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# The Equilibrium Real Exchange Rate of Argentina

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**Abstract**

An open economy model with two countries and two sectors (tradable and non tradable with sticky prices) is used to deduce the equation of the equilibrium real exchange rate, considering the maximization of the intertemporal utility function by the representative agent. Examined from a stock-flow perspective and based on the Johansen cointegration estimation methodology, the long-run behavior of the real exchange rate of Argentina in the period 1968-2002 can be explained by net foreign assets, relative sectoral productivities and terms of trade. On the basis of these fundamentals, the degree of misalignment is assessed. From the analysis of the dynamics of the model, it can be inferred that the collapse of the Convertibility fixed exchange rate was inevitable after the shocks initiated with East-Asian currency crises.

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Keywords: equilibrium real exchange rate, cointegration, currency crisis, Argentina

## 1. Introduction

Different questions arise after the collapse of Convertibility: was it the consequence of the accumulated competitiveness problems over the 90s? was it the result of the inconsistency between fixed exchange rate and expansionary fiscal policy? was the collapse inevitable after devaluation in the East-Asian region? or was it the direct result of the monetary policy mismanagement during 2001? To approach such wide variety of issues or to elaborate a model of the recent or past currency crisis in Argentina is not the purpose of this work. The hypothesis analyzed here is referred to establishing whether the exchange rate misalignment may have been one of the major causes of the crisis.

There is general agreement when pointing out that the deterioration of the fiscal solvency was a key factor in the recent currency crisis; however, there is no consensus about the role played by the competitiveness problem in the crisis. Some analysts just state that this last problem did not exist. It is the aim here to throw light in this discussion. In

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Argentine economic history over the past decades, the discussions about this issue have been very conflictive due to many reasons. First, the movements of the real exchange rate bring about significant alterations in sectoral income distribution (agricultural and industrial sectors versus services and financial sectors); second, the theoretical discussion is referred to the endless debate between Keynesians and Monetarists over price rigidity, third, the equilibrium exchange rate is a non-observable variable difficult to estimate, and finally, traditional theoretical models didn't have micro-foundations and were misspecified. If the starting point is the monetary hypothesis that prices are entirely flexible, any deviation from the real exchange rate with respect to the equilibrium rate is instantly corrected and, therefore, competitiveness problems do not exist. On the contrary, if there exist price rigidities in a fixed exchange rate system, there will be exchange rate misalignment and competitiveness problems at aggregate level. As a matter of fact, and because the real exchange rate represents an endogenous variable of the model, the discrepancies between the two positions come from the price flexibility assumption. Empirically, if price flexibility is assumed, it is suggested that the problem is considered in the long-term perspective, while price rigidity is a more appropriate assumption in the short term.

The exchange rate may deviate significantly from the long-term fundamental value; then, serious distortions may occur in the real economy, the labor market, production and investment. Theory tells us that after marked deviations, the real exchange rate tends to return to the long-term equilibrium value. Consequently, if there indeed was an important exchange rate misalignment over the last Convertibility years, a later reversal was foreseeable. But because of the significant institutional weakness and rigidities of the Argentine economy, it was hardly the case such reversal could be reached through a prolonged deflationary process. 2002 witnessed a severe reversal of the real exchange rate which was highly traumatic because abandoning the convertibility system took place in the worst possible context: rising unemployment, capital flight, bank crashes and default. This process was magnified by the overall violation of private property rights and the high degree of improvisation present in the economic policy during the first quarter of 2002.

To analyze the hypothesis of the peso overvaluation as a reason for the crisis, it is necessary to take a model that allows to estimate the equilibrium real exchange rate of the Argentine economy in order to be able to evaluate the degree of the misalignment from the long-term equilibrium. The fact that the equilibrium real exchange rate is not an observable variable makes the estimation very difficult. Nevertheless, economic theory indicates that macroeconomic variables determining the equilibrium real exchange rate are observable and that the actual exchange rate converges to the equilibrium exchange rate over the time. This allows the use of an econometric methodology like the error correction model to estimate both, the long-term equilibrium real exchange rate and the short-term deviations from this equilibrium.

The equilibrium real exchange rate will be derived from the extended version of the Obstfeld and Rogoff (1995) model. A simple and real version (no government and no money) of this model is used in this paper following Calderón (2002) and Lane and Milesi-Ferretti (2000) empirical approach. It can be anticipated that the model used is in line with new international macroeconomics where the aggregate performance is inferred from the micro-optimization of economic agents. The determinants of the real exchange rate that emerge in this process are: sectoral productivities in the domestic country and rest of the world, terms of trade and net foreign assets. The real exchange rate is determined not only by productivities and trade flows but also by net foreign assets stocks, in order to maintain capital flows equilibrium. The real exchange rate must be consistent with a balance of payments position where any current account imbalance is financed by a sustainable flow of international capitals, which cannot lead to an explosive accumulation of net foreign assets (or liabilities). In this framework, the equilibrium real exchange rate allows to sustain economy's long-run net foreign assets position.

The econometric estimation will follow the methodology of the error correction model which adapts perfectly to the problem to be dealt with and consists in establishing the existence of a long-term relation between the variables in order to later shape the short-term dynamics. The latter is influenced by the deviation that concerns the long-term relation. In this case, the equilibrium real exchange rate and its determinants represent the long-term equilibrium relation, and the exchange rate misalignments stand for the short-run deviations. If the real exchange rate is to return to long-term equilibrium, some of the variables -real exchange rate, net foreign assets, sectoral productivities, terms of trade- should react to the size of the misalignment. The error correction model captures this short-run dynamics.

The 1968-2002 estimation period includes four currency crises with maxi-devaluations: the so-called Rodrigazo (after the Economy Minister's name at that time) in 1975; exit from the active crawling peg ("tablita") in 1981-1982; hyperinflation in 1989-1990 and the Convertibility collapse at the end of 2001.

The paper is organized as follows. Section 2 introduces the basic model, and derives the real exchange rate equation. Section 3 details the sources and the data elaboration process. Section 4 deals with the empirical estimation and analysis of the results. Section 5 explores the short-run dynamics of real exchange rate and analyses the time path of adjustment. Section 6 deals with a comparative analysis of Argentina's adjustment process. Finally, section 7 concludes.

## 2. Theoretical Model

The model considered is a two-country model with two sectors, tradable and non-tradable. The tradable sector has a single homogeneous output ($y_T$), which is exchanged in competitive world markets at price ($P_T^x$), measured in terms of the imported good that is consumed internally, chosen as the numerary ($P_T^M$). The non tradable sector is the locus of the monopoly and sticky price problems. There is a representative agent *j* in each country (domestic country and rest of the world), who receives the constant endowment $y_T$ each period and has a monopoly power over production of one of the non-tradable goods $z \in [0,1]$. The number of producers in the domestic country has been standardized in the interval [0,n], while producers in the rest of the world have been represented in the interval (n,1]. All agents have similar preferences throughout the world over a real consumption index and work effort.

*The representative consumer-producer optimization problem*

The agent *j* maximizes a utility function that depends positively on consumption and negatively on work effort, which is positively related to output. The inter-temporal utility function is given by:

$$U_t^j = \sum_{s=t}^{\infty} \beta^{s-t} \left[ \frac{\sigma}{\sigma - 1} C_s^{1-\frac{1}{\sigma}} - \frac{\kappa}{2} y_{N,s}^2 \right] \qquad \text{where} \quad \beta \in (0,1) \text{ and } \sigma, \kappa > 0 \qquad (1)$$

Coefficient $\sigma$ indicates the intertemporal elasticity of substitution in consumption and $\beta$ denotes a subjective rate of discount.

The second term in (1) is negative because it represents the disutility resulted from the effort to produce non-tradable goods, assuming a certain technical relationship between labor and $y_N$ (established by the parameter $\kappa$[1]).

The consumption index ($C_t$), is an aggregate index of tradable and non-tradable consumption ($C_T$ and $C_N$, respectively):

$$C = \left[ \gamma^{\frac{1}{\theta}} \; C_T^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} \; C_N^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \qquad \gamma \in (0,1) \qquad \theta > 1 \qquad (2)$$

Where $C_N$ is the composite non-traded good consumption, defined by:

$$C_N = \left[ \int_0^1 c_N(z)^{\frac{\theta-1}{\theta}} \; dz \right]^{\frac{\theta}{\theta-1}}$$

Parameter $\theta$ represents the constant elasticity of intra-temporal substitution (i.e. elasticity of substitution between traded and non-traded consumption).

Agent *j* can invest in an internationally traded asset, denominated in units of the imported good. Thus, the representative agent maximizes the utility intertemporally subject to her flow budget constraint:

$$F_{t+1}^{j} = (1+r_t)\ \ F_t^{j} + p(j)_{N,t}\, y_{N,t} + P_{T,t}^{X}\, \overline{y}_{T,t} - P_t C_t^{j} \qquad (3)$$

where $F^j$ represents the agent's stock of net foreign assets, that pay off a real return *r* and $y_N$ is the individual's output. In addition, $p(j)_{N,t}$ is the price of non-tradable good produced by the agent *j*. The consumption-based price index for the domestic country is given by[2]:

$$P_t = \left[\gamma P_{T,t}^{1-\theta} + (1-\gamma)\, P_{N,t}^{1-\theta}\right]^{\frac{1}{1-\theta}} \qquad (4)$$

The producer of non-traded goods face the following demand curve:

$$y_{N,t}^{d} = \left[\frac{p(j)_{N,t}}{P_{N,t}}\right]^{-\theta} C_{N,t} \qquad (5)$$

where $C_N = \int_0^n C_{N,t}^{j}\, dj$ represents the domestic aggregate consumption of non-traded goods.

