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Explaining the Appreciation of the Brazilian <i>real</i>

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EXPLAINING THE APPRECIATION OF THE BRAZILIAN REAL

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ABSTRACT/RESUME

Explaining the appreciation of the Brazilian *real*

This paper seeks to identify factors explaining the appreciation of the Brazilian *real* observed since 2003, which was temporarily interrupted only during episodes of financial turbulence. Net foreign assets and the productivity differential relative to Brazil's main trade partners are found to be significant determinants of the real effective exchange rate in the long run. In the short term, exchange-rate developments are mostly explained by movements in net foreign assets. The production of oil is also found to explain developments in the real effective exchange rate in the long run. These results are robust to a wide range of tests. There is evidence of an over-valuation of the *real* in 2010, but the extent of the misalignment is hard to gauge. FEER estimations point to an overvaluation between 3-10% in 2010. Dynamic simulations of behavioural exchange-rate equations generally suggest an overvaluation of between 10-20%. However, these estimations remain subject to large uncertainties.

JEL classification codes: C10; F31
Keywords: Brazil; currency; equilibrium exchange rate; FEER; BEER

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Comment expliquer l'appréciation du *real* Brésilien

Ce papier cherche à identifier les facteurs expliquant l'appréciation du real Brésilien observé depuis 2003, qui a été temporairement interrompu uniquement durant des épisodes de turbulences financières. Les avoirs extérieurs nets et le différentiel de productivité relatifs aux principaux partenaires commerciaux du Brésil apparaissent comme des déterminants importants du taux de change effectif réel à long terme. À court terme, les évolutions des taux de change sont principalement expliquées par le mouvement des avoirs extérieurs nets. La production de pétrole explique également l'évolution du taux de change effectif réel à long terme. Ces résultats sont robustes à un large éventail de tests. Si la surévaluation du real en 2010 est évidente, l'ampleur de l'écart à l'équilibre reste difficile à mesurer. Les estimations FEER font état d'une surévaluation de 3 à 10% en 2010. Les simulations dynamiques des équations de comportement du taux de change suggèrent généralement une surévaluation de 10 à 20%. Ces estimations restent cependant soumises à de grandes incertitudes.

Classification JEL : C10 ; F31
Mots clefs : Brésil ; monnaie ; taux de change d'équilibre ; FEER ; BEER

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Explaining the appreciation of the Brazilian *real*

Annabelle Mourougane[1]

Introduction

The Brazilian *real* has steadily appreciated since 2003, except during the 2008-09 financial crisis and more recently when financial market turbulence weakened it. In total the bilateral rate against the US dollar rose by 74% from 2003 to 2010, raising concerns regarding loss of competitiveness for Brazilian firms.

This paper seeks to identify factors explaining these developments, including the role of global excess liquidity and capital inflows toward emerging-market economies. Another – and not necessarily competing – explanation could be that Brazil underwent major structural changes over the period leading to an increase in its "equilibrium exchange rate". This would explain, in particular, the co-existence of large movements in the exchange rate with broad stability in economic fundamentals experienced in the country over the last few years. One particular hypothesis examined in this work is to see whether the growing importance of the oil sector in the economy has had any effect on currency movements.

Many methods exist to estimate equilibrium exchange rates, and none of them is fully satisfactory. This paper focuses on two approaches. The first one is the Fundamental Equilibrium Exchange Rate (FEER) method, developed by Williamson (1994), whereby the equilibrium exchange rate is the rate consistent with domestic and external balances *i.e.* the full utilisation of potential production and sustainable capital flows. The second relies on a Behavioural Equilibrium Exchange Rate (BEER) model that ascribes exchange-rate movements to several structural factors.

The main conclusions of the analysis are the following:

- The extent of the Brazilian currency appreciation in real effective terms, which are those which ultimately matter for price competitiveness, depends on the deflator considered. While a GDP deflator-based measure points to a steady appreciation of the *real* in the recent period, a CPI-based measure shows a less pronounced increase. This is due to the trend improvement in Brazil's terms-of-trade, which has boosted the deflator relative to the CPI.

- Net foreign assets and the productivity differential relative to Brazil's main trade partners are found to be significant determinants of the real effective exchange rate in the long run. In the short term, exchange-rate developments are mostly explained by movements in net foreign assets.

1. Senior Economist in the OECD Economics Department. This paper reports on background work for the 2011 *OECD Economic Survey of Brazil*. The author is grateful for the valuable comments received on earlier drafts from Peter Jarrett and Sarquis B. Sarquis. Special thanks go to Anne Legendre for statistical assistance and to Mee-Lan Frank and Maartje Michelson for editorial support. The views expressed here are the author's personal views, and do not necessarily reflect those of the OECD or its member countries.

- The production of oil is also found to matter for fluctuations in the real effective exchange rate in the long run. This also holds for alternative proxies such as the export of oil. These findings are robust to a range of tests, including the inclusion of fiscal variables, of economic growth, of the terms of trade or of commodity prices in the specification.

