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**THE DECLINE OF THE EXCHANGE RATE PASS-THROUGH IN BRAZIL:
EXPLAINING THE ‘FEAR OF FLOATING’***

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Abstract: This paper argues that the pass-through in Brazil has fallen compared with estimates in other studies on earlier time periods, and remains low. Whereas pass-through effects were high and close to 1 in the high-inflation period, they seem to have fallen to around 0.2 after the Real Plan stabilization, a number that is similar to the Import Substitution Industrialization (ISI) period of the 1950s and 1960s. Conventional results suggest that low and stable inflation environments lead to low levels of exchange rate pass-through and thus contribute to weakening the ‘fear of floating’ phenomenon experienced by some developing countries. In spite of lower pass-through effects the Brazilian Central Bank has maintained high interest rates in order to control the exchange rate. This paper suggests that ‘fear of inflation’ provides justification for the central bank’s persistent ‘fear of floating.’

Keywords: Pass-Through, Inflation, Brazil

JEL Codes: E580, F410, O540

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1. Introduction

Since the collapse of Bretton Woods an increasing number of economies have adopted floating exchange rates. In Latin America after the exchange rate based stabilization policies of the 1990s, there has also been a tendency to adopt floating regimes. However, even the countries that formally adopt a floating system appear to intervene to manage the exchange rate. Calvo and Reinhart (2002) refer to this phenomenon as ‘fear of floating.’ The persistence of this phenomenon even in economies with low pass-through effects is puzzling, since the main cause for managing the exchange rate is usually the fear that depreciation would lead to inflation.

This paper suggests that the ‘fear of inflation’ is still the main cause behind ‘fear of floating’ even though pass-through effects have declined in the developing world. This seems to be the case in Brazil. This paper shows that the pass-through effect parameters are relatively large in Brazil, when a higher probability of occurrence is attached ex-ante to depreciations. This suggests that the central bank in Brazil still attaches great importance to the inflationary risk associated with depreciations.

The remainder of the paper is divided in four sessions. The following session reviews the neoclassical and Post Keynesian theories of partial pass-through effects, and suggests that the later provides a more solid basis of analysis. The subsequent session discusses the empirical estimation of the pass-through effect in Brazil, and shows the fundamental difference in the size of the effect in diverse inflationary environments. The next session deals with the econometric analysis, based on a Bayesian approach, and the economic interpretation of our results. The last session provides a brief conclusion of our argument.

2. Theories of limited exchange rate pass-through

Mainstream theories of limited exchange rate pass-through are closely related to the violations of the Law of One Price, which suggests that under perfect competition goods should have identical prices. For example, the conventional story would suggest that an exogenous increase in money leads to price increases, and exchange rate depreciation, generating a full pass-through. Changes in foreign money supply levels may change the exchange rate and foreign price levels at the same time generating little or no change in import or domestic prices. In both cases the Law of One Price and Purchasing Power Parity are not violated. In that sense, partial pass-through has been seen as an indicator that markets are less integrated than otherwise thought, and that this market imperfection is behind the failure of the Law of One Price (Frankel *et al.*, 2005).

Mainstream models must rely on *ad hoc* clauses that impose some imperfection that reduces the pass-through effect. In general, it is assumed that when an exogenous change in the foreign exchange occurs, domestic firms will pass only partially the costs to their prices because either prices are sticky in domestic currency in the short run, or firms engage in price discrimination. Krugman (1987) refers to the second case as ‘pricing to market,’ since firms do not change domestic prices automatically, but only proportionally to the firm’s elasticity of demand.

However, according to Post Keynesian price theory, the mainstream models of exchange rate pass-through are inappropriate. According to Arestis and Milberg (1993-94), the key difference between Post Keynesian and neoclassical theories of pass-through lies in their particular theories of the firm. The Post Keynesian firm is an oligopolist with a specific internal structure and set of investment requirements, based on its long-run

objective of survival and growth. This firm is fundamentally different from the neoclassical one, which is characterized by its short-run, profit maximizing behavior.

If limited exchange rate pass-through is *ad hoc* from a neoclassical perspective, and is only generated as the result of market imperfections, such behavior is perfectly consistent with standard Post Keynesian theories of pricing in manufacturing industries based on the full-cost principle. In Kalecki's (1971) framework, a rise in costs for domestic or foreign firms due to the exchange rate change is not fully passed on because of the degree of monopoly. In the Eichner's (1976) model, a change in the exchange rate also affects the cost of raising funds internally for future investments. As a result, the firm's investment plans are altered, the markup is reduced, and the exchange rate is passed through only to a limited degree.

In other words, whereas the neoclassical models imply that partial pass-through reflect market imperfections, the Post Keynesian approach imply that partial pass-through should be the norm, and there is no reason why a full or one-to-one pass-through should be found in the real world. In the neoclassical models one possible explanation for lower pass-through levels in the 1990s¹ and after would be that markets are now less integrated than before, a rather peculiar assumption, since the liberalization policies associated with the Washington Consensus have generated greater market integration around the globe.