There are three main relations emerged from the first order conditions to maximize (1) subject to (3) and (5). The first one, the optimal consumption transferring over periods is determined by[3]:

$$\frac{u'(C_t)}{u'(C_{t+1})}\frac{P_{t+1}}{P_t} = \beta(1+r_{t+1})$$

In this case, $u'(C_t) = C_t^{-1/\sigma}$ and $u'(C_{t+1}) = C_{t+1}^{-1/\sigma}$, turning the expression in

$$\left(\frac{C_{t+1}}{C_t}\right)^{\frac{1}{\sigma}} = \beta(1+r_{t+1})\frac{P_t}{P_{t+1}} \quad \rightarrow \quad C_{t+1} = \left[\frac{(1+r_{t+1})\ P_t}{P_{t+1}}\right]^{\sigma} \beta^{\sigma}\ \ C_t \qquad (6)$$

Having in mind the relationship between the optimal $C_t$ and the sectoral consumptions given by[4]:

$$C_{T,t} = \gamma\left(\frac{P_{T,t}}{P_t}\right)^{-\theta} C_t \qquad (7)$$

$$C_{N,t} = (1-\gamma)\left(\frac{P_{N,t}}{P_t}\right)^{-\theta} C_t \qquad (8)$$

and replacing $C_t$ from (7) to (6), the Euler condition for the optimal consumption path is found:

$$C_{T,t+1} = \left(\frac{P_t}{P_{t+1}}\right)^{\sigma-\theta}\left(\frac{P_{T,t+1}}{P_{T,t}}\right)^{-\theta}(1+r_{t+1})^{\sigma}\,\beta^{\sigma} C_{T,t} \qquad (9)$$

The second relation comes from the combination of (7) and (8), resulting in the intra-temporal substitution between consumption of both goods.

$$\frac{C_N}{C_T}=\frac{(1-\gamma)}{\gamma}\left(\frac{P_N}{P_T}\right)^{-\theta} \tag{10}$$

The last relation, the equation that determines the equilibrium supply of non-tradables, is deduced considering the following steps. First, deducing $p(j)_{N,t}$ from (5) and substituting into (3), the following is obtained:

$$F^j_{t+1}-(1+r_t)F^j_t-P^X_{T,t}\bar{y}_{T,t}+P_tC^j_t-(C_{N,t})^{\frac{1}{\theta}}\,(y_{N,t})^{\frac{\theta-1}{\theta}}P_{N,t}=0$$

in which $C_t$ is equal to:

$$C^j_t=\frac{(C_{N,t})^{\frac{1}{\theta}}\,(y_{N,t})^{\frac{\theta-1}{\theta}}\,P_{N,t}+P^X_{T,t}\bar{y}_{T,t}-F^j_{t+1}+(1+r_t)F^j_t}{P_t}$$

Plugging this equation into the utility function (1) and differencing it with respect to $y_N$ the equilibrium supply of non-tradables is obtained:

$$y_{N,t}^{\frac{\theta+1}{\theta}}=\left(\frac{\theta-1}{\theta\kappa}\right)(C^j_t)^{-\frac{1}{\sigma}}\,(C_{N,t})^{\frac{1}{\theta}}\left(\frac{P_{N,t}}{P_t}\right) \tag{11}$$

Equilibrium is characterized by equations (9), (10) and (11), that is:

$$\frac{C_{T,t+1}}{C_{T,t}}=\left[(1+r\,)\beta\right]^{\sigma}\left(\frac{P_t}{P_{t+1}}\right)^{\sigma-\theta}\left(\frac{P_{T,t+1}}{P_{T,t}}\right)^{-\theta} \tag{9'}$$

$$\frac{C_N}{C_T}=\frac{(1-\gamma)}{\gamma}\left(\frac{P_N}{P_T}\right)^{-\theta} \tag{10'}$$

$$y_{N,t}^{\frac{\theta+1}{\theta}}=\left(\frac{\theta-1}{\theta\kappa}\right)(C^j_t)^{-\frac{1}{\sigma}}\,(C_{N,t})^{\frac{1}{\theta}}\left(\frac{P_{N,t}}{P_t}\right) \tag{11'}$$

in conjunction with the budget constraint (3) and the transversality condition:

$$\lim_{T\to\infty}\prod_{s=t}^{t+T}\left(\frac{1}{1+r}\right)F_{t+T+1}=0$$

First, the Euler condition shows that consumption of tradables depends on the sequence of relative prices (the consumption-based real interest rate effect). Thus, if the aggregate price level relative to the price of tradables is currently low relative to its future value, then present consumption is preferred over future consumption as the consumption-based real interest rate is lower. However, it also encourages substitution from traded to non-traded goods. The former effect dominates if the intertemporal elasticity of substitution is greater than the elasticity of intra-temporal substitution ($\sigma>\theta$)

Second, the relationship between consumption of non-traded and traded goods shows that, if the relative price is equal to one, the relative consumption of non-traded goods is larger, the smaller is the parameter $\gamma$.

Third, the equation that postulates the equilibrium supply of non-traded goods shows that the higher is the consumption index C, the lower is the level of production, as agents increase leisure in line with consumption of other goods.

Any equilibrium must satisfy the first-order conditions, the net foreign asset market clearing condition and the non-tradable goods market clearing:

$$nF_t + (1-n)F_t^* = 0, \text{ where } F_t = \int_0^n F_t^j \, dj \text{ and } F_t^* = \int_n^1 F_t^{*j} \, dj$$

$$C_{N,t} = \int_0^n \frac{p_{N,t}(j)}{P_{N,t}} y_{N,t} dj = Y_{N,t}$$

Considering the whole domestic country, the budget constraint (3) becomes:

$$F_{t+1} = (1+r_t)F_t + P_{N,t}Y_{N,t} + P_{T,t}^X \overline{Y}_{T,t} - P_t C_t$$

where $C_t = \int_0^n C_t^j \, dj$ and $\overline{Y}_{T,t} = n\overline{y}_{T,t}$.

*Linear Approximation of Steady State Solution*

In steady state, the temporal path of all variables converges to a constant value over time (e.g. $F_{t+1} = F_t = F$).

The domestic country budget constraint becomes:

$$PC = P_N Y_N + P_T^X \overline{Y}_T + rF$$

This implies that consumption equals income (output of non-tradables plus endowment of tradables, plus income from net foreign assets holdings) in steady state.

Following the other first order conditions, it is possible to approximate a steady state solution for the consumer problem. Assuming that the price of non-tradables ($P_N$) and the price of exported goods ($P_T^X$) are normalized to one, from equations (11) and (8), it is obtained:

$$Y_N = C_N = \left(\frac{\theta - 1}{\theta \kappa}\right)^{\frac{\sigma}{\sigma+1}} (1-\gamma)^{\frac{1}{\sigma+1}} \tag{12}$$

Equation finds that the less taxing is work effort (the smaller is $\kappa$), the larger the production of non-tradables will be in the steady state.

Additionally, with the relation between consumption of both goods established in (10) and given that $Y_N = C_N$:

$$Y_T = C_T = \left(\frac{\gamma}{1-\gamma}\right) Y_N \tag{13}$$

Once exposed the two major equations which explicit optimal production and consumption for both goods, a log-linear approximation around the benchmark steady state is taken; where $\hat{x} = dx/x_0$ denotes the percentage change relative to this benchmark steady state. The determinants of the change in tradable consumption are deduced from the log-linear approximation of the steady state domestic country budget constraint:

$$\hat{C}_T = r\hat{F} + \hat{Y}_T + \hat{P}_T^X \quad (14)$$

Equation (14) shows how consumption of tradables is determined by the net foreign assets (F), the tradable product ($Y_T$) and the price of exported goods ($P_T^X$). Assuming that changes on the tradable supply $Y_T$ come from productivity shocks ($\hat{A}_T$), (14) becomes in:

$$\hat{C}_T = r\hat{F} + \hat{A}_T + \hat{P}_T^X \quad (14')$$

Additionally, by equations (10) and (13):

$$\hat{Y}_N = \hat{C}_N = \hat{C}_T - \theta\left(\hat{P}_N - \hat{P}_T\right) \quad (15)$$

Taking equation (12) and removing the assumption made above about normalizing prices[5]:

$$\hat{Y}_N = \hat{C}_N = \left(\frac{\sigma-\theta}{\sigma-1}\right)\gamma\left(\hat{P}_N - \hat{P}_T\right) + \left(\frac{2\sigma}{\sigma+1}\right)\hat{A}_N \quad (16)$$

Equation (16) expresses the proportional changes on the non-tradable supply around its benchmark steady state. $\hat{A}_N$ represents the impact of productivity surges in non-tradables.

Combining the results obtained in (14'), (15) and (16), the change in the relative price of non-tradables is given by:

$$\hat{P}_N - \hat{P}_T = \frac{1+\sigma}{\theta(1+\sigma)+\gamma(\sigma-\theta)}\left[r\hat{F} + \hat{A}_T + \hat{P}_T^X - \frac{2\sigma}{\sigma+1}\hat{A}_N\right] \quad (17)$$

Equation (17) has its counterpart for the rest of the world[6]:

$$\hat{P}_N^* - \hat{P}_T^* = \frac{1+\sigma}{\theta(1+\sigma)+\gamma(\sigma-\theta)}\left[\left(\frac{-n}{1-n}\right)r\hat{F} + \hat{A}_T^* + \hat{P}_T^M - \frac{2\sigma}{\sigma+1}\hat{A}_N^*\right] \quad (18)$$

*The Real Exchange Rate Equation*

The real exchange rate is the ratio of foreign to domestic price index:

$$q_t = \frac{P_t^*}{P_t} \quad (19)$$

Taking the log-linear approximation of (19)[7]:

$$\hat{q}_t = \left(\hat{P}_{T,t}^* - \hat{P}_{T,t}\right) - (1-\gamma)\left(\hat{P}_{N,t} - \hat{P}_{T,t}\right) + (1-\gamma)\left(\hat{P}_{N,t}^* - \hat{P}_{T,t}^*\right) \quad (20)$$

The term $\hat{P}_{T,t}^* - \hat{P}_{T,t}$ describes the relative price between foreign and domestic tradable goods. This term is expected to follow a stationary process, because the deviations from the law of one price in traded goods (although large and persistent) are stationary, due to the arbitrage that holds in this sector.