- There is evidence of an overvaluation of the *real* in 2010, but the extent of the misalignment is hard to gauge. FEER estimations point to an overvaluation between 3-10% in 2010. Dynamic simulations of behavioural exchange rate equations generally suggest an overvaluation of the real of between 10-20%. However, these estimations remain subject to large uncertainties.

Overall, although the appreciation of the *real* and its impact on the country's competitiveness is a legitimate concern, there is some evidence that part of this movement reflects a change in underlying fundamentals. To this extent, policy action should respond only to excessive fluctuations of the currency.

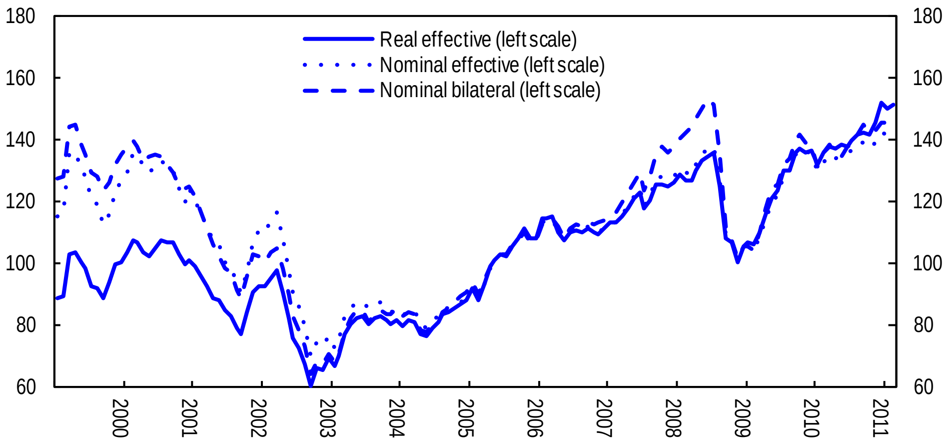
Quantifying the appreciation of the *real*

The debate over the value of the *real* has focused mostly on the nominal bilateral exchange rate *vis-à-vis* the US dollar. What matters for competitiveness, however, is the real effective exchange rate, which accounts for the relative weight of trade partners and the evolution of prices. The objective of this section is thus to derive several measures of real effective exchange rate to put the rise in the Brazilian currency into perspective.

In a first step, an effective exchange rate is computed as a weighted average of bilateral exchange rates, with weights corresponding to the share of Brazilian exports to a given country in total exports. Weights are time varying to account for the variation in the trade structure. This is particularly important as the trade structure has witnessed major changes over the last decade, with China becoming Brazil's major trading partner since 2009, while the importance of the United States has gradually declined. By contrast, the IPEA measure of the real exchange rate, which is commonly used in Brazil, relies on fixed 2001 weights. Although some divergence existed in the past and at some point in times between the nominal bilateral exchange rate against the dollar and the CPI-based real effective exchange rate, they appear to have recently moved largely in tandem (Figure 1).

Figure 1. **Bilateral and effective exchange rates**

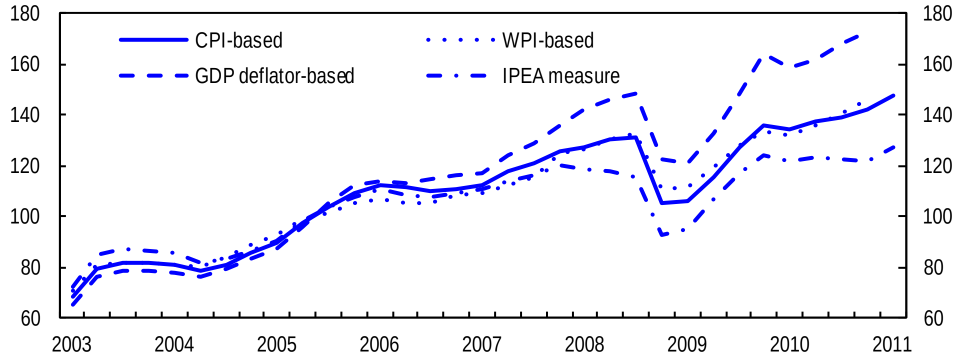
CPI-based measures



Source: OECD.

In a second step, real effective exchange rates are computed to incorporate price effects. For this purpose several measures have been calculated using respectively the CPI, WPI and GDP deflator. In all cases a "foreign price" has been derived using the same weights as for the effective exchange rate and the same price concept. For comparison the IPEA measure is also reported. All the measures point to a steady appreciation from 2003 to 2010 (Figure 2). However the amplitude of the appreciation varies widely from one measure to another, with the appreciation being particularly marked for the GDP deflator-based measure (Table 1).

Figure 2. **Selected measures of real effective exchange rate**



Source: OECD, IPEA.

