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Cyclical Fluctuations in Brazil's Real Exchange Rate: The Role of Domestic and External Factors

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Abstract

This paper examines the effects of capital inflows and domestic factors on Brazil's real exchange rate. It describes the analytical framework, and then estimates a near-VAR model linking capital flows, interest rate differentials, government spending, money-base velocity, and the temporary component of the real exchange rate (TCRER). Generalized variance decompositions indicate that world interest rate shocks largely explain medium-term fluctuations in capital flows and the TCRER. Generalized impulse response functions show that a reduction in the world interest rate (and, to a lesser extent, an increase in government spending) have significant effects on the TCRER and capital flows.

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Contents

SUMMARY

The paper examines the links between capital inflows and the real exchange rate in Brazil. The first part presents the analytical background. The second part estimates a vector autoregression model linking capital inflows, the interest rate differential, government spending, money-base velocity, and the temporary component of the real exchange rate, calculated with the Beveridge-Nelson technique.

The model is estimated using monthly data for the period 1988–95. Variance decompositions suggest that, in the short run, fluctuations in capital inflows are driven almost exclusively by their own historical innovations; in the longer run, shocks to the world interest rate play a more substantial role. Fluctuations in the temporary component of the real exchange rate are also associated mostly with their own historical innovations at short forecasting horizons, and with world interest rate shocks at longer horizons.

The analysis of impulse response functions indicates that a permanent reduction in the world interest rate leads almost immediately to an increase in the interest rate differential, a capital inflow, and an appreciation of the temporary component of the real exchange rate. Although there appears to be some cyclical movement in the interest rate differential in subsequent months, movements in capital inflows and the cyclical component of the real exchange rate display considerable persistence. A temporary increase in government spending leads to a significant reduction in the interest rate differential on impact, and with some lag, to a small but significant inflow of capital (which again shows some degree of persistence over time) and a short-lived appreciation of the temporary component of the real exchange rate. These results are broadly consistent with the predictions of the analytical framework.

I. INTRODUCTION

The potentially adverse effect of large capital inflows on domestic inflation and the real exchange rate (as well as, ultimately, the current account) has been one of the main concern of policymakers in developing countries and transition economies in recent years. As argued in a number of recent studies, the composition of capital flows, the degree of price stickiness and the degree of nominal exchange rate flexibility have been important factors in determining the effect of capital inflows on domestic macroeconomic outcomes. In countries where capital inflows have taken the form of portfolio investment (as opposed to foreign direct investment), they have often been associated with an increase in consumption rather than investment. In turn, the increase in consumption has often taken the form of a large increase in expenditure on nontradable goods, thereby leading to a real appreciation. In countries where a fixed (or predetermined) exchange rate has been used as a nominal anchor to reduce inflation (as was the case in Argentina, for instance), inertial factors have led to upward pressure on prices of nontraded goods and have led to a real appreciation.[2]

Brazil's experience in the early 1990s provides an interesting case to study the effects of capital inflows and macroeconomic policy response on the real exchange rate.[3] Large net outflows were recorded in the 1980s, reflecting both the uncertainty associated with the "stop and go" approach to stabilization as well as the restrictions on access to world capital markets that the country faced in the aftermath of the debt crisis. In the early 1990s (as shown in Figure 1) Brazil recorded a surge in inflows, reflecting partly the fact that interest rate differentials became highly favorable to domestic currency denominated assets, and partly changes in the institutional environment.[4] Immediately after the introduction of the Real Plan in mid 1994, capital inflows increased sharply. They fell substantially in early 1995, in the aftermath of the Mexican peso crisis. Capital inflows—in the form of both portfolio investment and foreign direct investment—resumed in the second half of 1995, as confidence in the exchange rate band system increased. Gross international reserves rose to record levels as of end-1995. In part because this increase posed problems for monetary management, the authorities took measures to limit capital inflows on several occasions

[2] See Agénor and Hoffmaister (1996) and Calvo, Leiderman and Reinhart (1996) for a discussion of these issues.

[3] See Cardoso (1997) for a detailed overview of macroeconomic policy (and responses to capital inflows) in Brazil in recent years.

[4] Restrictions on access of foreign institutional investors to domestic stock markets were lifted in 1991, and the limits on portfolio composition and the minimum holding period for investments were abolished. At the same time, the authorities approved the issuance of debentures convertible into stocks in domestic enterprises. In mid 1992, foreign financial institutions (mutual funds, investment companies, and institutional investors) were authorized to operate in the options and futures markets for securities, foreign exchange, and interest rates.

during the past four years, as summarized in Table 1—with a limited degree of effectiveness (Garcia and Barcinski, 1996).

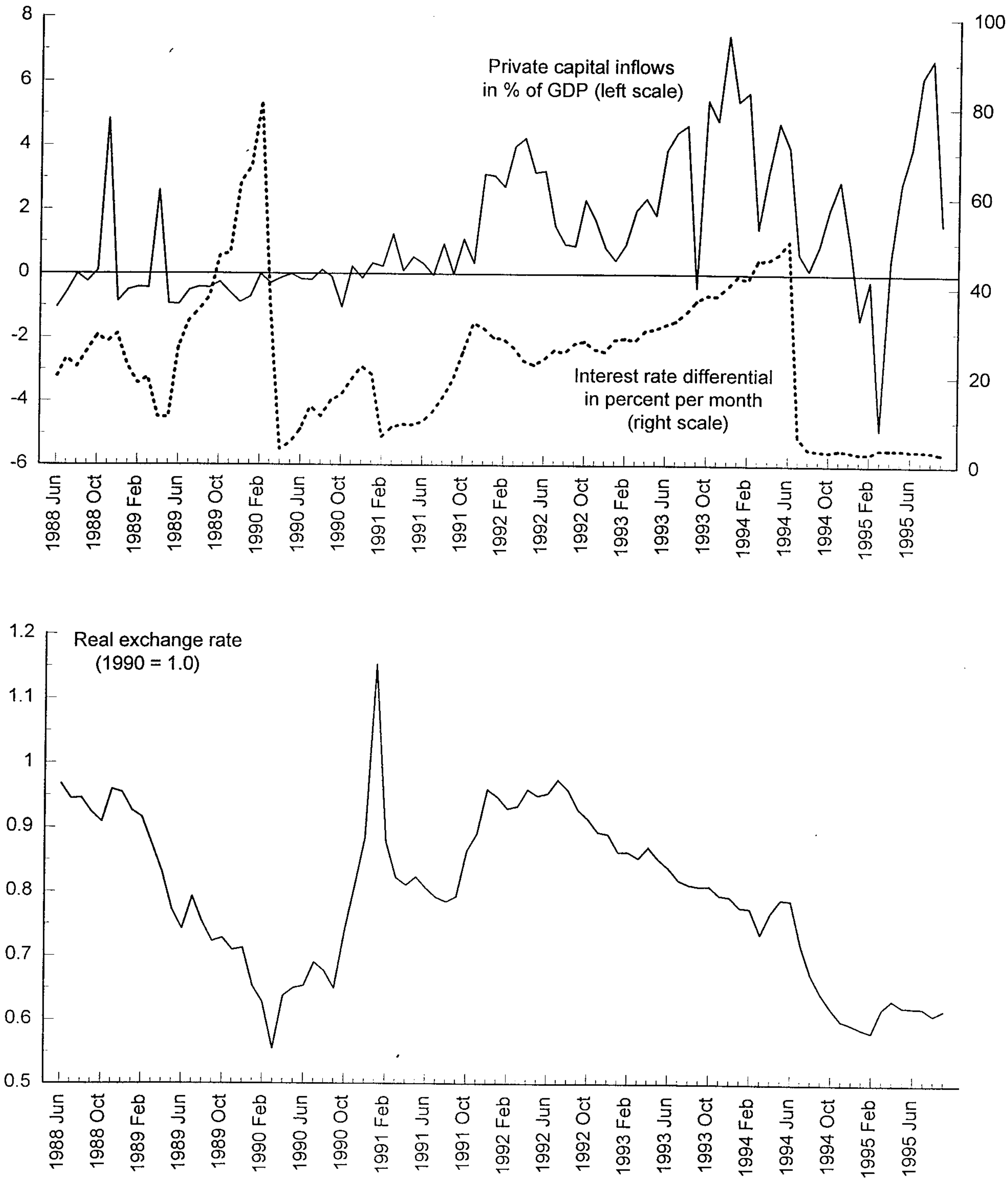
The behavior of the real exchange rate during the recent inflows episode is illustrated in Figure 1. In addition to potential effects of capital flows, changes in exchange rate policy have also been important. For most of the second half of the 1980s, Brazil had a relatively flexible exchange rate policy; but under the heterodox stabilization programs of the late 1980s, however, the domestic currency was temporarily fixed in terms of the U.S. dollar or adjusted by less than past inflation. These policies brought about a marked appreciation of the exchange rate, as illustrated in Figure 1. After a devaluation of the domestic currency in late 1991, exchange rate management aimed at maintaining the exchange rate stable in real terms. In the context of the Real Plan, the authorities introduced on July 1, 1994 a new currency, the real, with a floating exchange rate subject to a floor of R$1 per U.S. dollar. The real appreciated rapidly vis-à-vis the U.S. dollar, both in nominal and real terms. Following the Mexican peso crisis, the authorities introduced exchange rate bands in early March 1995, and have maintained that policy ever since.[5]