The last step is simply to plug (17) and (18) into (20), to express the equation of the changes in the equilibrium real exchange rate:

$$\hat{q}_t = \left(\hat{P}^*_{T,t} - \hat{P}_{T,t}\right) - \frac{(1-\gamma)(1+\sigma)}{\theta(1+\sigma)+\gamma(\sigma-\theta)}\left[\left(\frac{1}{1-n}\right) r\hat{F}_t + \left(\hat{A}_{T,t} - \hat{A}^*_{T,t}\right) - \frac{2\sigma}{\sigma+1}\left(\hat{A}_{N,t} - \hat{A}^*_{N,t}\right) + \left(\hat{P}^X_{T,t} - \hat{P}^M_{T,t}\right)\right] \quad (21)$$

This equation resumes the key point of the model. From (20), the unit root behavior in real exchange rate $q_t$ might be induced by a non-stationary behavior of the relative price of non-tradables in the country or/and in the rest of the world. According to (21), this non-stationarity could be driven by permanent technology shocks, permanent demand shocks or permanent terms of trade shocks.

*Empirical Implementation*

The equation to estimate is similar to (21), but in levels, this is:

$$\ln q_t = \eta + \beta_2\left(\frac{F}{PY}\right)_t + \beta_3 \ln\left(\frac{A_T}{A^*_T}\right)_t + \beta_4 \ln\left(\frac{A_N}{A^*_N}\right)_t + \beta_5 \ln\left(\frac{P^X_T}{P^M_T}\right) + \varepsilon_t \quad (22)$$

where $\eta = \ln\left(\frac{P^*_T}{P_T}\right)$. The random disturbance $\varepsilon_t$ is expected to be stationary. Additionally, from (21),

$$\beta_2 = \frac{\psi \;\; r}{(1-n)} < 0; \quad \beta_3 = \beta_5 = \psi < 0; \quad \beta_4 = -\frac{2\sigma\psi}{1+\sigma} > 0, \text{ where } \psi = \frac{-(1-\gamma)(1+\sigma)}{\theta(1+\sigma)+\gamma(\sigma-\theta)}$$

The assumptions made to build the model require that coefficients in equation (22) must have the following signs. First, if the country has significant levels of external liabilities, it needs to run consecutives trade surpluses in order to service those liabilities, and for this reason the country require a real exchange rate depreciation ("the transfer problem"). On the other hand, Obstfeld and Rogoff (1995), claim that a transfer of resources from the domestic to foreign country reduces domestic wealth making labor and non-tradable goods supply to raise. Since this effect push the price of non-tradables down, the real exchange rate increases. Therefore, $\beta_2 < 0$. Second, the exchange rate would appreciate if the productivity of tradables grows faster at the domestic country than does at the rest of the world, and it would depreciate if a relative improvement in domestic non-tradable productivity occurs; according to the Balassa-Samuelson effect. It follows that $\beta_3 < 0$ and $\beta_4 > 0$. Finally, terms of trade improvements would generate a positive wealth effect, increasing consumption and reducing labor supply in the non-tradable sector. This leads to an increase in the relative price of non-tradables and hence an appreciation of the real exchange rate ($\beta_5 < 0$).

**3. Sources and Data**

Annual data were used for the empirical estimations. Except for the stock of net foreign assets, calculated as a GDP percentage, all variables are in logarithms.

The real exchange rate (q) is the multilateral real exchange rate relative to the 10 main trade partners of Argentina. It was calculated using a weighted geometric average of the GDP deflators from each country. The weights ($\delta_i$) were obtained as the ratio of Argentina's exports and imports with the country *i* to Argentina's total imports and exports. This ratio was calculated for the years 1970, 1975, 1980, 1985, 1990, 1995 and 2000. Countries where the average share was higher than 3% were selected. The bilateral trade data were obtained from IMF Direction of Trade Statistics. Table 1 shows the selected shares. Finally, the former USSR countries were excluded because data were not available.

To calculate the real exchange rate, all GDP deflators were in dollars. The nominal exchange rate was obtained from the IMF International Financial Statistics (rf series); while the GDP deflators were taken from the World Development Indicators of the World Bank.

**Table 1:** Trade Shares

| | Shares | $\delta_i$ |
|---|---|---|
| USA | 15.43% | 0.236 |
| BRASIL | 13.87% | 0.212 |
| GERMANY | 7.08% | 0.108 |
| ITALY | 6.14% | 0.094 |
| JAPAN | 5.05% | 0.077 |
| Ex-USSR | 4.28% | - |
| NETHERLANDS | 3.89% | 0.059 |
| CHILE | 3.77% | 0.058 |
| FRANCE | 3.58% | 0.055 |
| SPAIN | 3.39% | 0.052 |
| CANADA | 3.23% | 0.049 |
| Total | 69.7% | 1 |

The formula used was:

$$q = \frac{\prod_{i=1}^{10} \left(P_i^* / E_i^*\right)^{\delta_i}}{P/E}$$

where an increase of the real exchange rate implies a real depreciation of the domestic currency.

The tradable and non-tradable productivities were obtained as the ratio of the sectoral product to its sectoral employment.

$$A_T / A_T^* = \frac{A_T / E}{\prod_{i=1}^{10} \left(A_{Ti}^* / E_i^*\right)^{\delta_i}} \qquad A_N / A_N^* = \frac{A_N / E}{\prod_{i=1}^{10} \left(A_{Ni}^* / E_i^*\right)^{\delta_i}}$$

Taking into account the International Standard Industrial Classification (ISIC) the tradable sector is represented by goods produced in:

C. Mining and quarrying
D. Manufacturing

The sectors that produce non-tradable goods are:

E. Electricity, Gas and Water
F. Construction
G. Wholesale and retail trade
H. Hotels and restaurants
I. Transport, storage, and communication
J. Finance intermediation,
K. Real state and business services
L. Public Administration and Defense
M. Education
N. Health and social services
O. Other social and personal services and community
P. Private households with employed persons

In Argentina, the tradable and non-tradable product data were elaborated using the statistics published by Dirección Nacional de Cuentas Nacionales of the Ministry of Economy, with 1993 as the base year. The sectoral product data of the countries in the rest of the world were obtained from: the OECD sectoral data base, the University of Groningen data base and World Bank's Conference Board (2002) and World Development Indicators.

For Argentina, the sectoral employment before 1980 was obtained from Llach and Sánchez (1984), "Los determinantes del salario en la Argentina. Un diagnóstico de largo plazo y propuestas de políticas", *Estudios*, Córdoba. Later data were derived from household surveys EPH of the Instituto Nacional de Estadística y Censos (INDEC).

For the rest of the world, sectoral employment data were obtained from the OECD sectoral database, the University of Groningen database (2002), the Key Indicators of the Labor Market (KILM) and the Chilean and Brazilian Bureau of National Statistics.

The tradable and non-tradable productivities from the rest of the world were calculated using the same methodology and weights as for the real exchange rate; that is to say, the result of the weighted geometric average of Argentina's 10 major trade partners.

The terms of trade were obtained from the statistics published by Argentina's Ministry of Economy.

The database and guidelines by Lane and Milesi-Ferretti (2001) were used to build the net foreign assets series (F). For a given period, the net foreign assets emerge from the following equation:

$$F_t = (FDIA_t - FDIL_t) + (EQA_t - EQL_t) + (DEBTA_t - DEBTL_t) + R_t \qquad (23)$$

Expressions $(FDIA_t - FDIL_t)$, $(EQA_t - EQL_t)$, $(DEBTA_t - DEBTL_t)$ stand for the stock of net foreign assets (assets minus liabilities) in direct investment, portfolio equity investment and debt instruments, respectively. Variable $R_t$ means the stock of international reserves.

The change in net foreign assets F can be approximated with the current account balance (CC), net of capital account transfers (TR).

$$\Delta F \cong CC - \Delta TR$$

Thus, after obtaining the initial level of net foreign assets, the F approximate series is built by accumulating the current account balances net of transfers.

To build the net foreign assets series as a GDP percentage the nominal exchange rate was used, plus a 10% black market premium to take into account periods with capital control (1971-76 and 1981-89). The present value of the future surpluses necessary to make a given foreign debt stock sustainable must be higher when the cost of financial dollars is higher than the commercial ones.