Taylor (2000) suggests an alternative explanation within the neoclassical approach for the decline of exchange rate pass-through in a lower inflationary environment. For him lower pass-through results mainly because that the pricing power

¹ Frankel *et al.* (2005) point out the downward trend in pass-through for developing countries is strong. They also conclude that long-term exchange rate variability has a strong negative effect on pass-through for developing countries. The pass-through coefficient has traditionally been higher for lower-income countries, but a strong downward trend in the coefficient during the course of the 1990s eliminated much of the gap. They suggest a model in which domestic adjust sluggishly to foreign exchange disturbances.

of firms declines as well, that is, globalization has intensified the degree of competition of domestic firms. Therefore, under this hypothesis it might be possible, especially for emerging market countries, to experience a transitions period, from high and unstable inflation environments to low and stable ones, during which the full benefits of a floating regime might not be present. However, once inflation stabilizes at low level, the pass-through weakens and movements of the exchange rate put less pressure on inflation, allowing the economy to fully benefit from the flexible exchange rate.

Baqueiro *et al.* (2003) also point out that the level of the exchange rate pass-through depends on the inflation environment. For a group of small open economies that in recent years have experienced disinflation processes the level of exchange rate pass-through weakened as the level of inflation fell. This result suggests that when a low and stable inflation environment is achieved, agent's expectations are likely to be in line with the authorities' inflation target and thus to be less influenced by short-term exchange rate variations. Under such circumstances is difficult to understand why the 'fear of floating' phenomenon should persist. Credibility in monetary policy as well as competitive markets should lead to free floating and reduced pass-through effects. However, 'fear of floating' is pervasive (Calvo and Reinhart, 2002).

In other words, according to conventional wisdom partial pass-through result from imperfections, and sluggish price adjustment, which seems contradictory in a more integrated world, or on a more competitive environment associated with globalization, leading to the logical result that central banks should let the exchange rate float, which is not a feature of the real world.

From a theoretical point of view, it would seem that Post Keynesian models

would provide a sounder basis for analysis. The hypothesis that globalization has reduced the degree of monopoly of domestic firms is perfectly compatible with the full-cost principle. However, Post Keynesians do not argue that once lower pass-through effects are established price stability would depend on the credibility of the central bank. Hence, the ‘fear of floating’ phenomenon is not associated to lack of credibility, and is not a puzzling result. In a Post Keynesian framework, ‘fear of floating’ would result from the central bankers’ ‘fear of inflation,’ so to speak. In a contested terrain view of central banking – one in which monetary policy affects income distribution – the central bank attaches considerably more importance to inflation than to unemployment in policy decisions.² In that case, even when pass-through effects fall considerably, central banks attach greater importance to any inflationary shock, no matter how small.

3. The pass-through effect in Brazil

During the period 1999-2002 the Real has undergone a large depreciation, which was passed through to domestic prices. Inflation, however, increased considerably less than the rate of depreciation of the Real. Developing countries traditionally experience exchange rate pass-through greater and more rapid than developed countries. But, as pointed out by Frankel *et al.* (2005), developing countries in the 1990s experienced a speedy descending trend in the degree of pass-through.

Baqueiro *et al.* (2003) reveal that stable inflation environments lead to low level of exchange rate pass-through and thus should contribute to weakening the ‘fear of floating’ phenomenon in developing countries. We extend the empirical analysis of

² For a critique of the neoclassical credibility theory and a discussion of the contested terrain alternative in the context of the Brazilian experience see Vernengo (2008).

Baqueiro *et al.* (2003) to examine the Brazilian case. Figure 1 shows the correlation between the nominal exchange rate variation and the consumer price index (CPI). Figure 2 presents a positive and strong correlation between the two variables during the period 1953-2007. In other words, one would imagine by looking at the period as a whole that pass-through effects are relatively high.

[FIGURE 1 HERE]

[FIGURE 2 HERE]

However, isolating the low inflation periods (1953-1978 and 1996-2007) we do not perceive the same strong positive correlation between the nominal exchange rate variation and the consumer price index as in the period 1979-1995 (see Figures 3 and 4). That is, the high pass-through effect results from a very limited period, and is associated to the high inflation era.

[FIGURE 3 HERE]

[FIGURE 4 HERE]

The essential econometric model used in this paper is similar to the one in Hausmann *et al.* (2000), but instead of using only the Ordinary Least Squares (OLS) and Maximum Likelihood Estimation (MLE) we apply the Bayesian approach developed by Agliari and Parisetti (1988) to understand the role of the exchange rate pass-through and the behavior of the policymakers in Brazil. Thus, the econometric model is given by:

$$CPI_t = \beta_1 + \beta_2(er_t - er_{t-1}) + \varepsilon_t \quad (1)$$

where

CPI_t = Consumer Price Index (%),

$er_t - er_{t-1}$ = Nominal Exchange Rate Variation (RS\$/US\$)

In the model β_2 means the level of pass-through from the exchange rate to prices but because of the omission of wages as well as other input prices it is possible that this coefficient will be upwardly biased, so the estimated level of exchange rate pass-through tends to be higher than it actually is. However, for the purpose of the paper this does not represent a difficulty since the idea is to compare the movement of the exchange rate pass-through across different periods and not to estimate the precise level. In other words, conclusions will be drawn from changes in the coefficient β_2 over time and not from the level of the coefficient.