This paper provides a quantitative analysis of the effects of capital flows (as well as domestic factors) on the short-run fluctuations in Brazil's real exchange rate in the early 1990s. The importance of assessing these effects is well illustrated in the recent literature on capital inflows (see Agénor and Hoffmaister, 1996). The magnitude of the inflows recorded by Brazil (as well as several other developing countries) in recent years, and the fears that they could be subject to abrupt reversal, have raised concerns among policymakers regarding their capacity to contain monetary and credit expansion, control inflation, and most importantly avoid a real exchange rate appreciation and a deterioration in the external current account.

Section II provides the analytical background for our analysis of the effects of domestic (namely, an increase in government spending) and external (namely, a reduction in the world interest rate) shocks on capital flows and the real exchange rate. Section III estimates a near-VAR model linking capital inflows, interest rate differentials, government spending, money-base velocity, and the transitory component of the real exchange rate. Generalized variance decompositions are used to assess the relative importance of various factors in explaining fluctuations in the temporary (or cyclical) component of the real exchange rate. The effects of temporary shocks to

[5]The initial band was set at R$0.86-R$0.90 per U.S. dollar and was to be effective through May 1, 1995. However, because of the uncertainty about the exchange rate policy that would be adopted after that date, severe exchange market pressures developed. On March 10, 1995 the authorities set the band at R$0.88-R$0.93 per U.S. dollar and announced that it would be effective for an indefinite period. The exchange rate band subsequently was modified on June 22, 1995 to R$0.91-R$0.99 per U.S. dollar, on January 30, 1996 to R$0.97-R$1.06 per U.S. dollar, and on February 18, 1997 to R$1.05-R$1.14 per U.S. dollar.

Figure 1
Brazil: Private Capital Inflows, Interest Rate Differential
and the Real Exchange Rate



Notes: The interest rate differential is measured as the difference between the overnight interest rate in Brazil minus the 90-day U.S. T-bill rate and the ex post, one-month ahead rate of depreciation of the domestic currency-U.S. dollar exchange rate. In the lower panel, a rise is a depreciation.

Table 1

Brazil: Main Changes in Capital Controls, 1993-95

• *August 1993*: Foreign investment in fixed income securities was restricted to a newly created fund of fixed income instruments (*Fundo de Renda Fixa-Capital Estrangeiro*) subject to the interest rate equalization tax (*imposto sobre operações financeiras*) of 5 percent. In October 1994, the authorities raised the interest rate equalization tax from 3 percent to 7 percent on new issues of bonds abroad and from 5 percent to 9 percent on new foreign investment in fixed-income instruments; introduced a tax of 1 percent on new foreign investment in the stock market; lowered the maximum maturity of anticipatory export settlements from 180 days to 150 days for small exporters and from 180 days to 90 days for large exporters; lengthened the minimum maturity of bank lending of foreign resources (*Resolução 63*) from 90 days to 540 days; and prohibited the anticipated payment for export operations.

• *January 1995*: In response to the large capital outflows recorded immediately after the Mexican peso crisis, the authorities eliminated the marginal reserve requirement on anticipatory export settlements, rescinded the measure of October 1994 on the maximum maturity for such financing, and reinstated the anticipated payments for export operations with a minimum term of 360 days.

• *March 1995*: The increases in the interest rate equalization tax adopted in October 1994 were reversed, the required minimum maturity period for foreign borrowing was reduced, and the prepayment of foreign loans was prohibited.

• *August 1995*: To limit capital inflows, the authorities reintroduced the interest rate equalization tax at a rate of 5 percent on foreign currency borrowing, increased this tax on foreign investments in fixed income funds from 5 percent to 7 percent, and established this tax at 7 percent on interbank operations between financial institutions in Brazil and abroad.

• *September 1995*: Differentiated interest rate equalization tax rates were set for financial loans with different maturities (with low rates for financial loans with long maturities).

government spending and the "world" interest rate (proxied by U.S. interest rates) are also assessed using generalized impulse response functions. The concluding section summarizes the main results of the paper and discusses the policy implications of the analysis.

II. ANALYTICAL BACKGROUND

A useful background framework for our empirical analysis of the effects of domestic and external shocks on capital flows and the real exchange rate in Brazil is the intertemporal optimizing model developed by Agénor (1997), which is summarized in Appendix I. The model considers an open economy in which four types of agents operate: households, producers, the government, and the central bank. The nominal exchange rate E (defined as the home-currency price of foreign currency) is devalued at the constant rate ε.[6]

Households supply labor inelastically, consume both traded and nontraded goods, and hold two categories of financial assets in their portfolios: domestic money (which bears no interest) and domestic government bonds. They also borrow on world capital markets. Real financial wealth, a, is thus given by

$$a = m + b - l^*, \tag{1}$$

where m denotes real money balances, b real holdings of government bonds, and l^* net borrowing from abroad. m, b and l^* are all measured in terms of the price of the consumption basket.

