Revised

Theory and Empirics of Real Exchange Rates
in Developing Countries

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Abstract

This paper develops a general equilibrium model of the real exchange rate (RER) for a small open economy, taking into account often overlooked characteristics of developing economies, such as the presence of significant aid flows, distorting trade taxes, and concentration of exports on natural resources. The equilibrium RER results from the intertemporal, optimal decisions of households on consumption, production, and trade of different goods, conditional upon government policies and external conditions. The model derives a concept of the sustainable current account based on the yield of the discounted present value of net exports, which provides a rigorous framework for the computation of the equilibrium RER and misalignment indexes. We test the model in a sample of 73 developing countries in the 1970-2004 period using the PMG estimator proposed by Pesaran et al. (1999) and find it to be an encompassing representation of the data.

1.   Introduction

The debate regarding the role of the real exchange rate (RER) in macroeconomic policy and long-run growth occupies a central position in economic research (Lane, 2001) and policy design (Hinckle and Montiel, 1999). The RER is an economy-wide relative price that has been linked to crucial macroeconomic phenomena. Sustained overvaluation has been linked to lower long-run economic growth (Aguirre and Calderón, 2006), lower financial deepening (Dehesa et al., 2007), and higher tendency to currency crises (Burkart and Coudert, 2002). Countries that have avoided persistent overvaluation, on the other hand, have been associated with foreign trade deepening and export diversification (Dollar, 1992; Elbadawi, 2002). RER instability has also been found to affect negatively macroeconomic performance, in particular long-run economic growth (Hnatskova and Loayza, 2004), private investment (Servén, 2003) and long-term productivity growth (Aghion et al., 2006).

The literature on the determinants of the RER and the effects of its misalignment is limited in three dimensions that this paper tries to overcome (see the critical review by Edwards and Savastano, 2000). First, the analysis ought to be undertaken within a dynamic, general equilibrium model because the RER is an economy-wide relative price and its effects are transmitted to –and impinge on— the entire economy. Until the 1990s, partial equilibrium and/or static models were standard in applied work; only recently general equilibrium models have been proposed and tested for developed economies (e.g., Chari et al., 2005). Dynamic general equilibrium models of the RER acknowledging the specificities of emerging economies are yet to be developed.

A second limitation of the literature is their notion of the equilibrium RER, which is a key element in computing misalignment. Authors often measure misalignment as the actual changes in the RER; the residuals from regressions of the RER on selected variables, time trends, or mechanical filters; or the distance between the actual RER and a PPP benchmark. In general, these methodologies do not provide for a consistent measure of the equilibrium RER and, more importantly, cannot distinguish between movements toward equilibrium from changes in misalignment.

A third limitation of the empirical literature is that it fails to include key elements which characterize changes in the RER and its misalignment in developing economies. Standard RER models for developing economies borrow their specifications from papers dealing with developed economies which typically omit fundamentals such as foreign aid flows, foreign trade taxes, workers remittances, and the concentration of exports on natural resources, which are structural characteristics of less developed economies.

This paper contributes to the literature in these three dimensions. First, it develops a first-principle, general equilibrium model for a small open economy, from which we derive the equilibrium RER that results from the intertemporal, optimal decisions of households on consumption and production of different goods, conditional upon government policies, and external conditions. Second, the solution of the model provides for an explicit, parametric, and encompassing empirical model of the dynamics of the RER that can be directly tested using panel data. Third, the model derives a concept of the sustainable current account and the equilibrium RER

which provides for a rigorous framework for the computation of the exchange rate misalignment. The sustainable current account is given by the discounted present value of net exports proceeds plus the net returns from foreign assets and foreign aid and remittances flows. In addition to accounting for the flow fundamentals, the model introduces the role of natural resources and human capital as potential determinants of the equilibrium RER. Therefore, our theory addresses important limitations of the current literature.

We test the model using annual data for 73 developing countries in the 1970-2004 period. The empirical specification is directly derived from our theory which provides a rigorous framework for the estimation, yet it is flexible enough to account for country-specific characteristics. We use the Pooled Mean Group estimator developed by Pesaran et al. (1999) to test the model as it conforms better with the econometric challenges posed by the our model. The empirical results validate our model as an encompassing representation of the data and provide new insights on the role of government policies and external shocks on the equilibrium real exchange rate.

Our results replicate well known results in this literature, namely the Balassa-Samuelson effect (productivity growth in the non-traded sector leads to an equilibrium appreciation in the RER), the typically appreciating effect of fiscal expenditures on the RER, and the stylized fact that more open economies tend to have more depreciated exchange rates. As for the novel results, we obtain that a greater abundance of natural resources relative to human capital stocks significantly appreciate the equilibrium RER and that small changes in tax rates can have substantial effects. We also find that often overlooked stock-flow restrictions are important drivers of the equilibrium exchange rate: our measure of the sustainable current-account indicates that one-standard deviation shocks –which occur in around 75% of the occasions— could induce swings in the RER of around 15%.

