run concave-down relationship between growth and the real exchange rate. In the bottom graph we have the assumed positive relationship between inflation and the real exchange rate.²¹ The points A and B in figure 3.1 represent the lower and upper bound of the inflation target set by the government. The implicit assumption is that the inflation target is set to be consistent with the real exchange rate that maximizes growth, that is, inflation at the mid-point between A and B is the central target, which is also compatible with the optimal real exchange rate.

FIGURE 3.1

First, consider a situation in which an external shock pushes the real exchange rate up and accelerates inflation above the central target, as represented in point B in figure 3.1. In this case the very own logic of inflation targeting recommends an increase in the domestic base interest rate to fight inflation. This action can be complemented by a sale of international reserves in the domestic foreign-exchange market, provided that the government has enough reserves to pursue such policy. However, since the government does not issue international currency, selling reserves is a limited strategy. It can only work temporarily and, if the market perceives this as unsustainable, there will be an incentive for speculation against the domestic currency as international reserves fall close to the minimum considered safe by the government. This asymmetry between the scopes of monetary policy and exchange-rate policy explains why monetary policy is usually the main tool to fight high inflation in face of an exogenous increase in the real exchange rate.

Now consider the situation in which an external shock pushes the real exchange rate down and decelerates inflation below the central target, as represented by point A in figure 3.1. In this case the logic of inflation targeting recommends a reduction in the base interest rate. Since this action also tends to depreciate the real exchange rate, it raises the long-run growth rate in the top graph of figure 3.1. Similarly with what happens in point B, in point A monetary policy can be complemented by government interventions in the foreign exchange market. The difference in this case is that the government would have to buy foreign exchange to avoid further deceleration in growth and inflation. Since there is no limit to the amount of domestic currency that the government can issue to buy foreign exchange, but there is a floor to the nominal interest rate set by the inflation target, in point A economic policy tend to rely more in foreign exchange operations than in the reduction in interest rates. The preference of the population for low inflation also pushes the government toward exchange rate operations rather than a reduction in the interest rate when the real exchange rate is too low. Eventually the limit to such action comes from public finance, that is, if the financial cost of sterilized interventions in the foreign exchange market becomes too high, the deterioration in public finance will increase risk aversion and push the real exchange rate up.

From the previous analysis we can conclude that there is an asymmetry between the response of economic policy to depreciation and appreciation in a country that targets inflation and tries to avoid too much volatility in its real exchange rate. When the real

²¹ We assume a linear relationship to simplify the analysis. As shown in Barbosa et al (2010), the actual relationship for Brazil during the period under analysis is a third degree polynomial, in which inflation goes up with a higher exchange rate either when the initial real exchange rate is too low or too high.

exchange rate is too high, economic policy tends to rely more on a contractionary monetary policy than on a reduction in international reserves in order to reduce inflation and stabilize the real exchange rate. In contrast, when the real exchange rate is too low, economic policy tends to rely more on reserve accumulation than on an expansionary monetary policy to control inflation and stabilize the real exchange rate.

Finally, there is one more issue we have to consider: can the government really control the real exchange rate? There is hardly a choice without risk in economic policy and the real exchange rate is no exception. A fixed exchange rate may lead to a balance-of-payment crisis and slow growth when the real exchange rate is kept too low for too long, and high inflation and speculative bubbles when the real exchange rate is kept too high for too long. In the first case the risk lies in the explosive current account deficits generated by an appreciated currency. Sooner or later the explosive imbalance in the current account leads to a Ponzi situation, and the fixed exchange rate collapses in a currency crisis.²² In the second case the risk lies in the high inflation that can be generated by the initially high nominal exchange rate. Since the government does not control domestic prices completely, an excessively high real exchange rate may lead to higher inflation, which in its turn brings the real exchange rate down to a more moderate level. Another risk is the financial cost of carrying the high volume of international reserves necessary to keep the real exchange rate depreciated, as we mentioned earlier. And even when the initial high real exchange rate does not bring high inflation and does not compromise public finance, the situation can still become unsustainable because of the asset inflation generated by low interest rates. When the government keeps its interest rate low to sustain a depreciated currency and its fiscal policy tight to control inflation, the problem may develop in private asset prices, since at low interest rates the climate becomes favorable for speculative bubbles.