Consumption decisions follow a two-step process: households first determine the optimal level of total consumption, and then allocate that amount between consumption of the two goods. The total cost of borrowing faced by households on world capital markets $i^* + \theta$ consists of the sum of a risk-free interest rate i^* and an endogenous premium θ, which is positively related to the outstanding level of foreign-currency debt of the household and some exogenous factors—reflecting, for instance, market sentiment.[7] Optimality conditions yield (see Appendix I):

- a money demand function, m^d, which is positively related to consumption and negatively to the domestic nominal interest rate;

[6] The assumption of a predetermined exchange rate is not, of course, a completely adequate characterization of Brazil's exchange rate policy in the past few years, as discussed in the introduction. However, it offers a reasonable approximation.

[7] This assumption is based on the existence of *individual* default risk. See Agénor (1997) for a detailed discussion.

- a demand function for foreign loans, L^* (measured in foreign-curreny terms), which is inversely related to the difference between the domestic interest rate, i, and the sum of the risk-free rate on world capital markets and the devaluation rate, $i^* + \varepsilon$; and
- a dynamic equation for consumption c, which shows that total consumption rises or falls depending on whether the domestic real interest rate exceeds or falls below the rate of time preference.

The second stage of the consumption decision process yields the demand for traded and nontraded goods, c_T and c_N:

$$c_N = \delta z^{1-\delta} c, \quad c_T = (1-\delta) z^{-\delta} c, \tag{2}$$

where $0 < \delta < 1$ is the share of expenditure on nontraded goods, and z the real exchange rate—the relative price of traded goods in terms of home goods. The consumer price index P is

$$P = P_N^{\delta} E^{1-\delta}, \tag{3}$$

where P_N (E) denotes the price of the home (traded) good, from which the inflation rate is derived.[8]

The economy produces both traded and nontraded goods, using capital and homogeneous labor. The capital stock in each sector is fixed, and labor is perfectly mobile across sectors. Technology for the production of both traded and nontraded goods is characterized by decreasing returns to labor. Labor demand is derived from the first-order conditions for profit maximization, and the equilibrium condition of the labor market determines the product wage in the traded good sector—which is negatively related to the real exchange rate. Supply of traded (nontraded) goods y_T^s (y_N^s) is positively (negatively) related to the real exchange rate:

$$y_T^s = y_T^s(\overset{+}{z}), \quad y_N^s = y_N^s(\overset{-}{z}). \tag{4}$$

The central bank defends the prevailing exchange rate by converting at no cost domestic money into foreign money, and vice versa. There is no credit to other agents in the economy, so that the real stock of high-powered money m^s is equal to the central bank's stock of net foreign assets measured in foreign currency terms, R^*:

$$m^s = z^{\delta} R^*. \tag{5}$$

Real profits of the central bank (interest and capital gains on its holdings of foreign assets) are transferred to the government, which consumes only home goods in

[8]The world price of the traded good is normalized to unity.

quantity g_N. The government balances its budget by levying lump-sum taxes τ (in real terms) on households:

$$\tau = z^{\delta-1} g_N - (i^* + \varepsilon) z^{\delta} R^*. \tag{6}$$

Finally, the model specifies equilibrium conditions for the home goods market

$$y_N^s = \delta z^{1-\delta} c + g_N, \tag{7}$$

and the money market:

$$m^s = m^d, \tag{8}$$

with the latter condition solved for the market-clearing interest rate.

The behavior of the economy over time can be described by a first-order differential equation system involving two variables: private consumption (which can jump on impact) and net external debt $D = L^* - R^*$, measured in foreign currency terms, which evolves gradually over time, and is given by:

$$\dot{D} = i^* D + \theta L^* + (1-\delta) z^{-\delta} c - y_T^s, \tag{9}$$

where the expression on the left-hand side is the sum of the trade balance $(c_T - y_T^s)$ and the services account $(i^* D + \theta L^*)$.

As shown in Appendix I, in the steady state the overall inflation rate and the rate of inflation in the price of home goods are equal to the devaluation rate, the real interest rate is equal to the rate of time preference, and the current account is in equilibrium. Net private indebtedness is positive as long as the pure rate of time preference of domestic private agents is greater than the foreign risk-free interest rate.[9]

In this setting, a permanent increase in government spending on home goods (financed by an increase in lump-sum taxes) has no long-term effect on the domestic nominal interest rate, which remains equal to the rate of time preference plus world inflation (see equation (A15) in Appendix I). It also has no long-run effect on foreign borrowing by the private sector, which depends (as indicated by equation (A16)) only on the difference between the world real interest rate and the rate of time preference. At the initial level of the real exchange rate, private consumption must fall to maintain equilibrium of the market for nontraded goods. Real money balances must therefore fall, as shown by (A17), since domestic interest rates do not change. The reduction in private consumption is proportionally less than the increase in government expenditure, so that total domestic spending on home goods rises and the real exchange rate

[9]Put differently, domestic households are net borrowers in the steady state if they value the present sufficiently.

appreciates to maintain equilibrium in the home goods market. Although the real appreciation tends to reduce output of traded goods, the trade balance surplus (which matches the initial deficit of the services account) must rise to maintain external balance—since the economy's stock of debt D increases, and the services account balance deteriorates. This increase in debt results from the fact that net foreign assets held by the central bank R^* (and thus the money supply) must fall to accommodate the reduction in the demand for real money balances, and from the fact that holdings of foreign assets by the private sector, L^*, do not change.

On impact, since the increase in government spending raises households' lifetime tax liability and thus reduces their lifetime wealth, private consumption falls immediately—to an extent that depends on the degree of intertemporal substitution. But the real exchange rate may now either appreciate or depreciate—depending on whether total spending on nontraded goods rises or falls. If the degree of intertemporal substitution in consumption is low, private consumption will change relatively little on impact, and total spending will increase—thereby leading to an appreciation of the real exchange rate on impact.

With a temporary increase in government spending, the adjustment path depends on the duration of the shock. Suppose that the degree of intertemporal substitution is sufficiently small, and that the shock is of a sufficiently long duration. Private consumption will again drop on impact and continue to fall for a while, and start rising subsequently.[10] The real exchange rate appreciates on impact, and depreciates gradually afterward. It then begins to appreciate (in line with the increase in consumption), until the moment government spending returns to its pre-shock level. At that point in time, a discrete depreciation occurs. Throughout the interval of time during which the level of government spending increases, the current account remains in deficit and the economy's external debt rises continuously. After the shock is reversed, the current account moves into surplus, and the external debt falls over time.

Consider now a permanent reduction in the world risk-free interest rate, i^*.[11] The long-run effects are a reduction in consumption, a depreciation of the real exchange rate, and an increase in foreign debt (a reduction in net holdings of foreign assets).[12] The initial effect of the reduction in the cost of borrowing on world capital markets, as can be inferred from equation (A16) in Appendix I, is an increase in private foreign

[10]Because the shock is known to be temporary, the optimal response for households is to reduce consumption on impact by less than they would if the shock was permanent.

