# Exchange Rate Management: The Case of Brazil


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## RESUMO

*O artigo apresenta um problema de escolha do regime de taxa de câmbio numa estrutura geral de precificação de títulos. O governo é considerado o principal agente otimizador no modelo onde mudanças de regime podem ocorrer uma vez que o governo pode exercer poder discricionário na administração do câmbio. Estimativas empíricas para o Brasil sugerem que mudanças de regime são determinadas pelo comportamento dos salários e da inflação. De uma forma geral, os resultados sugerem que os fundamentos têm um impacto mais significante sobre a taxa de câmbio no curto prazo. Os efeitos das variáveis de demanda agregada no processo de determinação da taxa de câmbio só se manifestam no longo prazo.*



## PALAVRAS-CHAVE

*taxas de câmbio, modelos Probit, Brasil*



## ABSTRACT

*The paper develops an exchange rate regime choice problem in a general asset-pricing set-up. The government has been considered the main optimising agent in the model whereby regime switches may occur because the government can exercise discretion in exchange rate management. Empirical estimates for the case of Brazil suggest that regime switches are determined by the behaviour of wages and inflation. Overall, the results suggest that price fundamentals have a more significant impact on the exchange rate in the short run. It is not until the long run that domestic expenditure variables play a part in exchange rate determination.*



## KEY WORDS

*exchange rates, probit models, Brazil*

## *INTRODUTION*

The increase in exchange rate volatility and the co-existence of a wide range of exchange rate regimes prompted by the collapse of Bretton Woods after 1973 have given rise to a vast literature on exchange rate determination and regime choice in both developed and developing countries. Studies of optimal exchange rate regime choice have attempted to classify countries according to their exchange rate regime, ranging from fixed to perfectly floating, thereby encompassing a broad spectrum of imperfect floats. Such classification efforts are not without problems (see AGHEVLI *et alii,* 1991, for further discussion) and have been an impediment to more rigorous empirical cross-country comparative analysis, in a number of cases.

At the heart of the problem of choosing an adequate exchange rate regime are the relative merits of flexibility, as opposed to rigidity, in exchange rate management. Most developing countries, including transition economies, have since the early 1990s opted for less flexible exchange rate management with the increased use of the nominal (exchange rate) anchors in disinflation programmes. A fixed or firmly pegged exchange rate would, in principle, create a deflationary bias in monetary policy and provide credibility to policy-makers committed to disinflation. In the case of countries having experienced chronic lack of monetary discipline, and persistent high inflation and/or hyperinflation, a fixed exchange rate also allows for the import of stable inflation, as long as the country has comfortable international reserves, is sufficiently small, open and integrated to the world economy in terms of both trade and capital flows. (FRANKEL, 1996) In the case of transition economies, there is evidence that disinflation in a flexible exchange rate regime tends to be more contractionary and likely to fail than under a firmly pegged exchange rate. (SACHS, 1996) However, varying degrees of flexibility are recommended at different stages in the life cycle of disinflation and macroeconomic stabilisation programmes.

It is also known that, when some degree of flexibility prevails, as in the case of a crawling peg, a major difficulty in exchange rate management is targeting the nominal exchange rate so as to preserve long-term international competitiveness and current account balance. In other words, the exchange rate regime has to be good enough to prevent the exchange rate from deviating from underlying fundamentals. However, little work has been done on real, rather than nominal, exchange rate targeting. A regime switch or policy reversal may be needed in the presence of an adverse domestic or external shock, or if the exchange rate hits a certain critical level, beyond which the current regime may be seen as unsustainable. If a regime switch is needed, credibility may be lost, which may have a destabilising impact on macroeconomic stability. Policy-makers are therefore confronted with the task of identifying, not without great difficulty, an acceptable critical level of the nominal exchange rate, but also the appropriateness of a policy reversal.

Previous studies in the area have formalised the exchange rate management problem in two basic ways: in terms of non-linear inflation-unemployment and credibility-flexibility trade-offs (OZKAN AND SUTHERLAND, 1995; EDWARDS, 1996a) and in terms of state- and time-contingent choices in an asset-pricing set-up. (SUTHERLAND, 1995) In empirical studies, exchange rate regimes tend to be formalised in a binary fashion, either fixed or flexible, and probit analysis is used to estimate the likelihood of regime changes. (COLLINS,1996; EDWARDS, 1996b) This paper develops an exchange rate regime choice problem in a general asset-pricing set-up. The government is the main optimising agent in the model. Regime switches may occur because the government can exercise discretion in exchange rate management, which introduces a stochastic element in exchange rate management. Discretion may also be exercised in response to adverse shocks.

