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## Structural Real Exchange Rate and Unemployment Interdependencies in Argentina

*Tipo de cambio real estructural y las interdependencias con el desempleo en Argentina*

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### ABSTRACT

*Based on a three-sector micro-founded model of a small open economy, this paper investigates the interdependences between the structural real exchange rate (defined as the relative prices tradable to non-tradable goods prices) and the unemployment rate with an application to Argentina. The empirical results suggest a significant, negative relationship between the structural real exchange rate and the rate of unemployment, suggesting that an appreciating real exchange rate may lead to Dutch disease effects – which effectively contract the size of the manufacturing sector – and damage long-term growth and employment opportunities.*

Keywords: Structural real exchange rate, unemployment rate, factor productivity, capital endowments, terms of trade.

JEL Code: C32, E24, F11, F31, F37, F41, J64.

### RESUMEN

*Utilizando un modelo micro-fundamentado de tres sectores para una pequeña economía abierta, se analiza la interdependencia entre la tasa de*

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*cambio real estructural (definida como el cociente entre el precio de los bienes transables y el de los no transables) y la tasa de desempleo, aplicándolo al caso de Argentina. Los resultados empíricos sugieren una relación negativa y significativa entre el tipo de cambio real estructural y la tasa de desempleo, lo cual indicaría que frente a una apreciación del tipo de cambio real se puede producir un efecto del tipo enfermedad holandesa - contrayendo el sector productor de manufacturas - afectando negativamente las oportunidades de crecimiento y empleo en el largo plazo.*

Palabras Clave: Tipo de cambio real, tasa de desempleo, productividad, stock de capital, términos de intercambio.

Código *JEL*: C32, E24, F11, F31, F37, F41, J64.

## I. INTRODUCTION

In developing economies the real exchange rate - defined as the relative price between tradable and non-tradable goods - is a key variable in determining the economic structure of the economy, given that it provides both an incentive for reallocating resources to the tradable sector and, given relative prices of the rest of the world, how productively the home country produces tradable goods. Furthermore, since the size of the traded goods sector is a vital determinant of the level of employment, there should be an observable link between the real exchange rate and the rate of unemployment. Such a link is potentially important for economic policy formulation as an over-appreciation of the real exchange rate may give rise to Dutch disease effects, whereby the size of the traded goods sector contracts and there is a rise in unemployment.

Despite a relatively large literature on micro-founded models of the real exchange rate (see, for example, Rodrick, 2008; Montiel, 2003) only a few, namely Hoon and Phelps (2002), Frenkel (2004), Frenkel and Ros (2006), Soto (2008), Soto and Elbadawi (2008) and Oslington (2001), explicitly link the structural real exchange rate to the rate of unemployment. Furthermore, one arm of this literature postulates, like Frenkel and Ros, that unemployment is a function of the structural real exchange rate, while the other strand, for example Soto and Elbadawi, has the structural real exchange rate as a function of unemployment. One contribution of this paper is therefore to develop a general model which nests both approaches within a general equilibrium framework, in which sector productivities, capital

endowments, the terms of trade, government expenditures and debt service simultaneously determine the equilibrium structural real exchange rate and unemployment rate.

A second contribution is that in the empirical version of the model, in contrast to a number of recent papers focusing on Argentina, (see, for example, Baldi and Mulder (2004), Falbo and Gaba (2005), Garegnani and Escudé (2005), Montiel (2007), Padua and Mastronardi (2008), Bastourre, et al (2008), Carrera and Restout (2008), and Bello, et al (2010)), the role of capital endowments are explicitly modelled. The results justify this modelling strategy in that capital endowments are found to be a significant factor in explaining unemployment, whilst there is an insignificant interdependence between unemployment and the structural real exchange rates.

A third specific modelling problem in the current literature is the choice of technology. Perfect competition and constant returns to scale in all sectors is assumed by Hoon and Phelps (2002), Rodrik (2008) and Soto and Elbadawi (2008), whereas in contrast, Montiel (2007) assumed perfect competition, but with diminishing returns to scale in all sectors. In this contribution it is assumed that perfect competition prevails in the tradable and non-tradable sectors, but that the non-tradable and tradables sectors are characterised by different technologies, as in Zarzosa Valdivia (2008), with the non-tradable sector assumed to have a linear technology and the tradable sectors Cobb-Douglas technologies.

The remainder of this paper is organized as follows. Section II outlines a general theoretical model, which generates a two-equation simultaneous system with relations for factor market and goods market equilibrium. Section III discusses the compilation and construction of the Argentinean data set and its time series properties. Section IV presents the empirical results from the estimated model and Section V offers some conclusions for policy.

## II. A GENERAL MODEL

Following the seminal contributions of Swan (1955) and Salter (1959), we assume a world with three goods: two tradable goods and one non-tradable good. Tradable goods consist of *primary goods*, of which the surplus over home consumption is exported and *manufactured goods*, of which the deficiency between home consumption and home production is imported. The law of one price is assumed to hold for the prices of tradable

goods and thus, the relative price of the primary good to the manufactured good is equal to the terms of trade ( $TT = P_X/P_M$ ), where  $TT$  refer to the terms of trade and  $P_X$  and  $P_M$  are the prices of primary and manufactured goods, respectively.

On the income side of the model total expenditure is divided between non-tradable goods and tradable goods in the proportion ( $\beta_C$ ) and  $(1 - \beta_C)$ , respectively, while the proportion,  $\delta$ , of the expenditure on tradable falls on primary goods and  $(1 - \delta)$  on manufactured goods. These assumptions are in line with Cobb-Douglas preferences in which a tradable price index ( $P_T$ ) has the following structure:

$$P_T = \delta^{-\delta} (1 - \delta)^{(1-\delta)} P_X^\delta P_M^{1-\delta} \quad (1)$$

In a developing-country context, the three-good model focuses on the three-internal real exchange rates: the exportable real exchange rate (relative primary to non-tradable price,  $P_X/P_N$ ); the importable real exchange rate (relative manufacturing to non-tradable price,  $P_M/P_N$ ); and the structural real exchange rate ( $SREER$ ) which is defined as the quotient between the tradable price and the non-tradable price,  $P_T/P_N$ , where  $P_N$  is the price of the non-tradable good. In addition, the economy consists of three internally homogenous production sectors: primary ( $X$ ), manufacturing ( $M$ ) and non-tradables ( $N$ ), all of which use labour and capital in their production processes. The technology of both tradable sectors is Cobb-Douglas, like Rodrik (2006), but in this case it is also assumed that there are diminishing returns to scale so that the sum of the elasticity of labour and capital in the primary sector ( $\phi_X$  and  $\psi_X$ , respectively) as well as the sum of the elasticity of labour and capital in the manufacturing sector ( $\phi_M$  and  $\psi_M$ , respectively) are less than one.