[11]As discussed in Agénor (1996, 1997), many economists have attributed the surge in capital inflows to developing countries in the early 1990s to a cyclical reduction in interest rates in major industrial countries.

[12]The analysis here focuses on the case where the country considered is a net debtor in the initial steady state ($\tilde{D} > 0$); this assumption appears to fit better the case of Brazil. Agénor (1996) considers the case of a net creditor country.

indebtedness. A reduction in i^* has two types of partial effects: on the one hand, at the initial level of the economy's stock of foreign debt, it lowers interest payments; on the other, since the increase in private foreign borrowing raises the premium-related component $\theta\tilde{L}^*$, it tends to increase interest payments to foreign creditors. Assuming that the former effect dominates the latter, the services account tends to improve. Second, since the economy's stock of debt also increases, debt service at the initial risk-free rate tends also to increase. it can be shown that the second effect tends to dominate, so that the net effect is a deterioration of the services account. Thus, to maintain external balance in the long run, the initial trade surplus must increase. Consumption must therefore fall. This leads to a depreciation of the real exchange rate, which in turn stimulates output of traded goods and further improves the trade balance. Since the nominal interest rate remains constant, real money balances—and thus official reserves—fall also (see equation (A17) of Appendix I). With foreign borrowing by private agents increasing, and net foreign assets held by the central bank falling, the economy's external debt unambiguously rises.

On impact, a permanent reduction in the world interest raises private spending and leads to an appreciation of the real exchange rate. The reason is that wealth and intertemporal effects associated with this shock operate in the same direction: the reduction in i^* not only encourages agents to save less and consume more today (the intertemporal effect), but it also lowers the debt burden and generates a positive wealth effect. Although the trade balance and the services account move in opposite direction (the former deteriorates, whereas the latter improves), the net effect is a current account deficit on impact—and thus an increase in external debt.

For a temporary reduction in the world interest rate, again, the expected duration of the shock matters for the adjustment path. Consider first the case where the period of time during which i^* falls is sufficiently large. Consumption will jump upward on impact and fall continuously—until the shock is removed. The real exchange depreciates gradually, following an initial step appreciation. The current account moves into deficit during the first phase of the transition process; however, the depreciation of the currency and the reduction in consumption lead progressively to a restoration of external balance; afterward, the economy generates a current account surplus, and the stock of debt declines continuously over time, until the initial equilibrium point E is reached.

Suppose now that the length of time during which the world risk-free interest rate falls is relatively short. As before, there is an initial upward jump in consumption and a real appreciation. Consumption then starts falling. Throughout the period during which i^* falls, the economy registers a current account surplus, that is, a reduction in external debt. After the shock is removed, the stock of debt begins rising over time. Intuitively, if the duration of the shock is sufficiently long, agents have an incentive to substitute intertemporally and increase consumption; the negative effect on the trade balance in that case outweighs the positive effect on the services account, so that the current account moves into deficit and external debt increases. By contrast, if the reduction in the world interest rate is expected to be short-lived, agents will not adjust their consumption path by much; the improvement in the services account will therefore outweigh the deterioration in the trade balance, and the current account will move into surplus—with external debt falling.

III. EMPIRICAL EVIDENCE

This section presents empirical evidence for Brazil of the size and importance of the links discussed above. The analysis is based on a near-vector autoregression (near-VAR) model that captures the key relationships emphasized in the analytical model.[13] We begin by discussing the near-VAR model and the generalized VAR analysis used in this study. We then examine the variance decompositions and the impulse responses to two key shocks: *a*) a decline in the world interest rate, and *b*) an increase of government spending.

A. Near-VAR Model

The specific variables included in the near-VAR model are private capital inflows as a proportion of aggregate output (denoted *ky*), changes in the uncovered interest rate differential ($\Delta idiff$), government spending as a proportion of aggregate output (*gy*), money-based velocity (*veloc*), the change in the "world" interest rate (Δi^*), and the temporary component of the real exchange rate (TCRER). To decompose the real exchange rate into a nonstationary (trend) component and a stationary one, the technique used here is the Beveridge-Nelson (BN) approach, as described in Appendix II.

The near-VAR model allows us to treat *gy* and Δi^* as block exogenous variables in the system. This treatment is consistent with the idea that *gy* is a policy variable that the authorities control and with the fact that world interest rates (Δi^*) are unlikely to be affected by domestic policies in Brazil. The endogenous block of the near-VAR consists therefore of *ky*, $\Delta idiff$, *veloc* and, TCRER. Precise definitions of all

[13] Our methodology is described in more detail in Agénor and Hoffmaister (1996). See Hamilton (1994) for a general discussion of the VAR methodology.

the variables, their time-series properties,[14] and the statistical adequacy of the near-VAR model are discussed in Appendix II.

In line with the analytical model described in the previous section, where the stock demand of foreign assets is related to the level of the interest rate differential, we relate changes in the interest rate differential to capital flows in the empirical model. This specification of the empirical model is consistent with the fact that these series have a unit-root as discussed in Appendix II.

The focus on the TCRER in this study is mostly motivated by the assumption that, in line with the analytical framework described in the previous section, it is the stock of net foreign assets, rather than change in this stock (capital flows), that affect the trend (or equilibrium) value of the real exchange rate. The temporary component can be interpreted as transitory deviations for its equilibrium path resulting from short-term cyclical and speculative factors. We also note that our focus is due to the fact that it would seem overambitious to try to identify *long-run* equilibrium movements of the real exchange rate given the short time span covered by the available data.

The empirical specification captures the key features of the theoretical framework, namely, the view that capital movements respond not only to external factors (such as Δi^*) but also to changes in domestic macroeconomic conditions (such as *veloc* and *gy*). The addition of money-based velocity plays the role of a control variable, meant to capture the indirect effects of changes in the money supply on capital flows through their impact on domestic interest rates.

The near-VAR model was estimated using monthly data over the period 1988:M6 through 1995:M9. The results presented in this paper are based on a model with five lags; the lag selection is discussed in Appendix III. In addition to seasonal dummies to control for seasonality, the near-VAR model included two dummy variables to control for the Real Plan (with a value of 1 from 1994:M7 onward) and for the "Tequila" effect that affected Brazil during the first quarter of 1995. These dummies have very small impact on the empirical results described below, but are nonetheless statistically significant.

[14] Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were employed (see Dickey and Rosanna, 1994). The results of these tests—based on a unit-root null versus a trend-stationary alternative—are reported in Table A1. Both test statistics give similar results. The evidence supports the assumption that the variables in the model are stationary.

B. Generalized VAR Analysis

The near-VAR model was used to variance decompositions and impulse response functions in a "generalized" VAR framework, as proposed by Koop, Pesaran, and Potter (1996). An attractive feature of this approach is that it does not suffer from the "compositional effect" inherent in standard VAR analysis. As is well known, variance decompositions and impulse response functions derived from standard VAR analysis, depend on the ordering of the variables used to obtain the orthogonal shocks.[15] This dependence reflects the fact that changing the ordering changes the implicit linear combination of the VAR innovations used to obtain the orthogonal shock, that is, changing the ordering changes the "composition" of the orthogonal shock.