The main implication of the results presented in this paper is a defense of moderate exchange-rate fluctuation. This can be achieved through a policy of floating exchange rates in which the government has no compromise with a fixed value of the nominal or the real exchange rate, but it intervenes in the foreign exchange market to avoid an excessive volatility of the real exchange rate. On the one hand, as presented above, fighting excessive appreciations or depreciations makes sense because economic growth tends to decelerate when the real exchange rate is either too high or too low. On the other hand, a rigid exchange-rate policy is too risky because it can lead the economy quickly into an unsustainable situation because of problems in the balance of payments, public finance, price inflation or asset inflation. The long-run relationships between the real exchange rate, growth and inflation change through time. What may seem as an optimal exchange rate nowadays may become very appreciated or depreciated in the near future. In the terms of our theoretical model, the long-run curves that link growth and inflation to the real exchange rate may change position and, therefore, adopting a rigid exchange-rate target may lead to unsustainable situations. At the end of the day the real exchange rate is an important determinant of growth, but it is not the only determinant of growth. Other factors such as fiscal policy and economic regulation assume an increasing importance for growth acceleration when inflation

²² The cases of Brazil in 1998 and Argentina in 2001 are the most recent examples of this situation.

control and the other constraints on economic policy limit the government actions in the foreign-exchange market.

References:

- Barbosa, N. (2010a), "Exchange Rates, Growth and Inflation: What If the Income Elasticities of Trade Flows Respond to Relative Prices?" In: Despande, A. (Org.), Capital Without Borders, Anthem Press: London.
- Barbosa, N. (2010b), Real Exchange Rate and the Balance-of-Payments Constraint, mimeo.
- Barbosa, N. (2010c), A Structuralist Model of Growth and Distribution in Open Economies, mimeo.
- Barbosa, N. and Taylor, L. (2006). "Distributive And Demand Cycles In The Us Economy-A Structuralist Goodwin Model," *Metroeconomica*, vol. 57(3), pages 389-411, 07.
- Barbosa, N., Silva, J., Goto, F, and Rocha, B. (2010), Real Exchange Rate and Inflation in Brazil: 1996-2009, mimeo.
- Bresser-Pereira, L.C. (2010), "Déficits, câmbio e crescimento", Estado de São Paulo, March 7, Page B9 .
- Dutt, A. (1990), Growth, Distribution and Uneven Development, Cambridge: Cambridge University Press.
- Foley, D.K. and Michl, T.R. (1999), Growth and Distribution, Cambridge: Harvard University Press.
- Marglin, S.A. (1984), Growth and Distribution, Cambridge: Harvard University Press.
- McCombie, J., Pugno, M. and Soro, B. (2003), Productivity Growth and Economic Performance: Essays on Verdoorn's Law, Palgrave MacMillan: London
- McCombie, J.S.L and Thirlwall, A.P. (2004), Essays on Balance of Payments Constrained Growth Theory and Evidence, Routledge: London.
- Ocampo, J.A, Rada, C. and Taylor, L. (2009), Growth and Policy in Developing Countries, Columbia University Press: New York.
- Pastore, A. C. (2010), "Câmbio Real e Crescimento Econômico", Estado de São Paulo, February 28, Page B5.
- Rada, C. (2007), "A Growth Model for a Two-Sector Economy with Endogenous Employment", *Cambridge Journal of Economics*, 31: 711-740.
- Taylor, L. (1991), Income Distribution, Inflation and Growth, Lectures on Structuralist Macroeconomic Theory, Cambridge MA: Harvard University Press.
- Taylor, L. (2004), Reconstructing Macroeconomics, Structuralist Proposals and Critiques of the Mainstream, Cambridge
- McCombie, J.S.L and Thirlwall, A.P. (1994) Economic Growth and The Balance-Of-Payments Constraint, Palgrave: London.

Annex: list of variables used in the econometric model

1. GDP: gross domestic product, seasonally adjusted (source: IBGE).
2. RER: effective real exchange rate according to consumer prices and the composition of Brazilian trade (source: Central Bank of Brazil).
3. DENERGY: dummy variable for the energy rationing in 2001, DENERGY equals one in the third and fourth quarters of 2001, and zero otherwise.
4. DCRASH: dummy variable for the international financial crash of 2008, DCRASH equal one in the fourth quarter of 2008 and first quarter of 2009, and zero otherwise.