Table 1. **Appreciation of the *real* using different measures of real effective exchange rates**

Per cent

	CPI-based	WPI-based	GDP deflator-based	IPEA measure
2003-2009	55.3	56.3	89.2	33.6
2009-2010	14.1	12.6	16.7	10.5
2011Q1	4.0			4.3

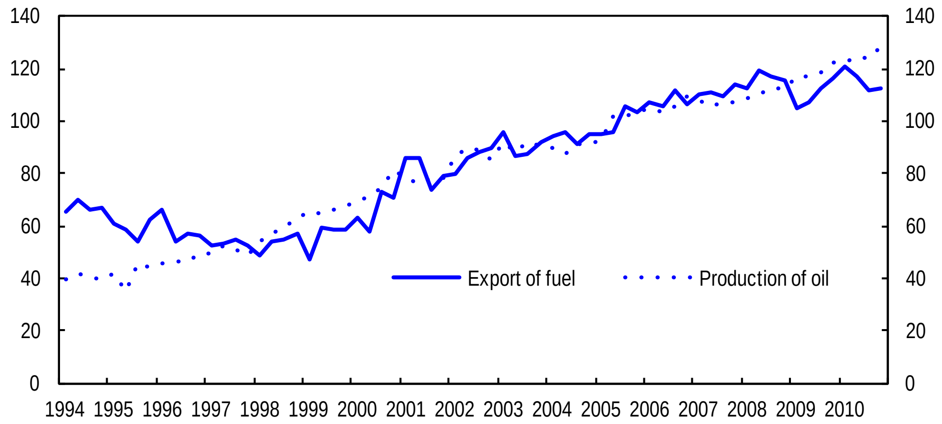
Explaining recent developments in the *real*

The objective of this section is to cast some light on the main factors underlying the appreciation of the *real* and in particular to examine the extent to which the growing size of the oil sector in the economy has helped to explain these developments. Oil production in Brazil has been increasing at a steady pace since the beginning of the 2000s (Figure 3). A range of different energy policies, which in the late 1990s injected competition in the oil market and eliminated subsidies to imports and price controls, has facilitated these developments, even though the industry remains dominated by the state-owned company *Petrobras* (Guan, 2010; Caselli and Michael, 2009).

Looking forward, the economy is likely to rely even further on oil production, especially of offshore oil, for both domestic use and export. In 2007, *Petrobras* discovered massive oil reserves in the Tupi and subsequently other offshore fields, known under the name "pre-salt" because the oil is located very deep underwater under a thick layer of salt. These fields have been estimated to double Brazil's current reserves, placing the country within the top ten countries in terms of oil reserves (Lobão, 2009).

Figure 3. **Production and export of oil**

Index 100 in 2005



Source: ANP, Funcex.

Approach

The analysis relies on a BEER framework, and seeks to explain the real effective exchange rate as a function of the productivity differential between Brazil and its trade partners, as well as capital flows and oil production, which is intended to capture developments in the oil sector:

$$q_t = c_o + c_1 * rprod_t + c_2 * oil_t + c_3 * nfa_t \qquad (1)$$

With q the real effective exchange rate (in log terms), *rprod* is the relative productivity, *oil* is oil production and *nfa* are net foreign assets (as a per cent of GDP).

Given the limited number of observations, the estimation uses a two-stage Engle and Yoo (1992) procedure, which is adapted to small samples. In a first stage we estimate equation (1). The stationarity of the residual is then tested and injected in the error correction model described in equation 2.

$$\Delta q_t = c_{10} * \Delta q_{t-1} + c_{11} * \Delta rprod_t + c_{12} * \Delta oil_t + c_{13} * \Delta nfa_t + c_{14} * ecm_{t-1} \qquad (2)$$

where ecm_{t-1} is the residual of equation (1).

Data

The estimations are carried out using the four different measures of the real effective exchange rate presented in the previous section, namely a CPI-based, a GDP deflator-based, a WPI-based measures as well as the indicator published by the IPEA. Following Paiva (2006), the relative productivity measure is computed as the difference between productivity in Brazil and in its main trading partners (using the same weights as for the real effective exchange rate). Productivity is proxied by relative price of tradables *versus* non tradables, namely the ratio of the CPI to the GDP deflator, given the absence of reliable sectoral productivity data. Arguably this is a very rough approximation of productivity differentials as relative prices may differ for reasons other than productivity developments.

Data for net foreign assets are taken from the IFS database and expressed as a percentage of GDP. ANP data are used for the production of oil. As a robustness check, the export of oil (using FUNCEX data) has also been tested. Both series are available on a monthly basis and have been seasonally adjusted and converted into quarterly terms. They display an upward trend since at least the beginning of the 2000s, although the trend may have came to an end in the case of oil exports. Other indicators such as the terms of trade using either national-accounts or balance-of-payments concepts have also been tested. In addition, the interest rate differential between Brazil and the United States was also tried.

Results

Granger tests have been run to investigate an eventual causality between the real exchange rate and the two proxies for oil developments. Results are inconclusive. In most cases, the hypothesis that the real effective exchange rate (oil developments) does not cause oil developments (the exchange rate) cannot be rejected (Annex 1).

By contrast, estimations of equations (1) and (2) point to a significant effect of oil developments in explaining exchange-rate movements, on top of traditional factors (Table 2). Annex 2 reports the results using alternative variables to capture oil developments, namely the export of oil and the different measures of the terms of trade.

In most equations, net foreign assets and the productivity differential are found to be significant determinants of real effective exchange rate in the long run. Net foreign assets are also seen to be the factor influencing the most exchange-rate developments in the short term.