The maximum likelihood estimation of the period (1953-2007), estimation of the parameters β_1 and β_2 , are $\hat{\beta}_1 = 0.0178$ and $\hat{\beta}_2 = 0.6895$. However, the estimated parameters for the high inflation period (1979-1995) are $\hat{\beta}_1 = 0.0139$ and $\hat{\beta}_2 = 0.9090$, so the exchange rate pass-through is larger when we consider a period with high inflation. The maximum likelihood estimation for the low inflation periods (1953-78 and 1996-2007) are $\hat{\beta}_1 = 0.0176$ and $\hat{\beta}_2 = 0.0242$. Using these results we could say that the exchange rate pass-through goes down to an insignificant level as the country moves from high to low inflation periods. These results are similar to the ones in Baqueiro *et al.* (2003) (see Table 1) for other countries.

[TABLE 1 HERE]

Estimates reported in other studies of the pass-through in Brazil also display a recent downward trend. Belaisch (2003) points out that the exchange rate pass-through to consumer prices is small but rapid, ending after two quarters. The model estimated suggest that about 6 percent of the exchange rate shock passes to consumer price in the same quarter as the shock occurs and 17 percent after a year with most of the shock likely absorbed along the supply chain. The impact on the wholesale price index, which contains a high percentage of tradable goods, is much larger and occurs more rapidly, with about a third of the initial exchange rate shock transmitted to prices in the same quarter, and about 100 percent in the course of a year. Finally, the general price index reacts, in a given year, by about one-half of the change in the exchange rate.

Belaisch (2003) concludes that the causes of the low pass-through are the depressed level of economic activity, and firms' preference for compressing margins to preserve business volumes rather than pass on higher costs to consumers, the availability of domestically produced goods as substitutes for imports for import-users, the slow adjustment of non-tradable prices and wages, and the belief that the depreciation was temporary.

The question that these empirical results raise is why do countries with considerably lower pass-through effects like Brazil still manage their currencies, and allow significant appreciation of the domestic currency. Before we discuss 'fear floating' we need to briefly address the movement away from hard pegs in the recent past in

developing countries.

The recurrent international financial crises, starting with the Tequila Crisis, passing through the Asian and Russian crises, the Brazilian 1999 crisis, and culminating in the Argentinean crisis in 2001, convinced several policymakers that fixed exchange rate regimes were very fragile. Eichengreen (2006) suggests that the repeated financial crises persuaded policymakers that soft currency pegs were crisis prone and that emerging markets should embrace greater exchange rate flexibility. In that case, it appeared that inflation targeting was able to provide a coherent alternative to exchange-rate-based monetary policy strategies that were overly restrictive and crisis prone.

In mid-1999, Brazil formally adopted inflation targeting. Arguably, the advantage of inflation targeting was that it would improve the credibility of the central bank to control inflation, without leading to the balance of payments problems connected with the appreciation implicit in pegged regimes. However, as noted by Eichengreen (2006), inflation targeting is difficult in emerging markets for at least three reasons. They have higher pass-through effects than developed countries, their liabilities are dollarized, and their policymakers lack credibility. Higher pass-through effects imply that central banks would be unwilling to allow the exchange rate to depreciate too much, since that would bring severe inflationary pressures. Liability dollarization introduces additional complications. Financial institutions and their clients are usually saddled with currency mismatches, given the difficulty developing countries have in borrowing abroad in their own currencies, the so-called 'original sin' hypothesis that suggests that depreciations are costly in countries where economic agents are unable to borrow long-term domestically and cannot borrow abroad in their own currency, and thus forced to borrow in foreign

currency (Eichengreen and Hausmann, 1999). This reinforces the central bank reluctance to let the exchange rate move. Finally, the lack of credibility associated to long inflationary histories implies that inflation targeting implementation will not lead to a reduction of interest rates to the levels of low inflation countries.

If even a small depreciation of the exchange rate threatens to destabilize balance sheets and output, then the central bank will be unwilling to let the exchange rate move. Further, if interest rates remain relatively high capital inflows would follow pressuring for the appreciation of the exchange rate. In this situation it seems that inflation targeting and hard peg are almost indistinguishable. In other words, if inflation targeting entails using the interest rate to control the exchange rate, it is tantamount to controlling the exchange rate. In fact, in the Brazilian case the real interest rates have remained high during both the pegged rate and inflation targeting (see Figure 5). In addition, the real exchange rate tended to appreciate after both strategies were implemented, being more appreciated at the end of 2006 than at the time of the crisis in January 1999.

[FIGURE 5 HERE]

The basic argument against a flexible exchange rate is based on the hypothesis that for some countries nominal exchange rate depreciations have negative effects and, consequently, although their exchange rate is flexible in theory, in practice they try to minimize exchange rate movements. The immediate implication of this argument is that monetary policy is effectively constrained and plays an accommodating role to achieve exchange rate stability. In this case the flexible exchange rate arrangement becomes *de*

facto a soft peg. Then, the valid comparison is not between hard pegs and free floats, but between hard and soft pegs.