Table 2.1: Brazil, 1996-2009 – Alternative error-correction models for the acceleration in GDP growth (the dependent variable is the 2nd difference of the natural log of GDP).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
C	0.0069	0.0100	0.0101	-0.0072	-1.3522	-0.9201
t-Statistic	3.5825	4.3254	4.5554	-0.1828	-2.9338	-2.0050
Prob.	0.0007	0.0001	0.0000	0.8557	0.0052	0.0505
DENERGY		-0.0136	-0.0118	-0.0126	-0.0141	
t-Statistic		-4.2740	-3.4670	-3.3312	-4.8980	
Prob.		0.0001	0.0011	0.0017	0.0000	
DCRASH		-0.0334	-0.0317	-0.0313	-0.0357	
t-Statistic		-6.6249	-5.4457	-5.3498	-6.8743	
Prob.		0.0000	0.0000	0.0000	0.0000	
$\Delta\text{LOG}(\text{GDP}_{t-1})$	-0.9301	-1.1193	-1.1442	-1.1456	-1.1867	-1.0127
t-Statistic	-6.5793	-7.4760	-7.3862	-7.3820	-9.1362	-7.3040
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
$\Delta\text{LOG}(\text{RER}_{t-1})$			-0.0210	-0.0224	-0.0151	-0.0356
t-Statistic			-1.7228	-1.7733	-1.0860	-1.8709
Prob.			0.0912	0.0825	0.2830	0.0673
$\text{LOG}(\text{RER}_{t-1})$				0.0038	0.5915	0.4006
t-Statistic				4.4120	2.9486	2.0025
Prob.				0.6610	0.0050	0.0508
$\text{LOG}(\text{RER}_{t-1})^2$					-0.0640	-0.0431
t-Statistic					-2.9364	-1.9816
Prob.					0.0051	0.0531
R-squared	0.4600	0.5999	0.6095	0.6122	0.6656	0.5213
Adjusted R-squared	0.4496	0.5759	0.5776	0.5718	0.6230	0.4822
Durbin-Watson stat	1.8900	1.8900	1.8900	1.8900	1.8900	1.8900
Prob(F-statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 3.1: Implications of a managed float of the exchange rate for inflation targeting.

Real exchange rate (RER)	Rate of inflation		
	Low (below target)	Neutral (on target)	High (above target)
Appreciated (below the optimal level for growth)	RER depreciation is consistent with inflation targeting	RER depreciation is NOT consistent with inflation targeting	RER depreciation is NOT consistent with inflation targeting
Neutral (at the optimal level for growth)	RER stability is consistent with inflation targeting	RER stability is consistent with inflation targeting	RER stability is NOT consistent with inflation targeting
Depreciated (above the optimal level for growth)	RER appreciation is consistent with inflation targeting	RER appreciation is consistent with inflation targeting	RER appreciation is consistent with inflation targeting