**Figure 1:** Real Exchange Rate

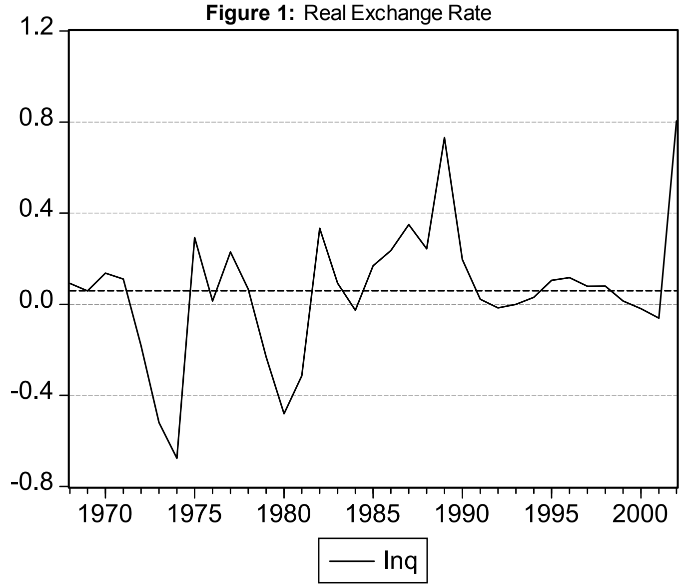
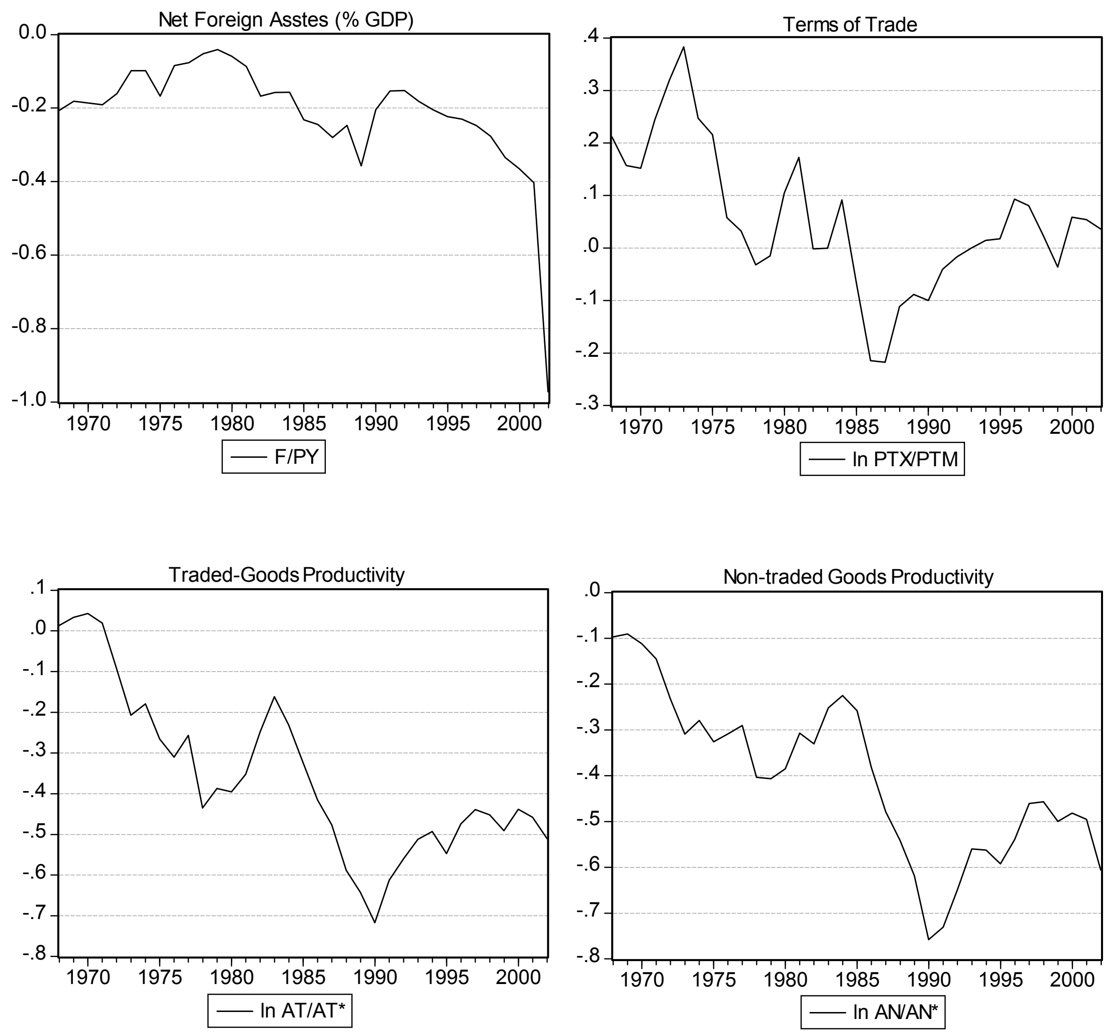



Figure 1 represents the real exchange rate evolution and shows the presence of low values in 1974 and 1980, and peaks in the hyperinflation of 1989, and in 2002 with the exit from Convertibility. During Convertibility, the real exchange rate was near the average of the period (dotted line), goes slightly up at the time of Brazil's Plan Real and drops over the last three years of Convertibility. A quick look at the series does not reveal that there was a significant misalignment during the last years of Convertibility. However, such an analysis is not right because this variable must be compared with its equilibrium value, not with a historical average.

Figure 2 shows the determinants of the real exchange rate. The figures of Argentina's relative tradable and non-tradable productivities with respect to the rest of the world show a constant fall from 1983-1984 to 1990, which can be explained by the poor performance of the economy over the 80s. In spite of the important Argentine productivity rise over the 90s, the level reached by such variables towards the end of the decade was far from the relative value recovery of the 1970s and 1980s, which may be accounted by the sustained productivity growth in the rest of the world, where Argentina's Lost Decade didn't exist.

Throughout the period, the stock of net foreign assets as a GDP percentage was negative because there have been permanent current account deficits since 1980 (with very few exceptions). By construction, this variable depends on the exchange rate level; this is why, during the 1989 hyperinflation, it reached the minimum value of the decade. It rapidly rose with the stabilization of Convertibility and the Brady Plan, and from a –18% value, the net foreign assets position was constantly eroded over the 1990s until –40% of the GDP is reached in 2001. This leads to a permanent increase of the equilibrium real exchange rate. The 2002 devaluation causes the abrupt fall of this ratio.

**Figure 2:** Determinants of the Real Exchange Rate



The terms of trade show a maximum value during the oil crisis in 1973 and a minimum value during the Plan Austral years.

## 4. Empirical Estimation and Results

This section begins with the description of the econometric framework. Then the results of Augmented Dickey-Fuller and cointegration tests are presented. Once the long-term equilibrium real exchange rate equation is obtained; the misalignments in different crises are discussed.

*Econometric procedure*

The econometric procedure employed is a version of the multivariate cointegrated systems originally developed by Johansen. Cointegration simply means that there is a linear combination (or cointegrating vector) between non stationary variables that is stationary.

The statistical model assumes a vector $y_t$ of random variables that make up a p-dimensional VAR with Gaussian errors (with p equal to the number of endogenous variables in the system). Assuming cointegration between the $y_t$ components, the model is written in the form of an autoregressive vector error correction model:

$$\Delta y_t = \mu + \alpha\beta' y_{t-1} + \sum_{i=1}^{k} \pi_i \Delta y_{t-i} + \varepsilon_t \qquad (24)$$

In this case, the short-term dynamics are represented by the series in first differences, and the long-term relations by the variables in levels. Following (24), any deviation in the long-term equilibrium may influence the short-term dynamics. Also, if $y_t$ is integrated of order one, then the matrix $\alpha\beta'$ is of reduced rank, and $\alpha$ (adjustment speed parameter) and $\beta$ (cointegrating vectors) are pxr matrices of rank r. Following this hypothesis, the $\Delta y_t$ process is stationary, $y_t$ is non stationary, but $\beta' y_t$ is stationary.

To be able to know the order of integration of the series that make up vector $y_t$, the Augmented Dickey-Fuller test (ADF) has been used. Table 2 shows the detailed results.

The real exchange rate (q) seems to be a stationary variable because the null hypothesis of unit roots is rejected at 1%. The deviations persist but they are not permanent; no trend is observed and there is mean reversion to the long-term value.

With the terms of trade, the hypothesis of unit roots can also be rejected but at 5% only. With the rest of the variables, the ADF test in levels does not allow to reject the null hypothesis of unit roots, but it can be rejected at 1% in first differences. This means that Argentina's relative tradable and non-tradable productivities with respect to the rest of the world, and the net foreign assets are integrated of order one I(1).

**Table 2:** Augmented Dickey-Fuller Test

| Variable | | Structure | Lags | t Statist |
|---|---|---|---|---|
| ln q | Level | | 0 | -3.2578** |
| | 1 diff | | 0 | -6.4121** |
| $\ln A_T/A^*_T$ | Level | Intercept | 0 | -1.567387 |
| | 1 diff | | 0 | -4.7613** |
| $\ln A_N/A^*_N$ | Level | Intercept | 1 | -1.629622 |
| | 1 diff | | 0 | -3.6850** |
| F / PY | Level | | 0 | 1.595074 |
| | 1 diff | | 0 | -3.8426** |
| $\ln P^X_T/P^M_T$ | Level | | 0 | -1.99692* |
| | 1 diff | | 0 | -5.1777** |

* denotes signif. at 5%
** denotes signif. at 1%

One of the most critical aspects of Johansen's approach is determining the rank of $\alpha\beta'$, since it essentially depends on the model being clearly specified. Firstly, to know the optimum lag structure (represented by the k value), the Schwartz criterion is applied. Such criterion chose only one lag (k = 1) for the variables. Secondly, univariate (for each component) and multivariate (over the whole system) tests were used to check normality and serial correlation over the residuals.

For the normality test, the multivariate extensions of the Jarque-Bera test were used, which compare the third and the fourth moments of the residuals with those corresponding to normal distribution. The Cholesky factorization was used for the orthogonalization of the errors suggested by Lütkepohl. With respect to the autocorrelation, the Ljung-BoxQ was chosen for the first five lags. All results (for each component and for the whole system) were satisfactory to test that errors are normally distributed with no autocorrelation (tables are shown in Appendix 4).

*Cointegration Test*

The Johansen test with two statistics, $\lambda$ trace y $\lambda$ max[8] was used for the analysis of the cointegrating vectors. The statistics are built using the eigenvalues of the matrix $\alpha\beta'$ from (24), following the hypotheses of the number of cointegrating equations (the value of r).

If there is at least one cointegrating vector between the variables, the model by means of (24) can, then, be estimated. Table 3 summarizes the results. In both cases, only one cointegrating vector is found at 1% significance.

**Table 3:** Johansen Test

| Number of Coint eq | Eigen-value | λ trace Statistics | Critical Values 5% | 1% | Signif | λ max Statistics | Critical Values 5% | 1% | Signif |
|---|---|---|---|---|---|---|---|---|---|
| None | 0.75093 | 87.870 | 59.46 | 66.52 | ** | 48.651 | 30.04 | 35.17 | ** |
| At most 1 | 0.47223 | 39.220 | 39.89 | 45.58 | | 22.368 | 23.8 | 28.82 | |
| At most 2 | 0.30553 | 16.851 | 24.31 | 29.75 | | 12.761 | 17.89 | 22.99 | |
| At most 3 | 0.07272 | 4.0899 | 12.53 | 16.31 | | 2.64252 | 11.44 | 15.69 | |
| At most 4 | 0.04051 | 1.4474 | 3.84 | 6.51 | | 1.44739 | 3.84 | 6.51 | |

*(**) denotes significance at 5%(1%)

Once a long-term relation between the exchange rate and its determinants is proved, the coefficients of vector β are obtained. Table 4 describes the values and shows that all are significantly different to zero. All coefficients possess the expected signs.