The paper is organised as follows. Section 1 contains the derivation of the theoretical model and the basic theoretical findings. Section 2 discusses the data and its statistical properties. In section 3 we establish the main variables to be used as the fundamentals governing the exchange rate determination process, and in section 4 we present the results of probit estimations. Finally, section 5 contains our concluding remarks.

## *1. THE MODEL*

This section develops a model to explain exchange rate regime switches as a result of the government's optimising behaviour. Let $e$ denote the exchange rate, defined as the domestic currency price of foreign currency. Let the country's exchange rate regime be characterised by a dirty peg such that exchange rate re-alignments are carried out in line with some deterministic rule defined as $f(e,t)$, where $t$ is time. Let the deterministic rule depend on a set of fundamentals, such as inflation and interest rate differentials in the domestic economy and abroad, changes in the domestic and foreign economic environments, income and expenditure variables, etc.[1]

1 FLOOD AND GARBER (1983) propose a model in which $e = f[k(t)]$, where $k$ is a control variable interpreted as a composite 'fundamental' measuring the effect on the exchange rate of money and income variables. Exchange rate regime switches can therefore be state-contingent. Time-contingent regime switches can be examined if the exchange rate is re-defined as $e = f[k(t),t]$, as in SUTHERLAND (1995).

Also, let there be a probability $\lambda$ that the government will exercise discretion in exchange rate determination, thereby departing from the exchange rate deterministic rule. Departures form the deterministic rule can also be attributed to adverse domestic and external shocks. The government can therefore exercise an "escape clause" in exchange rate management and a departure from the deterministic rule in exchange rate determination characterises a regime switch. Because discretion is exercised with probability $\lambda$, exchange rate determination is also governed by a stochastic element $h(e,t)dq$, where $q$ is a standard Brownian motion process with zero drift and unit variance. Let, in addition, $dq = u$, if $p(u) = \lambda dt$, and 0, otherwise.

Changes in the exchange rate are therefore defined as:

$$de = f(e,t)dt + h(e,t)dq . \qquad (1)$$

By equation (1), the exchange rate follows a deterministic path and has a stochastic component, which is a Poisson process with probability $\lambda$ of a regime switch. If the exchange rate deviates from the underlying deterministic rule, it becomes $e^D = e + h(e,t)u$. On the other hand, if there is no deviation from the deterministic rule, the exchange rate is defined as $e^R = e + f(e,t)dt$. In the absence of deviations from the deterministic path, the exchange rate regime gains credibility, which can be defined by a function $C(e^R,t)$. Let $C$ be an increasing function of $e^R$.

Overall, changes in the exchange rate regime are based on the government's policy choice problem, which consists of comparing two payoffs: one, if the current exchange rate regime is preserved and credibility is enhanced, and another, if it is allowed to deviate, due to discretion in policy-making or an accommodation of adverse shocks. The choice of whether the current exchange rate regime should be preserved or not depends on the government's perceived relative benefits of alternative regimes. Let the payoff to the government in the case of a regime change be $F(e^D,t)$ and, if the deterministic rule is preserved, the government's payoff is $F(e^R,t|e^D)$. The policy choice can be defined in function $F(e,t)$ such that:

$$F(e,t)=\max\{F(e^D,t),C(e^R,t)+\alpha E[F(e^R,t|e^D]\}, \tag{2}$$

where $E$ is the expectations operator conditional on information available at time $t$.

Parameter $\alpha$ in equation (2) is the government's rate of substitution between alternative exchange rate regimes. A low $\alpha$ means that the government is more indifferent between deviating from the deterministic rule (exercising discretion or accommodating a shock) and sticking to the current regime. Parameter $\alpha$ may also be interpreted as the political cost of regime reversals, which is, in this set-up, independent of the severity of the regime switch, or exchange rate re-alignment. The higher the political cost associated with a regime switch, the higher the parameter $\alpha$. An alternative interpretation of parameter $\alpha$ is the degree of temptation of the government to exercise discretion or to accommodate a shock, thereby promoting a policy reversal. If the political cost of exercising discretion is low and the government is indifferent between the two alternatives (low $\alpha$), then it is more tempted to allow deviations in exchange rate management.

