An Estimation of the Equilibrium Multilateral Real Exchange Rate of Argentina: 1975-2005

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Abstract

This paper contains an empirical analysis of Argentina’s Multilateral Real Exchange Rate (MRER) during 1973-2004 using an equilibrium correction model. It shows that the U.S.A.’s MRER (measured by the Federal Reserve’s Real Broad Dollar Index) and Argentina’s terms of trade are good long and short run determinants of Argentina’s MRER. Whereas MRER misalignments were not significantly corrected at all during the periods of unilateral pegs to the U.S. dollar, during the rest of the sample there was a correction of around 24% during the first quarter. Furthermore, the paper shows that the level of the rate of growth of the MRER is significantly affected by whether or not there was a unilateral peg to the dollar.

Key words: JEL: C22, E41.

Introduction

Argentina has been an amazing laboratory of exchange regimes over the last 30 years. Its experience has shown that extended periods of pegging to the U.S. dollar, when they coincide with major real appreciations of the U.S. dollar, can have devastating effects on Argentina’s economy. This is precisely what happened at least twice in the last 30 years: first during the period of crawling pegs to the U.S. dollar (the “Tablita” experience) in the late 70s and, second, during the more protracted Convertibility experience of the 90s. During both episodes the inability of unilateral pegs to a single currency to

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facilitate the adjustment of the economy to external shocks (among them the real appreciation of the U.S. dollar), led to the accumulation of major macroeconomic imbalances such as lack of competitiveness due to a significant real exchange rate misalignment, high unemployment and an explosive growth of public debt. Significantly, both episodes ended in severe triple crises (debt, currency and banking), and both during periods of real dollar appreciations (see Escudé (2004a)).

This paper delves into the data to look for the main driving forces behind Argentina’s Multilateral Real Exchange Rate (MRER). After presenting a condensed version of the basic model, the paper focuses on the empirical estimation of an equilibrium correction model for Argentina’s MRER during the period 1975:1-2004:1, using quarterly data. This method identifies a set of fundamental variables that determine internal and external equilibrium and then links them to the multilateral real exchange rate (MRER). The cointegration analysis is made using the system-based procedure from Johansen (1988) and Johansen and Juselius (1990). This method has the advantage of determining the long-run relationship between the real exchange rate and its determinants that is valid in the long-run although there could be large deviations in the short run.

We find that the MRER of the U.S.A. and Argentina’s Terms of Trade (TT) are highly significant in explaining Argentina’s MRER and can be used in a very parsimonious model that does an excellent job of tracking the path of the latter and prima facie can be used to obtain a measure of real exchange rate misalignment. We find that when a unilateral peg to the U.S. dollar does not prevail, around a quarter of the misalignment is corrected in the first quarter. However, during the periods with unilateral pegs to the U.S. dollar, there is no significant correction of the misalignment. Furthermore, the level of the rate of growth of the MRER is significantly lower (meaning that the rate of real peso deprecation is lower, or the rate of real peso appreciation higher) when there are such unilateral pegs.

We know that much more needs to be done to have a reliable measure of real exchange rate misalignment for Argentina. In particular, the lack of reliable and sufficiently long macroeconomic time series and the recurrence of crises, regime changes and structural breaks makes it an awesome task. Hence, we take the results of this paper as a very preliminary but nevertheless promissory step in that direction.

The next section briefly describes the theoretical model we have in mind. Section 3 presents a description of the data and the econometric results. Section 4 shows graphically how the model tracks the MRER and the resulting misalignment of the MRER from its (preliminary) long run determinants, and section 5 concludes.
1 A synthesis of a plausible theoretical model

The estimation of exchange rate misalignment is one of the most challenging empirical problems in open-economy macroeconomics (Edwards (1989), MacDonald (1997), Hinkle and Montiel (1999), Hoffmann and MacDonald (2000), among others). The main difficulty is that the equilibrium MRER is not observable. Baffes, Elbadawi and O’Connell (1999) perform a single-equation procedure for estimating both the equilibrium real exchange rate and the degree of misalignment, based on a theoretical model by Montiel (1999), and apply it to Côte d’Ivoire and Burkina Faso. In this paper we use that methodology as a baseline, and adapt it to some of the peculiarities of Argentina’s experience with exchange regimes based on a model by Escudé (2005).

The model we have in mind represents a medium run, which abstracts from investment, growth and changes in the multilateral structure of the small open economy’s (SOE) international trade, as we specify below. There are three goods: an exportable good (which is also consumed domestically), imported inputs to production, and non tradables (i.e. goods that are produced domestically and only consumed domestically). Firms in the non tradable sector are monopolistically competitive. In both sectors output is produced with labor (which is mobile between sectors and immobile internationally) and capital (which is bolted down and does not depreciate).

The SOE is assumed to be a price taker for exportable and imported goods. Firms in the exportable sector are perfectly competitive and have a (constant) imported input requirement \( \varepsilon \) per unit of output. For simplicity, the Law of One Price (LOP) prevails for exports and imports, with full and instantaneous pass-through of nominal depreciations to peso prices. This simplification, however, is ameliorated by our assumption of a multilateral non-commodity trade environment (with the U.S.A. and Europe as trade partners) where in the model’s long run the LOP does not hold for the goods that the U.S.A. and Europe produce and trade, for any of the multiple reasons that have been used to justify this fact, which include pricing to market and local currency pricing (Obstfeld (2002), Engel (2002)). Due to non tradable price stickiness, this makes the U.S.A.’s MRER a key fundamental for the SOE’s MRER, along with its TT.