**Table 4:** Coefficients of the cointegrating vector β

| Variable | Coefficient | Statistics | Significance |
|---|---|---|---|
| $\ln q$ | 1.000000 | | |
| $F / PY$ | 1.470020 | 7.58156 | ** |
| $\ln A_T/A^*_T$ | 0.851656 | 2.01689 | * |
| $\ln A_N/A^*_N$ | -1.147019 | -2.69849 | ** |
| $\ln P^X_T/P^M_T$ | 0.709655 | 4.01950 | ** |

*(**) denotes significance at 5%(1%)

$$\ln q_t = -1.47\left(\frac{F}{PY}\right)_t - 0.85\ln\left(\frac{A_T}{A_T^*}\right)_t + 1.15\ln\left(\frac{A_N}{A_N^*}\right)_t - 0.71\ln\left(\frac{P_T^X}{P_T^M}\right) + \varepsilon_t \qquad (25)$$

In equation (25), the relative productivities and the terms of trade coefficients are elasticities, and the net foreign assets coefficient is a semi-elasticity.

There is no intercept, indicating the probable absolute parity that holds in tradable goods sector, $\eta = \ln\left(\frac{P_T^*}{P_T}\right) = \ln(1) = 0$.

*Misalignment and currency crisis*

Figure 3 shows the real exchange rate deviations with respect to the long-term equilibrium given by the cointegrating equation. The real exchange rate misalignments may be read in percentages since the variables are in logarithms.

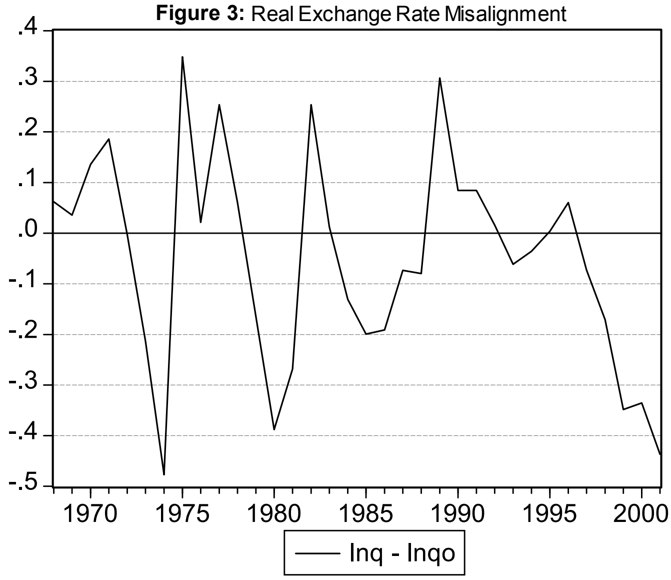
The three episodes with a marked currency overvaluation (1974, 1980, 2001) close to or higher than 40%, correspond to end of stabilization plans that led to currency crises with maxi-devaluation. The first one is related to the end of the Gelbard stabilization plan that had

had its start in 1973 with the introduction of a freeze in prices and wages. The crisis broke out in March of 1975, and the exchange rate correction began with that maxi-devaluation under Minister Celestino Rodrigo.

The second period of great overvaluation occurred when “tablita” (active crawling peg) was left behind and Martinez de Hoz stepped down in 1981. He was replaced by Lorenzo Sigaut, who decided on devaluation to reestablish the equilibrium. This devaluation was followed by a sequence of maxi-devaluations that were carried through until the third quarter of 1982. The real exchange rate went from a negative deviation near 40% to a positive deviation higher than 20%. Such phenomenal change in relative prices caused an extraordinary disorganization of the economy. The 1985-86 moderate overvaluation (20%) corresponds to the end of Plan Austral stabilization.

The last currency overvaluation period took place at the time of the Convertibility collapse, with a 44% deviation; the misalignment was started timidly (7%) at the time of the East-Asian crisis in 1997.

**Figure 3:** Real Exchange Rate Misalignment




The model shows that the absence of competitiveness during the convertibility period can only be observed after 1997 and grew rapidly in later years. The results were confirmed by Perry and Servén (2002). For these authors, the size of the misalignment is 53%, a figure somewhat higher than our own estimation (44%). There are four points to account for the difference: a) the multilateral trade shares (1995 vs. the average of 1970, 1975, 1980, 1985, 1990 ,1995, 2000); b) the model (without micro-foundations vs. representative agent’s model); c) the sectoral productivities indicators (consumer and wholesale prices vs. average labor product in each sector); and d) the real exchange rate index (CPI-based vs. GDP Deflator-based).

The initial devaluation (40%) under Minister Remes Lenicov at the start of 2002 and the immediate adoption of a flexible exchange rate generated a maxi-depreciation.

**Figure 4:** Actual vs. Equilibrium Real Exchange Rate

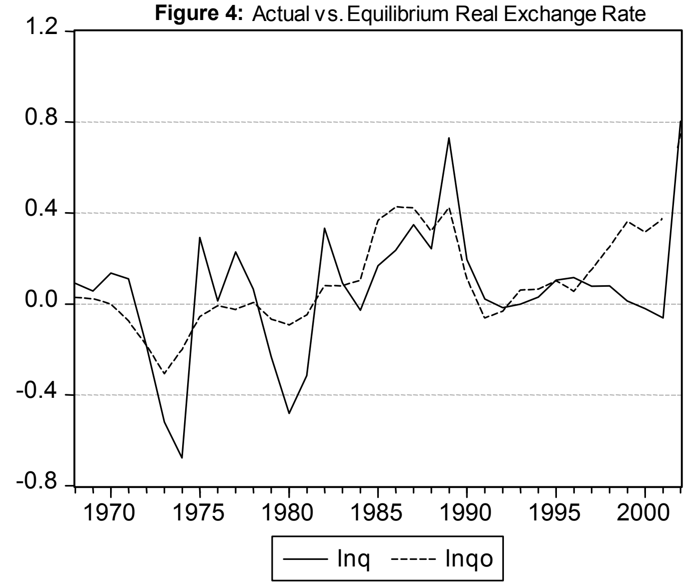
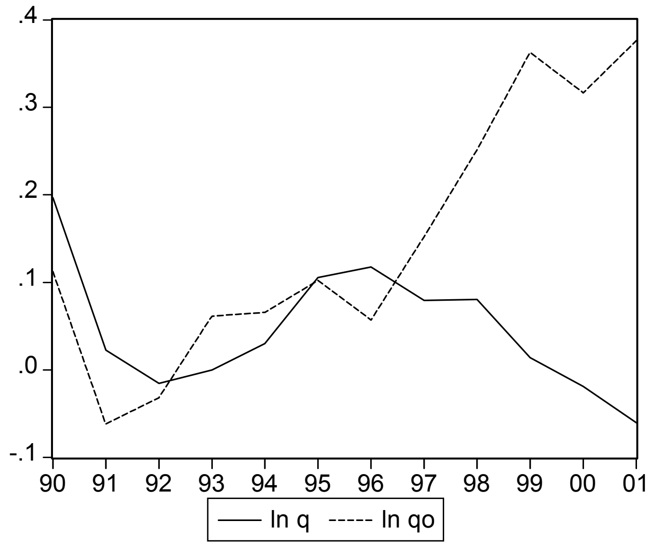



Figure 4 shows the actual real exchange rate (lnq) and the equilibrium rate ($lnq_o$) calculated from the cointegrating equation, and it serves to determine whether the misalignment is due to movements in the actual rate or in the long-term equilibrium rate. In the latter case, it may be seen that the 2001 misalignment is due both to the rise in the equilibrium real rate and to the fall in the actual rate; although the movement of the non observed variable is of greater magnitude. This is the reason why the non specialized analysts did not detect the major exchange rate misalignment that led to the collapse of Convertibility Plan. Table 5 shows the real exchange rate deviation the model provides for the 1990s. Figure 5 shows that the real appreciation of the real exchange rate during 1990-1991 appears consistent with an equilibrium real appreciation of the exchange rate.

**Table 5:** Misalignment

| Year | $\ln q_t - \ln q°$ |
|---|---|
| 1990 | 0.08 |
| 1991 | 0.08 |
| 1992 | 0.02 |
| 1993 | -0.06 |
| 1994 | -0.04 |
| 1995 | 0.00 |
| 1996 | 0.06 |
| 1997 | -0.07 |
| 1998 | -0.17 |
| 1999 | -0.35 |
| 2000 | -0.34 |
| 2001 | -0.44 |

**Figure 5:** Equilibrium Real Exchange Rate over the 1990s



## 5. Short-run Dynamics of the Real Exchange Rate

Judging by the characteristics of the Argentine economy as shown by the model, the dynamics of the process inevitably led to devaluation after the shock of the East Asian crisis. The results of the error correction model will be analyzed to further consider this hypothesis.

**Table 6:** Adjustment coefficients $\alpha$

| Variable | Coefficient | Statistics | Significance |
|---|---|---|---|
| Ln q | -1.549304 | -6.46967 | ** |
| F / PY | 0.294268 | 4.60434 | ** |
| Ln $A_T/A^*_T$ | -0.061880 | -0.69381 | |
| Ln $A_N/A^*_N$ | 0.000670 | 0.00930 | |
| Ln $P^X_T/P^M_T$ | 0.197430 | 2.74209 | ** |

*(**) denotes significance at 5%(1%)

Table 6 shows in detail the estimated adjustment coefficients (elements of vector $\alpha$ in equation 24). Only those corresponding to the ln q, F/PY and ln $P^X_T/P^M_T$ variables are significant. Then, a negative deviation of the exchange rate (an overvaluation) causes the net foreign assets diminish in an amount equal to the deviation times 0.29. This is logical because financing the current account deficit reduces the net foreign assets stock. In turn, the imbalance increases because $\beta_2<0$. It is similar with the terms of trade coefficient (0.20), although in this case the coefficient should not be expected to be significant if the terms of trade were a totally exogenous variable. Nevertheless, if there exists full price arbitrage in exported goods (commodities), but not in imported goods (import substitution sector); the terms of trade may become endogenous. Thus, given an overvaluation, the terms of trade decrease (this would be consistent with the coefficient sign) and the long-term imbalance increases because $\beta_5<0$. Because the movement of the two variables above mentioned tends to increase the misalignment, the adjustment coefficient $\alpha_1$ (the one for the real exchange rate) tends to be unusually large.