Following Henderson and Quandt (1980, p. 80) and Varian (1986, p. 338), the factor demands and the corresponding supply functions of both tradable sectors are presented in terms of their total factor productivities, their prices, the domestic wage and the interest rate, formally:

$$L_x = \left[ TFP_x P_x (\phi_x/w)^{1-\psi_x} (\psi_x/r)^{\psi_x} \right]^{\gamma_x^{-1}} \left[ TFP_x \frac{P_x}{P_T} SREER \left( \phi_x \frac{P_N}{w} \right)^{1-\psi_x} \left( \psi_x \frac{P_N}{r} \right)^{\psi_x} \right]^{\gamma_x^{-1}} \quad (2)$$

$$L_M = \left[ TFP_M P_M (\phi_M/w)^{1-\psi_M} (\psi_M/r)^{\psi_M} \right]^{\gamma_M^{-1}} \left[ TFP_M \frac{P_M}{P_T} SRED \left( \phi_M \frac{P_N}{w} \right)^{1-\psi_M} \left( \psi_M \frac{P_N}{r} \right)^{\psi_M} \right]^{\gamma_M^{-1}} \quad (3)$$

$$X = \left[ TFP_X (P_X)^{\phi_X+\psi_X} (\phi_X/w)^{\phi_X} (\psi_X/r)^{\psi_X} \right]^{\gamma_X^{-1}} = \left[ TFP_X (SRED)^{\phi_X+\psi_X} \left( \frac{P_X}{P_T} \right)^{\phi_X+\psi_X} \left( \phi_X \frac{P_N}{w} \right)^{\phi_X} \left( \psi_X \frac{P_N}{r} \right)^{\psi_X} \right]^{\gamma_X^{-1}} \quad (4)$$

$$M = \left[ TFP_M (P_M)^{\phi_M+\psi_M} (\phi_M/w)^{\phi_M} (\psi_M/r)^{\psi_M} \right]^{\gamma_M^{-1}} = \left[ TFP_M (SRED)^{\phi_M+\psi_M} \left( \frac{P_M}{P_T} \right)^{\phi_M+\psi_M} \left( \phi_M \frac{P_N}{w} \right)^{\phi_M} \left( \psi_M \frac{P_N}{r} \right)^{\psi_M} \right]^{\gamma_M^{-1}} \quad (5)$$

where  $TFP$  is the total factor productivity of the factors employed and  $L$  is the labour input, with the subscripts  $X$  and  $M$  referring to the primary and manufacturing sectors, respectively, and where  $w$  and  $r$  are the domestic wage and the interest rate.  $\phi_X$ ,  $\phi_M$ ,  $\psi_X$  and  $\psi_M$  all lie between zero and one, and  $\gamma_X^{-1} = (1 - \phi_X - \psi_X)^{-1}$  and  $\gamma_M^{-1} = (1 - \phi_M - \psi_M)^{-1}$ .

The second expression of the right hand sides of equations (2) - (5) are obtained by multiplying and dividing the first expression by  $SRED$ . Taking into account that  $P_X/P_T$  and  $P_M/P_T$  depend positively and negatively, respectively, on the terms of trade, equations (4) and (5) show that the supply of each tradable good is positively related to the structural real exchange rate, while terms of trade improvements increase the supply of primary goods, but decrease the supply of manufacturing goods. Less resources would also be reallocated to the tradable sector when the cost of any factor in terms of non tradable prices increase.

The production technology for the non-tradable goods sector is assumed to be of the constant of elasticity of substitution (CES) variety, such that equation (6) shows the unit cost function ( $W$ ) of the non-tradable goods sector:

$$W = TFP_N^{-1} \left\{ \varphi_N w^{1-\sigma_N} + (1-\varphi_N) r^{1-\sigma_N} \right\}^{\frac{1}{1-\sigma_N}} \quad (6)$$

where  $TFP_N$  is the total factor productivity,  $\varphi_N$  is the distribution parameter ( $0 < \varphi_N < 1$ ) and  $\sigma_N$  is the absolute value of the elasticity of substitution between labour and capital employed in the non-tradable sector.

From the first-order condition of the non-tradable producer's optimization problem, the value of the marginal product ( $P_N TFP_N$ ) equals the factor price index ( $W$ ); in other words,  $W = P_N TFP_N / SRER$ . When the relative factor price,  $w/r$ , is constant, the non-tradable producer adjust his demand for factors and supply of goods up to the point at which the percentage variation of any factor price equals the percentage variation of the non-tradable price. In our economy with perfect factor mobility between sectors, factor prices are equal in all sectors and, therefore, their percentage variation is equal to the percentage variation of the total factor productivity of the non-tradable sector minus the rate of change of the structural real exchange rate; that is:

$$\hat{w} = \hat{r} = \hat{P}_T - \hat{SRER} + \hat{TFP}_N \quad (7)^1$$

where the hats denote the rates of growth of the respective variables; i.e.

$$\hat{z} = (dz / dt)(1 / z)$$

## II.1 Factor market equilibrium

In our model labour and capital are perfectly mobile between sectors, but only capital is fully employed. Equation (8) defines the employed labour force,  $L$  as consisting of the (constant) economically active population ( $EAP$ ) and the unemployment rate ( $u$ ):

$$L = \frac{EAP}{100} (100 - u) \quad (8)$$

If the relative factor price is given, due to rigidities in the factor markets the unemployment rate, or the employed labour force, would be endogenous and its equilibrium rate driven by the macroeconomic fundamentals that affect the economy. Thus, when the relative factor price is constant and there is full employment of the capital factor, the adjustment of the labour market occurs through an adjustment of quantities, the unemployment.

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1. Note that both factor prices are endogenous variables, but they depend on the structural real exchange rate. Once the structural real exchange rate is determined, factor prices are also determined.

When both factor markets are in equilibrium the capital intensity of the economy is given by  $k$  which equals the quotient between the capital and employed labour force, or alternatively:

$$\theta_{L_X} k_X + \theta_{L_M} k_M + (1 - \theta_{L_X} - \theta_{L_M}) k_N = k = K/L \quad (9)$$

where  $k_X = K_X/L_X$ ,  $k_M = K_M/L_M$  and  $k_N = K_N/L_N$  are the capital intensity of the primary, manufacturing and non-tradable sectors, respectively;  $K_X$ ,  $K_M$  and  $K_N$  are the capital inputs of the primary, manufacturing and non-tradable sector, respectively; and  $\theta_{L_X} = L_X/L$  and  $\theta_{L_M} = L_M/L$  are the shares of the labour employed in the primary and manufacturing sector in the employed labour force, respectively. Rearranging (9) gives:

$$\frac{k}{k_N} = 1 + \theta_{L_X} \left( \frac{k_X}{k_N} - 1 \right) + \theta_{L_M} \left( \frac{k_M}{k_N} - 1 \right) \quad (10)$$

Assuming constant relative factor prices, the derivative of (10) depends on the demand for labour in the primary and manufacturing sectors and the variation of the factor endowments, that is:  $d\theta_{L_X} = \theta_{L_X} (\widehat{L_X} - \widehat{L})$  and  $d\theta_{L_M} = \theta_{L_M} (\widehat{L_M} - \widehat{L})$  and  $dk = k(\widehat{K} - \widehat{L})$ . Substituting for  $\widehat{L_X}$  and  $\widehat{L_M}$  from (2) and (3) gives the production-side equilibrium of the model:

$$d(\log(100 - u)) = -\widehat{\lambda}_1 \widehat{TFP_X} - \widehat{\lambda}_2 \widehat{TFP_M} + \widehat{\lambda}_3 (\widehat{TFP_N} - \widehat{SRER}) + \widehat{\lambda}_5 \widehat{K} - \widehat{\lambda}_6 \widehat{TT} \quad (11)$$

$$\text{where: } \widehat{\lambda}_1 = \gamma_X^{-1} \theta_{L_X} [(k_X/k_N) - 1]$$

$$\widehat{\lambda}_2 = \gamma_M^{-1} \theta_{L_M} [(k_M/k_N) - 1]$$

$$\widehat{\lambda}_3 = \widehat{\lambda}_1 + \widehat{\lambda}_2 > 0$$

$$\widehat{\lambda}_5 = (k/k_N) > 0$$

$$\widehat{\lambda}_6 = \delta \widehat{\lambda}_1 - (1 - \delta) \widehat{\lambda}_2$$

According to equation (11), the effect of the structural real exchange rate on the unemployment rate that equilibrates both factor markets depends on the relative sectoral capital intensities: that is,  $\widehat{\lambda}_3$  is positive (negative)

if both tradable goods sectors are more capital (labour) intensive than the non-tradable goods sector; and  $\lambda_2$  is negative if the manufacturing sector is more labour intensive than the non-tradable sector, so that when  $TFP_M$  improves the manufacturing sector requires more labour than the non-tradable sector releases and so the unemployment rate is pushed down.