The production of oil appears to matter for fluctuations in the real effective exchange rate in the long run. This also holds for the export of oil and the two measures of the terms of trade. In the short term, however, the impact of these variables appears to be fairly limited, if not insignificant.

Table 2. **Estimation results**

Equation with oil production

Estimation period 2001Q1-2009Q4	CPI-REER		PGDP-REER		WPI-REER		IPEA-REER	
	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat
Long-term								
Rprod	1.71	1.85	-0.08	-0.08	1.34	1.81	1.80	2.02
Oil production	0.78	2.10	1.13	2.46	0.79	2.63	1.03	2.87
Nfa	0.11	3.93	0.07	2.04	0.10	4.50	0.07	2.71
Stationarity of the residual	-3.70***		-3.33**		-4.09***		-3.51**	
Dynamics								
Δq(-1)	0.27	2.98	0.35	4.29	0.28	2.57	0.20	2.62
Δ(rprod)	1.13	1.19	-1.96	-2.57	1.87	2.08	0.99	1.10
Δ(oil production)	0.60	2.73	0.84	5.09	0.65	2.96	0.63	3.06
Δ(nfa)	0.11	4.89	0.03	1.42	0.11	4.86	0.10	4.98
ECM	0.57	-5.79	-0.41	-6.08	-0.61	-4.71	-0.63	-6.87
R-squared	0.82		0.90		0.74		0.86	
S.E.	0.038		0.021		0.036		0.035	

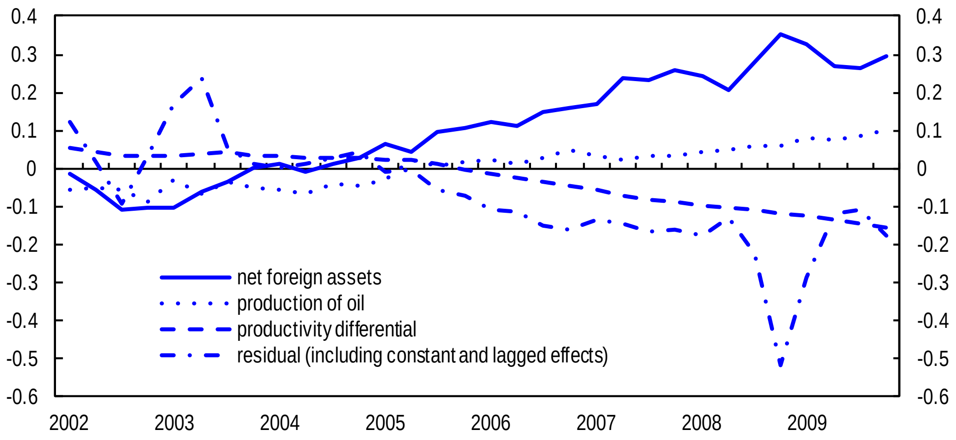
Note: ***,** and * denote stationarity at 1%, 5% and 10%.

The equations appear to be well specified. In general, the residual derived from the long-term relationship is found to be stationary and significant in equation (2). The dynamics vary widely from one equation to the other, as well as the overall fit of the equations. Those making use of the GDP-deflator version of the real effective exchange rate appear often display a wrongly signed coefficient for the productivity differential.

Overall, there is some evidence that foreign capital inflows have contributed to the appreciation of the *real* over the period and have played a predominant role in explaining short-term developments (Figure 4). In addition, structural factors such as growing oil production have increasingly contributed to push the currency up over the long term. By contrast, the contribution of the productivity differential between Brazil and its trading partners has been decreasing. Interest-rate differentials are not found to influence exchange-rate developments, probably because their effects are already captured by capital inflows, which are included in the specification. Estimations using alternative measures of the exchange rate would lead to qualitatively similar conclusions.

Figure 4. **Contributions to the CPI-based real effective exchange rate quarter-on-quarter changes**

Percentage point



Robustness tests

In order to check the robustness of the results, equations (1) and (2) have been complemented by a range of variables that have sometimes been found to matter for exchange-rate developments in the literature.

The fiscal stance is likely to affect exchange-rate developments through market expectations. To test this assumption several fiscal measures have been tested: the primary fiscal balance and the headline balance (as a per cent of GDP) as well as the debt-to-GDP ratio. In most cases, these variables do not explain real effective exchange-rate developments (Annex 3).

Another robustness test examines whether the oil proxy is in fact not capturing the effect of economic growth. Given the potential existence of endogeneity between real GDP growth and exchange rate movements the lag of real GDP has been included in equations (1) and (2). As a result, economic growth is not always significant, but when it is, the oil proxy continues to explain developments in the real exchange rate (Annex 3).

The inclusion of the terms of trade has also been tested. Again, the influence of oil production on exchange-rate fluctuations in the long term continues to hold.

Finally, to test whether the significant effect of the production of oil does not capture the more general influence of commodities in the economy, a measure of non-oil commodity prices (using IPEA data) has also been tested. These variables have been found to matter in some specifications, but oil production remained significant in explaining exchange-rate developments in the long term.

Is the *real* overvalued?