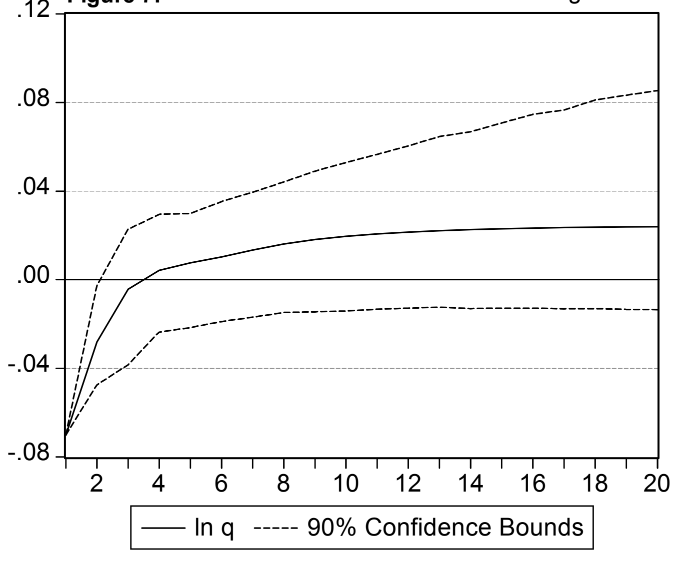
When a currency overvaluation takes place, for example 10%, the real depreciation of the following period that the error correction model estimates is 15.5%. If this correction doesn't take place because of the fixed exchange rate and nominal price rigidities; the exchange rate misalignment in the following period will be greater. The misalignment will, then, speedily grow. This was just the Argentina's case after devaluations in East-Asian countries.

In 1993 and 1994, the small misalignment was not corrected with nominal devaluation; however, the multilateral real exchange rate was depreciated for exogenous reasons (Plan Real in Brazil). Since 1997, when a exogenous-based minor currency overvaluation (7%) reappeared, there has been no factor in favor; on the contrary, the competitive devaluation in East Asia began to produce its effects; the situation was worsened by Brazil devaluation in 1999 (which tended to deteriorate the multilateral real exchange rate even more). The dynamics of the model indicate that under such circumstances, Convertibility could not be maintained.

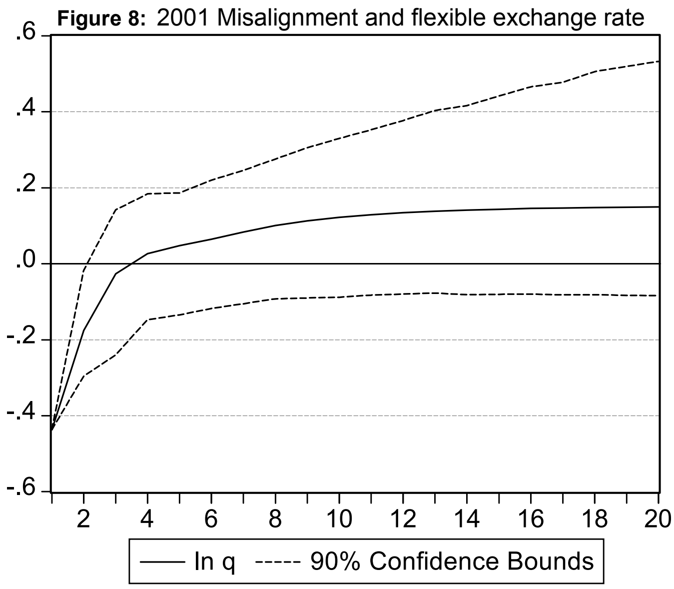
Three exercises with the impulse-response function now follow. Figures 7, 8 and 9 present the simulated responses with their respective 90% confidence bounds. These bounds were constructed following the bootstrap[9] methodology, developed in Hamilton (1994).

Figure 7 shows the impact of East-Asian currency crises of a 7% negative shock over Argentina real exchange rate. If the exchange rate had been allowed to float, the model indicates that the resulting equilibrium real exchange rate would have been only 2% higher than the initial rate. Abandoning Convertibility was, probably, the optimum response to the 1997 shock. Figure shows that it takes 3 years to return to equilibrium real exchange rate path.

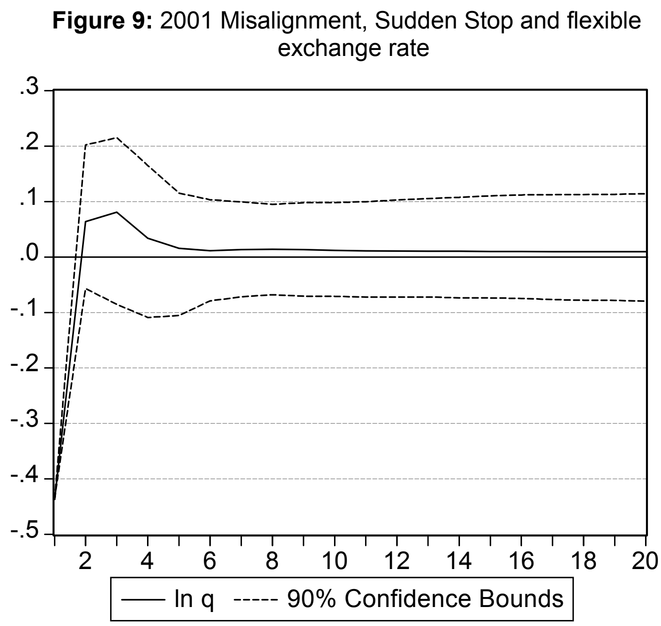
**Figure 7:** 1997 Asian crisis and flexible exchange rate




In Figures 8 and 9, there is a negative shock of 44% over the real exchange rate to simulate the 2001 overvaluation.




In the impulse of Figure 9, a shock over the net foreign assets equal to the 2002 current account surplus is also introduced. It can be seen that there is no gradual adjustment, in one period the real exchange rate is over the equilibrium path (overshooting) like the 2002 Argentina's case.




## 6. Comparative analysis: Argentina versus panel of 67 countries

$$\ln q_t = -0.21\left(\frac{F}{PY}\right)_t - 1.30\ \ln\left(\frac{A_T}{A_T^*}\right)_t + 0.18\ \ln\left(\frac{A_N}{A_N^*}\right)_t - 0.74\ \ln\left(\frac{P_T^X}{P_T^M}\right) + \varepsilon_t \qquad (26)$$

Equation (26) shows the coefficients obtained by Calderón (2002) in a panel of 67 countries, for a similar period. The main discrepancy between equations (25) and (26) is given by the net foreign assets coefficient, which is 7 times greater for Argentina. Is this not the cause to make Argentina a peculiar country, justifying the say that there are four different types of countries: developed, developing, Japan and Argentina? A further explanation of this structural characteristic of Argentine economy will be discussed below.

Equation (26) was estimated following a different methodology. This equation was deduced from an error correction model that disregards the influence of the modifications in the equilibrium real exchange rate over its determinants. Thus, the estimation of the first equation of the system in (24), given by:

$$\Delta \ln q_t = \alpha_1 \beta' y_{t-1} + \pi_1 \Delta y_{t-1} + \varepsilon_{1t} \qquad (27)$$

where $\pi_1$ is a (1x5) matrix and $\alpha_1, \varepsilon_{1t} \in \Re$; yields the coefficients of vector $\beta$ in (26). This methodology is statistically applicable only if variations in the equilibrium real exchange rate in t-1 don't modify the value of net foreign assets, relative sectoral productivities or terms of trade in t. By construction, the remaining equations of (24) are defined by:

$$\Delta y_t^* = \alpha^* \beta' y_{t-1} + \pi^* \Delta y_{t-1} + \varepsilon_t^* \qquad (28)$$

where $y_t^*$ denotes a vector containing the determinants of the equilibrium real exchange rate. Additionally, $\alpha^*$ and $\varepsilon_t^*$ contain the remaining adjustment coefficients and error terms, respectively. Given (28), the condition to estimate (27) may be summarized in testing whether $\alpha^*$ equals the null vector. In other words, each one of these adjustment coefficients must be zero. Therefore, the first term in (28) is annulled, obtaining an equation that is not influenced by the movements in the real exchange rate. If this hypothesis is true, the determinants used to estimate the equilibrium real exchange rate are weakly exogenous.

Table 7 shows the results of testing the restriction for $\alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$. It can be inferred from the last row (the test for all coefficients) that, in Argentina's case, the fundamentals of the equilibrium real exchange rate are not weakly exogenous. There exists a feed back relationship. Therefore, the use of the single-equation approach applied many times in the literature becomes impossible, and Johansen approach (which estimates the joint system) would be the only way to estimate the equilibrium real exchange rate for Argentina.

**Table 7:** Testing for weak exogeneity

| Variable | $\chi 2$ | DF | Significance |
|---|---|---|---|
| $\alpha_2 = 0$ | 15.74439 | 1 | ** |
| $\alpha_3 = 0$ | 0.532208 | 1 | |
| $\alpha_4 = 0$ | 0.000093 | 1 | |
| $\alpha_5 = 0$ | 6.044851 | 1 | * |
| Joint | 25.83601 | 4 | ** |

*(**) denotes significance at 5%(1%)

One more element about weak exogeneity is related to the speed of adjustment towards the equilibrium. The parameter to assess the rate at which the convergence is achieved comes from the following expression:

$$\Delta x_t = \phi x_{t-1} + \vartheta_t \qquad (29)$$

where $x_t$ is the degree of misalignment and parameter $\phi$ is the general form of the speed of adjustment.

Regardless the methodology used, the series $x_t$ can be derived simply contrasting the actual with the equilibrium real exchange rate ($x_t$ = ln $q_t$ – ln $qo_t$). The behavior of $x_t$ is detailed in figure 3. For Argentina, the estimated $\phi$ assumes the value $-0.6763$. The empirical literature points out that, in general, coefficient $\phi$ is found in the [-0.24, -0.14] interval. Once obtaining this value, the half-life of adjustment (h) may be deduced from:

$$h = \frac{\ln(0.5)}{\ln(1+\phi)} \cong 0.615$$

The value of h must be interpreted as the time it takes to diminish the misalignment in one half. In this case, it takes less than one year.