## II.1 Goods market equilibrium

The presence of non-tradable goods partly determines the structure of the economy because non-tradable prices are set by the local supply and demand conditions, such that the supply of non-tradable goods and the consumption of non-tradable goods (private expenditure plus the government spending that falls on non-tradable goods) are therefore equal, as in equation (12):

$$N = (\beta_C E + aG) / P_N \quad (12)$$

where  $E$  is domestic private expenditure and  $a$  is the proportion of government spending ( $G$ ) that is devoted to non-traded goods.

In this model it is assumed that the interaction between each individual sector of the economy and the rest of the world is through changes in the real exchange rate. It is also assumed that the current account ( $CA$ ) is at a 'sustainable' level, in that it is consistent with eventual convergence to the stock-flow equilibrium. Thus the current balance is the difference between domestic output ( $GDP$ ) and total domestic expenditure ( $E+G$ ) plus any invisible earnings and transfers, as given by equation (13):

$$\begin{aligned} CA &= GDP - (E + G) + r^*F + Tr \\ &= (P_X X + P_M M) - (1 - \beta_C)E + r^*F + Tr - (1 - a)G \end{aligned} \quad (13)$$

where  $GDP = P_X X + P_M M + P_N N$ , is Gross Domestic Product,  $r^*$  is the international interest rate,  $F$  is the net foreign asset position and  $Tr$  are the international transfers. In this model government spending falls on tradable and non-tradable goods without affecting directly the relative allocation of the private expenditure, as it would be in the case if government spending were introduced in the utility function in a separable way implying that the marginal rate of substitution in private consumption does not depend on it (see, for example, Garcia (1999)). The equilibrium of a perfectly competitive economy implies no extraordinary profits and therefore the income generated by all sectors,  $GDP$ , equals the factor rewards,  $wL+rK$ . Rearranging (13) gives:



$$\beta_c DS + (\beta_c - a)g = \frac{P_x X + P_M M}{wL + rK} - (1 - \beta_c) \quad (14)$$

where  $DS = -(r^*F + Tr) / GDP$  measures the debt services minus transfers-to-GDP ratio and  $g = G/GDP$  is the government expenditure as a share of GDP. Differentiating (14) gives:

$$\begin{aligned} \beta_c d(DS) + (\beta_c - a)d(g) &= \theta_x(\hat{P}_x + \hat{X}) + \theta_M(\hat{P}_M + \hat{M}) \\ &\quad - \theta_T \theta_L(\hat{w} + \hat{L}) - \theta_T \theta_K(\hat{r} + \hat{K}) \end{aligned} \quad (15)$$

where  $\theta_T = \theta_x + \theta_M$ . Substituting for the the supply functions of the primary and manufacturing sectors, from (3) and (4) and noting the definition of the terms of trade, (15) becomes (16):

$$\begin{aligned} \widehat{SREER} &= -\Phi_1 \widehat{TFP}_x - \Phi_2 \widehat{TFP}_M + \Phi_3 \widehat{TFP}_N + \Phi_4 d(\log(100 - u)) \\ &\quad + \Phi_5 \hat{K} - \Phi_6 \widehat{TT} - \Phi_7 d(g) + \Phi_8 d(DS) \end{aligned} \quad (16)$$

where the parameters are defined as follows:

$$\begin{aligned} \Phi_0 &= (\gamma_x^{-1} \theta_x + \gamma_M^{-1} \theta_M)^{-1} > 0 & \Phi_1 &= \Phi_0 \gamma_x^{-1} \theta_x > 0 & \Phi_2 &= \Phi_0 \gamma_M^{-1} \theta_M > 0 \\ \Phi_3 &= \Phi_1 + \Phi_2 = 1 & \Phi_4 &= \Phi_0 \theta_T \theta_L > 0 & \Phi_5 &= \Phi_0 \theta_T \theta_K > 0 \\ \Phi_6 &= \delta \Phi_1 - (1 - \delta) \Phi_2 \stackrel{\leq}{>} 0 & \Phi_7 &= \Phi_0 (\beta_c - a) > 0 & \Phi_8 &= \Phi_0 \beta_c > 0 \end{aligned}$$

Equation (16) implies that the equilibrium of the goods market requires a *SREER* depreciation when the unemployment rate increases as  $\Phi_4$  is unequivocally positive. In other words, reductions in the unemployment rate increase the employed labour force and the total supply of goods. The resulting excess supply of non-tradable goods pushes non-tradable prices downwards and the *SREER* upwards.

Equations (11) and (16) postulate bi-directional causality between the *SREER* and unemployment rate and the equilibrium is reached when the *SREER* and unemployment rate are simultaneously determined. Unemployment in our model, as in Frenkel and Ros (2006), is partly an equilibrium

phenomenon and partly a disequilibrium one. It is consistent with factor market equilibrium at any *SRER* level, but at the same time, it has an important disequilibrium component from which there are no forces that drive relative factor prices to their equilibrium values. The conjunction of equations (11) and (16) imply that the *SRER* and the unemployment rate are driven by macroeconomic fundamentals, such as factor productivity, capital endowments, terms of trade, government spending and the external debt services minus transfers and the response of these variables to exogenous shocks depends not only on preference and technology parameters, but also on the economic structure of a country (as captured by the sectoral and functional income distribution ratios, sectoral capital intensities and labour shares to the total employed labour force and external restrictions).<sup>2</sup>

The theoretical model is particularly well-suited for small, dependent economies like Argentina, where the primary and manufacturing sectors are mainly net exporters and importers, respectively. The estimated model is in log-linear form and so Equations (11) and (16) are replaced with (18) and (17), respectively, where lower case letters denote the logarithms of the upper case letters in equations (11) and (16) and where in addition, in the empirical model  $\bar{e}$  and  $\bar{w}$  are constant parameters, *DMI* is the intercept dummy variable, which is a zero one vector, with ones after the 1st quarter of 2002 and zero before, and *DMC* is the crisis dummy variable, with ones in the 1st and 2nd quarter of 2002 and zeros elsewhere and  $\varepsilon$ 's are the random error terms.

$$\begin{aligned} srer = & \bar{e} - \Phi_1 tfp_X - \Phi_2 tfp_M + (\Phi_1 + \Phi_2) tfp_N + \Phi_4 \log(100 - u) + \Phi_5 \Delta(k) - \Phi_6 tt + \Phi_7 g \\ & + \Phi_8 DS + \Phi_9 DMI + \Phi_{10} DMC + \varepsilon_s \end{aligned} \quad (17)$$

$$\begin{aligned} \log(100 - u) = & \bar{w} - \tilde{\lambda}_1 tfp_X - \tilde{\lambda}_2 tfp_M + (\tilde{\lambda}_1 + \tilde{\lambda}_2) (tfp_N - (SRER - \Phi_9 DMI - \Phi_{10} DMC)) \\ & + \tilde{\lambda}_3 \Delta(k) - \tilde{\lambda}_6 tt + \varepsilon_u \end{aligned} \quad (18)$$

2. In case of perfect international capital mobility, the domestic and international interest rate would be the same and exogenous for our small economy. If we assume three factors, skilled and unskilled labour and capital, that there is always full employment of the skilled factor and that the wage gap between skilled and unskilled labour is constant, our theoretical results will again suggest interdependences between the structural real exchange rate and the unemployment rate, but they will add the international interest rate as an additional macroeconomic fundamental.