Hausmann *et al.* (1999) illustrate that flexible exchange rate regimes have not been able to provide the benefits that an independent monetary policy should, particularly the ability to smooth out the business cycle. Their evidence suggests that, in some of the Latin American countries with flexible exchange rates, the interest rates were used in order to keep the exchange rate under control and inflation relatively low. In other words, ‘fear of inflation’ is the real cause of the ‘fear of floating.’ This policy, they argue, has resulted in higher and more volatile real interest rates, smaller financial systems, persistence of wage indexation, more sensitivity of domestic interest rates to international interest rates, and a pro-cyclical monetary policy.³

Post Keynesian authors like Bresser and Nakano (2002) argue that a competitive exchange rate is necessary for a developing country like Brazil, since particularly in those countries a competitive exchange rate fosters the exports sector, which is central to avoid balance of payments crises, and to maintain sustainable rates of output growth. In order to achieve and sustain a devaluated exchange rate Brazil would have to reduce the interest rate, and as a result contain short-run capital flows and reduce the pressure on the overvalued exchange rate. The resistance to interest rate reductions and the insistence in maintaining a relative appreciated currency reflect the exaggerated ‘fear of inflation’. The question that this persistence in using the exchange rate to control inflation raises is why it persists even with a lower pass-through effect. We believe that looking at the probability attached by the monetary authority to short and long-run intervals associated with depreciations may shed light on the puzzling persistence of ‘fear of floating.’

³ On the pro-cyclicality of macroeconomic policies in emerging economies see Ocampo (2007-8).

3. Bayesian Considerations on the Pass-Through Effect

In contrast to the long-standing frequentist approach to statistics, the Bayesian approach makes explicit use of prior information and is based on the subjective view of probability.

⁴Bayesian econometrics takes probability theory as applying to all situations in which uncertainty exists, including uncertainty over the values of the parameters. We apply the A-g prior method developed by Agliari and Parisetti (1988) to access the posterior means of the exchange rate pass-through.

In that methodology the A matrix is the masterpiece to work out the degree of influence from the prior information to the posterior means and the posterior distributions (see appendix). On the one hand, if the confidence level in terms of the prior information is high the values for a 's on the main diagonal of the A matrix will be also high. On the other hand, if the confidence level in the prior information available is low the values along the main diagonal will be close to zero.

The values of the prior betas, β_{1a} and β_{2a} , were estimated using the maximum likelihood estimator approach on the sample data (1979-1995). The betas are $\hat{\beta}_{1a} = 0.0139$ and $\hat{\beta}_{2a} = 0.9090$, but the model introduced by Agliari and Parisetti (1988) allows the use of any other predicted betas to access the prior information. We use the simple assumption for the variance of the prior distribution and the degree of precision g . This application assume, like Agliari and Parisetti (1988), $\sigma_a^2 = 1$ and $g = 1$. The final step involves the combination of the prior information and the likelihood function to predict

⁴ Some authors suggest that there is a connection between Keynes's views on probability and the subjectivist Bayesian approach, even though Keynes' views cannot be defined as Bayesian. For a discussion of Keynes's theories of probability see Bateman (1987).

the posterior means as well as the posterior distribution (equation 8).

Table 2 presents the posterior means as their dependency to the values on the main diagonal of the A matrix, varying from 10 to 0.1, so it demonstrates that the confidence level, in terms of the obtained prior information, is decisive to define the posterior means. Again, if the confidence level is high the values on the main diagonal of the A matrix are also high (value equal 10), which indicate that the posterior means will be close to the prior estimators, ($\beta_{1a} = 0.0139, \beta_{2a} = 0.9090$) and ($\beta_{1p} = 0.0139, \beta_{2p} = 0.9068$). However, if the level of confidence is low the values on the main diagonal will be lower (fluctuates from 0.1 to 5.0) and the result will depend on how substantial is the uncertainty. In the case of an extreme uncertainty, the values on the main diagonal of the A matrix will be 0.1 and, consequently, the values of the posterior means will be very close to the maximum likelihood estimators of the complete dataset ($\hat{\beta}_1 = 0.0178, \hat{\beta}_2 = 0.6895$) and ($\beta_{1p} = 0.0177, \beta_{2p} = 0.6916$).

[TABLE 2 HERE]

In terms of the distribution among the posterior means, there is an important effect caused by confidence level too. If there is a strong conviction among the policymakers that they know the true posterior means, the distribution around them will be very tiny. On the other hand, if the confidence level varies a lot, then we will see that the variance of the betas will become larger as long as the posterior betas move toward the maximum likelihood estimators of the entire data, so it is representing the level of confidence in terms of the true betas. The maximum likelihood estimates in the period (1953-2007) for

the parameters β_1 and β_2 are $\hat{\beta}_1 = 0.0178$ and $\hat{\beta}_2 = 0.6895$. The combination of the prior information and the likelihood function to predict the posterior means are presented in table 3.