In order to relate the value of $\phi$ with the parameters $\alpha$, it must be taken into account whether the fundamentals of the equilibrium real exchange rate are weakly exogenous or not. It can be demonstrated that, when these fundamentals are not weakly exogenous, the speed of adjustment is given by[10]:

$$\phi \cong \alpha_1 - \beta_2\alpha_2 - \beta_3\alpha_3 - \beta_4\alpha_4 - \beta_5\alpha_5 \qquad (30)$$

As it is mentioned above, in Argentina's case, $\alpha_3 = \alpha_4 = 0$, turning the expression (30) in:

$$\phi' = \alpha_1 - \beta_2\alpha_2 - \beta_5\alpha_5 \qquad (31)$$

where its value can be directly deduced from the estimated parameters:

$$\phi' = -1.549 + 0.294 * 1.47 + 0.1974 * 0.7097 = \text{-}0.9767$$

This value is certainly greater than the one obtained from (29). This could be driven by the assumption of making matrix $\Pi$ equals to the null matrix, as it is pointed out in Appendix 5.

*Consistency checks of estimated coefficients with calibrated parameters*

In order to contrast the coefficients of the vector $\beta$, they will be compared with the calibrated parameters that could be obtained using the available values in the literature on industrial countries. The parameters calibrated by Stockman and Tesar (1995), quoted by Calderón (2002), will be used. The inter-temporal substitution elasticity ($\sigma$) is 0.5; the intra-temporal substitution elasticity ($\theta$) is 0.44; the share of tradables in the consumption basket ($\gamma$) is (0.5) and the international interest rate (r) is 4%. The calibrated parameter $\beta_2$ = -0.1494 is ten time smaller than the estimated for Argentina.

Let us think that the average international interest rate in the period was 6% and that the average country risk premium for Argentina was 930 basis points. Now, the estimated parameter $\beta_2$ turns out to be 4.5 times higher than the calibrated one (-1.4700 vs. -0.3252).

The way to equalize the estimated $\beta_2$ value with the calibrated one is to assume that Argentina's *n* parameter is 34% greater than the parameter used by Calderón (0.952 vs. 0.709). This could well be the result of an economy like Argentina's, too much oriented towards the production of non-tradables.

**Table 8:** Calibrated vs. Estimated Coefficients

| | Calibration | | Estimation |
|---|---|---|---|
| | Stockman | Argentina | |
| $\sigma$ | 0.50 | 0.50 | |
| $\theta$ | 0.44 | 0.44 | |
| $\gamma$ | 0.50 | 0.50 | |
| r | 0.04 | 0.06 | |
| n | 0.709 | 0.952 | |
| $\psi$ | -1.0870 | -1.0870 | |
| $\beta_2$ | -0.1494 | -1.4700 | -1.4700 |
| $\beta_3$ | -1.0870 | -1.0870 | -0.8517 |
| $\beta_4$ | 0.7246 | 0.7246 | 1.1470 |
| $\beta_5$ | -1.0870 | -1.0870 | -0.7097 |

## 7. Conclusions

A new open economy model with two countries and two sectors is used, where the non tradable sector is the locus of the monopoly and sticky price problems. Each individual begins period *t* with existing net foreign assets holdings and an endowment of tradable goods, and choose how much non tradable good to produce, how much to consume and what level of net foreign asset to hold. These choices are made to maximize the intertemporal utility function.

The long run behavior of the real exchange rate can be explained in terms of real factors, such as Balassa-Samuelson relative productivity effect, terms of trade and net foreign assets (transfer effect). On the basis of these fundamentals, the degree of misalignment is assessed. The real exchange rate misalignment estimated by the model in the periods before Rodrigazo, exit from “tablita” and the collapse of Convertibility Plan are close to 40%. This work presents empirical evidence relative to the discussion about the exchange rate misalignment of Convertibility. The analysis supports the notion that the real exchange rate misalignment until 1997 has been quite modest or inexistent, given that Brazil’s Plan Real allowed to correct the small 1993-1994 deviation. However, the shock brought about by the 1997 East Asian devaluations could not be assimilated by the Argentinean economy because the model does not allow endogenous correction of competitiveness in the short-run given nominal price rigidity and exchange rate anchor.

By considering the budget restrictions, the model allows to detect the main problem that led to the collapse of Convertibility. In effect, any foreign debt increase (in % of GDP) implies an increase of the equilibrium real exchange rate because today the foreign debt amount must be equal to the present value of the future current account surpluses. Not to have taken such restriction into account is the main mistake made by economic authorities over the 1990s. It was believed that, under Convertibility, it was possible to maintain trade deficits over decades if they were financed by direct foreign investment. Strictly speaking, in a world of sticky prices, if the foreign debt grows more than GDP, something is wrong in the statement. In fact, it has been estimated a foreign assets semi-elasticity of the real exchange rate of –1.47%; this means that if the economy is stagnant and the current account deficit is 4% of the GDP, the real exchange rate should go up 5.9%, an increase which can hardly be generated by domestic price deflation. The structural features of the Argentine economy suggest that the economy could not support large current accounts deficits during currency overvaluation periods.

The model also offers an explanation for this historical experience: in Argentina there is no fixed exchange rate regime (not even a currency board) in condition to manage a deviation of such size because the dynamics is explosive, which would show that the recurrent Argentine currency crises are no incidental. Once a significant misalignment takes place, the dynamics of the model indicates that under a fixed exchange rate and sticky prices, there is no mechanism that allows correcting the imbalance, which will continue to grow. Now, if the country obtains financing, the problem will continue to remain concealed for some time but the permanently diminishing net foreign assets will flash a red light to international investors about the impending devaluation due to foreign solvency problems. This gives way to an abrupt reversion of capital flows (Sudden Stop). The model is compatible with Perry and Servén's view (2002) that the Sudden Stops operate as amplifiers rather than as the cause of the crisis.

The test of weak exogeneity shows that, in Argentina, the fundamentals of the equilibrium real exchange rate are not weakly exogenous. Therefore, it is not possible to employ the single-equation approach normally used in the literature for other countries. The only way to estimate the equilibrium real exchange rate is through Johansen methodology. This peculiar feature of the Argentine economy is originated in the systematical use of exchange-rate-based stabilization programs. Thus, currency overvaluation generates loss of reserves and/or an increase in the stock of gross external debt, which in turn, raise the equilibrium real exchange rate, magnifying the degree of misalignment.

Deflation was not a viable policy and the assertions that Convertibility could continue to hold are not valid due to the structural characteristics of the Argentine economy as presented in the model. The model also allows to reject the argument that without governance problems in Argentina, a 5 to 6 year prolonged deflation would have allowed the exchange rate correction. As a matter of fact, if the deviation is not corrected rapidly, the misalignment becomes higher speedily due to the dynamics of net foreign assets.

It can also be stated that the policy of applying an 8% fiscal devaluation in 2001 when the misalignment was 30% stood no chance of success.

It may be argued that to allow a devaluation or to leave the currency to float was a better alternative not because default and the run on banks could have been averted, but because the alternative to clinging on to Convertibility or dollarize the economy stood no chance at all. The crux of the matter lay in planning the exit at the least social cost.

From the calibration of the parameters of the model, it can be inferred that the non-tradable sector of the Argentine economy is too large, regarding to its development stage (almost 30%). In view to the future, the model shows that in an economy like Argentina's, as long as openness remains narrow, a flexible exchange rate policy may be helpful to isolate the economy from external shocks. The priority in the future economic policy should, then, be to modify the structure of Argentina's economy towards greater openness. Unluckily, the two trade and financial last openness experiences, the 1976-1981 period and the 1990 decade, were not well designed and/or managed. They took place in a context of excess of liquidity on international financial markets, disregarding the required complementary policies to set relative prices in line with an export oriented growth strategy. Such policies would have made reforms sustainable.

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## Appendix 1: The Price Index

The optimal price index results from the maximization of consumption in both goods (given by equation 2), subject to:

$$Z = P_T C_T + P_N C_N \qquad \text{(a.1)}$$

where Z is the total expenditure in terms of the tradable good. Conforming the Lagrange function:

$$L = C + \lambda\left[Z - P_T C_T - P_N C_N\right]$$

The first-order conditions are:

$$\frac{\partial L}{\partial C_T} = \gamma^{\frac{1}{\theta}} C_T^{-\frac{1}{\theta}} C^{-1} - \lambda P_T = 0 \qquad \text{(a.2)}$$

$$\frac{\partial L}{\partial C_N} = (1-\gamma)^{\frac{1}{\theta}} C_N^{-\frac{1}{\theta}} C^{-1} - \lambda P_N = 0 \qquad \text{(a.3)}$$

$$\frac{\partial L}{\partial \lambda} = Z - P_T C_T - P_N C_N = 0 \tag{a.4}$$

Combining (a.2) with (a.3), the Euler of this problem is found:

$$\frac{C_N}{C_T} = \left(\frac{1-\gamma}{\gamma}\right)\left(\frac{P_N}{P_T}\right)^{-\theta} \tag{a.5}$$

Equation (a.5) establishes the optimal allocation between consumption of both goods. With (a.4) and (a.5) the optimal level of consumption for both goods is obtained:

$$C_T^{\circ} = \frac{\gamma P_T^{-\theta} Z}{\gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta}} \tag{a.6}$$

$$C_N^{\circ} = \frac{(1-\gamma) P_N^{-\theta} Z}{\gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta}} \tag{a.7}$$

Replacing (a.6) and (a.7) in (2), the optimal value of consumption, C°, in terms of Z, $P_N$ and $P_T$ can be found:

$$C^{\circ} = \left\{ \gamma^{\frac{1}{\theta}} \left[ \frac{\gamma P_T^{-\theta} Z}{\gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta}} \right]^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} \left[ \frac{(1-\gamma) P_N^{-\theta} Z}{\gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta}} \right]^{\frac{\theta-1}{\theta}} \right\}^{\frac{\theta}{\theta-1}}$$

$$C^{\circ} = Z \left[ \gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta} \right]^{\frac{1}{\theta-1}} \tag{a.8}$$

The optimal price index allows to consume a quantity C° with the minimal expenditure (Z):

$$Z^{\circ} = P^{\circ} C^{\circ}$$

$$P^{\circ} = \frac{Z^{\circ}}{C^{\circ}} \tag{a.9}$$

Considering C°=1 (to standardize consumption) in (a.8), and plugging Z° from (a.9) into (a.8):

$$1 = P^{\circ} \left[ \gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta} \right]^{\frac{1}{\theta-1}}$$

$$P^{\circ} = \left[ \gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{a.10}$$

Expression (a.10) determines the price index for this economy, taking into account the shares of the two goods in total consumption ($\gamma$) and the intra-temporal elasticity of substitution between T and NT ($\theta$).