By equation (2), the government chooses the highest payoff. In the absence of a regime switch, credibility is enhanced by $\alpha E[F(e^R,t|e^D]$. The higher the political cost associated with a regime switch (or, equivalently, the lower the rate of substitution between both policy options or the degree of temptation), the higher the term $\alpha E[F(e^R,t|e^D]$, which increases the second argument on the right-hand side of equation (2). In particular, $F(e,t)$ can be defined as a variable that measures the relative attractiveness of preserving the current exchange rate regime, as opposed to changing it. In other words, by equation (2), the government trades off the benefits of avoiding exchange rate disequilibria and of re-alignment, given the costs inherent in both options.

By equation (2), preserving the current exchange rate regime is optimal if:

$$F(e^D,t)<C(e^R,t)+\alpha\int F(e^R,t)d\Theta(e^R|e^D) \tag{3}$$

where $\Theta(e^R|e^D)$ is the cumulative probability distribution function of the exchange rate under the current regime rule, conditional on the exchange rate if the regime changes.

The opposite sign in equation (3) guarantees that the government's payoff is greatest if there is a change in the exchange rate regime. A fall in the political cost associated with a policy reversal, or equivalently, in the degree of temptation or the relative valuation of the current regime against alternative regimes increases the attractiveness of exercising an "escape clause" in exchange rate management. On the other hand, a low $\alpha$ (or a fall in $\alpha$), as in countries that have a bad reputation in exchange rate management, increases the relative weight of the credibility element in the second argument on the right-hand side of equation (2). This explains why countries with a reputation problem may choose to "tie their own hands", by sticking to the current regime as a means to boost credibility. As a result, a regime switch can be prevented not only due to reputational forces at work, but also due to the cost associated with a regime change. The immediate policy prescriptions to avoid a regime switch are hence raising the political cost of policy reversals, or equivalently, the relative valuation of the current regime as opposed to alternative regimes.

The important question is whether a critical exchange rate ( $e^*$ ) can be defined to prompt the government to change the current regime. This critical rate can be thought of as a trigger point at which it is optimal for the government to switch to an alternative regime. Consider the proposition below.

**Proposition**: Let there be a critical value $e^*$ of the exchange rate such that an exchange rate appreciation ( $e < e^*$ ) triggers an exchange rate regime shift.

**Proof**: Subtracting $F(e^D,t)$ from both sides of equation (3) yields:

$$\Psi(e^R,t) = C(e^R,t) + \alpha \int F(e^R,t) d\Theta(e^R|e^D) - F(e^D,t) > 0. \qquad (4)$$

Using equation (4), and letting $Z(e,t) = F(e,t) - F(e^D,t)$, equation (2) can be re-written as:

$$Z(e,t) = \max\{0, \Psi(e^R,t) + \alpha \int Z(e^R,t) d\Theta(e^R|e^D]\}. \qquad (5)$$

Assuming that (i) $\dfrac{\partial\Theta(e^R|e^D)}{\partial e^D} > 0$ and (ii) $\Psi(e^R,t)$ is a monotonically increasing function of $e$, the second argument in equation (5) is increasing. As in the analysis of optimal stopping problems in Dixit and Pindyck (1994),

$Z(e,t)$ is a contraction and its fixed-point solution, $e^*$, defines a critical exchange rate such that the second argument in equation (5) is positive if $e > e^*$, and negative, otherwise. Q.E.D.

The existence of a critical trigger point in exchange rate management can be further explored in more flexible exchange rate regimes. In a fixed exchange rate regime, the decision on a policy reversal depends on whether the exchange rate crosses the threshold defined by $e^*$. In the case of a crawling peg, the bands within which the exchange rate is allowed to float can be defined as confidence intervals around the critical trigger rate. The policy reversal decision is then defined in a wider interval of exchange rate, rather than just one threshold point, as in standard optimal stopping models.