Households are assumed to consume exportable and non-tradable goods (or services), which are also the two categories of goods produced domestically. Hence, it is convenient to define the MRER as the relative price between exportable (X) and non-tradable (N) goods. Given our assumption on the LOP and full and immediate pass-through for the SOE, we can define the MRER as \( e \equiv (\phi S^m)/P_N \), where \( S^m \) is the multilateral nominal exchange rate (pesos per a geometrically trade weighted basket of currencies), \( \phi \) is the...
geometrically trade weighted basket of export price indexes, and $P_N$ is the peso price of non-tradables.

In (at least) two of the subperiods we consider below, Argentina has had a unilaterally fixed (during the Convertibility period) or almost fixed (the crawling peg regime of the Tablita period) of the peso to the U.S. dollar\textsuperscript{2}. Let $S_t$ be the peso/dollar nominal exchange rate, and assume that a significant fraction of trade ($\alpha_{EU}$) is done with the Euro area and the rest ($\alpha_{US} = 1-\alpha_{EU}$) with the U.S.A., and that these coefficients hold both for exports and imports. Furthermore, these coefficients are constant in the model's long run (which, hence, is actually a medium run). The MRER ($e$) can be defined as a geometrically weighted average of bilateral real exchange rates (first equality), or equivalently, as a ratio between the multilateral nominal exchange rate and the non-tradables price index (second equality):

$$
e = \left( \frac{SP^{US}}{P_N} \right)^{\alpha_{US}} \left( \frac{(S/\rho)^{PEU}}{P_N} \right)^{\alpha_{EU}} = \frac{\phi S/\rho}{P_N} \tag{1}$$

where $P^{US}$ and $P^{EU}$ are the price indexes of the U.S.A. and Europe, $\rho^*$ is the exogenous euro/dollar nominal exchange rate,

$$\rho \equiv (\rho^*)^{\alpha_{EU}} \equiv (1)^{\alpha_{US}}(\rho^*)^{\alpha_{EU}}$$

is the exogenous trade weighted basket of foreign currencies per dollar nominal exchange rate ("dollar strength"),

$$S/\rho = S^{\alpha_{US}}(S/\rho^*)^{\alpha_{EU}}$$

is the country's multilateral nominal exchange rate (that we represented as $S^m$ previously), and

$$\phi_t \equiv (P^{US}_{t})^{\alpha_{US}}(P^{EU}_{t})^{\alpha_{EU}}$$

is the export price index. $\phi$ will also be our TT because, to simplify, we assume that there is no inflation in import prices and that the multilateral import price index is normalized to one. Hence, our TT is basically the index of the dollar and euro invoiced prices of the goods that the U.S.A. and Europe, respectively, import from Argentina. Under our definition of the MRER, $e$ is the relevant relative price for output decisions as well as consumption decisions.

If the consumption sub-utility function has a Cobb-Douglas specification for the consumption of exportable and non-tradable goods, the (dual) Consumer

\textsuperscript{2} We also evaluate below the inclusion of the recent period in which the nominal exchange rate with the dollar has been fluctuating within a small band or 2.9 pesos/dollar with strong daily Central Bank sterilized intervention in the foreign exchange market within the unilaterally fixed (or almost fixed) exchange rate period.
Price Index is also a Cobb-Douglas index of these goods’ prices:

\[ P \equiv (\phi S / \rho)^\theta (P_N)^{1-\theta}, \]  

where \(0<\theta<1\). The actual definition of Argentina’s (and the Federal Reserve’s) MRER actually uses the CPI \((P)\) in the denominator. But this is of no consequence because if we define \(e^o = (\phi S / \rho) / P\) then:

\[ e^o = e^{1-\theta}, \]

so it is very easy to go from one relative price to the other.

Let \(w \equiv W / P_N\) be the product wage in the domestic sector, where \(W\) is the index for nominal wages. Then the product wage in the exportable sector is \(W / (\phi S / \rho) = w / e\). It is convenient to express Argentina’s multilateral nominal exchange rate as \(S / \rho\) because \(S\) is dependent on the SOE’s exchange regime whereas \(\rho\) (which represents the dollar’s international strength) is exogenous for the SOE. The definition of \(e\) shows that dollar appreciations (increases in \(\rho\)) generate deflationary pressure in the peso price of exportable goods, creating an incentive for substitution in production towards non tradables and away from exportables. Let us briefly consider the nature of the difficulties that unilaterally pegging the peso to the U.S. dollar generates when the dollar strengthens. Assuming nominal wage and non tradable price level stickiness, real dollar appreciations tend to increase the product wage in the export sector through their impact on \(e\).