Following (a.9) and (a.10), it is possible to go back to the optimal paths for consumption of both goods, given by (a.6) and (a.7), to replace and find that:

$$C_T = \gamma \left(\frac{P_T}{P}\right)^{-\theta} C \qquad \text{(a.6')} \qquad\qquad C_N = (1-\gamma)\left(\frac{P_N}{P}\right)^{-\theta} C \qquad \text{(a.7')}$$

**Appendix 2: Percentage Variations in the Real Exchange Rate**

It is possible to show that the index P, in Appendix 1, has a constant intra-temporal elasticity of substitution ($\theta$). Assuming that this parameter tends to one, P converges to a linear homogeneous Cobb-Douglas function. Taking limits to the log of P:

$$\lim_{\theta \to 1} \ln \left\{ \left[ \gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta} \right]^{\frac{1}{1-\theta}} \right\} = \lim_{\theta \to 1} \frac{\ln\left[ \gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta} \right]}{1-\theta} = \frac{0}{0}$$

By L'Hopital,

$$\lim_{\theta \to 1} \frac{\gamma P_T^{1-\theta} \ln P_T + (1-\gamma) P_N^{1-\theta} \ln P_N}{\gamma P_T^{1-\theta} + (1-\gamma) P_N^{1-\theta}} = \gamma \ln P_T + (1-\gamma) \ln P_N$$

$$\ln P = \gamma \ln P_T + (1-\gamma) \ln P_N \qquad \Rightarrow \qquad P = P_T^{\gamma} P_N^{1-\gamma} \tag{a.11}$$

Considering the same shares ($\gamma$) in both countries, the real exchange rate is equal to:

$$q = \frac{P^*}{P} = \left( \frac{P_T^*}{P_T} \right)^{\gamma} \left( \frac{P_N^*}{P_N} \right)^{1-\gamma} \tag{a.12}$$

in which * denotes foreign variables. Taking the log-linear approximation, (a.12) turns in:

$$\hat{q}_t = \left( \hat{P}_{T,t}^* - \hat{P}_{T,t} \right) - (1-\gamma) \left( \hat{P}_{N,t} - \hat{P}_{T,t} \right) + (1-\gamma) \left( \hat{P}_{N,t}^* - \hat{P}_{T,t}^* \right) \tag{a.13}$$

## Appendix 3: Argentina's real exchange rate misalignment

| Year | ln q - ln qo |
|---|---|
| 1968 | 0.0619 |
| 1969 | 0.0357 |
| 1970 | 0.1361 |
| 1971 | 0.1860 |
| 1972 | -0.0030 |
| 1973 | -0.2133 |
| 1974 | -0.4771 |
| 1975 | 0.3481 |
| 1976 | 0.0214 |
| 1977 | 0.2535 |
| 1978 | 0.0602 |
| 1979 | -0.1649 |
| 1980 | -0.3878 |
| 1981 | -0.2683 |
| 1982 | 0.2535 |
| 1983 | 0.0122 |
| 1984 | -0.1306 |
| 1985 | -0.1992 |
| 1986 | -0.1914 |
| 1987 | -0.0737 |
| 1988 | -0.0797 |
| 1989 | 0.3065 |
| 1990 | 0.0843 |
| 1991 | 0.0843 |
| 1992 | 0.0164 |
| 1993 | -0.0614 |
| 1994 | -0.0357 |
| 1995 | 0.0034 |
| 1996 | 0.0605 |
| 1997 | -0.0726 |
| 1998 | -0.1708 |
| 1999 | -0.3485 |
| 2000 | -0.3353 |
| 2001 | -0.4366 |

## Appendix 4: Residual Tests

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Ho: residuals are multivariate normal
Sample: 1968 2002
Included observations: 35

| Component | Jarque-Bera | Df | Prob. |
|---|---|---|---|
| 1 | 0.802003 | 2 | 0.6696 |
| 2 | 2.051997 | 2 | 0.3584 |
| 3 | 1.017296 | 2 | 0.6013 |
| 4 | 2.325974 | 2 | 0.3126 |
| 5 | 3.846392 | 2 | 0.1461 |
| Joint | 10.04366 | 10 | 0.4367 |

VEC Residual Portmanteau Tests for Autocorrelations
Ho: no residual autocorrelations up to lag h
Sample: 1968 2002
Included observations: 35

| Lags | Q-Stat | Prob. | Adj Q-Stat | Prob. | df |
|---|---|---|---|---|---|
| 1 | 7.118123 | NA* | 7.327479 | NA* | NA* |
| 2 | 30.74708 | 0.1975 | 32.38849 | 0.1471 | 25 |
| 3 | 57.69598 | 0.2121 | 61.86386 | 0.1212 | 50 |
| 4 | 83.65540 | 0.2311 | 91.17288 | 0.0986 | 75 |
| 5 | 96.99031 | 0.5666 | 106.7303 | 0.3041 | 100 |

*The test is valid only for lags larger than the VAR lag order.

## Appendix 5: The speed of adjustment

The speed of adjustment can be deduced from the VECM in (24). First, it can be demonstrated that the change in the equilibrium real exchange rate is given by:

$$\Delta \ln qo_t = \beta_2 \, \Delta\left(\frac{F}{PY}\right)_t + \beta_3 \, \Delta \ln\left(\frac{A_T}{A_T^*}\right)_t + \beta_4 \, \Delta \ln\left(\frac{A_N}{A_N^*}\right)_t + \beta_5 \, \Delta \ln\left(\frac{P_T^X}{P_T^M}\right)_t \qquad \text{(a.17)}$$

On the other hand, the change in each fundamental is determined by the VECM equations in (24):

$$\Delta\left(\frac{F}{PY}\right)_t = \alpha_2 \, \beta' y_{t-1} + \pi_2 \, \Delta y_{t-1} + \varepsilon_{2t} \qquad \text{(a.18)}$$

$$\Delta \ln\left(\frac{A_T}{A_T^*}\right)_t = \alpha_3 \beta' y_{t-1} + \pi_3 \Delta y_{t-1} + \varepsilon_{3t} \qquad (a.19)$$

$$\Delta \ln\left(\frac{A_N}{A_N^*}\right)_t = \alpha_4 \beta' y_{t-1} + \pi_4 \Delta y_{t-1} + \varepsilon_{4t} \qquad (a.20)$$

$$\Delta \ln\left(\frac{P_T^X}{P_T^M}\right)_t = \alpha_5 \beta' y_{t-1} + \pi_5 \Delta y_{t-1} + \varepsilon_{5t} \qquad (a.21)$$

Finally, subtracting (a.17) from (27), replacing conveniently and denoting the misalignment ($\beta' y_t$) as $x_t$, it is possible to find:

$$\Delta \ln q_t - \Delta \ln qo_t = \Delta x_t = (\alpha_1 - \beta_2\alpha_2 - \beta_3\alpha_3 - \beta_4\alpha_4 - \beta_5\alpha_5)\, x_{t-1} + \overline{\Pi}\, \Delta y_{t-1} + \vartheta_t \qquad (a.22)$$

where $\overline{\Pi} = \pi_1 - \beta_2\pi_2 - \beta_3\pi_3 - \beta_4\pi_4 - \beta_5\pi_5$ and $\vartheta_t = \varepsilon_{1t} - \beta_2\varepsilon_{2t} - \beta_3\varepsilon_{3t} - \beta_4\varepsilon_{4t} - \beta_5\varepsilon_{5t}$

Equation (a.22) describes the behavior of $x_t$ on a dynamic perspective. Assuming that the matrix $\overline{\Pi} \cong \mathbf{0}$ **[11],** the rate at which $x_t$ converges is given by:

$$\phi \cong \alpha_1 - \beta_2\alpha_2 - \beta_3\alpha_3 - \beta_4\alpha_4 - \beta_5\alpha_5 \qquad (a.23)$$

---

[1] The final term in the period utility function, $-(\kappa/2)y_{N,t}^2$, captures the disutility experienced in producing more output. If the disutility from effort $\ell_N$ is given by $-\psi\,\ell_N$ and the production function is $Y_N = A_N \;\; \ell_N^{\alpha}$ $(\alpha < 1)$, if $\alpha$=0.5, then $\kappa = 2\psi / A^2$ and we have the output term in equation (1). Note that a rise in productivity $A_N$ is captured in this model by a fall in $\kappa$ with $\hat{\kappa} = -2\hat{A}_N$. A more general formulation allows the elasticity of disutility from output $\mu \geq 1$, to differ from 2, then the utility from work effort is $-(\kappa/\mu)y_{N,t}^{\mu}$

[2] The price index is defined as the minimal expenditure needed to purchase a unit of C. Appendix 1 shows in detail how the price index is obtained.

[3] See Obstfeld and Rogoff (1996), chapter 4, for a more formal and detailed analysis of the conditions

[4] These two relations are determined in Appendix 1.

[5] Appendix 2 describes how the proportional change in P is determined.

[6] It is assumed that the price of the exported goods in the foreign country is simply the price of the imported goods in the domestic country.

[7] Appendix 2 describes how equation (20) is deduced from (19).

[8] A further analysis of the statistics used in Johansen test may be found in Enders (1995).

[9] Bootstrap is a data-based simulation method used to estimate variance and bias of an estimator and provide confidence intervals for parameters where it would be difficult to do so in the usual way. In this case, it is used to find the confidence intervals of the impulse-response functions.

[10] See Appendix 5 for a formal deduction of (29)

[11] In fact, it can be proved from the VECM estimation that the values of this matrix are closed to zero.