Generalized VAR analysis is based on re-thinking what is to be "recovered" from the estimated VAR (or near-VAR) model. Consider impulse responses. Typically a VAR is subjected to an orthogonal shock, and the impulse responses trace out the dynamic response of the model to that shock. Note that implicitly these impulse responses compare the evolution of the model following the shock to a baseline model not subject to the shock. Generalized impulse responses (GIR) build upon this idea and propose to look instead at a "typical" historical shock. GIR compares the "average" dynamic responses of the model given a "typical" historical shock and the history of the model, compared to the "average" baseline model not subject to the shock given the history of the model. Specifically, GIR compares the conditional expectation of a variable in the model given an arbitrary current shock v_t and history ω_t, to the conditional expectation of that variable given history:

$$GIR(x_{t+k}, v_t, \omega_t) = E[X_{t+k} \mid v_t, \omega_t] - E[X_{t+k} \mid \omega_t].$$

It is important to note that since the GIR captures the historically-observed information regarding shocks in the data, it does not pretend to recover the responses to a "pure" world interest rate shock. Likewise, the generalized variance decompositions (GVD) measure does not pretend to measure the percentage of the variance attributed to "pure" shocks, and hence would not typically add up to 100 percent.

[15] Analysts that conduct so-called "atheoretical" empirical investigations frequently note that their results are robust to the ordering used. However, robustness to different orderings does not guarantee that standard VAR analysis has succeeded in recovering economically meaningful shocks. See Keating (1996) for a full discussion of this issue.

C. Generalized Variance Decompositions

Table 2 presents the GVD for the main endogenous variables, namely $\Delta idiff$, ky and TCRER. At very short forecasting horizons movements of $\Delta idiff$ are mostly associated with its own historical innovations, and with the historical innovations of *veloc*. As the forecasting horizon increases, however, the importance of historical innovations of gy increase and explain about 22 percent of the movements of $\Delta idiff$. It is interesting to note that historical innovations associated with Δi^* appear to have a small role in explaining movements of $\Delta idiff$. These results suggest that monetary factors dominate the very short-run movements of *idiff* and that the importance of these factors diminishes in the "medium run" where fiscal policy appears to play a substantive role in explaining these movements.

The GVD for ky suggests that its movements at short forecasting horizons is driven almost exclusively by its own historical innovations. As the forecasting horizon increases, the importance of historical innovations associated with gy rise to about 10 percent. Interestingly, the evidence suggests a large role for external factors, that is, Δi^*, in explaining movements in ky. These results suggest that movements in capital inflows are mostly due to their own historical shocks, although movements in world interest rates appear to play a role in the "medium" term. Our results confirm the importance of external (push) factors in determining movements in capital flows. This is line with some the available evidence, which suggests that the surge in capital flows to developing countries since the early 1990s was associated with "external" factors (see Calvo, Leiderman, and Reinhart, 1996).

The GVD for the TCRER suggests that its movements at short forecasting horizons are mostly associated with its own historical innovations. As the forecasting horizon increases to six months the historical innovations associated with Δi^* explain about 20 percent of the movements of the TCRER. Interestingly enough, the evidence suggests that historical innovations associated with external factors (Δi^*) appear to explain a large part of the movements of the TCRER in the medium term. Nonetheless, more than half of the movements of the TCRER are associated with its own innovations in the medium-term.[16]

[16]Evidence in support of a larger effect of government spending shocks on the real exchange rate for Brazil is provided by Hoffmaister and Roldós (1996). Note, however, that their results are not inconsistent with those obtained here, since they do not focus on the temporary component of the real exchange rate.

Table 2. Generalized Variance Decomposition

Months	Percentage of the variance associated with historical shocks to:					
	Δi*	Δidiff	TCRER	ky	gy	Veloc.
			Δidiff			
1	2.7	100.0	0.3	6.9	1.0	21.0
3	6.6	81.1	9.3	5.9	5.2	20.6
6	7.4	63.6	7.0	5.6	21.8	18.2
12	8.1	60.1	6.8	6.9	22.6	18.0
24	9.9	58.8	6.9	6.9	22.2	17.7
			ky			
1	0.3	6.9	1.0	100.0	2.0	2.9
3	2.3	16.6	2.4	91.2	1.4	3.6
6	19.0	19.1	2.8	70.3	5.1	5.0
12	30.8	20.0	3.0	57.2	8.0	5.0
24	37.8	19.5	3.0	50.1	9.0	4.7
			TCRER			
1	3.4	0.3	100.0	2.6	0.2	0.2
3	5.2	1.8	90.8	4.0	1.4	2.1
6	20.6	5.1	67.3	4.0	5.0	4.8
12	21.5	7.0	59.6	7.1	6.2	5.4
24	26.2	8.0	54.8	7.8	6.1	5.3

Note: Based on the estimated near-VAR model discussed in the text. The percentage of the variance attributed to the historical shocks do not necessarily add up to 100.

D. Generalized Impulse Responses

Figure 2 contains the GIR for the change in the interest rate differential, the capital inflows-GDP ratio, and the TCRER. One-standard error bands for each variable are also shown.[17] We consider in turn a shock to the "world" interest rate, and a shock to the government spending-output ratio.

Interest rate shock

A temporary (one-period only) reduction in Δi^*—that is, a *permanent* decline in i^*—leads on impact (and with a one-month lag) to a significant increase in the interest rate differential, a capital inflow, and an appreciation of the TCRER.[18] Although there appears to be some cyclical movement in the interest rate differential in subsequent months, movements in capital inflows and the TCRER display considerable persistence: the inflow of capital continues to rise, and the TCRER continues to appreciate, four months after the shock. Thereafter both variables return slowly to their baseline values; moreover, these movements remain significant throughout the adjustment period.

How do these results compare with the predictions of the analytical framework described above? The response of capital movements and the (temporary component of the) real exchange rate is consistent with the qualitative implications of the model. The reduction in the rate of return on foreign assets leads, on impact, to a reallocation of private agents' portfolios towards domestic assets. With agents being initially net debtors, the reduction in the world interest rate exerts a positive wealth effect; at the same time, it reduces the incentive to save. As a result of both factors, consumption rises, thereby exerting upward pressure on the relative price of nontraded goods.[19]

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[17] In all figures the dotted lines for the GIRs show one standard error band in each direction and are based on 1000 Monte Carlo replications. In each replication we sample the near-VAR coefficients and the covariance matrix from their posterior distribution. From these replications we calculate the square root of the mean squared deviation from the impulse response in each direction. By construction these bands contain the impulse response function but are not necessarily symmetric. See Kloek and VanDijk (1978) for details of the posterior distributions.

[18] Throughout this discussion a "significant" change means that the interval defined by the error bands does not contain the value zero. Note that in the figure, the immediate impact of the change in Δi^* is not significant in this sense.