According to our assumptions, the export sector is perfectly competitive and has immediate pass-through of international prices \((\phi)\) and exchange rates \((S / \rho)\) to prices. Hence, its peso price falls when \(\rho\) increases. On the other hand, since there is sticky price setting in the domestic sector, output there is demand determined. Assume also that there is high capital mobility but the possibility of sudden stops, that there is nominal wage stickiness and that the exchange rate is firmly pegged to the dollar. Then the impact of dollar appreciations are clearly recessionary: the strong dollar appreciates the peso in real terms and substitutes demand away from non tradable goods, hence reducing non tradable sector output (because firms there are quantity takers), while the production of exportable goods falls because the product wage increases in this competitive sector. Hence, output and employment fall in both sectors and tax collection falls.

Both the private and public sectors can smoothen out the negative effects of the shock on income by financing the trade balance deterioration through foreign indebtedness. Therefore, the economy becomes more vulnerable to a sudden stop, at least if there is an unknown threshold for debt beyond which sudden stops are triggered. When on top of this there is a misguided process of financial deregulation (as in the Tablita experience in the late 70s) or a
complete disregard for the currency mismatches of bank debtors (as during the Convertibility period), the potential for a triple crisis can be very large. In fact, the last two periods in which Argentina pegged to the U.S. dollar, ended in triple crises (debt, currency and banking). Both of these crises occurred during periods in which the dollar was going through a protracted phase of real appreciation. Furthermore, there is abundant evidence on the highly adverse effects of the consequent real appreciations of the peso on the domestic economy. ³

Let us now turn to the long run effects of this and other potential shocks to the economy. First, as in Escudé (2005) assume there is monopolistic competition with price (wage) rigidity in the non-tradable sector (households), and that the private sector does not incur in debt but saves by purchasing peso denominated bonds that are issued by the Central Bank. ⁴ Foreign investors invest in dollar denominated government bonds but require an interest rate \( (i^*) \) that includes a risk premium on top of the risk-free international rate \( (r^*) \). Assume that the risk premium has both an exogenous (time varying, stochastic) component \( (\zeta) \) and an endogenous component that varies positively with the dollar denominated public debt net of Central Bank international reserves \( (p(DG - R_0)) \):

\[
1 + i^* = (1 + r^*)[1 + \zeta + p(DG - R_0)].
\]  

Here we take the international reserves as constant because we use as benchmark a model that has inflation targeting with a pure float as monetary regime. Nevertheless, Escudé (2005) shows that alternative Central Bank policy rules can be constructed so that the same non-stochastic steady state is shared by different monetary/exchange rate regimes (including a fixed exchange rate regime, an exchange rate that is fixed to a trade weighted basket of currencies and inflation targeting with a managed float). We also assume that there are arbitrageurs that ensure that the uncovered interest parity condition between domestic peso and dollar denominated bonds holds. This condition, along with the inflation targeting monetary policy feedback rule and households’ first order conditions for utility maximization imply that the steady state dollar and peso interest rates must be equal to the intertemporal discount rate \( i = i^* = 1/\beta - 1 \) (where \( \beta \) is the inter-temporal discount factor). Hence, the

³ The first period was quite similar in Chile and Uruguay (and indeed often is often made to the "Southern Cone experience"), and also resulted in severe crises in these countries. See Díaz-Alejandro (1985) and Edwards and Cox Edwards (1987).

⁴ This is a stylized representation of Argentina’s experience during Convertibility, where the bulk of the increase in foreign currency debt was incurred by the government. To better represent the Southern Cone experience in the late 70s and early 80s (in particular, Chile’s experience during the first 10 years of the liberalization process), this basic framework would need some modifications, since it was the private sector that incurred most of the increase in foreign debt and this was mostly "nationalized" (i.e. socialized) as an integral part of the management of the crisis.
(non-stochastic) steady state dollar denominated government debt is given by:

\[ D^G = R_0 + p^{-1} \left( \frac{1/\beta}{1 + r^*} - (1 + \zeta) \right) \tag{4} \]

where now the variables are at their steady state values.

In Escudé (2005) it is shown that the steady state values of non-tradable output \((y_N)\), the non-tradable product wage \((w)\), the MRER \((e)\), total employment \((L)\), total private consumption \((c)\), and the marginal utility of real savings \((\lambda)\), are determined by the following 6 equations:

\[ F_N'(F_N^{-1}(y_N)) = \mu_Fw \tag{5} \]
\[ \lambda w = \mu_H e^\theta v'(L) \tag{6} \]
\[ e^{\xi + (1-\zeta)\sigma} \lambda = \kappa \tag{7} \]
\[ y_N = (1 + g^*)\tau(1 - \theta)e^\theta c \tag{8} \]
\[ L = (F_X')^{-1} \left( \frac{w}{e} \frac{\phi}{\phi - \epsilon} \right) + F_N^{-1}(y_N) \tag{9} \]
\[ TB(e, w, c) = \left( \frac{1}{\beta} - 1 \right) D^G - r^*R_0. \tag{10} \]

where \(F_K(L_K)\) \((K = X, N)\) are the two sectors’ production functions, \(v(L)\) is the disutility of work, \(\kappa\) and \(\tau\) are functions of parameters such as \(\beta\), \(\sigma\) is the coefficient of relative risk aversion, and \(\xi\) is the habit formation coefficient (which is between 0 and 1) and \(g^*\) is government expenditures. Also, the steady state value of government dollar debt \(D^G\) is given by (4) and, for ease of notation, we have defined the following function for the steady state trade balance \((TB)\):

\[ TB(e, w, c) \equiv \frac{\phi}{\rho} \left[ (1 - \frac{\epsilon}{\phi})F_X \left( (F_X')^{-1} \left( \frac{w}{e} \frac{\phi}{\phi - \epsilon} \right) \right) \right] - (1 + g^*)\tau \theta c \left( \frac{\epsilon}{\epsilon - \theta} \right). \tag{11} \]