### III. THE DATA SET

The data requirements of the model are quite demanding and so we first report the sources and construction of the series before identifying and discussing some of the main patterns in the data.

The price indices, sectoral value added, export and import price indices, unemployment rates, government expenditure and capital stock series were obtained from the National Statistic office (INDEC, Instituto Nacional de Estadísticas y Censos). The Argentinean Central Bank provides series of the multilateral PPP real exchange rate ( $RER_{PPP}$ , the relative price between the foreign price level, expressed in domestic currency, and domestic price level), debt services and transfers. Labour market data were obtained from the Ministry of the Economy (Dirección General de Estudios y Estadísticas Laborales, Subsecretaría de Programación Técnica y Estudios Laborales), a seasonally adjusted unemployment rate series is provided on a biannual basis between 1974 up to 2003. This series has been converted into a quarterly series by the cubic interpolation method.<sup>3</sup> INDEC provides quarterly data of unemployment from the first quarter of 2003 onwards.

The annual capital stock series are provided by the INDEC up to the year 2006. The quarterly data was obtained from the extrapolation of these series based on the depreciation to gross fixed investment ratio and the annual net investment series. Net investment series from 2006 onwards were obtained from applying the depreciation to gross fixed investment ratio of the year 2006 to the gross investment series.

Primary, manufacturing and non-tradable sectors have been classified based on the International Standard Industrial Classification revision 3.1 (ISIC Rev.3.1) of the United Nations. The first includes agriculture, hunting, forestry, fishing and mining and quarrying sectors (codes A, B and C of the ISIC Rev.3.1). The second includes all the manufacturing sectors (code D of the ISIC Rev. 3.1). In line with Gay and Pellegrini (2003), the non-tradable sector includes: electricity, gas and water, construction, wholesale and retail, hotel and restaurants, transport, storage and communication, financial intermediation, real estate and business services, public administration and defense, education, health and social work, other community, social and personal service

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3. This method assigns each value in the low frequency series to the last high frequency observation associated with the low frequency period, and then places all intermediate points on a natural cubic spline connecting all the points.

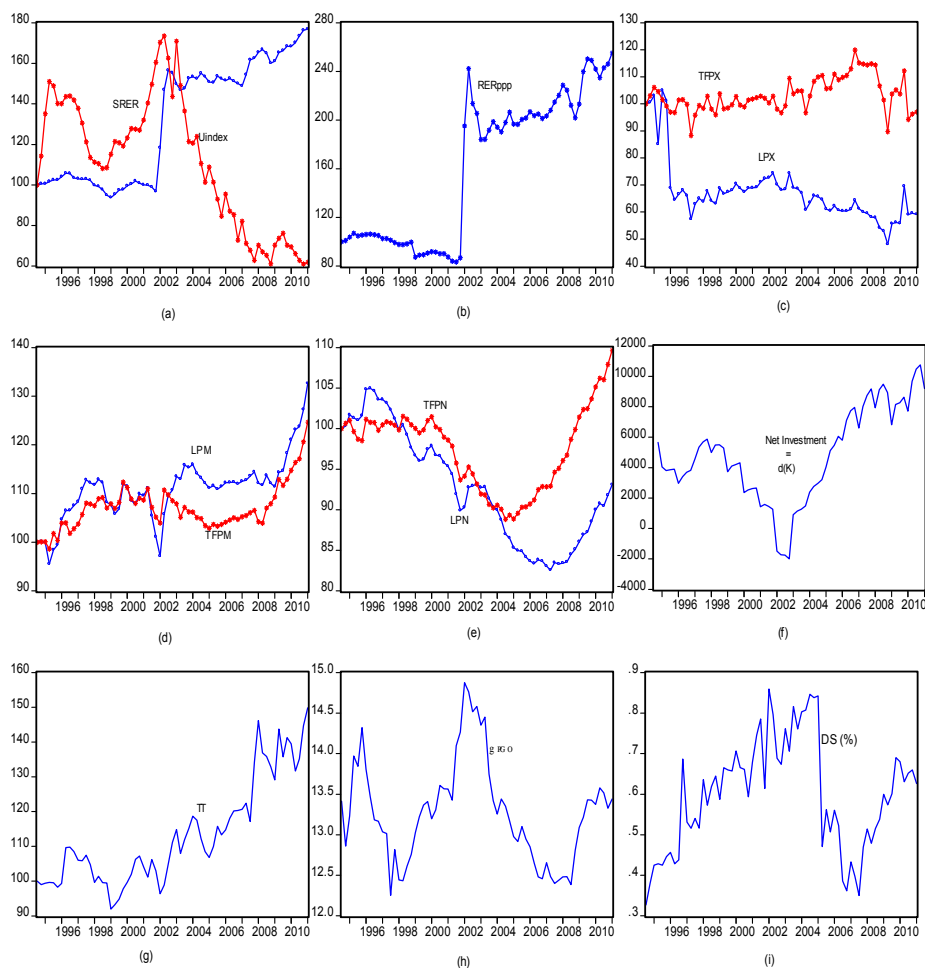
activities and private households with employed persons (codes E, F, G, H, I, J, K, L, M, N, O and P of the ISIC Rev.3.1). Sectoral GDPs are expressed in volumes (constant prices of the base year 1993). Aggregate GDP series are the sum of primary, manufacturing and non-tradable production values. Sectoral value added (sectoral outputs) and labour employed have been calculated taking into account the sector classification criteria mentioned above. Sectoral labour productivities ( $LP$ ) are calculated as the ratio of sectoral product to its employment. Appendix A describes how the sectoral  $TFPs$  are measured.

Assuming that all variables follow a stochastic seasonal process, the XII-ARIMA model of the Census Bureau of National Statistics of the U.S. has been applied and where seasonality was found, the seasonally adjusted data were used to construct the relevant macroeconomic variables.

The dataset used for the estimation of the model includes 67 quarterly observations from 1994Q3 to 2011Q1 on the nine variables plotted in Figure 1. At the beginning of this sample period Argentina's economic policy was changing substantially, as ambitious stabilization and market-oriented reform programs were introduced. To promote transparency and credibility, monetary policy was initially constrained by a commitment to a fixed exchange rate. Although economic performance in the first half of the 1990s was promising, fragility and contagious vulnerability became evident in the aftermath of the Mexican, Asian and Russian financial crises. At the end of 2001, Argentina was unable to meet to the constraint of a fixed exchange rate and abandoned it, triggering a severe economic crisis with higher levels of unemployment and simultaneous debt crisis.