Figure 1.1: profit share of income as a function of the income-capital ratio

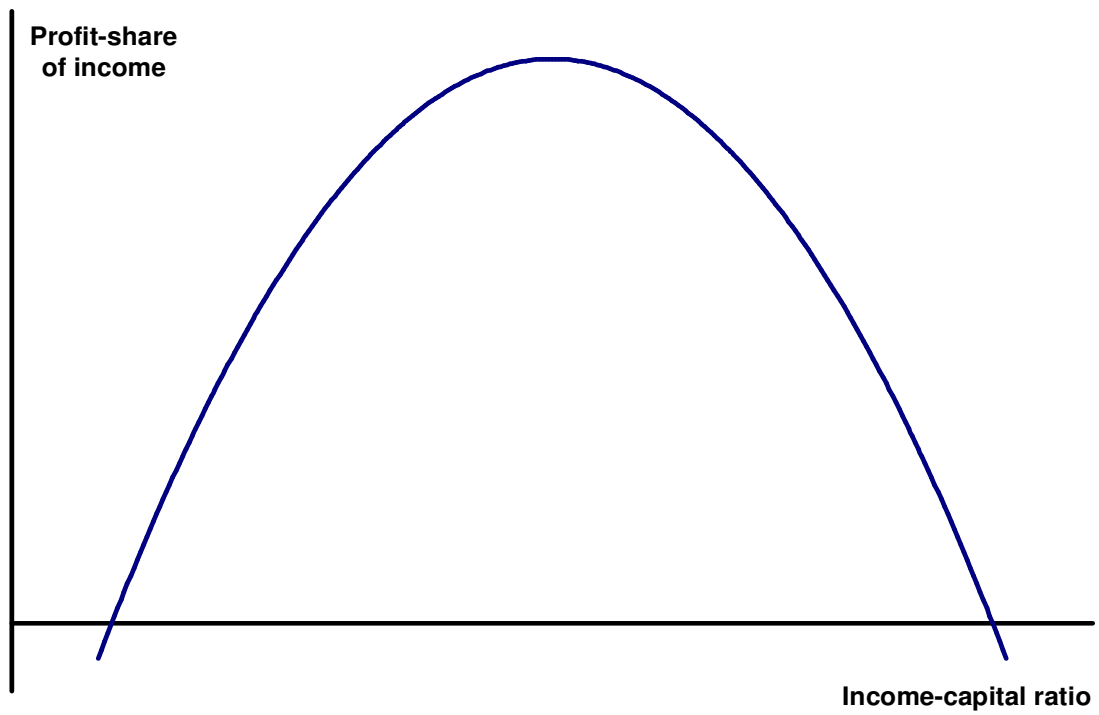


Figure 1.2: rate of profit as a function of the income-capital ratio

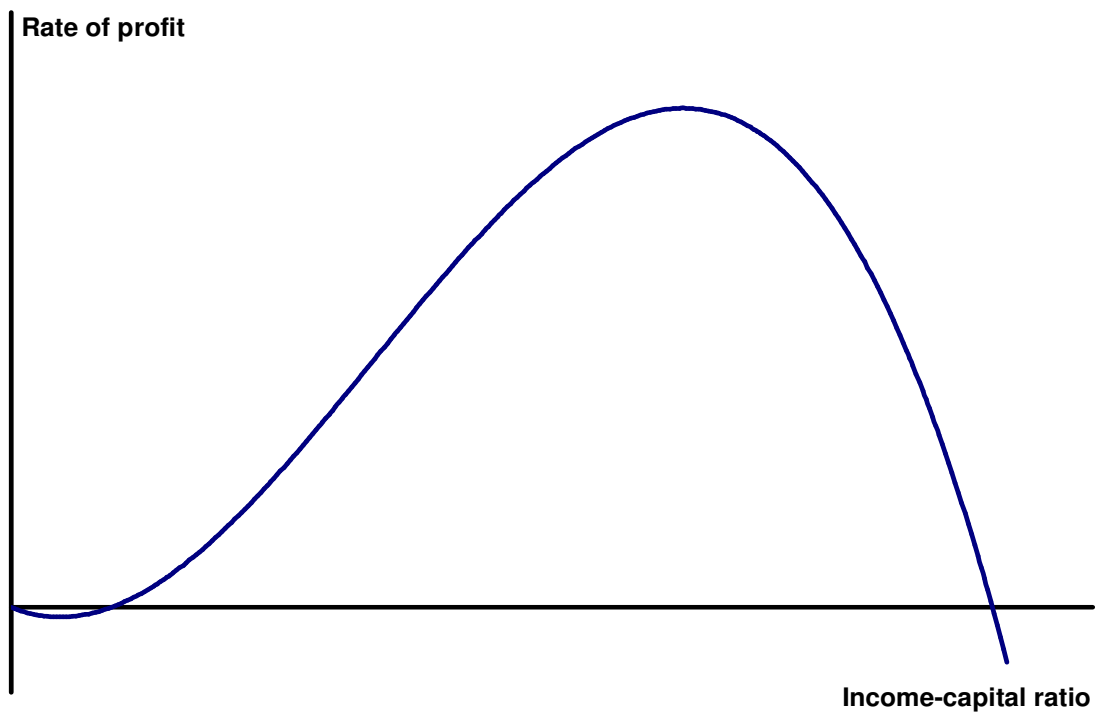