The estimated econometric model also unveils substantial differences among countries in the speed of adjustment to equilibrium. For 39 countries in the sample, we find that a shock takes around ten years to dissipate: of these, 15 are African economies and 13 are Latin American countries. On the other hand, in 18 countries adjustment takes less than five years to dissipate, 13 of which belong to the African continent. The evidence indicates that differences in the speed of adjustment depend on the exchange rate regime: countries belonging to exchange rate agreements or pegging to hard currencies as well as members of monetary unions, tend to adjust much slower than economies where the exchange rate is market determined.

Section 2 of the paper reviews conceptual and empirical approaches to modeling the RER and puts in perspective the concepts of equilibrium and misalignment we later use in our theory. Section 3 describes the model and indicates how it can address some of the major limitations of the existing literature. Section 4 describes the econometric procedures and analyzes the estimation results. Section 5 provides a summary of the contributions and main findings of the paper.

2.   *Modeling Real Exchange Rates and Misalignment*

There are two research agendas dealing with the analysis of the real exchange rate, its determinants, and the effects of its misalignment. The first is based on the purchasing power parity or PPP hypothesis, while the second focuses on behavioral models linking the RER to a set of determining variables or *fundamentals.*

The PPP hypothesis posits that in equilibrium foreign and domestic currencies should have the same purchasing power. Given a basket of goods, this definition provides an easy-to-compute benchmark for the equilibrium RER. The empirical evidence, however, tends to reject PPP-based models in both developed and developing countries because they fail to explain persistent deviations of the real exchange rate from the PPP benchmark (Mussa, 1986) and/or because the rate of convergence to equilibrium is too slow to be compatible with the PPP hypothesis, even if one is to allow for plausible nominal rigidities (Rogoff, 1996). Recent papers claim that a weaker version of PPP —allowing for short-term deviations— could provide a useful benchmark for assessing misalignment in the very long run, i.e., 10 to 20 years (Yotopoulos and Sawada, 2006; Sarno and Valente, 2006). However, even if one is willing to use such long-horizon benchmark, it should be acknowledged that PPP-based models are unlikely to provide an adequate description neither of the causes of the RER fluctuations nor of its fluctuations.

A consensus has formed that the long-run equilibrium RER is subject to the influence of a relatively wide range of time-varying exogenous and policy fundamentals.[1] In this strand of the literature, the equilibrium RER is defined as the relative price of traded to non-traded goods that is consistent with internal and external balance. Despite the simplicity of this concept, its practical implementation offers a number of alternative methodological approaches. Following Clark and MacDonald (1999), we distinguish between two broad classes of models: the fundamental equilibrium RER (FEER) and the behavioral equilibrium RER (BEER).

In the FEER approach, internal and external balances are usually defined as those compatible with ideal conditions determined by the econometrician.[2] Thus, the equilibrium exchange rate is derived as a function of what the researcher thinks is the optimum internal balance (e.g., the non-accelerating inflation-rate unemployment) and the sustainable external flows (usually projected or assumed to obtain in the medium-to-longer run). Because these conditions are imposed ex-ante, and may not prevail in the future, the FEER corresponds to a normative notion of equilibrium RER. Moreover, being essentially a medium-term flow model, the FEER does not account for longer-run stock equilibrium considerations, such as the impact of foreign debt levels on the equilibrium RER. Tests undertaken by Barisone et al. (2006) for the six major OECD economies suggest that the FEER approach represents an improvement over PPP in explaining medium-to-long term trends in the RER, yet it fails to capture a substantial fraction of variations of the RER.

BEER models, on the other hand, consider short-term flow variables as well as factors influencing long-run stock equilibria (Edwards, 1989). The approach is intertemporal as the equilibrium is assumed to be influenced not only by the current value of the fundamentals, but also

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1   Hinkle and Montiel (1999) provide a comprehensive survey of this extensive literature.
2   The FEER concept was originally proposed by Williamson (1985) and extended, among others, by Bayoumi et al. (1994) and Isard and Faruqee (1998).

by anticipations regarding the future evolution of these variables. Elbadawi (1994) develops a methodology in the context of a cointegrating-error correction time-series model that (1) computes the equilibrium RER as a forward-looking function of the fundamentals; (2) allows for flexible dynamic adjustments toward equilibrium; and (3) allows the identification of the influence of macroeconomic policies on the equilibrium RER. The empirical application of BEER models is subject to limitations, as noted by Edwards and Savastano (2000). In particular, the lack of a general equilibrium connection between the equilibrium RER and the current account position, and the frequent disconnect between the econometric specification and the analytical model. Consequently, the interpretation of the results is controversial and policy evaluation is not always rigorous.

In the next section, we aim at overcoming some of the limitations of models in the BEER tradition and develop a general equilibrium model of the equilibrium RER flexible enough to account for the characteristics of developing countries.