[TABLE 3 HERE]

A possible interpretation of these econometric results is that the monetary authorities attach greater probability to depreciation experiences than to the long trajectory of the exchange rate. In other words, the Brazilian central bank is extremely focused on the very short run effects of depreciation, and discards the evidence regarding the long-run effects of depreciations. The evidence, as tables 2 and 3 show, suggest that when one attaches greater probability to the short-run, then the pass-through effect is closer to 1, whereas in the long-run the effect is closer to 0.2. This suggests that in the very short-run the pass-through is, in fact, quite high, and the only reason that the central bank attaches considerably more importance to the short-run effects is the existence of what Baqueiro *et al.* (2003) termed ‘fear of inflation.’

An interesting question that arises from the marked difference between the parameters when a high probability is attached to a short rather than a long interval around the depreciation, in particular, why in the 1979-1995 period the higher pass-through effects still perceived in the short-run lingered over time. In that period the process of indexation that was developed in the late 1960s was widespread, and the short-run effects of depreciation on domestic prices fueled the wage-price spiral, whereas after the Real stabilization almost all indexation mechanisms were eliminated. It is, in fact, the

elimination of indexations mechanisms that makes the ‘fear of floating’ a puzzling phenomenon.

The excessive preoccupation with inflation, however, is not a Brazilian phenomenon, and has its roots in the so-called Great Inflation of the 1970s. In the developed world the inflation paranoia is usually associated with the concept of the natural rate of unemployment, and outcries about the danger of inflation take place whenever the economy is deemed to be beyond that threshold. The doctrine of the natural rate has survived even though nobody can determine what its level actually is. However, in developing countries, where high disguised unemployment is the norm, the role of the natural rate concept is minimal. The Great Inflation in Brazil, as in the rest of Latin America, was associated with maxi-depreciations, and the ‘fear of inflation’ explains the persistence of ‘fear of floating.’ As much as the natural rate, the fear of large pass-through effects has survived beyond its empirical relevance.

4. Conclusion

Countries that formally adopt a floating system and have low pass-through effects should not be expected to intervene to manage the exchange rate. However, ‘fear of floating’ is a pervasive phenomenon in developing countries, including Brazil. This paper suggests that the ‘fear of inflation’ is still the main cause behind ‘fear of floating’ even though pass-through effects have declined in the developing world. This paper shows that the pass-through effect parameters are close to 1 in Brazil, when a higher probability of occurrence is attached ex-ante to depreciations. On the other hand, when the prior density for the estimated parameters is increased the pass-through effect becomes increasingly

smaller and gets closer to 0.2.

In a technical sense, it is the relatively large pass-through associated with the higher probability attached to short intervals that explains ‘fear of floating.’ The economic problem behind that result is that in the short-run domestic prices do react fast to depreciations, and the ‘fear of inflation’ is still a central feature of the behavior of policy makers. The political economy implications are beyond the scope of this paper, but we believe that there is reason to believe that the excessive preoccupation with inflation is a reflection of the priority given by central bankers to financial interests.

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Appendix

The Bayes' theorem tells us that the posterior density for the parameters is proportional to a prior density times the likelihood function. Thus information contained in a prior density for the parameters is combined with sample information enclosed in a likelihood function to provide a posterior density that includes all the information, sample and prior: $f(\beta|Y) \propto l(\beta|Y)f(\beta)$.

According to Agliari and Parisetti (1988), there are many different procedures for assessing the prior density for β and σ^2 in the natural conjugate, but many of those models are complex to evaluate the prior covariances for the elements of β . In that case, Zellner (1983) introduced a procedure for assessing the prior density, it was named as g-Reference Informative Prior (g-RIP) and it is based on:

(a) a conceptual sample y_0 that is assumed to be generated by a model

$$y_0 = X\beta + u_0 \quad u_0 \sim N\left(0, \frac{\sigma^2}{g} I_n\right)$$

with $g > 0$, given.

(b) β_a and σ_a^2 for β and σ^2 are assessed.

Agliari and Parisetti (1988) point out that the Zellner's g-RIP is efficient in the analysis of engineering systems or in modeling biological phenomena. In these cases,

subjective knowledge can often be formalized in the assignment of parameter values β_a and σ_a^2 , and in the indication of a degree of precision g of the conceptual sample y_0 . However, most of the time we have information available about the behavior of the independent variables in the model, so Agliari and Parisetti (1988) proposed an extension of Zellner's model (1983).

$$(2) y = X\beta + u$$

where y is a $(N \times 1)$ vector of the observations, X is a $(N \times K)$ non-stochastic matrix, β is a $(K \times 1)$ parameters vector and u is the $(N \times 1)$ error vector and assumed to be normally distributed, $N(0, \sigma^2 I_n)$. They consider a conceptual sample y_0 generated by the following model:

$$y_0 = XA\beta + u_0 \tag{3}$$

where A is a diagonal matrix with elements $(a_1, \dots, a_k), a_i \geq 0$ and u_0 is the $(N \times 1)$ error vector. The error u_0 is normally distributed as $N(0, \sigma^2 I_n / g)$ where $g > 0$. The posterior distribution based on the sample data and the diffuse prior density $p(\beta, \sigma) \propto 1/\sigma$ is defined as:

$$p(\beta, \sigma | y_0, X) \propto \frac{1}{\sigma^{n+1}} \exp \left\{ -\frac{g}{2\sigma^2} [vs_0^2 + (\beta - \hat{\beta})' AX' XA(\beta - \hat{\beta})] \right\} \tag{4}$$

where $vs_0^2 = (y_0 - XA\hat{\beta})'(y_0 - XA\hat{\beta})$, $v = n - k$

The estimated betas are calculated through:

$$\hat{\beta} = (AX'XA)^{-1}AX'y_0 \quad (5)$$

Now, it is important to point out that in Agliari and Pariseti (1988) the process involves two steps. First, we have to estimate the parameters $\hat{\beta}$ s; and second, we use the parameters to access the posterior distribution.