The same reasoning applies in the case of exchange rate targeting, where the government determines how large an exchange rate disequilibrium has to be before a regime switch is triggered. The decision consists of defining a lower and an upper bound for the critical exchange rate, as in Gerlach (1995) and Ozkan and Sutherland (1995). One such situation is illustrated by an exchange rate regime whereby the rate of depreciation of the domestic currency is set by the government irrespective of the behaviour of prices in the domestic economy. An increase in domestic inflation would lead to the appreciation of the domestic currency, unless the exchange rate regime is altered. Exchange rate misalignments are to be avoided, given their detrimental impact on both internal and external balances, in terms of domestic output and employment, in the former case, and the current account, in the latter. Discretion would be characterised, in this case, by an unexpected increase in the rate of depreciation of the domestic currency. A critical or trigger exchange rate can therefore be defined as the highest acceptable value of the domestic currency relative to the foreign currency to which it is pegged. Reaching such a critical value prompts a regime switch.[2]

## 2. *DATA DESCRIPTION*

As for the Brazilian experience, Figure 1 illustrates the behaviour of the exchange rate since 1980. During most of the 1980s, Brazil maintained a policy of real

2 OZKAN AND SUTHERLAND (1995) analyse the choice of optimal trigger rates so that the government minimises interest rate-induced output volatility.

exchange rate targeting, whereby nominal adjustments to the exchange rate were made in line with inflation to preserve the real exchange rate from drastic swings. A major policy reversal occurred in 1983 due to the deterioration of the current account at the beginning of the debt crisis. A maxi-devaluation was implemented and the exchange rate was allowed to rise to give the country the competitive edge needed to generate successive trade surpluses capable of offsetting the deterioration of the current account. In the non-orthodox policy era in the post-1985 period, crawling peg slow-downs often characterised the aftermath of adjustment plans which were short-lived, given that the underlying fiscal imbalances were never satisfactorily eliminated. More recently, in the 1990s, a real appreciation of the domestic currency was the product of a less accommodating exchange rate policy, given the removal of the liquidity constraints of the 1980s and reinsertion of the country in international capital markets.[3]

*FIGURE 1- REAL EXCHANGE RATE - (JANUARY 1978 - JUNE 1994)*


An important preliminary step is to identify determinants of $f(e,t)$, in equation (1). There is nevertheless considerable controversy over the choice of fundamentals in exchange rate determination.[4] The variables to be chosen should

3 FERREIRA (1998, 1999), ROSSI (1995) and ZINI AND CATI (1993) have tested the purchasing power parity (ppp) hypothesis for the case of Brazil. FERREIRA (1998, 1999) has confirmed the validity of the monetary model to explain the process of exchange rate determination in Brazil using cointegration analysis. His results, which incorporate more recent data, conflict with those of ROSSI (1995) and ZINI AND CATI (1993), who have rejected the ppp hypothesis.

4 For further discussion, see EDWARDS (1989) AND YOTOPOULOS (1996).

embody the trade-offs envisaged by the government when solving its regime choice problem, and the fundamentals governing the deterministic element of the exchange rate. The literature on exchange rate determination (e.g., COLLINS, 1996; EDWARDS, 1996) suggests that the following variables could be used as fundamentals for the underlying process of exchange rate determination: consumer price inflation, capacity utilisation, real sales in manufacturing, nominal wages, industrial production, federal bond yields, the short-term interest rate, and the trade balance. All of these variables are considered on a monthly basis and in logarithmic form, including the exchange rate. The sources of the data are the *Central Bank of Brazil* (prices, interest rates and trade balance), the *Brazilian Statistical Bureau* - ***IBGE*** (wages, industrial production), and the *Federation of Industries of the State of São Paulo* - ***FIESP*** (sales, and capacity utilisation).

Preliminary time series analysis of the data was carried out examining the integration properties of the variables under consideration. In order to determine the appropriate lag length of each variable, we have followed a general-to-specific methodology, as in Ng and Perron (1995). Augmented Dickey-Fuller and Phillips-Perron unit root tests were then performed and the results are reported in Table 1. There is evidence that all variables are I(1), with the exception of the consumer price index for which there was mixed evidence as to the correct order of integration; while the traditional ADF test rejected the null of stationarity in favour of nonstationarity in the first difference, the Phillips and Perron test suggested stationarity in first differences. In line, however, with other empirical studies we have assumed that prices behave as an I(1) process for Brazil (see CATI *et alii,* 1999).