Figure 1.3: effective rate of profit and required rate of profit

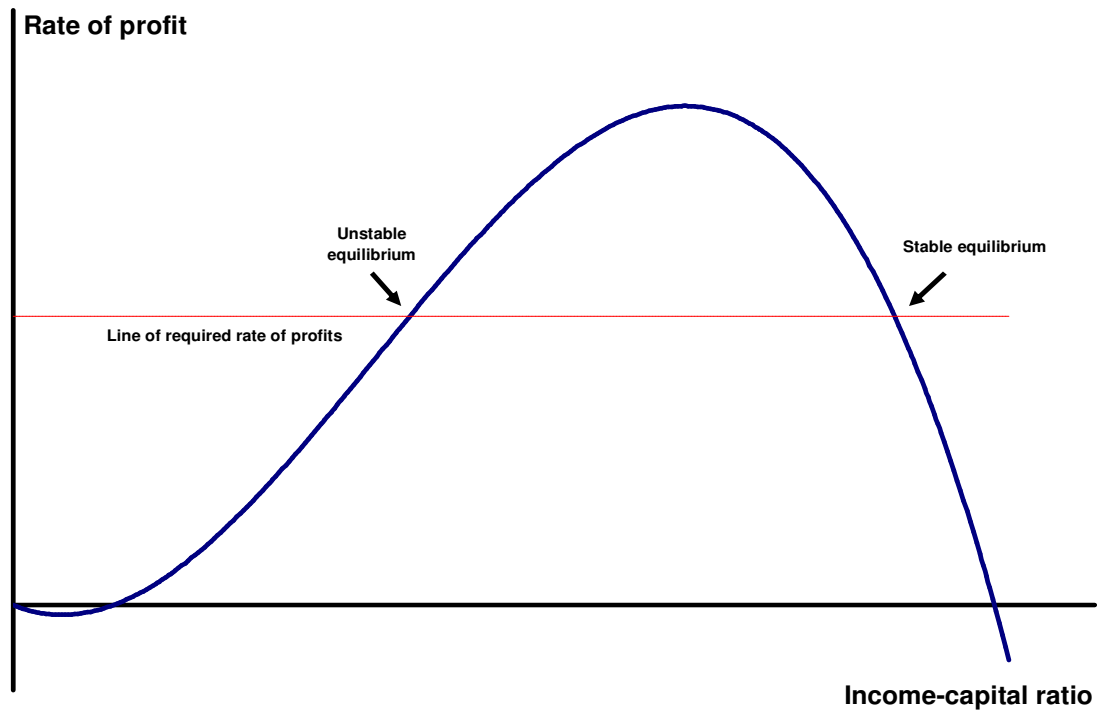


Figure 1.4: effect of an increase in the real exchange rate on the income-capital ratio