Many methods exist to estimate equilibrium exchange rates, and none of them is fully satisfactory (see Direction de la Prévision, 2000 for an overview). This section focuses on the Fundamental Equilibrium Exchange Rate (FEER) approach developed by Williamson (1994), and applies it to Brazil. The equilibrium exchange rate is defined in real and effective terms as the exchange rate consistent with the economy being in both internal and external balance. Misalignments are also examined through a BEER approach, using dynamic simulations of equation (2).

The FEER approach

The model

As in Wren-Lewis and Driver (1998), FEER is estimated by modelling only the trade balance and using conventional aggregate trade equations. This has the advantage of simplicity, and as a consequence it is relatively easy to determine the factors behind a particular FEER and to examine its sensitivity to key assumptions.

A relationship is derived for the differential between the actual and equilibrium real exchange rate on the one hand, and the gap between the "desired" current account (or target) and the actual current account on the other hand. This is then used to compute the difference between the exchange rate and its equilibrium.

A single country model for Brazil is considered, with the rest of the world being exogenous and with a number of other simplifying assumptions. *First*, export and import prices are expected to be fully determined by foreign prices. In the calculation this assumption implies $p_X = p_M = p_W$ where p_W is the foreign price. This assumption is not likely to hold in reality, as a number of studies have shown that the pass-through of exchange rate to import prices is usually incomplete. *Second*, investment income and transfers are assumed to be independent of the real effective exchange rate. *Third*, trend output is not affected by the real exchange rate.

The definition of the trade balance gives:

$$TB = p_X X - p_M RM$$

with TB the trade balance, X and M respectively export and import volumes, p_X and p_M respectively export and import prices and R the effective real exchange rate.

It is straightforward to derive a relation between the deviation of the trade balance from its desired level and the corresponding deviation of exports, imports and the real exchange rate:

(3) $\frac{dTB}{p_M.R.M} = \tau\frac{dX}{X} - \frac{dR}{R} - \frac{dM}{M}$ where $\tau = \frac{p_X X}{p_M R.M}$

where dZ denotes the deviation of the variable Z from its equilibrium level Z*.

X and M can be expressed as a function of demand and the real effective exchange rate:

(4) $X = aY_w^{\eta_X} R^{\varepsilon_X}$

and (5) $M = bY^{\eta_M} R^{-\varepsilon_M}$

where Y is domestic demand (in our case GDP) and Y_W is the foreign demand facing Brazilian exporters and a and b are constants.

Relations (4) and (5) can be re-written as:

(6) $\frac{dX}{X} = \eta_X OG_W + \varepsilon_X \frac{dR}{R}$

and (7) $\frac{dM}{M} = \eta_M OG - \varepsilon_M \frac{dR}{R}$ with $OG_W = \frac{dY_W}{Y_W}$ and $OG = \frac{dY}{Y}$ respectively the foreign and the Brazilian output gaps.

Moreover, by denoting $ca = \frac{CA}{pY}$, the current account in percentage of GDP, and $ca^* = \frac{CA^*}{p^*Y^*} \approx \frac{CA^*}{pY^*}$, the current account target, the trade balance differential can also be expressed as:

(8) $\frac{dTB}{p_M.R.M} = \frac{dCA}{p_M.R.M} = \frac{1}{\mu}(ca - ca^*)$ where $\mu = \frac{p_M RM}{pY}$

Combining equations (3) , (6) , (7) and (8), a relationship is found between the deviation of the real effective exchange from its equilibrium level, the deviation from the current account from its target and the relative output gap (*i.e*. the difference between domestic and foreign output gaps).

(9) $\frac{dR}{R} = \frac{1}{\mu}\left[\frac{1}{\tau\varepsilon_X + \varepsilon_M - 1}(ca - ca^*) + \mu(\eta_M OG - \tau\eta_X OG_W)\right]$

with $\tau = \frac{p_X X}{p_M R.M}$ and $\mu = \frac{p_M RM}{pY}$

Data

Deviation of the real effective exchange rate from its equilibrium level is then calculated using equation (9) with quarterly data from OECD *Economic Outlook and IMF International Financial Statistics.* Trade elasticities were derived from the estimation of standard trade equations for Brazil, whereby trade volumes are expressed as a function of demand and competitiveness (Table 3). Pain *et al.* (2005) provide a justification for these specifications.

In the FEER method, estimates of misalignment depend heavily on how the current account target is calibrated. To compute this target, we derive long-term projections for the current account using United Nations population projections and equations for the current account reported in Cheung *et al.* (2010) for emerging-market and developing countries, which account for the effect of demographics (proxied by the old-age and the youth dependency ratios) and convergence (captured by as the country income gap relative to the world).[2] Depending on whether the convergence effect is included or not and the period considered the long-term average of the current account is found to be around -1.0/-1.5% (see Table 4).

Table 3. **Parameters used in estimation**

ε_X	ε_M	η_X	η_M
-0.5	-0.5	1	1

Note: ε_X and ε_M are respectively the price elasticity of export and import volume. η_X and η_M the demand elasticity of export and import volumes.