Equations (5) and (6) are the (monopolistic competition) non-tradable price and wage setting conditions in the steady state, in which there is price and wage flexibility. The first states that the non-tradable price is a markup \((\mu_F)\) over marginal cost, while the second states that the nominal wage is a markup \((\mu_H)\) over the marginal rate of substitution of real savings for leisure. Note that (6) essentially involves the real wage \(w/e^\theta\). Equation (7) is the steady state of the first order condition for consumption. Equations (8) and (9) are the market clearing conditions (or resource constraints) for non-tradable goods and labor, respectively. Finally, the last equation is the balance of payments, which states that the trade surplus must be equal to the risk adjusted interest payments.
on the dollar government debt (which is in the hands of non-residents), net of the (risk-free) interest earned on Central Bank international reserves.

We now collapse these equations to obtain an Internal Balance (IB) equation and an External Balance (XB) equation that jointly determine the steady state values of \( e \) and \( c \). First, note that (8) expresses non-tradable output in terms of those two variables:

\[
y_N = ae^\theta c, \quad a \equiv (1 + g^*)\tau(1 - \theta)
\]

Inserting this expression in (6) yields \( w \) as a decreasing function of \( e \) and \( c \):

\[
w = (1/\mu_F)F_N'(F_N^{-1}(ae^\theta c)) \equiv w(e^\theta c), \quad w' < 0.
\]  
(12)

Inserting the last two expressions in (9) gives labor demand in terms of \( e \) and \( c \):

\[
L = (F_X')^{-1}\left(\frac{w(e^\theta c)}{e} \frac{\phi}{\phi - \gamma} \right) + F_N^{-1}(ae^\theta c) \equiv L(e, c)
\]

\[L_e > 0, L_c > 0.\]

Now use (7) to eliminate \( \lambda \) from (6) and use the functions for \( w \) and \( L \) to obtain the following expression for the internal balance equation:

\[
\mu_H e^\theta c^\xi + (1 - \xi)\psi(L(e, c)) = \kappa w(ae^\theta c).
\]  
(13)

It is convenient to rearrange this equation as the equality of labor demand and labor supply:

\[
L(e, c) = (v')^{-1}\left(\frac{\kappa w(ae^\theta c)}{\mu_H e^\theta c^{\xi + (1 - \xi)\psi}}\right) \equiv L^S(e, c)
\]

\[L_e^S < 0, L_c^S < 0.\]

Given the signs of the partial derivatives, it is clear that the IB equation has a negative slope in the \( e-c \) plane, as in Figure 1.

To obtain the External Balance equation, insert the expression for \( w \) in (11) to obtain:

\[
T(e, c) \equiv \frac{\phi}{\rho} \left(1 - \frac{e}{\gamma}\right)F_X \left((F_X')^{-1}\left(\frac{w(ae^\theta c)}{e} \frac{\phi}{\phi - \gamma} \right)\right)
\]

\[-(1 + g^*)\frac{\tau\theta c}{e^1 - \theta}.
\]

\[T_e > 0, T_c < 0?, T_\rho < 0, T_\phi > 0, T_\epsilon < 0, T_{g^*} < 0?\]
In this case we have two partial derivatives with ambiguous sign. We shall assume that the direct effects through the demand for exportables predominates over the indirect effect through the product wage in the exportable sector. Under this assumption, inserting $T(e, c)$ and (4) in (10) yields the External Balance equation with a positive slope in the e-c plane, as depicted in Figure 1:

$$T(e, c) = \left(\frac{1}{\beta} - 1\right) p^{-1} \left(\frac{1}{1 + r^*} - (1 + \zeta)\right) + \left(\frac{1}{\beta} - 1 - r^*\right) R_0.$$ 

We can now easily see the effects of permanent changes of the mean values of exogenous variables on the long run equilibrium values of the MRER and private consumption. For example, a permanent dollar strengthening (increase in $\rho$) has the effect of shifting the XB line leftward (which is what the minus sign underneath this variable means in the graph). This makes the steady state MRER increase and private consumption of private goods decline. The reason, of course, is that the strengthening of the dollar makes the trade weighted trade surplus decline in dollar terms. To restore the dollar trade surplus, the MRER must increase, given c, or c must decline, given e. In fact, both e rises and c falls, the relative magnitude of these changes being given by slope of the Internal Balance line.