$$\begin{aligned} \beta_a &= E[\beta | y_0, X] = \hat{\beta} \\ \sigma_a^2 &= E[\sigma^2 | y_0, X] = g \frac{vs_0^2}{v-2} \end{aligned} \quad (6)$$

The equation (6) defines the prior estimator (β_a) as the estimator of the conceptual sample and the prior variance (σ_a^2), as a function of the degree of precision (g). Thus, the prior information is a transformation of the probability distribution function in equation (3).

$$p(\beta, \sigma) \propto \frac{1}{\sigma^{v+1}} \exp\left\{-\frac{(v-2)\sigma_a^2}{2\sigma^2}\right\} \frac{1}{\sigma^k} \exp\left\{-\frac{g}{2\sigma^2}(\beta - \beta_a)'AX'XA(\beta - \beta_a)\right\} \quad (7)$$

Finally, the posterior distribution function is proportional to the prior distribution

(7) and the likelihood function.

$$p(\beta, \sigma | y, X) \propto \frac{1}{\sigma^{n+v+1}} \exp\left\{-\frac{1}{\delta\sigma^2}(\beta - \beta_p)'(gAX'XA + X'X)(\beta - \beta_p)\right\} \quad (8)$$

$$\text{where } \frac{1}{\delta} = \frac{1}{2} \left\{ (v-2)\sigma_a^2 + vs_0^2 + (\hat{\beta} - \beta_a)' X' [X(gAX'XA + X'X)^{-1} X' + I]^{-1} X(\hat{\beta} - \beta_a) \right\}$$

The posterior betas are estimated as follow:

$$\beta_p = (gAX'XA + X'X)^{-1} (gAX'XA\beta_a + X'X\hat{\beta}) \quad (9)$$

The variance and covariance are, respectively:

$$E(\sigma^2 | y, X) = \frac{2}{\delta(v+n-2)} \quad (10)$$

$$Cov(\beta_p | y, X) = (gAX'XA + X'X)^{-1} \frac{2}{\delta(v+n-2)}$$

Figure 1 - Nominal Exchange Rate Variation and the Consumer Price Index in Brazil (1953-2007)

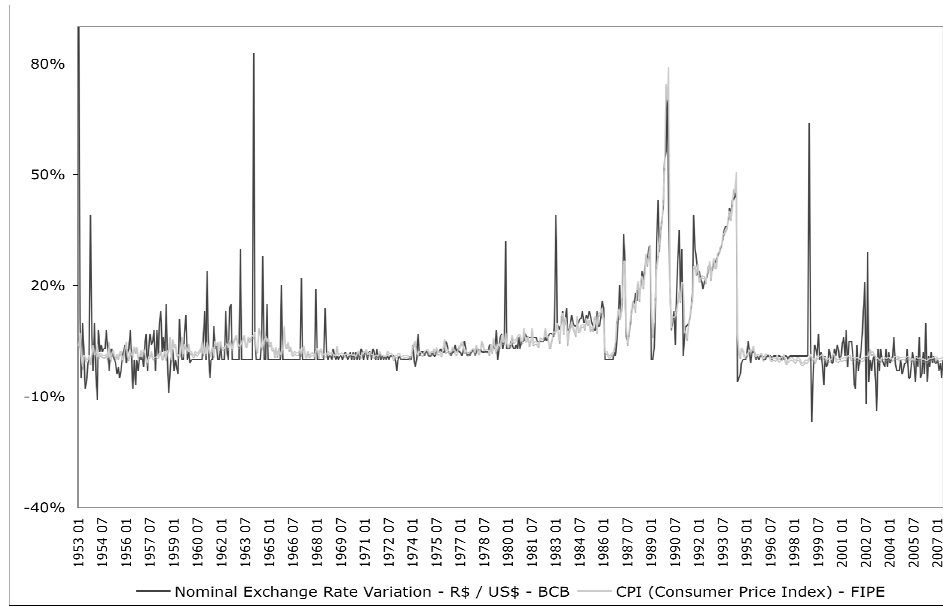


Figure 2: The Relationship between the Nominal Exchange Rate Variation and the Consumer Price Index in Brazil (1953-2007)