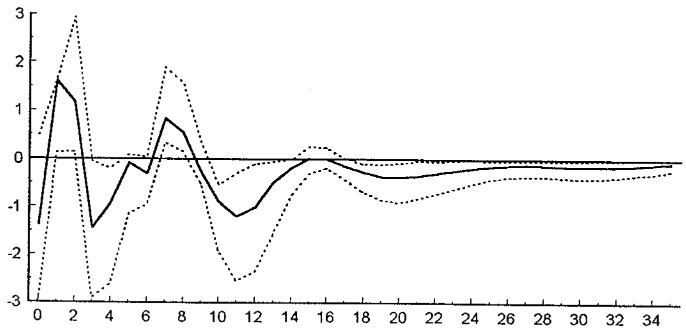
[19] The persistence effects of the shock could be related, for instance, to price inertia in the nontradable goods sector or to adjustment costs involved in changing the allocation of assets. Such factors were not explicitly considered in discussing the analytical framework.

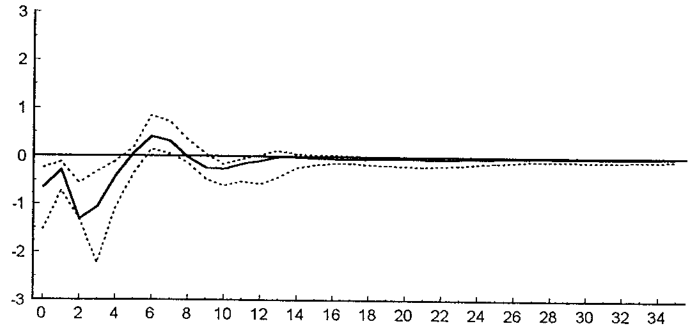
Generalized Impulse Responses

Negative Shock to Δi^*

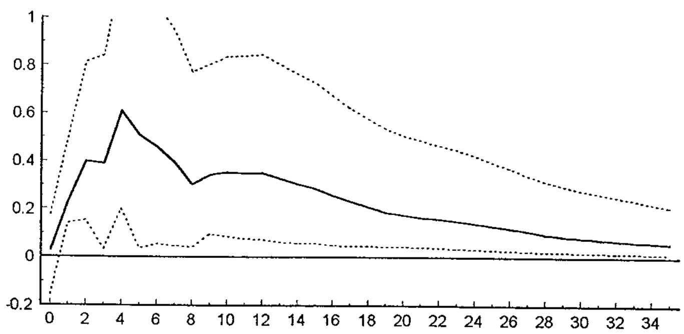
Positive Shock to gy

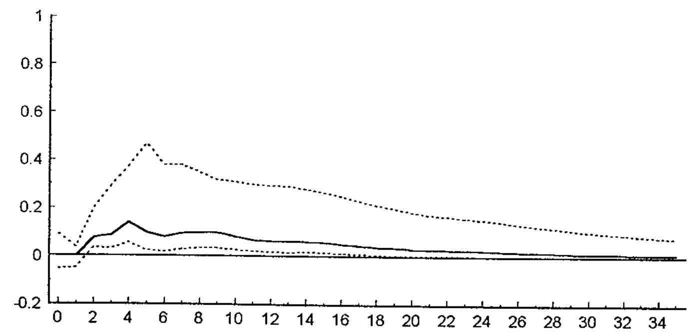
Δidiff



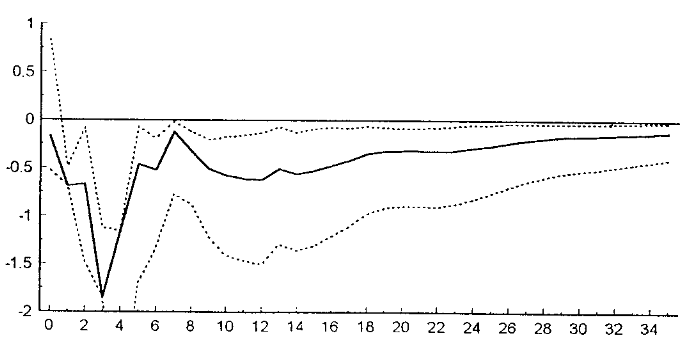


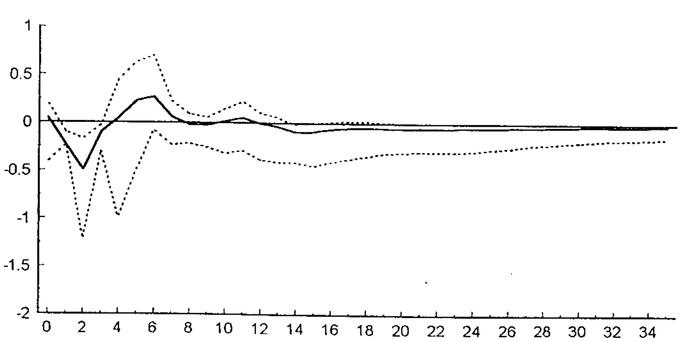
ky





TCRER
(a rise is a depreciation)





Government spending shock

A temporary increase in *gy* leads on impact to a significant reduction in the interest rate differential, with no immediate apparent movement in capital flows or the TCRER. However, the subsequent increase in the interest rate differential (between the second and sixth months after the shock) is accompanied by a small but significant inflow of capital and a short-lived appreciation of the TCRER. Capital flows show again some degree of persistence, but the TCRER does not.

The empirical evidence on the effects of an increase in government spending (which can be viewed as falling mostly on nontraded goods) can also be rationalized in terms of the model described earlier. The lack of response of the TCRER to the increase in *gy* on impact, and the subsequent small and short-lived response, may reflect an offsetting effect in private consumption. As previously emphasized, the response of private expenditure on impact depends on agents' propensity to smooth their consumption path over time. What these results may imply, therefore, is that there could be some (albeit small) degree of intertemporal substitution.[20] This implication of the results does not appear to be inconsistent with the available evidence for other Latin American countries (see Agénor and Montiel, 1996, Chapter 10).

The significant drop in the interest rate differential on impact is also consistent with the predictions of the model: at the initial level of the real money stock, a fall in private consumption requires a fall in the domestic interest rate to maintain equilibrium of the domestic money market. Private capital inflows appear to respond with a two-month delay.

IV. SUMMARY AND CONCLUSIONS

The purpose of this paper has been to examine the links between capital inflows and the real exchange rate in Brazil. The first part presented the analytical background, consisting of a two-sector intertemporal optimizing model of an economy in which agents face imperfect world capital markets. A key feature of the model is the interaction between domestic interest rates (determined through the equilibrium condition of the money market), private foreign borrowing, consumption decisions, and the real exchange rate. The second part estimated a near-vector autoregression model

[20]Note that in the analytical model the response of the real exchange rate depends also on the sensitivity of the supply of nontraded goods to changes in relative prices. Thus, in principle, even with a very low degree of intertemporal substiution (and thus almost no movement in private consumption), the increase in supply of home goods can offset the effect of a rise in government spending on relative prices.

linking capital inflows, the interest rate differential, government spending, money-base velocity, and the temporary component of the real exchange rate, calculated with the Beveridge-Nelson technique.

The model was estimated using monthly data for the period 1988-95. Variance decompositions suggest that in the short run, fluctuations in the interest rate differential are associated with domestic monetary factors; at longer horizons, government spending plays a larger role. Fluctuations in capital inflows are driven almost exclusively by their own historical innovations, at short forecasting horizons. In the longer run, shocks to the world interest rate play a substantial role. Fluctuations in the TCRER are also associated mostly with its own historical innovations at short forecasting horizons, and with world interest rate shocks at longer horizons.