Table 4. **Long-term current account**

Per cent of GDP

	Demographics	Demographics and convergence
Average 1995-2025	-1.5	-1.1
Average 2000-2025	-1.1	-1.1
Average 2010-2025	-1.5	-1.1

We thus use as a benchmark target for the current-account deficit the value of 1% of GDP. Given the uncertainties surrounding the computation of such a target, a confidence interval of equilibrium exchange rates is derived using current-account target of + or – 0.5 percentage point around the 1% benchmark. It should be noted, however, that this procedure is not sufficient to quantify estimation errors, as it does not address the issue of parameter uncertainties, which can be significant (Kramer, 1996).

2. Net foreign assets as well as the public deficit to GDP are also found to be important factors, as well as oil consumption and production, but we omit these factors from the analysis, given the difficulty of constructing reliable long-term projections for them.

Results

The *real* appears to have overshot from substantial undervaluation to overvaluation in the course of 2009 (Figure 5). Cline and Williamson (2010) find similar trends, though their estimates point to stronger misalignment (of about 15% in December 2009). According to the estimation presented here, the real effective exchange rate was overvalued by 6-12% in 2010 on average, depending on the current account target chosen (Table 5).

Limits of the approach

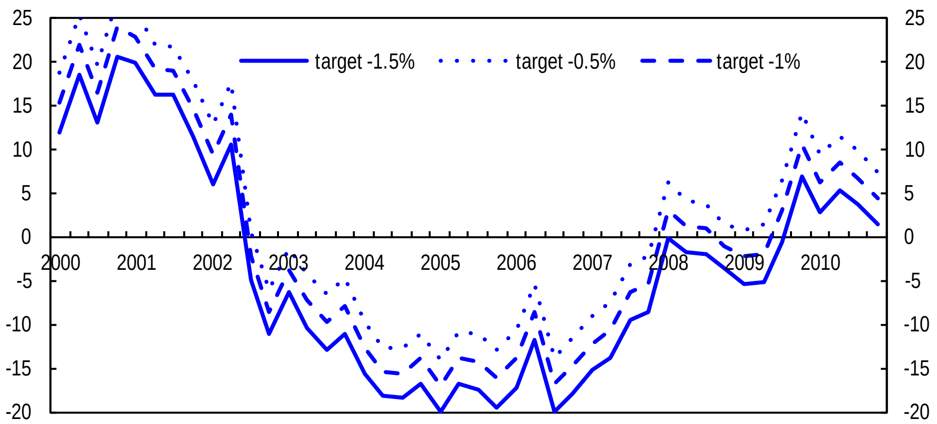
One of the disadvantages of this approach is that the model does not ensure the consistency between the assessments of trend output and structural capital flows. More importantly, any feedback from the FEER to the inputs for trend output and structural capital flows is ruled out. Lastly, this method gives no indication of what are the main factors influencing the value of the *real*.

Table 5. **FEER estimates for 2010**

Current account target (per cent of GDP)	-0.5	-1.0	-1.5
Deviation from equilibrium in per cent[1]	9.6	6.4	3.3

1. A positive sign indicates that the actual exchange rate is above its equilibrium level *i.e.* overvaluation.

Figure 5. **FEERs estimates for Brazil**



The BEER approach

In the second approach, a BEER framework is used to explain the real effective exchange rate as a function of productivity differentials between Brazil and its trading partners, as well as capital flows and oil production (see equations 1 and 2). Dynamic simulations of these equations suggest an overvaluation of the *real* by the end of 2009, supporting the conclusions of the FEER analysis. However, the extent of overvaluation varies markedly across estimates. In most cases the *real* was found to be overvalued by 4-9% at the end of 2009 and 10-20% by mid 2010 (Table 6). Equations using the wholesale price measure of the real effective exchange rate sometimes point to estimates outside that range, but the fit of these equations is relatively poor compared to other specifications. The specification the real exchange rate based on the GDP deflator has not been used in this exercise, as it would lead to implausible results, because of the wrongly signed productivity term. Removing this term would lead to estimate of overvaluation in the range of what is found for the other specifications.

Table 6. **Extent of overvaluation using dynamic simulations, per cent**

	2009	2010	2010 Q4	2011 Q1
Baseline equation with				
CPI	5.5	15.4	18.6	16.2
Wholesale price	5.2	17.2	24.8	
IPEA measure	6.0	9.6	8.6	7.3
Equation including real GDP growth with				
CPI	4.5	19.2	24.5	20.8
Wholesale price	9.0	26.3	35.4	
IPEA measure	4.3	13.7	14.5	12.3