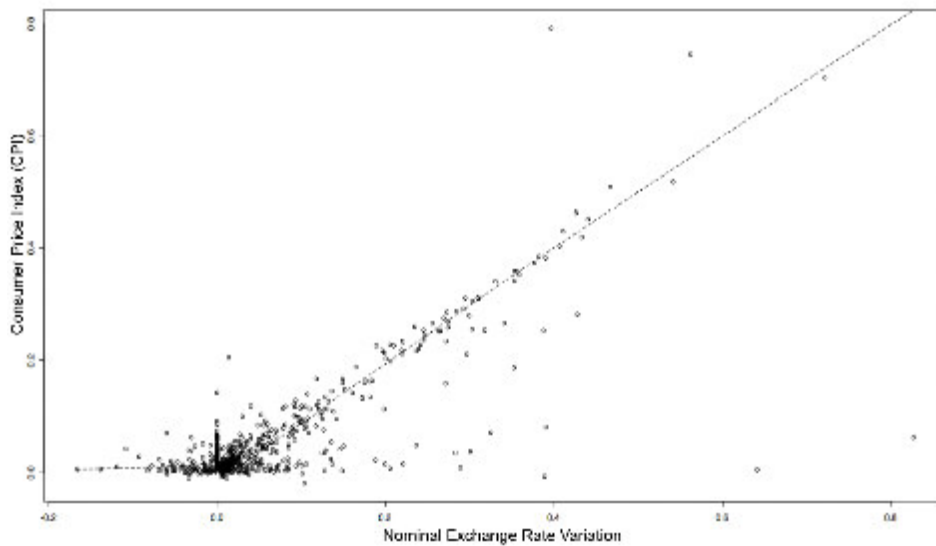


Figure 3: The Relationship between the Nominal Exchange Rate Variation and the Consumer Price Index in Brazil (1953-78 and 1996-2007)

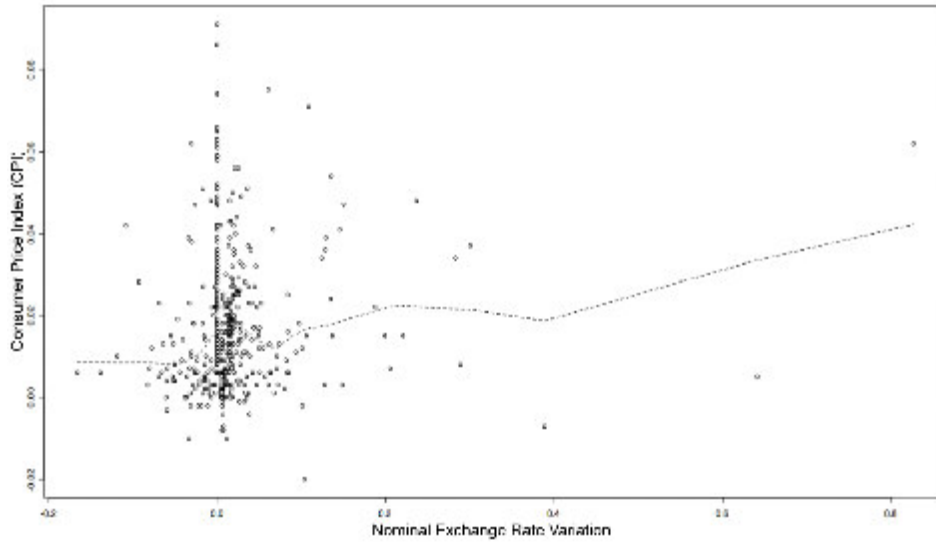


Figure 4: The Relationship between the Nominal Exchange Rate Variation and the Consumer Price Index in Brazil (1979-1995)