The analysis of impulse response functions indicates that a permanent reduction in the world interest rate leads almost immediately to an increase in the interest rate differential, a capital inflow, and an appreciation of the TCRER. Although there appears to be some cyclical movement in the interest rate differential in subsequent months, movements in capital inflows and the TCRER display considerable persistence. A temporary increase in government spending leads to a significant reduction in the interest rate differential on impact, and with some lag, to a small but significant inflow of capital (which again shows some degree of persistence over time) and a short-lived appreciation of the TCRER.

We caution, however, that care is needed when interpreting these results as the high frequency data used, in particular capital inflows and government spending, are not without caveats. High frequency data for short-term credit lines are not available and thus our measure of net private capital inflows is not as comprehensive as we would have liked. In principle we could have incorporated these flows by interpolating the annual short-term credit. We are, however, apprehensive about using mechanical methods because little high frequency information could be gained by "smoothing" this highly volatile series and using a related series (the world interest rate, for instance) for interpolation introduces information favoring a particular hypothesis (in this case, changes in world interest rates). Regarding government spending data, those available to us refer to expenditure on a cash basis and cover outlays by the federal government only. The problems of mismatching the moment when the expenditures are accrued and the moment when the expenditures are recorded become more evident with higher frequency data.[21]

While it is impossible to know with certainty how these data limitations affect

[21] Moreover, the process of de-centralization of fiscal expenditures, that has intensified in recent years introduces a systematic and increasing understatement of expenditures that tends to obscure the actual impact that government expenditures has on the economy.

our results, we speculate that had high frequency data on short-time credit lines been available the impact of world interest rates would have been even more pronounced. This is because a decline in world interest rates, by reducing the cost of short-term borrowing, would tend to reinforce net capital flows to Brazil. It is also possible that the important role of world interest rates in explaining capital inflows in the medium and long term would be reinforced and perhaps extended to the short run as well. We are less clear, however, how our results might be affected by using a more comprehensive measure of government outlays.

Analytical Framework

In addition to (1)-(8), the model can be summarized by the following equations:[22]

$$\dot{a} = y + ib - c - \tau - (i^* + \theta)l^* - \varepsilon l^* - \pi a, \tag{A1}$$

$$\int_0^\infty \left\{ \frac{c^{1-\eta}}{1-\eta} + \chi \frac{m^{1-\phi}}{1-\phi} \right\} e^{-\rho t} dt, \quad \rho, \chi > 0, \quad \eta, \phi \neq 1. \tag{A2}$$

$$m^d = m^d(\overset{+}{c}, \overset{-}{i}), \tag{A3}$$

$$L^* = (i - i^* - \varepsilon)/\gamma, \tag{A4}$$

$$\dot{c}/c = \sigma(r - \rho), \tag{A5}$$

$$P = P_N^\delta E^{1-\delta} \Rightarrow \pi = \varepsilon - \delta \dot{z}/z, \quad 0 < \delta < 1 \tag{A6}$$

$$y_h = y_h(n_h), \quad y_h' > 0, \; y_h'' < 0, \quad h = N, T \tag{A7}$$

$$n_T^d(w_T) + n_N^d(z w_T) = n^s \Rightarrow w_T = w_T(\bar{z}), \; |w_T'| < 1. \tag{A8}$$

$$m^d = m^s \Rightarrow i = i(\overset{+}{c}, \overset{-}{m}). \tag{A9}$$

[22] Except otherwise indicated, partial derivatives are denoted by corresponding subscripts, while the total derivative of a function of a single argument is denoted by a prime. A sign over a variable refers to the sign of the corresponding partial derivative. Also, by definition, $\dot{x} \equiv dx/dt$.

a, m, b and l^* are defined in the text. Specifically, $l^* \equiv EL^*/P$, where E is the nominal exchange rate, P the price of the consumption basket, and L^* foreign borrowing measured in foreign-currency terms. Equation (A1) is the flow budget constraint, with y denoting net factor income (derived below), and c, τ defined in the text, i the domestic nominal interest rate, and π the domestic inflation rate. The term $-\pi a$ accounts for capital losses on total wealth resulting from inflation, and $-\varepsilon l^*$ the capital loss resulting from the increase in the domestic-currency value of foreign-currency liabilities due to exchange rate depreciation ($\varepsilon \equiv \dot{E}/E$). The household-specific world interest rate is $i^* + \theta$, with $\theta = \theta(L^*, \cdot)$, with $\theta_{L^*} > 0$.

Equation (A2) is the representative household's discounted lifetime utility, where ρ denotes the constant rate of time preference. Equations (A3), (A4), and (A5) are derived by maximizing (A2) subject to (1) and (A1). Equation (A3) is the money demand function, and is derived by equating the marginal rate of substitution between consumption and real money balances to the opportunity cost of holding money, the domestic nominal interest rate. Equation (A4), where $\gamma = 2\theta_{L^*}$, shows that private foreign borrowing is inversely related to the difference between the domestic interest rate and the sum of the risk-free rate on world capital markets and the devaluation rate. Equation (A5) is the Euler equation which shows that total consumption rises or falls depending on whether the domestic real interest rate (equal to $r = i - \pi$) exceeds or falls below the rate of time preference. $\sigma = 1/\eta$ is the intertemporal elasticity of substitution.

Equation (2) in the text is derived from the second stage of the consumption decision process, whereby the household maximizes a Cobb-Douglas sub-utility function subject to the static budget constraint on total expenditure Pc. Equation (A6) is derived from (3).

Equations (A7), where y_h denotes output of good h (with $h = N, T$), and n_h the quantity of labor employed in sector h, define the production functions. Equation (A8) is the equilibrium condition of the labor market, with the labor demand functions n_T^d and n_N^d derived from the first-order conditions for profit maximization; n^s denotes the (exogenous) supply of labor, w_T is the product wage in the traded goods sector. with perfect wage flexibility, this equation can be solved for w_T, which is negatively related to the real exchange rate. Using this result and the labor demand functions—and noting that $d(zw_T)/dz > 0$—yields the sectoral supply functions (4). Finally, equation (A9) is the equilibrium condition of the money market—which can be solved for the domestic nominal interest rate.

Substituting equations (1), (5), (6) and (7) in (A1), and noting that real factor income y is given by $z^{\delta-1}(y_N + zy_T)$, yields

$$\dot{R}^* - \dot{L}^* = i^*(R^* - L^*) + \theta(L^*, \cdot)L^* + y_T^s - c_T, \tag{A10}$$

which represents the consolidated budget constraint of the economy. From (2) and (7), the short-run equilibrium real exchange rate is obtained as

$$z = z(\bar{c}; \bar{g_N}). \tag{A11}$$

Let $D = L^* - R^*$ denote and net external debt measured in foreign currency terms. The model can be summarized by

$$L^* = [i(c, m) - i^* - \varepsilon]/\gamma, \tag{A12}$$

$$\dot{c}/c = \sigma[i(c, m) - \varepsilon + \delta\dot{z}/z - \rho], \tag{A13}$$

$$m = z^\delta R^* = z^\delta(L^* - D), \tag{A14}$$

together with equations (9) and (A11); equation (6) determines residually lump-sum taxes. The model can be further condensed into a first-order differential equation system involving c (which is a jump variable) and D, which evolves gradually over time (see Agénor, 1997).