*TABLE 1 - UNIT ROOT TESTS ON THE 1ST DIFFERENCES OF VARIABLES*

| Variable | Phillips-Perron | Augmented Dickey-Fuller |
|---|---|---|
| Consumer Price Inflation | -4.43** | -2.79 |
| Capacity Utilisation | -5.85** | -3.80** |
| Total Sales | -13.77** | -4.04** |
| Real Exchange Rate | -11.40** | -4.30** |
| Wages | -10.62** | -11.81** |
| Industrial Production | -16.27** | -6.69** |
| Federal Bond Yield | -13.33** | -10.94** |
| Short-Term Interest Rate | -12.82** | -10.89** |
| Trade Balance | -20.62** | -4.044** |

## 3. EXCHANGE RATE DETERMINATION: THE FUNDAMENTALS

Equation (1) can be estimated as:

$$\Delta e_t = a + b\Delta X_t + v_t , \tag{5}$$

where $v$ is a white-noise disturbance term, and $X$ is a vector of fundamentals.

By equation (5), the stochastic component of equation (1), $h(e,t)dq$, can therefore be estimated as a residual in the process of exchange rate determination. However, this procedure depends on the variables chosen as the fundamentals governing the deterministic element of the exchange rate.

Since the choice of fundamentals is somewhat arbitrary, we start with the simplest case, which is to consider that the impact of fundamentals on the exchange rate is captured by a deterministic time trend. The result of the estimation is reported in the first column of Table 2 and suggests the existence of a negative time trend in the period under examination. The negative trend suggests a steady appreciation of the domestic currency. However, because a deterministic trend may not capture the dynamics of irregular or transitory and regular or permanent components of the exchange rate over time, we also experimented with a stochastic, rather than deterministic, trend. The technique consists of decomposing the time series into the sum of a random walk plus drift and a stationary component. (BEVERIDGE AND NELSON, 1981; ENDERS, 1995) The time series can therefore be decomposed into a stochastic trend and an irregular component. The best-fitting ARMA process used to model the permanent component of the exchange rate in the period 1978:1 to 1994:6 is as follows:

$$\Delta e_t = -0.003 + 0.20\Delta e_{t-1} + v_t , \tag{6}$$

$$(-1.471) \quad (2.795)$$

$$R^2 = 0.04 , \; SSR = 0.225 , \; Q(12) = 14.73(0.142) .$$

*TABLE 2 - EXCHANGE RATE DETERMINATION*

| Ind. Variables | Dependent Variable $e_t$ | $e_t$ | $\Delta e_t$ |
|---|---|---|---|
| Intercept | 4.68 | 1.91 | -0.002 |
| | (196.75) | (2.63) | (-0.357) |
| Time Trend | -0.004 | | |
| | (-21.09) | | |
| SR Interest Rate | | -0.11 | 0.02 |
| | | (-4.60) | (2.021) |
| Lagged SR Int. Rate | | | 0.02 |
| | | | (2.909) |
| Trade Balance | | 0.06 | 0.63 |
| (x $10^{-4}$) | | (2.774) | (1.568) |
| Cons. Price Inflation | | | -0.38 |
| | | | (-6.628) |
| Lagged Inflation | | -0.82 | 0.32 |
| | | (-4.231) | (5.481) |
| Capacity Utilisation | | 0.30 | |
| | | (2.242) | |
| Ind. Production | | | |
| Lagged Ind. Prod. | | 0.20 | |
| | | (1.940) | |
| Total Sales | | | |
| Lagged Total Sales | | 0.05 | |
| | | (4.063) | |
| Adj. $R^2$ | 0.69 | 0.65 | 0.18 |
| D.W. | 0.04 | 0.18 | 1.36 |
| AR1 | 649.94 | 149.64 | 5.247 |
| ARCH | 106.9 | 65.74 | 1.8235 |
| Normality | 4.7823 | 9.060 | 92.288 |
| Heteroscedasticity | 25.366 | 3.247 | 0.162 |
| RESET | 71.664 | 7.8452 | 0.834 |

Note: t-statistics in parenthesis.

The real exchange rate in Brazil (in first differences) is best described by an AR(1) process. The regular or permanent component of the autoregressive process above is decomposed by calculating $n$-step-ahead in-sample forecasts of the series for each observation in the sample, where $n$ is set arbitrarily equal to 20. The irregular or temporary component of the series is calculated as the difference between the actual observation at each time period and the fitted value of the successive forecasts. The latter are the stochastic portion of the trend. Motivation for the decomposition of the series as above is found in the argument that the impact of policy action on the real exchange rate is essentially transitory. (CALVO *et alii,* 1995) In this case, short-run deviations from a trend may be attributed largely to government action.