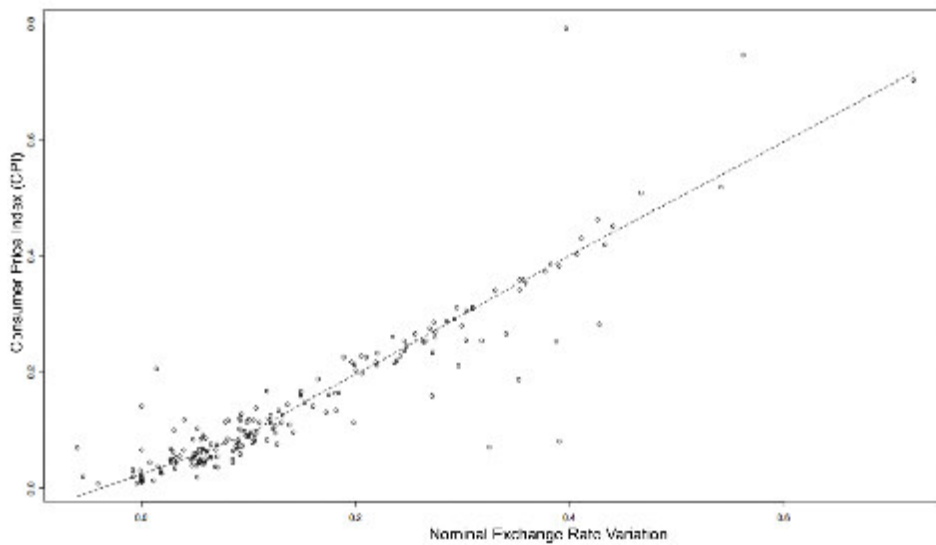
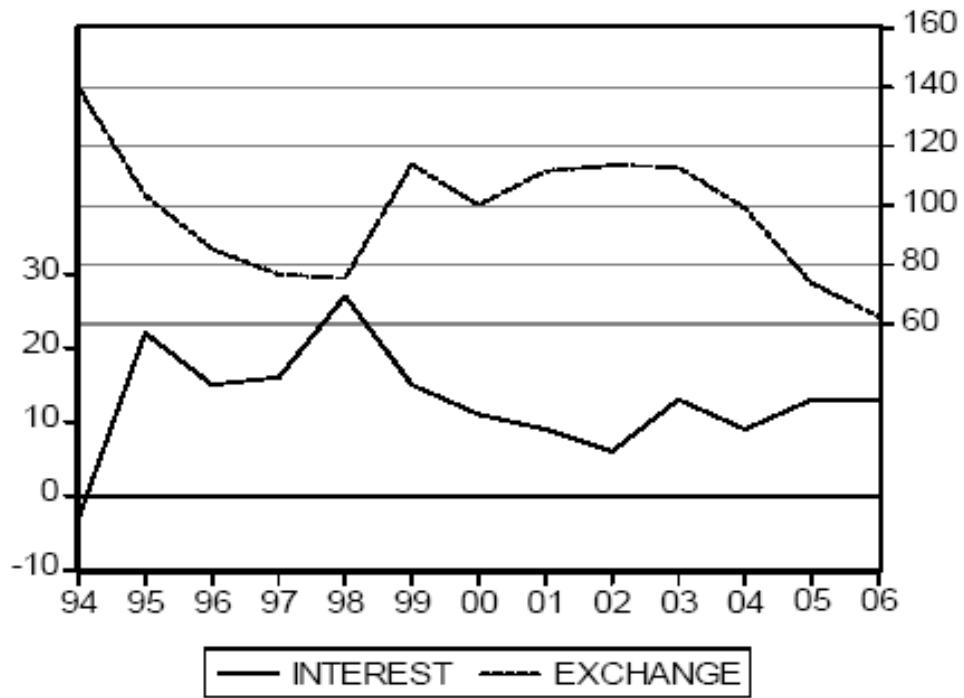


Figure 5: Real Exchange Rate and Real Interest Rate in Brazil (1994-2007)



Source: IPEA Data and Author's Calculations

Table 1: Exchange rate pass-through - Baqueiro *et al.* (2003)

Country and "type" of inflation		Sample period (months: 1-12; quarters: I-IV)		Pass-through coefficient
		From	To	
Australia	"High"	1979:I	1990:IV	1.27*
	"Low"	1991:I	2001:III	0.19
Canada	"High"	1976:01	1983:03	1.34*
	"Medium"	1983:04	1991:12	-0.51*
	"Low"	1992:01	2001:11	0.54*
Colombia	"High"	1994:03	1999:03	2.56*
	"Low"	1999:01	2001:12	0.77*
Czech Republic	"High"	1976:01	1998:12	0.61
	"Low"	1984:05	2001:12	-0.59*
Finland	"High"	1995:08	1984:04	1.02*
	"Low"	1998:07	2001:12	0.01
France	"High"	1976:01	1984:03	2.05*
	"Low"	1984:05	1998:12	-0.01
Hungary	"High"	1995:08	1998:06	1.03*
	"Low"	1998:07	2001:12	0.77*
Italy	"High"	1976:01	1984:01	2.09*
	"Low"	1984:02	1998:12	0.59*
Mexico	"High"	1996:10	1999:11	1.35*
	"Low"	1999:12	2002:06	-0.48
New Zealand	"High"	1979:I	1988:IV	1.98*
	"Low"	1989:I	2001:III	0.08
Norway	"High"	1976:01	1984:01	1.05*
	"Low"	1984:02	2001:12	0.25*
Peru	"High"	1994:04	1997:11	1.94*
	"Low"	1998:08	2001:12	0.70*
Poland	"High"	1995:07	1998:07	1.69*
	"Low"	1998:08	2001:12	-0.54*
Portugal	"High"	1984:09	1993:03	2.29*
	"Low"	1993:04	1998:12	1.36*
Spain	"High"	1976:01	1984:10	2.24*
	"Low"	1984:11	1998:12	1.61*
Sweden	"High"	1976:01	1993:12	1.41*
	"Low"	1994:01	2001:12	-0.36*

* Statistically significant at the 5% level

Table 2. Posterior means with:

$$\beta_{1a} = 0.0139, \beta_{2a} = 0.9090$$

a_1	a_2	β_{1p}	β_{2p}
10.0	10.0	0.0139	0.9002
5.0	5.0	0.0140	0.8749
1.0	1.0	0.0157	0.4666
0.1	0.1	0.0175	0.0329

Table 3. Posterior means with:

$$\beta_{1a} = 0.0139, \beta_{2a} = 0.9090$$

a_1	a_2	β_{1p}	β_{2p}
11.0	10.0	0.0139	0.9068
5.0	5.0	0.0140	0.9005
2.0	1.0	0.0158	0.7992
0.1	0.1	0.0177	0.6916