The steady-state solution of this system is obtained by setting $\dot{c} = \dot{D} = 0$. From equation (A3), $\tilde{\pi} = \pi_N = \varepsilon$. From equation (A5),

$$\tilde{r} = \tilde{i} - \varepsilon = \rho \Rightarrow \tilde{i} = \rho + \varepsilon. \tag{A15}$$

Substituting this result in (A12) yields

$$\tilde{L}^* = (\rho - i^*)/\gamma, \tag{A16}$$

and from (A3) and (A15):

$$\tilde{m} = m(\tilde{c}, \rho + \varepsilon). \tag{A17}$$

Agénor (1996, 1997) establishes the short- and long-run effects of a reduction in i^* and an increase in g_N.

Data Sources and Unit Root Tests

The data used in this study are at a monthly frequency and cover the period 1988:M1 to 1995:M10. The variables are measured as follows.

lzc is the temporary component of the real exchange rate. The raw series corresponds to the real effective exchange rate, obtained from the IMF. *lzc* is the residual series, as explained in Appendix III.

ky is the ratio of net private capital inflows to nominal GDP. The data on net capital inflows were provided by the Brazilian authorities, and comprise net direct investment, net portfolio investment (equity and debt securities) and net private loans (intercompany loans, commercial paper, bonds, notes and bank loans). It excludes reinvested profits and short-term credit lines. The former was excluded on economic grounds as these are typically not considered to be capital inflows, and are small (roughly 15 percent of total net private capital inflows). The latter was excluded due to data limitations as they are available on an annual basis. Despite their size reaching upwards of 17 billion U.S. $ in 1995, no mechanical interpolation of the annual data was attempted as the resulting (smoothed) interpolated series is unlikely to reflect the true high frequency magnitude of short-term credit lines. GDP at current prices was also provided by the Brazilian authorities.

$\Delta idiff$ is the change in the interest rate differential, calculated as the change in the quantity: $(1 + i/100) - (1 + i^*/100)E_{+1}/E$, where i the overnight interest rate in Brazil, i^* the U.S. treasury bill rate (both at monthly rates), and E is the period average spot exchange rate of one US dollar to E units of *reales*. We thus use the ex post (that is, realized) domestic-currency rate of return on foreign assets.

gy is the ratio of total government expenditure at current prices on nominal GDP. Government spending was also obtained from the Brazilian authorities.

Table B1

Unit Root Test Statistics

	ADF test		PP test
	k	test statistic	
ky	0	-5.336***	-5.393***
idiff	1	-2.305	-2.155
Δ*idiff*	0	-8.223***	-8.444***
lz	0	-1.867	-2.043
lzc	0	-9.183***	-9.181***
veloc	1	-3.156*	-2.924
gy	4	-3.278*	-4.417***
i^*	3	-1.724	-1.081
Δi^*	0	-4.803***	-5.138***

Notes: Variables are as defined in the text. Estimation period is 1988:06-1995:09-. Asterisks *, ** and *** denote rejection of the null hypothesis of a unit root at the 10%, 5% and 1% significance levels. Critical values are from McKinnon (1991).

TCRER Estimation and Near-VAR Tests

The real exchange rate is decomposed into a nonstationary (trend) component and a stationary component using the Beveridge-Nelson (BN) approach.[23] This approach is based on the fact that ARIMA$(p, 1, q)$ series can be represented in terms of a stochastic trend plus a stationary component (TCRER), where the former is a random walk (possibly with drift) and the latter is an ARMA(p, q) process.

To implement the BN approach we model the first difference of the log real exchange rate as an ARMA process. The order of the ARMA process is obtained by testing down for highest statistically significant AR and MA components beginning from an ARMA(6,6). This procedure suggested that an ARMA(3,3)—estimated over the period 1988:M6-1995:M9—was appropriate to model the monthly real exchange rate in Brazil. Note that to deal with seasonality in the real exchange rate series, the deterministic component of the ARMA model contained a full set of monthly dummies.

The resulting BN decomposition suggests that during the 1990s the trend real exchange rate has appreciated slightly at an average annual rate of less than 1/2 of 1 percent. It is interesting to note that the implied decomposition suggests that the trend real exchange rate accounts for only about 20 percent of the variance of the actual real exchange rate depreciation in Brazil.[24]

To determine the number of lags to include in the near-VAR model, we started by calculating standard lag-length tests, that is, Akaike's Information Criterion (AIC) and Hannan-Quinn (HQ). These tests compare the cost of increasing the lag length (reduced degrees of freedom) to the benefit (increased information extracted from the data). To deal with seasonality, the deterministic part of the near-VAR model used in these tests included a full set of seasonal dummies.

Using a maximum lag length of six, these test statistics suggested that only two lags were necessary. A priori these test results do not appear to be reasonable, even in

[23] A widely used alternative for decomposiing the trend and temporary component is based on the Hodrick-Prescott (HP) filter. We have chosen not to use the HP filter in this study due to serious concerns regarding its ability to meaningfully decompose trend from temporary components, especially in the context of integrated series. See Cogley and Nason (1995), King and Robelo (1993), Park (1996), and Agénor and Hoffmaister (1996) for a more informal discussion.

[24] This calculation stems from the fact that the TCRER and the trend real exchange rate are orthogonal. Note that it is not feasible to calculate the percentage of the variance attributed to the trend for the level of the real exchange rate because the real exchange rate has a unit root so its variance is not defined.

light of the fact that seasonal dummies help to pickup seasonal information. Moreover, judging from Ljung-Box Q statistics the residuals from the near-VAR model with two lags were not white noise. We thus opted to override the lag length tests and increase the lag length until the residuals from the VAR model were white noise. We found that five lags were needed to "whiten" the residuals, and thus five lags were used to obtain the empirical results discussed in this paper.

Conditional on five lags, we tested the appropriateness of the near-VAR model where Δi^* and gy are jointly block exogenous. This was done using the multivariate generalization of the Granger causality test proposed by Doan (1992). This test is a multivariate likelihood ratio test that compares the likelihood under the null of the near-VAR to that under the alternative of a full VAR. The resulting test statistic is distributed χ^2 with degrees of freedom equal to the number of variables excluded from the VAR under the null. In our model, the near-VAR specification excludes 5 lags of 5 variables in 2 equations for a total of 50 degrees of freedom. The test statistic ($\chi^2 =$ 44.6) does not reject the null hypothesis of the near-VAR specification at conventional significance levels.

The time series properties of these series are summarized in Table B1. The unit root tests suggest that, with the exception of the velocity of money, all of the series used to estimate the near-VAR model reject the null hypothesis of a unit root at conventional significance levels. For the velocity of money the augmented Dickey-Fuller test results marginally rejects the unit root null. We proceeded, nonetheless, to include it in our model due to the well know fact that these tests tend are typically not powerful enough to discriminate between a highly persistent series from a true unit root process.

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