![Figure 1: Internal and External Balance](image)

An increase in the TT ($\phi$) shifts XB to the right due to the increased trade balance and IB to the left because the increased labor demand in the exportable sector makes $w$ increase. This makes $e$ fall, and has an ambiguous effect on $c$. An opening of the economy based on higher import requirements for the exportable sector has the opposite effects of an increase in the terms
of trade: it decreases the trade balance due to increased imports and reduces
the demand for labor in the exportable sector. Hence, $e$ increases.

An increase in the international dollar interest rate or in the exogenous com-
ponent of the risk premium increases the cost of the public foreign debt, gen-
erating a reduction in the steady state debt level (4) and, hence, in the net
interest payments abroad. Hence, the trade balance can fall, shifting XB to
the right and making $e$ fall and $c$ increase.

An increase in the provision of public goods (increase in public expenditures)
increases the demand for non-tradables and hence the demand for labor in the
non-tradable sector. This reduces the product wage in this sector $w$, according
to (12). Therefore, labor demand increases while labor supply falls because,
given $e$, the real wage falls. Both effects shift IB to the left. The increase in
government demand for exportables reduces the trade balance, thus requiring a
higher MRER, given $c$, or requiring lower private consumption of exportables
$\tau \theta c$, given $c$. Of course, the effect on welfare is in general ambiguous and
depends on the utility of the consumption of public goods relative to the
utility of the consumption of private goods.

Although we have not formalized it here (see Escudé (2005)) an across the
board increase in productivity ($z^F$) shifts both lines to the right, increasing $c$
with an ambiguous effect on $e$, and an exogenous increase in the participation
rate (or willingness to work $z^H$) increases $e$ and $c$ by shifting IB to the right.

In the empirical part of this paper, below, the MRER of the U.S.A. ($\rho$) is
shown to play an important role as an explanatory variable for Argentina’s
MRER. Our interpretation hinges around this stylized model. The U.S. mul-
tilateral real exchange rate typically presents long phases of appreciation and
depreciation. Hence, when the strong dollar phase begins it is probable that
the appreciation will get gradually more pronounced and that this will persist
during a number of years. Producers in a country that pegs its currency to the
dollar but only has a small fraction of its trade with the U.S.A. hence find it in-
creasingly difficult to compete domestically with imported goods or in foreign
markets unless their increase in productivity is sufficiently fast to compensate
for the real appreciation (or trade and/or fiscal policy is/are especially geared
to compensate for this). But the speed and persistence of real dollar apprecia-
tions are too high to make compensating increases in productivity (or changes
in trade or fiscal policy) a realistic possibility.

The importance of “dollar strength” is highlighted by the Argentine experience
during the last two periods in which it pegged to the dollar: the “Tablita”
episode of 1979-81 and the extended Convertibility period (1991-2001). In
both periods, international dollar appreciations combined with a domestic
predetermined exchange rate regime that pegged the peso to the dollar, and a
vulnerable process of financial liberalization or expansion, ended in an abrupt triple crisis (debt, currency and banking). In the above model, a real dollar appreciation has the impact effect of reducing Argentina’s MRER. In a world with considerable price and wage stickiness, a predetermined (and unilateral) nominal exchange rate that is pegged to the dollar has the effect of preventing a timely correction of the resulting real exchange rate misalignment. This is also true for the effects of other external shocks, such as those that arise from the TT, the international interest rate, or the risk premium that international investors charge for foreign debts. As we show below, more flexible exchange regimes are better suited for preventing the persistence of misalignments.

2 Empirical results

The traditional approach for verifying the existence of long-run relationships among a group of variables is based on cointegration techniques. These techniques require the study of the time-series properties of the data. Our data set begins in the first quarter of 1975 and ends in the first quarter of 2005. The MRER (denominated \text{rexchrate} below), corresponds to the trade weighted exchange rate with the three main trade partners of Argentina: the U.S.A., Brazil and the E.U. The macro variables that have been considered as potential fundamental determinants of the MRER are: (i) the Terms of Trade, \((tt)\), which is the ratio between the foreign currency price of exports and the foreign currency price of imports; (ii) differential productivity, \((prod)\), which is the difference in labor productivity between Argentina and the U.S.A.; (iii) the MRER of the U.S.A., as measured by the Federal Reserve’s Real Broad Dollar index \((rbdi)\); (iv) the government expenditure/Gross Domestic Product (GDP) ratio; (v) industrial wages; (vi) the trade balance/GDP ratio and (vii) the imports/GDP ratio.

The starting point of the econometric study is the analysis of the time-series properties of the variables. We analyze the order of integration of the data using the Augmented Dickey Fuller (ADF) test, a standard unit root test. These test have a null hypothesis of non-stationarity against the alternative of stationarity. All variables are integrated of order 1, since we can’t reject the null hypothesis of the unit-root tests at traditional significance levels (see Appendix 1). Given this, the cointegration analysis is made using the system-based procedure from Johansen (1988) and Johansen and Juselius (1990). In order to validate a conditional model of the MRER on the macro variables of the system, “weak exogeneity” is also evaluated by means of the Likelihood Ratio (LR) tests.
Although the system included all the variables previously described, only three of them were found to have a long-run relationship in the sample period. After simplifications, the empirical results are presented in Table 1.