This change in policy is starkly shown in Figure 1 panel (a) by the sharp depreciation of the  $SRER$  in 2001. Comparing its mean before and three quarters after the crisis, the  $SRER$  and  $RER_{PPP}$  (in panel b) jumped by over 40% and 124%, respectively. After the collapse, both real exchange rate measures exhibit similar positive trends. The  $SRER$  is measured by the wholesale to consumer price index ratio, where the wholesale price index has been constructed to only include the prices of primary and manufactured goods. The wholesale to consumer price index ratio serves as a proxy measure of the structural real exchange rate since the wholesale price index predominantly measures traded goods prices, while the consumer price index has a significant component of services, which are generally not traded; see Edwards (1988), Faruque (1995), Hinkle and Montiel (1999) and Harberger (2004).

Figure 1: Macroeconomic Variables (1994Q3-2011Q1, base year 1994Q3)



The unemployment rate as shown by the uindex line, also in panel (a), shows no discernable trend prior to 2003q3, but from 2003q4 it exhibits a strong downward trend to the end of the sample.

Figure 1 panel (c) shows labour productivity in the primary sector ( $LP_X$ ) declined until the first quarter of 1997 but then increased slowly until 2002q1, after which it decreased again until 2009q3.  $TFP$  in the primary sector ( $TFP_X$ ) followed a slightly steady upward trend up to the third quarter of 2003, a positive trend until the third quarter of 2008 and a decreasing one thereafter. Labour productivity manufacturing sector ( $LP_M$ ) (panel, d) increased until the second quarter of 1998, decreased until the exchange rate regime changed, but increased thereafter.  $TFP$  in the manufacturing sector ( $TFP_M$ ) increased until the fourth quarter of 1999 but decreased until the first quarter of 2005, increasing thereafter. Labour productivity in the non-tradable sector ( $LP_N$ ) – as shown in panel (e) – mostly decreased throughout the period.  $TFP$  in the same sector ( $TFP_N$ ) has been almost constant up to the first quarter of 2001. It decreased until the fourth quarter of 2003 but increased thereafter.

Net investment – panel (f)- declined up to the last quarter of 2002 but rebounded thereafter. The terms of trade (panel g) decreased between the second quarter of 1996 and the first quarter of 1999, and then embarked on a broadly upward trend until the end of the sample. Public consumption (as a share of GDP),  $g$ , in panel (h), fell until 1998q2, from where it picked up again. It reached a peak at the time of the exchange rate collapse and again contracted up to the fourth quarter of 2006. It was almost constant until 2008q3, but increased thereafter. Panel (i) effectively shows the debt service ratio, due to the low level of transfers<sup>4</sup>, the pattern of  $DS$  increased up to 2004q4, but decreased substantially after 2004q4, a period in which Argentina restructured its foreign obligations.

#### IV. ECONOMETRIC RESULTS

Prior to estimating the postulated relationships the time series properties of the individual series need to be investigated. Following Plasmans, et al (2007, p. 2) the general-to-specific sequential testing procedure is used, starting with third order of integration and moving downwards to lower or-

4. Like other South American countries, Argentina depend less of its remittances. Remittances in South America were, in 2006, not higher than 1%GDP, while up to 10%GDP in Central America (Bello, Heresi, & Pineda, 2010, p. 20).

ders of integration. Each unit root test has three versions: an unrestricted model (including trend and intercept), a trend restricted model (including intercept but not trend) and a trend-intercept restricted model (neither trend nor intercept). The unit root models for the *SRER* include a crisis dummy variable that captures the effects of the collapse of the fixed exchange rate regime at the end of 2001.

Table 1 provides the ADF (augmented Dickey-Fuller) statistic of each unit root test. There is no evidence of three unit roots in any series at the 1% significance level. The null hypothesis of two unit roots is rejected at the 1% significance level for all series, except for the capital series. If the one unit root test is applied to the capital series, the trend parameter of the unrestricted model is significantly different from zero at the 5% level, thus the capital stock series is a trend stationary process rather than a data stationary process. Table 1 suggests that it is reasonable to proceed on the assumption that all series are I(1) processes.

The Johansen procedure, Johansen (1991), is applied to test for simultaneity between the real exchange rate and the unemployment rate. Equation (19) shows a VAR of order  $p$  written in the form of an autoregressive error correction model, which include the capital series in first differences and two dummy variables as follows:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \quad (19)$$

where  $y_t = [srer_t, \log(100 - u)_t, tfp_{Xt}, tfp_{Mt}, tfp_{Nt}, \Delta(k)_t, tt_t, g_t, DS_t]$  is a vector of non-stationary variables,  $x_t = [DMC, DM2Q02]$  is the vector of deterministic dummy variables; and  $\varepsilon_t$  is a vector of innovations. Equation (19) was tested with a one-period lag, which was optimal according to the Schwartz criterion, and Table 2 shows that there are two cointegrating vectors at the 5 per cent level.<sup>5</sup>

With more than one cointegration relation, however, there is some ambiguity in the interpretation of the estimated cointegrating vector, as the estimated coefficients are more related to the reduced form relationships than to the interdependent relationships (Johnston & Dinardo, 1997, p. 305). In this case it is not possible to estimate behavioural relationships as cointe-

5. This result is fully consistent with Bello, et al (2010) who also find two cointegration vectors for Argentina over the period 1969-2006.

Table 1: Observed ADF statistics of the unit root test

Model	Three unit root tests			Two unit roots			One unit root		
	Un	T	TI	Un	T	TI	Un	T	TI
<b>srer</b>	-10.3***	-10.4***	-10.3***	-14.3***	-14.2***	-14.4***	-0.67	0.88	0.80
<b>u</b>	-13.9***	-14.0***	-14.0***	-5.54***	-5.60***	-5.52***	-1.80	-0.79	-1.19
<b>lpx</b>	-13.3***	-13.4***	-13.5***	-8.30***	-8.11***	-7.96***	-3.33*	-3.41**	-1.41
<b>tfp<sub>x</sub></b>	-14.6***	-14.7***	-14.8***	-7.64***	-7.69***	-7.74***	-2.66	-2.34	-0.34
<b>lp<sub>x</sub></b>	-14.7***	-14.89***	-15.07***	-3.717**	-3.69***	-3.73***	-1.358	-1.168	0.0009
<b>lp<sub>m</sub></b>	-13.7***	-13.8***	-13.9***	-5.94***	-5.85***	-5.53***	-0.28	0.25	1.67*
<b>lp<sub>n</sub></b>	-10.1***	-10.1***	-10.2***	-4.7***	-4.3***	-4.3***	0.2	-1.4	-0.7
<b>tfp<sub>n</sub></b>	-11.0***	-11.1***	-11.1***	-5.21***	-4.22***	-4.18***	1.04	0.03	0.71
<b>k</b>	-8.10***	-8.14***	-8.19***	-1.55	-1.16	-0.30			
<b>tt</b>	-12.0***	-12.1***	-12.2***	-6.99***	-6.94***	-6.74***	-2.15	-0.20	1.41
<b>DS</b>	-16.0***	-16.1***	-16.2***	-7.68***	-7.68***	-7.71***	-1.93	-2.01	0.14
<b>g</b>	-15.4***	-15.5***	-15.6***	-4.74***	-4.78***	-4.82***	-2.21	-2.18	-0.01

where

srer, lpx, tfpx, lpm, tfpm, lpn, tfpn, k and tt are the logarithms of SRER, LP<sub>x</sub>, TFP<sub>x</sub>, LP<sub>MP</sub>, TFP<sub>MP</sub>, LP<sub>NP</sub>, TFP<sub>NP</sub>, K and TT.