Given the unit root properties of the data, we proceed to estimate another two variants of equation (5). The first consists of estimating equation (5) in levels, and the second in first differences. In doing so, we estimate first a long-run relationship between the exchange rate and the fundamentals and, subsequently, a short-run relationship stemming from the common trend among the fundamentals. Because the fundamentals are I(1) processes, stationarity is reached after first differencing the series. The results of the estimations of the impact of the fundamentals on the exchange rate in the short and the long run are summarised in Table 3. In the short run, the exchange rate is affected by the domestic short-run interest rate and the inflation rate. In the long run, the exchange rate is also affected by the trade balance and by capacity utilisation. Our results suggest that price fundamentals have a more significant impact on the exchange rate in the short run. It is not until the long run that domestic expenditure variables play a part in exchange rate determination.[5]

Because we are interested in the residuals of the equations above, three different measures of the deviation of the exchange rate from a deterministic path can be identified. The three measures of deviation are shown in Figure 2. Overall, the deviations from the underlying fundamentals are in general lower in the long run (*ResLR*) than deviations from a long-run deterministic trend (*Restrd*). This is particularly true in the 1980s, but not in the 1990s, whereby suggesting that fundamentals play a more crucial role in exchange rate determination in periods of severe international liquidity constraints. When these constraints are less severe, the government can afford more latitude in exchange rate determination and hence more pronounced deviations are tolerated. As expected, by Figure 2, short-run deviations (*ResSR*) are much smaller than the other two measures of long-run deviation. In addition to the three measures above, we also use the irregular or temporary component of the exchange rate, calculated as a deviation from the stochastic, rather than deterministic, trend.[6] The deviations obtained using the decomposition technique described above are defined according to the data generating process and not to arbitrarily chosen fundamentals or deterministic processes.

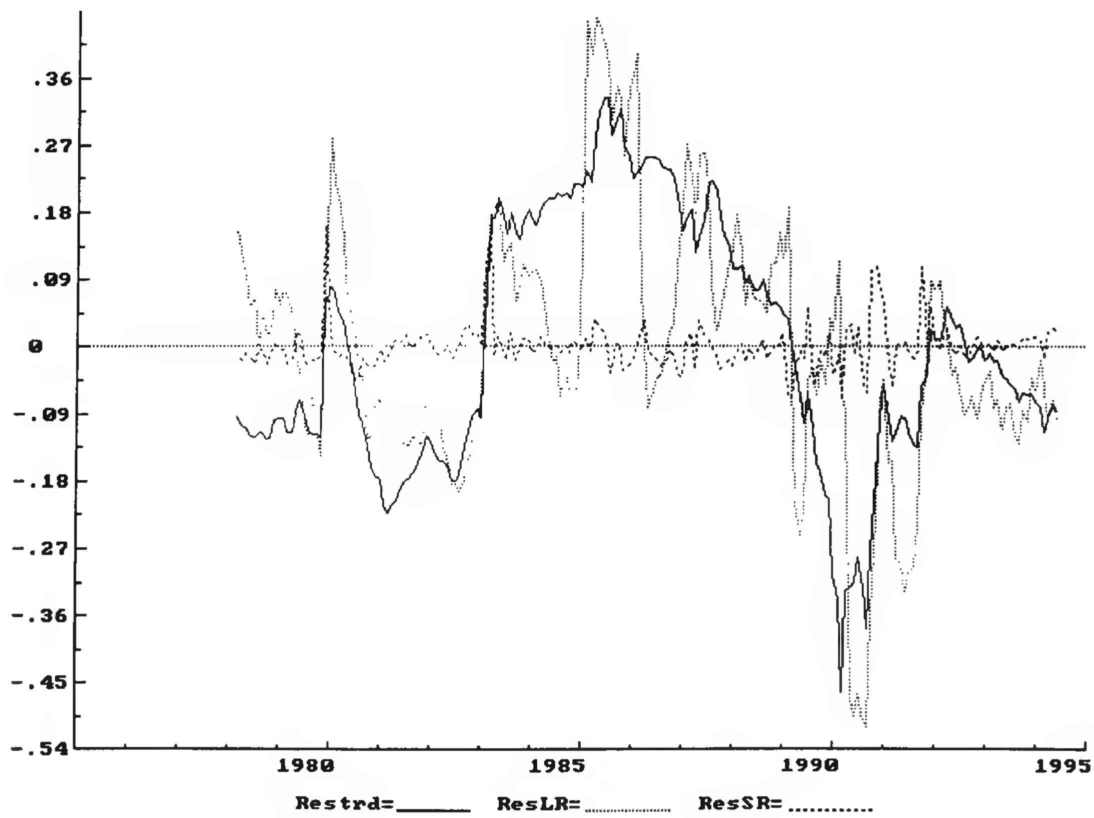
5 The latter confirms the results in CARNEIRO *et alii* (1997), where temporal causality tests suggest that the Brazilian trade balance is found to be more responsive to domestic expenditure than the exchange rate in the first half of the 1990s. FERREIRA (1993) also finds that changes in the exchange rate did not affect the trade balance in the period 1972:2/1989:1. In general, usual explanations for the results above rest on low price elasticities (THIRLWALL, 1988), such that the Marshall-Lerner condition fails, and/or relatively stable real exchange rates. The former does not seem to be the case in Brazil, whereas the latter is true for most of the 1980-92 period.