Inspecting the eigenvalues and their associated statistics (Maximum and Trace) a rank equal to zero is rejected in favor of a rank equal to one. That is, there is one cointegration vector. The MRER, the TT and the Real Broad Dollar Index have a long-run (cointegration) relationship with coefficients (1, 1.3, 3.9). Differential productivity, the industrial wage, the trade balance/GDP ratio and the imports/GDP ratio were also included but no long-run relationship with them was found.

Table 1

The Cointegration Analysis of the rexchrate, tt and rbdi System

<table>
<thead>
<tr>
<th>Cointegration analysis 1976 (2) to 2005 (1)(6 lags and the dummiesd812; d822; d844; d881; d892; d911; d021 and constant unrestricted).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>eigenvalue</strong></td>
</tr>
<tr>
<td>0.264313</td>
</tr>
<tr>
<td>0.0963049</td>
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<tr>
<td>0.0306444</td>
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<table>
<thead>
<tr>
<th>Ho:rank=p</th>
<th>-Tlog(1-\mu) using T-nm</th>
<th>95% -T\sum \log(.) using T-nm</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>p == 0</td>
<td>35.3**</td>
<td>29.77**</td>
<td>21.0</td>
</tr>
<tr>
<td>p &lt;= 1</td>
<td>11.65</td>
<td>9.823</td>
<td>14.1</td>
</tr>
<tr>
<td>p &lt;= 2</td>
<td>3.579</td>
<td>3.019</td>
<td>3.8</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>standardized \beta' eigenvectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>rexchrate       tt               rbdi</td>
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<td>1.0000          1.3341           3.9097</td>
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</table>

<table>
<thead>
<tr>
<th>standardized \alpha coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>rexchrate       tt               rbdi</td>
</tr>
<tr>
<td>-0.11323        0.0015702        -0.00037429</td>
</tr>
</tbody>
</table>

α is the matrix of standardized weight coefficients and β' the matrix of eigenvectors.

The validity of modelling the MRER on the rest of variables of the system was analyzed by means of the LR tests shown in Table 2. LR statistics indicate that we can reject α_0=0 (the weight of the cointegration relation in the rexchrate equation) whereas we cannot reject α_1=0 and α_2=0 (the weight of the

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5 The variables were expressed in logs with the exception of the trade balance/GDP ratio.

6 The government expenditure/GDP ratio was linearly correlated with the terms of trade.
cointegration relation in the $tt$ and $rbdi$ equations, respectively). The LR tests indicate the validity of the conditional model of the MRER on the TT and the Real Broad Dollar Index. That is, the disequilibrium from the cointegration relationship is significant only in the real exchange rate equation (Johansen (1992), Urbain (1992) and Ericsson (1994)).

Therefore the relationship between these three variables can be formulated as a simple version of an equilibrium correction model where the equilibrium correction term becomes:

$$\Delta rexchrate_t = -0.11 [rexchrate_{t-1} - (-1.3)tt_{t-1} - (-3.9)rbdi_{t-1}]$$

Table 2
The Exogeneity Analysis

<table>
<thead>
<tr>
<th>General cointegration restrictions:</th>
<th>Headings</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_0=0$;</td>
<td>LR-test, rank=1: Chi$^2(1) = 23.632$ [0.0000] **</td>
</tr>
<tr>
<td>$\alpha_1=0$;</td>
<td>LR-test, rank=1: Chi$^2(1) = 0.020456$ [0.8863]</td>
</tr>
<tr>
<td>$\alpha_2=0$;</td>
<td>LR-test, rank=1: Chi$^2(1) = 0.010505$ [0.9184]</td>
</tr>
</tbody>
</table>

LR is the likelihood ratio statistics assuming rank =1

The econometric analysis continues with the estimation of a general model which includes the previous equilibrium correction term and also the variables that did not enter in the long-run relationship but could be relevant in the short-run equilibrium correction. Dummy variables that allow for homoscedastic white-noise and normal residuals are also included. After simplifications, the model is shown in Table 3.

Table 3
The Equilibrium Correction Model

The null hypothesis of homoscedasticity in the White test of squares is not rejected at the 1% significance level but is rejected at the 5% significance level.
The results show that the MRER is determined in the long-run by the TT and the Real Broad Dollar Index, as the equilibrium correction term (EqC_1) is individually significant at traditional levels and has the correct sign. The acceleration of the TT (DD3ltt) also has a short-run effect on the real exchange rate with a three period lag: a 1% increase in this variable has a negative effect of –0.41. The other long-run determinant, rbdi, did not result significant in the short-run. The fourth lag of the dependent variable is also found to be significant at traditional levels.