Un, T and TI refer to the unrestricted, trend restricted and trend-intercept restricted models, respectively

H<sub>0</sub> = there are k(=3, 2 or 1, respectively) unit roots

(\*), (\*\*) and (\*\*\*) indicate that the null of k unit roots is rejected at 10%, 5% and 1% significance levels, respectively



Table 2: Johansen Test (one lag)

Number of Cointegration Equations	Eigen Value		Trace test		Maximum Eigenvalue test	
	Statistics	Critical Values (5%)	Statistics	Critical Values (5%)	Statistic	Critical Values (5%)
None	235.08	208.44	56.30	59.24	0.59	0.59
At most 1	178.78	169.60	46.56	53.19	0.52	0.52
At most 2	132.22	134.68	40.41	47.08	0.47	0.47
At most 3	91.81	103.85	29.59	40.96	0.37	0.37
At most 4	62.22	76.97	23.89	34.81	0.31	0.31
At most 5	38.33	54.08	17.71	28.59	0.24	0.24
At most 6	20.62	35.19	10.48	22.30	0.15	0.15
At most 7	10.13	20.26	7.34	15.89	0.11	0.11
At most 8	2.79	9.16	2.79	9.16	0.04	0.04

\*\* (\*\*\*) denotes significance at the 5% (1%). The  $\lambda_{Trace}$  and  $\lambda_{Max}$  are the statistics corresponding to the trace and maximum eigenvalue test

gration vectors without out-of sample information, Greene (2003, p. 652). Assuming the theoretical model is well-suited for Argentina, it provides exact information about the endogenous variables (the structural real exchange rate and the unemployment rate), their interrelation (equations (17) and (18)) and the exogenous variables. Following Greene (2003, p. 655), the Engle and Granger (1987) method is based on assessing whether single-equation estimates of the equilibrium errors appear to be stationary. We proceed therefore by using the Engle and Granger (1987) two-step cointegration method<sup>6</sup> combined with an iterative OLS method for simultaneous equations, which has the additional advantage of enabling direct estimation of the parameters  $\Phi_4$ ,  $\lambda_1$  and  $\lambda_2$ .

Equations (17) and (18) are simultaneously estimated by the iterative OLS method.<sup>7</sup> Equations (17) and (18) have 13 parameters (excluding the intercept and crisis dummy variables), but their corresponding reduced-form equations have 14 parameters. Equation (17) is exactly identified, but equation (18) is overidentified. The overidentification of equation (18), however, is solved by the exclusion of government spending. Moreover, as the inclusion of government spending does not give rise to any significant changes in the size or significance of the estimated parameters then the exclusion of government spending does not invalidate the results.

Table 3 includes the estimated pre-equilibrium and equilibrium equations for the *SRER* and unemployment rate. It also includes the estimated pre-equilibrium equations based on the PPP real exchange rate. For instance, the first row suggests that the structural real exchange rate that equilibrates the goods market increases in a 0.32% when the employed labour force increases in 1%; while the second suggests that, in order to keep the factor

6. As a first step, the Engle and Granger cointegration approach tests the order of integration of each of the variables involved in the analysis. Then, it runs the long-run relationships, given in our case by equations (17) and (18). The fact that variables are cointegrated implies that there is some adjustment process which prevents the errors in the long-run relationships from continuously increasing. Thus, the estimated relationships are non-spurious if their residuals are stationary; the critical values of the Dickey-Fuller statistic applied to these residuals depend on the non-deterministic exogenous variables. Also, when their residuals are stationary, each cointegrated relationship has a matching error correction short-run model, which is an equation with variables in first differences and with an error correction term (residual from the long-run relationship lagged one period).

7. The simultaneity problem arises because endogenous variables are correlated with the relevant stochastic disturbances. The Hausman's test has been applied to check whether  $\log(100-u)$  and the error term are correlated. The Hausman specification error test estimates the reduced-form equations for *SRER* and then estimates equation (18) considering the *SRER* equal to the estimated *SRER* of the previous step minus  $\Phi_9DMI$  and the error term of the estimated *SRER* as explanatory variables. It does not then reject the null of interdependences between the *SRER* and the unemployment rate.

Table 3: SRER and Unemployment rate interdependences in Argentina

Variables	srer	log(100-u)	C	tfpx	tfpm	tfpn	A(k)	tt	DS	g	DMI	DMC	Statistics
Pre-equilibrium conditions		0.32	1.07	-0.01	-0.26	0.28	0.15	0.39	0.02	0.03	0.38	0.09	R2 0.988
		(0.19)	(0.84)	(0.04)	(0.13)	(0.13)	(2.32)	(0.05)	(0.03)	(0.01)	(0.01)	(0.02)	AdjR2 0.986
	*	*	*	**	**	**	***	***	***	***	***	***	ADF -8.03***
log(100-u)	0.23	3.27	0.02	0.21	-0.23	8.45	0.01						R2 0.87
	(0.07)	(0.20)	(0.03)	(0.08)	(0.07)	(1.00)	(0.05)						AdjR2 0.86
	***	***	***	***	***	***	***						ADF -4.44**
srer		2.29	-0.01	-0.21	0.22	3.08	0.42	0.42	0.02	0.03	0.38	0.09	R2 0.99
		(0.26)	(0.05)	(0.14)	(0.14)	(2.03)	(0.05)	(0.05)	(0.03)	(0.01)	(0.01)	(0.02)	AdjR2 0.99
		***	***	**	***	***	***	***	***	***	***	***	
Equilibrium relationships		3.80	0.02	0.16	-0.18	9.17	0.10	0.10	0.01	0.006			R2 0.99
		(0.14)	(0.04)	(0.08)	(0.07)	(1.31)	(0.03)	(0.03)	(0.01)	(0.003)			AdjR2 0.99
		***	**	**	***	***	***	***	**	**			
RERPPP		0.35	1.00	-0.14	-1.13	1.27	4.93	0.34	0.02	0.04	0.77	0.52	R2 0.98
		0.43	1.88	0.10	0.29	0.29	5.14	0.11	0.07	0.02	0.03	0.04	AdjR2 0.97
			***	***	***	***	***	***	*	*	***	***	ADF -8.79***
PPP Pre-equilibrium relationships	-0.02	3.74	0.02	-0.03	0.02	6.83	0.16						R2 0.83
	0.09	0.38	0.08	0.10	0.09	1.91	0.07						AdjR2 0.82
		***	***	***	***	***	***	***	***	***	***	***	ADF -3.97*

The pre-equilibrium conditions are the estimated equations (14) and (15), while the equilibrium relationships are their corresponding reduced forms

The estimated PPP pre-equilibrium conditions refer to the estimates of equation (14) and (15) based on the PPP real exchange rate. The first row in each cell refers to the estimated parameters while values in parenthesis to its standard deviation. (\*), (\*\*), (\*\*\*) indicate that the estimate is significant different from zero at the 10%, 5% and 1% significance levels. ADF is the observed Dickey-Fuller statistic of the estimated residuals, which are stationary at the 5% level.

markets in equilibrium, the employed labour force increases in 0.23% when the structural real exchange rate increases in 1%.