6 A more rigorous analysis of stationarity of the four residuals was performed using unit root tests. The results are available upon request.

*TABLE 3: PROBIT ESTIMATIONS - (dependent Variable: $Y_t$)*

| Explanatory Variables | Deviation from: Deterministic Trend | Stochastic Trend | Short-Run Fundamentals | Long-Run Fundamentals | |
|---|---|---|---|---|---|
| Intercept | -0.60 | -0.61 | -0.41 | -0.51 | 2.15 |
| | (-4.354) | (-4.370) | (-4.366) | (-4.288) | (0.561) |
| Deviation | 82.43 | 86.29 | 3.93 | 62.81 | |
| | (8.249) | (7.894) | (2.822) | (7.330) | |
| Lagged | -82.33 | 14.73 | -3.65 | -2.363 | |
| Deviation | (-8.197) | (3.284) | (-2.691) | (-0.523) | |
| Inflation | | | | | -10.38 |
| | | | | | (-3.487) |
| Lagged Inflation | | | | | 9.60 |
| | | | | | (3.048) |
| Wages | | | | | 5.30 |
| | | | | | (3.065) |
| Lagged Wages | | | | | -5.86 |
| | | | | | (-3.421) |
| Observations | 197 | 195 | 195 | 195 | 196 |
| Log. Likelihood | -53.54 | -52.49 | -121.12 | -74.95 | -111.27 |
| $R^2$ | 0.77 | 0.77 | 0.05 | 0.51 | 0.15 |
| % Correct Predictions | 0.95 | 0.95 | 0.68 | 0.85 | 0.74 |

*FIGURE 2 - DEVIATION FUNDAMENTALS 1978/1994:6*



## 4. PROBIT ESTIMATIONS

In this section, we estimate the following equation:

$$Y_t = \delta_0 + \delta_1 v_t + \varepsilon_t, \tag{7}$$

where $v$ is the residual of equation (5) and $\varepsilon$ is a white-noise disturbance term.

The latent variable ($Y_t$) in equation (7) measures changes in the exchange rate regime, defined as changes in the slope of the exchange rate path over time. The latent variable is constructed as follows: $Y_t = 0$, if $\frac{de}{dt} < 0$, and $Y_t = 1$, otherwise. Accordingly, the latent variable takes value 0 in the case of an appreciation of the domestic currency, and 1, in the case of a depreciation. A change in the slope of the exchange rate path can be deemed to occur at the critical values of the exchange rate ($e^*$) defined in Proposition 1. As a result, equation (7) estimates the likelihood of regime switches to come from deviations from the fundamentals governing exchange rate determination. These deviations can be the product of policy and/or exogenous shocks.