A multiplicative dummy variable is introduced in order to take into account the effect of the different exchange regimes on the fraction of the long-run disequilibrium that is corrected in the first quarter. The variable EqCmult_1 is EqC_1 times a dummy variable that takes the values 0 during the periods of flexible exchange rate and 1 during fixed exchange rate periods (the “Tablita” years 1979-80 and the Convertibility period, 1991-01). The significance of EqCmult_1 indicates that the exchange rate regime is relevant for determining the fraction of the deviation from the equilibrium relation that is corrected in each quarter. In fact, it turns out that there is no significant correction of misalignments during the years under fixed (or almost fixed) exchange rate regimes, since the hypothesis that there is no quarterly correction of the disequilibrium from the cointegration relationship during fixed exchange rate regimes (βEqC_1 + βEqCmult_1 = 0) is not rejected, according to the linear restriction test (Table 4). On the other hand, during the remaining period (with more flexible exchange rate regimes) about 24% of the disequilibrium is corrected in the first quarter. An additive dummy variable
also reflects that the exchange rate regime is significant in determining the rate of real appreciation (or depreciation). We find that the level of the rate of growth of the MRER is on average 10% lower (meaning that the rate of real peso depreciation is lower, or the rate of real peso appreciation is higher) when there are fixed exchange regimes.

Table 4
Wald test for linear restrictions

\[ \beta EqC \_1 + \beta EqCmult \_1 = 0.0000 \]
\[ F(1,103) = 1.6223[0.2056] \]

Finally the constancy of the parameters of the model was evaluated -and not rejected- by their recursive estimation as observed in the following graphs. Observe that the recursive estimates of the main coefficients are within 2 standard error intervals of the previous estimates.

Although we are considering a multilateral exchange rate, given the high weight of the dollar in this basket, the nominal exchange rate (see the graph in the Appendix) exhibits low variability during the Convertibility period, jumps with the devaluation of January 2002 and then declines somewhat but remains...
As the exchange rate was highly managed since the third quarter of year 2003, with sizable daily Central Bank interventions in the foreign exchange market, we decided to see what happens when we include this period as fixed as having a fixed or almost fixed regime by means of the definitions of the additive and multiplicative dummy variables. The results of this model are presented in Table 5 below, where the additive dummy is denoted as \textit{dumfixa} and the multiplicative dummy \textit{EqCmulta\_1}.

Table 5

The Equilibrium Correction Model

\begin{tabular}{lcc}
\textbf{Drexchrate} = & +0.0448 & -0.09837 Drexchrate\_4 & -0.3838 DD3ltt \\
(SE) & (0.0137) & (0.0406) & (0.1093) \\

-0.2375 EqC\_1 & +0.2224 EqCmulta\_1 & -0.07396 dumfixa \\
(0.03127) & (0.03996) & (0.01714) \\

-0.03827 seas7591\_2 & +0.3573 d812 & +0.2366 d822 \\
(0.0212) & (0.07512) & (0.07499) \\

+0.7188 d823 & +1.034 d892 & -0.267 d90234 \\
(0.07539) & (0.07478) & (0.04401) \\

+0.6169 d021 & +0.2257 d022 & \\
(0.07698) & (0.07567) & \\

\end{tabular}

\[ R^2 = 0.846539 \quad F(13,102) = 43.282 \quad [0.0000] \quad \sigma = 0.0727366 \quad DW = 1.56 \]
\[ RSS = 0.5396429838 \text{ for 14 variables and 116 observations} \]

Residual tests and functional form

\begin{tabular}{lcc}
AR 1- 4 & F(4, 98) = 1.9293 [0.1116] & \\
ARCH 4 & F(4, 94) = 1.0043 [0.4093] & \\
Normality Chi^2(2) & = 3.2797 [0.1940] & \\
Xi^2 & F(17, 84) = 1.5214 [0.1069] & \\
RESET & F(1,101) = 2.7222 [0.1021] & \\

\end{tabular}

The results are quite similar to those obtained previously and shown in Table 3. The MRER is again determined in the long-run by the TT and the Real Broad Dollar Index. The acceleration of the TT again has a short-run effect on the real exchange rate with a three period lag (a 1\% increase in this variable has a negative effect of \(-0.38\)). Once again, the other long-run determinant, the \textit{rbdi}, did not result significant in the short-run and the fourth lag of the dependent variable was found to be significant at traditional levels.

The multiplicative and additive dummy variables include the 2003:3–2005:1 period as having a fixed exchange rate regime. The variable \textit{EqCmulta\_1} is \textit{EqC\_1} times a dummy variable that takes the values 1 during fixed exchange rate periods (the “Tablita” years, 1979-80; the Convertibility period, 1991-01 and the post-crisis period 2003:3-2005:1) and 0 in the rest of the sample. The hypothesis that there is no quarterly correction of the disequilibrium from
the cointegration relationship during fixed exchange rate regimes ($\beta EqC_1 + \beta EqCmulta_1 = 0$) is again not rejected, according to the linear restriction test (Table 6). During flexible exchange rate regimes about a 24% of the disequilibrium is corrected in the first quarter. The additive dummy variable reflects that the level of the rate of growth of the MRER is on average 7% lower (meaning that the rate of real peso depreciation is lower, or the rate of real peso appreciation is higher) when there is no fixed exchange rate regime.

Table 6

Wald test for linear restrictions

$$\beta EqC_1 + \beta EqCmulta_1 = 0.0000$$

$$F(1, 102) = 0.36097[0.5493]$$

Finally the constancy of the parameters of the model was evaluated -and again not rejected- by their recursive estimation as observed in the following graphs. Observe that the recursive estimates of the main coefficients are within 2 standard error intervals of the previous estimates.