The estimated pre-equilibrium conditions suggest negative interdependences between the *SRER* and the unemployment rate at the 10% significance level. The negativity of the estimated  $\lambda_2$  parameter implies from the theoretical model that the manufacturing sector is more labour intensive than the non-tradable sector in Argentina.<sup>8</sup> The application of the three stage least squares method also yields negative interdependences between the *SRER* and the unemployment rate at the 5% significance level. Further, when sector labour productivities are used instead of sector TFPs, significant negative interdependences between the *SRER* and the unemployment rate are still be found;  $\lambda_2$  is again negative and statistically different from zero.

The Argentinean economic environment may have changed after the collapse of the fixed exchange regime at the end of 2001. To test for this major structural shock the Quandt-Andrews unknown break test for each variable was applied: so when the null hypothesis of no break points is rejected at the 10% significance level, a dummy variable is included for the corresponding varying regressor. There is, however, still evidence of negative interdependence between the *SRER* and the unemployment rate, although only the *SRER-u* relationship of Equation (17) is now statistically significant.<sup>9</sup>

According to the pre-equilibrium conditions, Argentinean TFP improvements in any of the tradable sectors reallocate resources pushing the *SRER* and the unemployment rate down. Once the interactions between the *SRER* and the unemployment rate have been taken into account, the equilibrium relationships show that these productivity improvements appreciate the equilibrium *SRER* and reduce the unemployment rate. Both the pre-equilibrium and equilibrium conditions confirm the presence of the Balassa-Samuelson

8. Referring to Neary and Purvis' (1982) paper, which assumed a labour-intensive non-traded sector, Fleming (1982, p. 256) wrote "non-tradable sector includes extremely capital-intensive public utilities (electricity, generation and transport) as well as housing. It is quite probable that the tradable goods sector is less intensive of capital". If it is still expected a non-tradable sector more labour intensive than the tradable sectors, our result can be seen as a paradox. Nonetheless, if our model refers to skilled and unskilled labour instead of labour and capital, full employment of the unskilled labour and constant or exogenous relative factor price, the negativity of  $\lambda_2$  would suggest that the manufacturing sector is more skilled-labour intensive than the non-tradable sector.

9. The quality of the Argentinean official data on prices has drastically diminished since the year 2006. Nonetheless, the Quandt-Andrews break point test does not reveal significant variations in the behaviour of the *SRER* from the 2006 year onwards. Also, the results are not that different from estimations based on data up to the second quarter of 2006.

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Additional investment depreciates the pre-equilibrium and equilibrium *SRER*, but reduces the pre-equilibrium and equilibrium unemployment rate. According to the pre-equilibrium and equilibrium conditions, terms of trade improvements depreciate the *SRER* and reduce the unemployment rate. The effect of debt service minus transfers (*DS*) on the pre-equilibrium

and equilibrium conditions is as theoretically expected, with reductions in  $DS$  appreciating the equilibrium  $SRER$  and raising the unemployment rate.

Government spending impacts positively on the  $SRER$  (as in Bastourre, et al (2008, p. 274) and in Padua and Mastronardi (2008, p. 17)), but its impact on the unemployment rate is negative. The sign of the estimated parameter  $\Phi_7$  would suggest that reductions in the proportion of government spending that falls in non-tradable goods depreciate the  $SRER$  and reduce the unemployment rate. The intercept and crisis dummy variables reveal that the long-run  $SRER$  was up by 38% with a 18% overshooting as a consequence of the exchange rate regime collapse at the end of 2001.

The residuals of the pre-equilibrium conditions of Table 3 are stationary at the 5 per cent significance level. Consequently, an error correction model (ECM) for the  $SRER$  and the unemployment rate is estimated. Both ECMs also include the second difference of capital as well as lagged values of the differences of the dependent variables. Both ECMs are estimated by the iterative SUR method, in which the matrix of covariances and coefficients are corrected for heteroskedastic disturbances. They are estimated by modeling from the general-to-specific with non-significant variables at the 10 per cent level dropped. In Table 4, the error correction terms of both ECMs are negative and statistically significant at the 10 per cent level; thus each cointegration relationship has a matching ECM. Also, the statistical significance of the lagged dependent variables, at the 10 per cent level, show

**Table 4: Short-run relationships**

Variables	$\Delta(\text{tfpn})$	$\Delta(\Delta(k))$	$\Delta(\text{tt})$	DMC	ECF	Lag(-1)	Lag(-2)	Statistics	
$\Delta(\text{SRER})$	0.24		0.13	0.20	-0.11	0.21	-0.10	R2	0.87
	(0.16)		(0.04)	(0.01)	(0.05)	(0.06)	(0.05)	AdjR2	0.86
			***	***	**	***	*		
$\Delta(\log(100-u))$		2.32			-0.41	0.16		R2	0.26
		(0.91)			(0.08)	(0.10)		AdjR2	0.24
		**			***	*			

Values in brackets refer to the corresponding standard deviation

$\Delta$  refers to the lag of the corresponding variable,  $\Delta(\Delta..)$  refer to the second difference of the involved variable, Lag(-1) and Lag(-2) refer to the first difference of the dependent variable lagged one or two periods, respectively

(\*), (\*\*) and (\*\*\*) indicate statistical significances at the 10%, 5% and 1% levels.

that the adjustment process to the equilibrium of the goods and factors markets is not immediate but implies a learning process. The PPP real exchange rate measures the value of a domestic goods in terms of foreign goods. When it increases, domestic goods become cheaper in terms of foreign goods and the competitiveness of the domestic economy improves. The PPP real exchange rate, however, only moves in line with the structural real exchange rate when law of one price holds and the foreign structural real exchange rate is constant. As equation (19) shows the distinction between the real exchange rate and the *SZER* measures is not innocuous and the bias may be particularly important in the presence of interdependences between the *SZER* and the unemployment rate

$$\widehat{RER}_{PPP} = \left( \widehat{S} + \widehat{P}_r^* - \widehat{P}_r \right) + (1 - \beta_c) \widehat{SZER} - (1 - \beta_c^*) \widehat{SZER}^* \quad (20)$$

where *S* is the nominal exchange rate, *RER<sub>PPP</sub>* is the PPP real exchange rate and a star denotes a foreign variable. Consequently, equations (17) and (18) have also been estimated using the multilateral PPP real exchange rate as a proxy variable of the *SZER*. Only the linkage between the PPP real exchange rate and the unemployment rate postulated by equation (17) has the expected sign, but it is not statistically significant even at the 10% level (see the rows of the PPP pre-equilibrium conditions of Table 3). There is therefore no evidence of interdependences between the PPP real exchange rate and the unemployment rate.

## V. CONCLUSIONS

This research, using a micro-based structural model, finds evidence of significant negative linkages between the Argentinean structural real exchange rate and unemployment rate. It is important to note that this negative interdependence does not exist when the real exchange rate is measured as the PPP real exchange rate. The importance of the interdependence between the structural real exchange rate and the unemployment rate is essential for the conduct an appropriate and efficient economic policy and in particular, for the avoidance of Dutch disease-type effects, whereby an appreciation of the structural real exchange rate leads to a rise in the rate of unemployment. Appropriate economic policies, as suggested by Diewert (2006), can foster productivity improvements via investment in physical and human capital, although the implications for unemployment and the structural real exchange rate are likely to be complex as the model developed here demonstrates. For Argentina, it seems that the influence on the economy

of the TFP in the tradable sector is mainly due to the impact of the TFP in the manufactured goods sector with the role of TFP in both manufactured and non-traded goods sectors being statistically significant. Moreover, since these TFP coefficients have opposite signs and are almost of the same magnitude, a simultaneous rise in these variables will have offsetting effects on the structural rate exchange rate and the rate of unemployment. However, to the extent that productivity in the manufacturing sector typically exceeds that of the non-traded goods sector, then unemployment is likely to fall, even if there is some appreciation of the equilibrium, structural real exchange rate in the long run. There is also evidence that additional investment reduces the Argentinean unemployment rate, while terms of trade improvements depreciate the structural real exchange rate, but reduce the unemployment rate.