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Annex 1

Granger tests

H0: Oil variable does not granger-cause real exchange rate	**Probability**	**H0: Real exchange rate does not granger-cause oil variable**	**Probability**
Oil export→CPI-REER	0.18	CPI-REER→ Oil export	0.06
Oil export →PGDP-REER	0.81	PGDP-REER→ Oil export	0.00
Oil export →WPI-REER	0.25	WPI-REER→ Oil export	0.10
Oil export →IPEA-REER	0.19	IPEA-REER→ Oil export	0.32
Oil production→CPI-REER	0.15	CPI-REER→ Oil production	0.30
Oil production →PGDP-REER	0.02	PGDP-REER→ Oil production	0.85
Oil production→WPI-REER	0.29	WPI-REER→ Oil production	0.13
Oil production →IPEA-REER	0.68	IPEA-REER→ Oil production	0.68
TERMS-OF-TRADE→CPI-REER	0.13	CPI-REER→TERMS-OF-TRADE	0.00
TERMS-OF-TRADE→PGDP-REER	0.04	PGDP-REER→TERMS-OF-TRADE	0.00
TERMS-OF-TRADE→WPI-REER	0.24	WPI-REER→TERMS-OF-TRADE	0.00
TERMS-OF-TRADE→IPEA-REER	0.03	IPEA-REER→TERMS-OF-TRADE	0.00
TERMS-OF-TRADE GOODS→CPI-REER	0.37	CPI-REER→TERMS-OF-TRADE GOODS	0.02
TERMS-OF-TRADE GOODS→PGDP-REER	0.15	PGDP-REER→TERMS-OF-TRADE GOODS	0.00
TERMS-OF-TRADE GOODS→WPI-REER	0.65	WPI-REER→TERMS-OF-TRADE GOODS	0.02
TERMS-OF-TRADE GOODS→IPEA-REER	0.99	IPEA-REER→TERMS-OF-TRADE GOODS	0.05

Note: A probability below 0.05 indicates the null hypothesis cannot be rejected at 5%.

Annex 2

Estimation results with alternative measure of oil developments

Estimation period 2001Q1-2009Q4	CPI-REER		PGDP-REER		WPI-REER		IPEA-REER	
	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat
	Equation with the terms of trade good and service							
Long-term								
Rprod	1.34	1.52	-0.58	-0.51	0.85	1.14	1.24	1.40
Terms-of-trade	1.00	1.96	0.66	1.15	0.72	1.67	1.15	2.25
Nfa	0.11	4.04	0.10	2.59	0.11	4.56	0.08	2.84
Stationarity of the residual	-3.39**		-2.79*		3.33**		-3.74***	
Dynamics								
Δq(-1)	0.33	2.74	0.49	3.87	0.34	2.53	0.30	2.62
Δ(rprod)	0.57	0.47	-2.99	-2.71	1.08	1.00	0.34	0.27
Δ(terms-of-trade)	0.11	0.35	-0.35	-1.61	0.10	0.35	0.07	0.25
Δ(nfa)	0.10	3.66	0.01	0.45	0.11	3.79	0.10	3.57
ECM	-0.52	-4.07	-0.29	-3.18	-0.51	-3.39	-0.58	-4.32
R-squared	0.71		0.79		0.62		0.73	
S.E.	0.048		0.03		0.043		0.048	
	Equation with the terms of trade goods							
Long-term								
Rprod	2.13	2.64	0.97	0.88	1.16	1.49	1.79	2.02
Terms-of-trade goods	2.36	3.77	2.42	3.28	1.19	1.97	2.02	2.94
Nfa	0.12	4.78	0.11	3.45	0.11	4.88	0.09	3.22
Stationarity of the residual	-3.66***		-2.77*		-3.59**		-4.38***	
Dynamics								
Δq(-1)	0.26	1.79	0.42	2.48	0.26	1.66	0.24	1.87
Δ(rprod)	1.06	0.82	-2.72	-1.97	1.32	1.22	0.64	0.49
Δ(terms-of-trade goods)	0.86	1.61	0.07	0.16	0.67	1.50	0.70	1.40
Δ(nfa)	0.11	3.29	-0.00	-0.10	0.11	3.60	0.11	3.33
ECM	-0.51	-3.03	-0.26	-2.11	-0.51	-4.87	-0.61	-3.58
R-squared	0.65		0.68		0.61		0.70	
S.E.	0.052		0.038		0.044		0.051	
	Equation with oil exports							
Long-term								
Rprod	1.98	2.48	0.16	0.19	1.54	2.49	1.90	2.41
Fuel	0.15	3.69	0.19	4.50	0.14	4.46	0.16	4.02
Nfa	0.12	4.73	0.08	2.98	0.11	5.67	0.08	3.40
Stationarity of the residual	-4.33***		-4.74***		-5.55***		-4.47***	
Dynamics								
Δq(-1)	0.32	3.24	0.34	2.01	0.37	3.00	0.30	3.12
Δ(rprod)	0.92	0.87	-2.26	-1.71	1.97	1.88	0.70	0.64
Δ(fuel)	0.02	0.86	0.04	1.24	0.03	1.17	0.02	0.70
Δ(nfa)	0.09	3.62	0.01	0.30	0.10	3.90	0.08	3.18
ECM	-0.70	-5.92	-0.44	-2.56	-0.72	-4.53	-0.73	-5.96
R-squared	0.80		0.71		0.70		0.81	
S.E.	0.04		0.036		0.038		0.041	

Note: ***,** and * denote significance at 1%, 5% and 10%.