Given that both models show stable parameter estimates and that the model of Table 5 has only a small advantage in terms of goodness of fit, the models
were also compared by encompassing tests.

The model that considered as fixed the 2003:3 – 2005:1 period offered an alternative econometric model, so we extended the evaluation to test encompassing. If one of the models can explain the results of the other, that model is the “preferred” one, but if none of them can encompass the other, a progressive research strategy could suggest a joint model including both variable sets (see Ahumada, 1985; Ericsson, 1983; Hendry and Richard, 1989; Mizon, 1984 and Mizon and Richard, 1986, for a more detailed discussion). The following Table presents the results of four encompassing tests. Model 1 corresponds to the model of Table 3, and Model 2 to the one of Table 5.

<table>
<thead>
<tr>
<th>Model 1 v Model 2</th>
<th>Form</th>
<th>Test</th>
<th>Form</th>
<th>Model 2 v Model 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4.79239</td>
<td>N(0,1)</td>
<td>Cox</td>
<td>N(0,1)</td>
<td>-0.644271</td>
</tr>
<tr>
<td>4.24068</td>
<td>N(0,1)</td>
<td>Ericsson IV</td>
<td>N(0,1)</td>
<td>0.598462</td>
</tr>
<tr>
<td>13.3864</td>
<td>Chi^2(3)</td>
<td>Sargan</td>
<td>Chi^2(2)</td>
<td>3.43632</td>
</tr>
<tr>
<td>4.97932</td>
<td>F(3,100)</td>
<td>Joint Model</td>
<td>F(2,100)</td>
<td>1.7432</td>
</tr>
<tr>
<td>[ 0.0029]</td>
<td></td>
<td></td>
<td></td>
<td>[ 0.1802]</td>
</tr>
</tbody>
</table>

The results show that Model 2 encompasses Model 1. Therefore, the model that considers the recent period of managed exchange rate as fixed is “preferred” to the one where the 2003:3-2005:1 period is considered as one with a flexible exchange rate regime.

3 Graphical analysis of real exchange rate misalignment

The misalignment of MRER can be calculated as the log difference between the MRER and its long-run equilibrium level, as determined by the two fundamental variables. Hence, the gap can be interpreted as an approximation to the percentage deviation between both variables. This gap is shown in the first graph below. The graph shows that the peso was substantially overvalued at the end of the Convertibility regime. This deviation was corrected during 2002 with overshooting, and during the following years there was no significant correction. Although the actual MRER fell somewhat, so did its long-run equilibrium value due mostly to the U.S. dollar depreciation. The misalignment, according to this measurement, was 28% in the first quarter of 2005. The second graph shows the residual or gap between the actual MRER and the theoretical MRER that includes not only the long-run relation but also the short-run influences of the rates of growth of the fundamentals on the rates of growth of the MRER. The quarters that show peaks in the residual reflect periods of great macroeconomic instability.
4 Conclusions

This paper contains an empirical analysis of Argentina’s Multilateral Real Exchange Rate. It develops an equilibrium correction model that is very parsimonious but nevertheless seems to be able to track the path of the MRER very well. Only two fundamental determinants of the equilibrium MRER are used: the MRER of the U.S.A. as measured by the Federal Reserve’s Real Broad Dollar Index, and Argentina’s terms of trade. Various other variables were tried and finally discarded. Through the use of a multiplicative dummy, it is shown that MRER misalignments are not significantly corrected at all during periods of unilateral pegs to the U.S. dollar, as happened during the
Tablita experience during the late 70s, during the protracted period of Convertibility and also since the middle of year 2003 until the beginning of 2005. However, during periods of more flexible exchange rate regimes, about a 24% of the disequilibrium is corrected in the first quarter. Also, an additive dummy shows that the rate of growth of the MRER is significantly affected by the type of exchange regime in place.

5 Appendix 1

Unit–Root Tests

<table>
<thead>
<tr>
<th>Serie</th>
<th>ADF(j)</th>
</tr>
</thead>
<tbody>
<tr>
<td>rexchrate</td>
<td>ADF(1)=-2.118</td>
</tr>
<tr>
<td>tt</td>
<td>ADF(1)=-2.864</td>
</tr>
<tr>
<td>prod</td>
<td>ADF(1)=-0.851</td>
</tr>
<tr>
<td>rbdi</td>
<td>ADF(1)=-1.728</td>
</tr>
<tr>
<td>goexp/GDP</td>
<td>ADF(1)=-1.866</td>
</tr>
<tr>
<td>tradebalance/GDP</td>
<td>ADF(1)=-2.167</td>
</tr>
<tr>
<td>wages</td>
<td>ADF(1)=-2.184</td>
</tr>
<tr>
<td>imports/GDP</td>
<td>ADF(1)=-1.949</td>
</tr>
</tbody>
</table>

All cases include the constant and j indicates the lags of the Augmented Dickey-Fuller (ADF) test.

6 Appendix 2

Log of the MRER

Multilateral Real Exchange Rate
7 References


Escudé, Guillermo J. (2005), "Alternative Monetary Regimes in a DSGE Model of a Small Open Economy with Two Sectors and Sticky Prices and Wages", unpublished, BCRA.