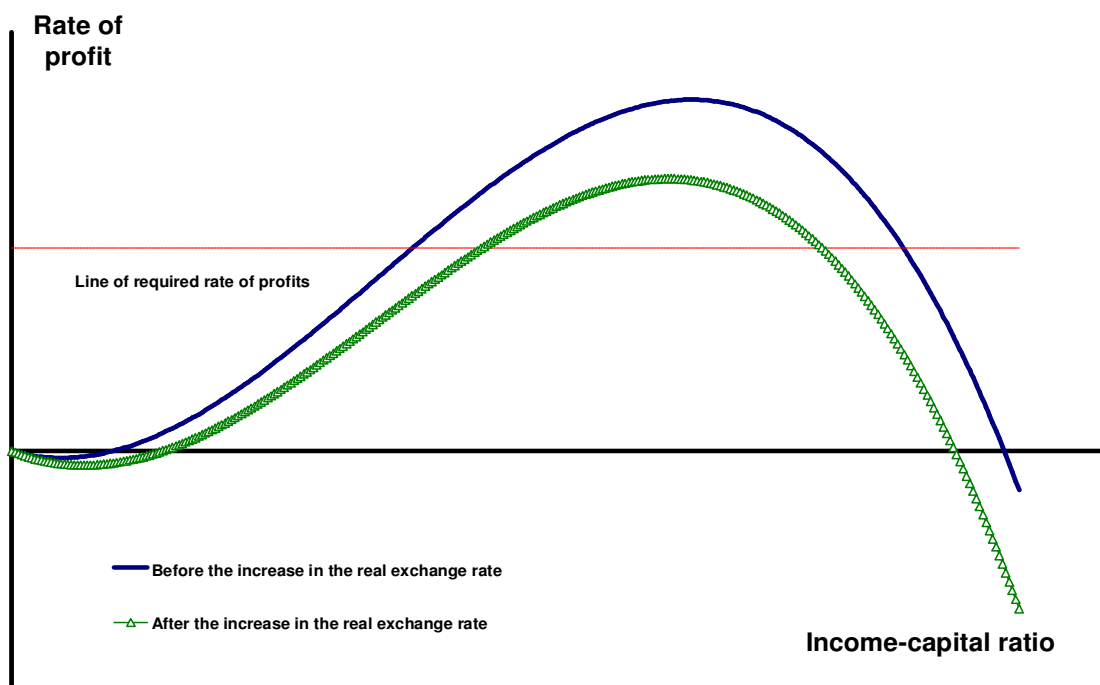


Figure 1.5: long-run economic growth in terms of income

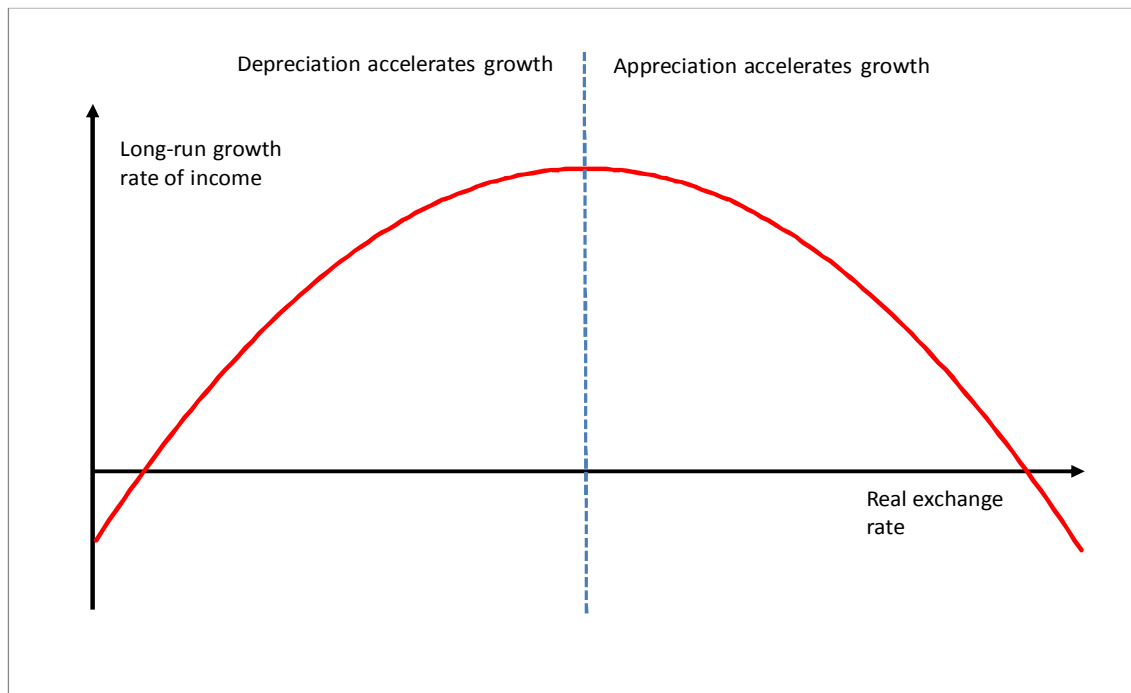
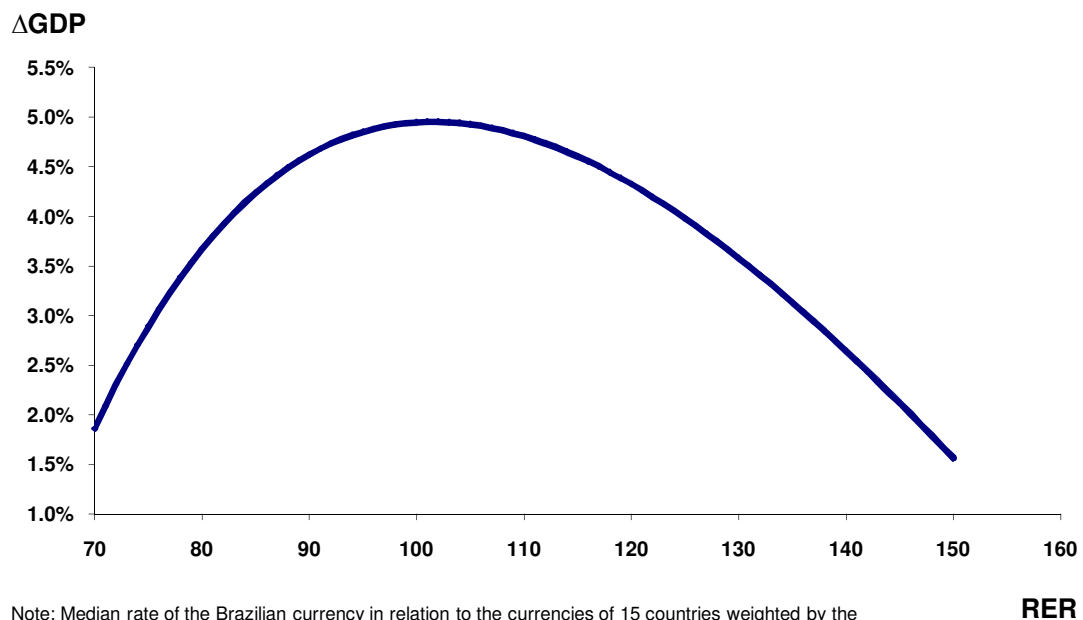
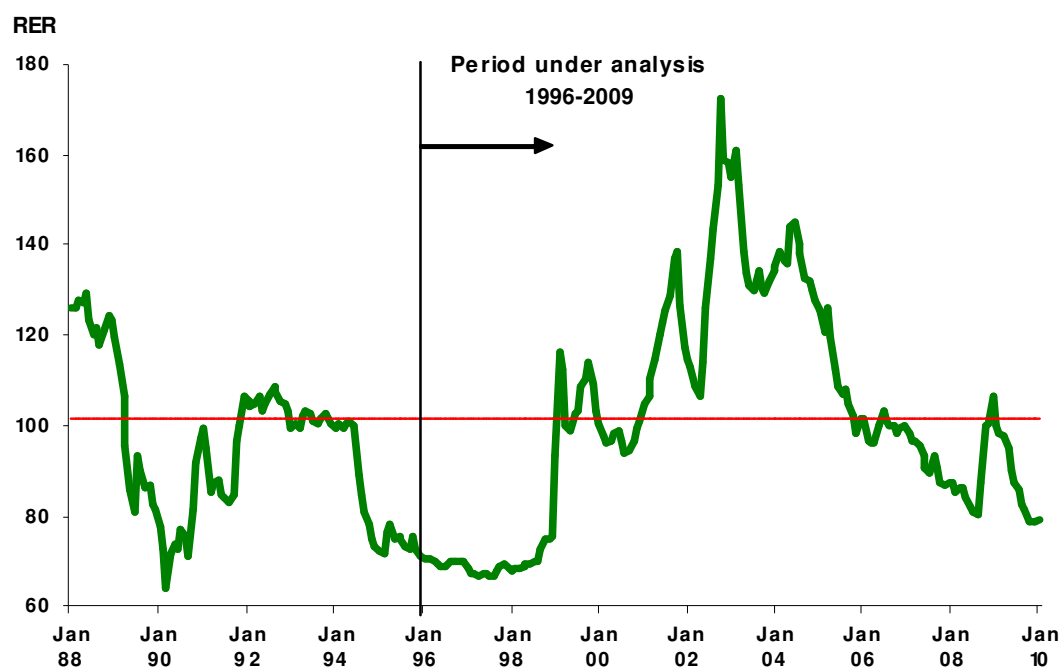


Figure 2.1: Real exchange rate (1994=100) and annual GDP growth – Brazil



Note: Median rate of the Brazilian currency in relation to the currencies of 15 countries weighted by the participation of these countries in the total Brazilian exports to this group of countries.
Source: Central Bank of Brazil

Figure 2.2: Real exchange rate in Brazil



Source: Central Bank of Brazil

Figure 3.1: Real exchange rate, economic growth and inflation