Annex 3

Robustness tests

Introduction of fiscal variables

(The dependent variable is CPI-based real exchange rate)

Estimation period 2001Q1-2009Q4	Primary balance		Headline balance		Public debt	
	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat
Long-term						
Rprod	1.48	1.49	1.9	2.03	1.04	0.82
Oil production	0.73	1.97	0.8	1.99	0.70	1.86
Nfa	0.11	3.82	0.11	3.36	0.06	0.88
Fiscal	-0.27	-2.98	-0.01	-0.44	-0.013	-1.04
Stationarity of the residual	-4.42***		-4.26***		-2.92**	
Dynamics						
Δq(-1)	0.31	3.3	0.31	3.34	0.23	2.81
Δ(rprod)	0.97	0.93	0.93	0.95	-0.49	-0.54
Δ(oil production)	0.81	4.01	0.72	3.36	0.78	4.5
Δ(nfa)	0.09	3.92	0.10	4.37	0.03	1.33
Δ(fiscal)	0.01	0.42	0.01	0.89	-0.02	-3.83
ECM	-0.53	-5.08	-0.51	-5.19	-0.47	-5.47
R-squared	0.81		0.81		0.86	
S.E.	0.039		0.039		0.35	

Note: ***,** and * denote significance at 1%, 5% and 10%.

Introduction of real GDP growth

Estimation period 2001Q1-2009Q4	CPI-REER		PGDP-REER		WPI-REER		IPEA-REER	
	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat
Long-term								
Rprod	1.92	2.28	0.85	1.04	1.99	3.39	1.95	2.39
Oil production	0.69	1.82	1.11	2.83	0.56	2.10	0.98	2.64
Nfa	0.10	2.97	0.03	0.86	0.07	2.92	0.06	2.06
Log GDP (-1)	0.67	0.87	1.83	2.43	1.62	3.04	0.45	0.60
Stationarity of the residual	-3.89***		-4.10***		-5.93***		-3.82***	
Dynamics								
Δq(-1)	0.29	3.29	0.25	2.65	0.29	2.81	0.24	3.15
Δ(rprod)	0.36	0.40	-2.46	-4.28	1.05	1.22	0.11	0.13
Δ(oil production)	0.52	2.45	0.69	4.51	0.47	2.37	0.57	2.89
Δ(nfa)	0.09	4.65	0.02	1.12	0.09	4.58	0.09	4.88
Δlog(GDP(-1))	-0.45	-0.89	0.14	0.39	-0.0	-0.0	-0.70	-1.5
ECM	-0.6	-6.15	-0.46	-5.64	-0.76	-5.8	-0.63	-6.85
R-squared	0.84		0.91		0.79		0.88	
S.E.	0.04		0.019		0.033		0.033	

Note: ***,** and * denote significance at 1%, 5% and 10%.

Introduction of the terms of trade

Estimation period 2001Q1-2009Q4	CPI-REER		PGDP-REER		WPI-REER		IPEA-REER	
	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat	Coeff	T-Stat
Long-term								
Rprod	2.01	2.23	0.33	0.30	1.55	2.1	2.13	2.52
Oil production	0.71	1.99	1.22	2.74	0.74	2.52	0.95	2.82
Nfa	0.10	3.59	0.06	1.69	0.10	4.17	0.06	2.34
Terms of trade	0.90	1.85	0.84	1.63	0.61	1.55	1.01	2.21
Stationarity of the residual	-3.8***		-4.1***		-4.0***		-3.9***	
Dynamics								
Δq(-1)	0.29	2.70	0.45	4.37	0.29	2.31	0.24	2.52
Δ(rprod)	1.46	1.32	-1.97	-2.19	2.12	2.04	1.35	1.26
Δ(oil production)	0.63	2.51	0.80	4.04	0.66	2.72	0.66	2.75
Δ(nfa)	0.10	3.94	0.01	0.55	0.11	4.16	0.09	3.82
Δ(terms of trade)	0.14	0.53	-0.16	-0.89	0.16	0.61	0.12	0.47
ECM	-0.55	-4.55	-0.35	-4.02	-0.59	-3.85	-0.63	-5.24
R-squared	0.78		0.88		0.69		0.81	
S.E.	0.042		0.025		0.039		0.041	

Note: ***,** and * denote significance at 1%, 5% and 10%.

Introduction of commodity prices

(The dependent variable is CPI-based real exchange rate)

Estimation period 2001Q1-2009Q4	Commodity price		Non-oil commodity price	
	Coeff	T-Stat	Coeff	T-Stat
Long-term				
Rprod	1.98	2.46	2.48	2.69
Oil production	0.64	1.96	0.98	2.76
Nfa	0.09	3.38	0.09	3.01
Commodity price	0.29	3.17	0.38	2.3
Stationarity of the residual	-3.5***		-3.8***	
Dynamics				
Δq(-1)	0.28	3.20	0.26	2.63
Δ(rprod)	1.29	1.23	1.35	1.20
Δ(oil production)	0.43	2.00	0.58	2.53
Δ(nfa)	0.09	4.2	0.10	4.12
Δ(commodity price)	0.09	0.86	0.12	0.74
ECM	-0.70	-6.03	-0.61	-5.43
R-squared	0.84		0.81	
S.E.	0.036		0.039	

Note: ***,** and * denote significance at 1%, 5% and 10%.

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