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## APPENDIX A: MEASURING TOTAL FACTOR PRODUCTIVITIES

The recent real exchange rate literature has focused on proxy variables for TFP as “data on sector TFP are unavailable for developing countries because its calculation involves data on sector labour and capital stocks, as well as estimates of sector labour shares in production, which are almost unavailable for most developing countries” (Carrera & Restout, 2008, p. 12). De Gregorio and Wolf (1994, p. 8) also note that most work on real exchange rates has relied on labour productivity rather than on TFP. This distinction is not innocuous since labour shedding may introduce substantial differences between changes in average labour productivity and TFP (De Gregorio, Giovannini, & Krueger, 1994) and the bias may be particularly important in the presence of unemployment. Recently for Argentina, Bastourre, Carrera and Ibarlucia (2008) use GDP per-capita as a TFP proxy while Bello, Heresi and Pineda (2010) measure TFP based on the GDP-to-labour force ratio, where GDP is expressed in constant dollars adjusted by the purchasing power parity.

TFP can be calculated by four different approaches: (a) the growth accounting approach, which requires the explicit specification of a neo-classical production function and identifies TFP as the output that cannot be accounted for by the growth in inputs according to a specific production function (under Cobb-Douglas, TFP is commonly called the Solow residual); (b) the index number approach, which is an extension of (and complement to) growth accounting and involves dividing a (real) output quantity index by an input quantity index to obtain a measure of TFP, the critical issue regarding this approach is the choice of the appropriate index; e.g. the Fischer or Törnquist indices; (c) the distance function approach, which separates TFP into changes resulting from movements toward the production frontier (technical efficiency change) and shifts of this frontier (technical change); it requires full information about the state of technology at every point and identical production functions for all production units; and (d) the econometric approach, which involves estimating the parameters of an aggregator function (cost, profit or production function) and measures TFP in terms of the estimated parameters.

In this paper, Argentinean sectoral TFP series have been constructed assuming a constant relative factor price.<sup>10</sup> Cobb-Douglas and CES production functions are homothetic in the sense that the optimal capital / labour ratio depends only on the relative factor price. Thus, if the relative factor price is constant, the proportional change in the labour and capital employed are the same ( $\% \Delta K_i = \% \Delta L_i$ , where  $i$  refers to the sector under analysis).

When the technology is Cobb-Douglas, the proportional change in the product ( $\% \Delta y_i$ ) is equal to: (a)  $\phi_i(\% \Delta L_i) + \psi_i(\% \Delta K_i) + (\% \Delta TFP_i)$  or (b)  $(\phi_i + \psi_i) * (\% \Delta L_i + \% \Delta TFP_i)$ ; where  $\phi_i$  and  $\psi_i$  are the output elasticities of labour and capital employed in sector  $i$ , respectively. In the case of the CES technology, the proportional change in the product ( $\% \Delta y_i$ ) can be approximated by (a)  $(1-\phi)(\% \Delta L_i) + \phi(\% \Delta K_i) + (\% \Delta TFP_i)$  or (b)  $(\% \Delta L_i) + (\% \Delta TFP_i)$ . It means that only one factor - labour (available) in this case - can be used to calculate the proportional change in TFP as a residual; a special case of Solow residual. Assuming that TFP changes take one year (four quarters) to manifest itself, equation (A.1.1) has been estimated for the primary, manufacturing and non-tradable sector.

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10. The ARKLEMS project measures Argentinean TFPs following the KLEMS (capital, labour, energy and intermediate inputs) methodology. Its data base refer, however, to annual TFP series between 1993 and 2006; see also Coremberg (2003) who, based on the Solow residual, measures the aggregate TFP for Argentina.

$$\begin{aligned} \Delta(\log(y_t)) = & c_{11}\Delta(\log(L_t)) + c_{12}\Delta(\log(L_{t-1})) + c_{13}\Delta(\log(L_{t-2})) + c_{14}\Delta(\log(L_{t-3})) \\ & + c_{15}\Delta(\log(y_{t-1})) + c_{16}\Delta(\log(y_{t-2})) + c_{17}\Delta(\log(y_{t-3})) + \varepsilon_t \end{aligned} \quad (\text{A.1.1})$$

Table A1 displays the estimated results of equation (A.1.1); not statistically significant variables have been dropped. Equation (A.1.2) displays the expected variation of the sector output  $y_t^e$  after the TFP has manifested itself, while equation (A.1.3) describes the variation in output that cannot be accounted for by growth in ‘capital’ and labour.

$$\Delta(\log(y_t^e)) = \frac{c_{11}\Delta(\log(L_t)) + c_{12}\Delta(\log(L_{t-1})) + c_{13}\Delta(\log(L_{t-2})) + c_{14}\Delta(\log(L_{t-3}))}{1 - c_{15} - c_{16} - c_{17}} \quad (\text{A1.2})$$

$$\Delta(\log(TFP_t)) = \Delta(\log(y_t)) - \Delta(\log(y_t^e)) \quad (\text{A1.3})$$

**Table A1: TFP measures,  
OLS estimations of  $\% \Delta y_i = (\phi_i + \psi_i) * (\% \Delta L_i) + (\% \Delta TFP_i)$**

Sector labour employed	Sector value added		
	Primary	Manufacturing	Non-tradable
	$\Delta(\log(y_t))$	$\Delta(\log(y_t))$	$\Delta(\log(y_t))$
$\Delta(\log(L_t))$		2.32*** (0.20)	0.81*** (0.12)
$\Delta(\log(L_{t-1}))$	0.11 (0.08)		-0.18 (0.13)
$\Delta(\log(L_{t-2}))$		-1.10*** (0.15)	
$\Delta(\log(L_{t-3}))$	0.16* (0.08)		-0.16** (0.07)
$\Delta(\log(y_{t-1}))$	-0.41*** (0.10)	-0.17* (0.09)	0.31* (0.11)
$\Delta(\log(y_{t-2}))$	-0.24** (0.10)		
<i>DM2Q10</i>	0.23*** (0.04)		
R <sup>2</sup>	0.40	0.71	0.73
R <sup>2</sup> <sub>Adjusted</sub>	0.36	0.70	0.72

where:

values below each estimated coefficient refer to their corresponding standard error (\*), (\*\*) and (\*\*\*) shows statistical significances at the 10%, 5% and 1% levels, respectively; y and L variables refer to the sector value added and labour employed in the sector corresponding to each column, respectively; The subscripts (-1), (-2) and (-3) indicate that the corresponding variable is lagged one, two and three periods, respectively;  $\Delta$  refers to the first difference of the corresponding variable; DM2Q10 refers to a dummy variable with one in the second quarter of 2010 and zero elsewhere; R<sup>2</sup> and R<sup>2</sup><sub>Adjusted</sub> are the R-squared and Adjusted R-squared, respectively