Because four different models were estimated using equation (5), the estimation of equation (7) benefits from some flexibility in the characterisation of deviations from deterministic fundamentals in equation (1). In the case where the fundamentals are captured by a deterministic time trend, the result of the equation (7) is satisfactory and provides broad support for the theoretical argument outlined in Section 2. There is little difference between the estimations based on deviations form a deterministic and a stochastic trend.[7] The same conclusion applies in the case of the deviations from the explicit fundamentals chosen above. Overall, in the four cases, deviations from fundamentals have a positive impact of the latent variable, whereby leading to a depreciation of the domestic currency. The depreciation may be due to adverse shocks or to changes in the exchange rate policy. The impact of lagged deviations is negative, irrespective of the measure used. The coefficient of the lagged deviation from long-run fundamentals is nevertheless not statistically significant at conventional levels. This finding confirms the intuition of no lagged responses to deviations, once long-run equilibrium is achieved.

7 It is not surprising that the results are similar with deterministic and stochastic trends. This is because the exchange rate is best described as an AR(1) process in the period under examination. Should the exchange rate follow a more complex process, as in a MA($q$) or combined ARMA($p$,$q$) process, the irregular component in the series would be subject to more complex unobservable dynamics.

To assess the robustness of the fundamentals chosen above, we estimated an alternative probit model as follows:

$$Y_t = \zeta_0 + \zeta_1 X_t + \omega_t, \tag{8}$$

where $X$ is the vector of fundamentals and $\omega$ is a white-noise disturbance term.

By equation (8), regime switches are explained directly by fundamentals, and not indirectly, by the stochastic component in exchange rate determination, defined as deviations from fundamentals, as above. The result of the estimation is reported in the last column of Table 3. Accordingly, regime switches are determined by the behaviour of wages and inflation. The variables are correctly signed, indicating that an increase in lagged inflation leads to a depreciation of the domestic currency. The converse is true in the case of wage increases. As for the contemporaneous impact of wages and inflation, an increase in the former and a fall in the latter lead to an appreciation of the domestic currency.

Most importantly, the results above lend empirical support to a broad class of theoretical models built upon the dynamic relationship between prices, wages and the exchange rate. (OZKAN AND SUTHERLAND, 1995; EDWARDS, 1996b) In those models, it is frequently postulated that wage changes are indexed to inflation and exchange rate movements or, equivalently, that the inflation rate depends on the rate of depreciation of the domestic currency and the rate of change in wages. This class of models yields a dynamic trade-off between unemployment and inflation, which underlies the problem of exchange rate determination, in general, and the choice of exchange rate regime, in particular. The inflation-unemployment trade-off is mirrored by a credibility-flexibility trade-off in intertemporal policy making, as far as the choice of the exchange rate regime is concerned.

## *5. CONCLUSION*

Previous studies have formalised the exchange rate management problem in two basic ways: in terms of non-linear inflation-unemployment and credibility-flexibility trade-offs (OZKAN AND SUTHERLAND, 1995; EDWARDS, 1996a) and in terms of state- and time-contingent choices in an asset-pricing set-up. (SUTHERLAND, 1995) In this paper, we have developed an exchange rate regime choice problem in a general asset-pricing set-up. The government has been considered the main optimising agent in the model whereby regime switches may occur because the government can exercise discretion in exchange rate management.

In the empirical part of the paper, we have first established the fundamentals of the underlying exchange rate determination process. In line with recent studies (COLLINS, 1996; EDWARDS, 1996a) these were defined as the short-run interest rate on public bonds, the trade balance, the consumer price inflation, capacity utilisation, industrial production and real sales. In the short run, it has been found that the exchange rate is affected by the domestic short-run interest rate and the inflation rate. In the long run, the exchange rate is also affected by the trade balance and by capacity utilisation.

In a later stage, we estimated a Probit model to investigate the likelihood of changes in the exchange rate regime for a given change in the fundamentals governing exchange rate determination. The Probit estimations have shown that there is little difference between the estimations based on deviations from a deterministic and a stochastic trend. Overall, the results suggest that price fundamentals have a more significant impact on the exchange rate in the short run. It is not until the long run that domestic expenditure variables play a part in exchange rate determination. Regime switches are therefore largely determined by the behaviour of wages and inflation; an increase in lagged inflation leads to a depreciation of the domestic currency while the converse is true for wage increases.

Because very little work has been done on real, rather than nominal, exchange rate targeting, the paper also attempts to fill the analytical gap in the literature by looking into the experience of Brazil. Broadening the sample of countries would shed more light on the theoretical issue under examination and allow more solid conclusions on the grounds of robust empirical regularities in different country experiences with exchange rate targeting.

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