3.   Stylized Facts and Theoretical Model

As mentioned, we define the real exchange rate as the relative price between non-traded and traded goods. Figure 1 presents the evolution of the average RER for a sample of 73 developing countries, by continent, in the 1970-2004 period. Real effective exchange rates are derived by deflating a trade-weighted average of the nominal exchange rates that apply between trading partners.[3] An increase in the effective RER index indicates an appreciation. The sample comprises 36 Sub Saharan African economies, 19 Latin American countries, and 18 Asian and Middle East economies for which consistent measures of the RER and its determinants could be obtained. As a benchmark for comparison, we include a group of 21 developed economies. The data were obtained from the IMF Statistical database and is described in detail in Appendix 1.

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3   Chinn (2005) discusses the issues of measurement of the RER based on price indices, compares this measure against other alternatives such as labor costs and concludes that for the analysis of competitiveness the latter is preferred but it is not as available as the former.

Figure 1
Real Exchange Rate (simple average by continent, 2003=100)
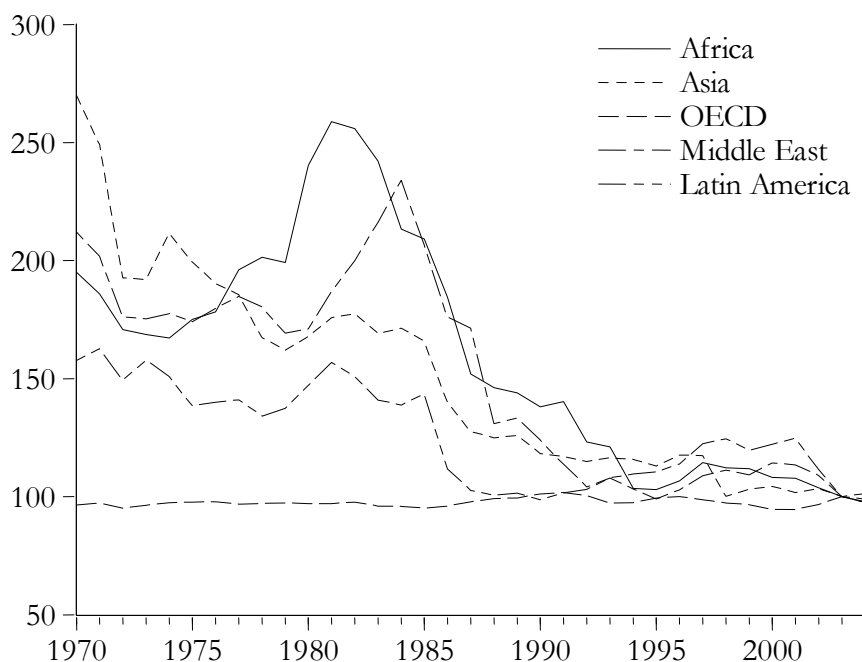
Three elements emerge as important stylized facts that analytical models should account for. First, there are wide fluctuations in the real exchange rate in time and among countries, as suggested when comparing the experiences of Latin American and African countries. On the contrary, the RER in OECD countries tends to be remarkably stable; in the 1970-2004 period, the average coefficient of variation of the RER in developed economies was one tenth that of Asian, Latin American or African countries. Second, the departures of the RER from trend exhibit substantial persistence and little evidence of mean reversion in short horizons. Third, there has been a generalized path towards a more depreciated RER in developing economies, yet the pace and the timing of the convergence differed quite markedly among the different continents. In Latin America, the RER depreciated sharply and substantially in the mid 1980s. On the contrary in Asian economies, the depreciation pace had been smooth and sustained since the mid 1970s. African and MENA countries stand in a very different pattern: the RER appreciated quite markedly in the 1970s and early 1980s, only to revert its tendency sharply in the 1990s.

Naturally, RER determinants –such as terms of trade and government policies— have evolved differently in developing economies and, consequently, have had a differential effect on the RER. To provide a general impression of the link between the average RER and some of its fundamentals, we have compute sample correlations for the median country in each continent in the 1970-2004 period and collected the results in Table 1.

It can be seen that additional stylized facts appear. First, in all developing countries the RER is highly correlated to terms of trade, while there is virtually no correlation in developed economies. The appreciating effect of higher terms of trade on the RER is a standard result, found by several authors in different countries and time periods (Edwards and Savastano, 2000). Devereux and Engel

(2006) provide a rationale for this link based on exchange rate policies enacted by a government wishing to smooth fluctuations in real exchange rates so as to reduce distortions in consumption allocations, but facing the need to allow for flexibility in the nominal exchange rate so as to facilitate the adjustment to terms of trade shocks.

Second, there is an equally positive association between the RER and government consumption in developing economies; the link is less strong in OECD countries. This evidence is broadly consistent with models that highlight the role of government policies in affecting the evolution of the RER and inducing misalignment (Elbadawi and Soto, 1997).

Third, taxes seem to have a significant association with RER behavior in developing countries. Taxes on traded and non-traded goods seem to have a significant yet opposite correlation to real exchange rates in Asian, MENA and Latin American economies. In Africa, on the other hand, there is no correlation between real exchange rates and taxes on non-traded goods, perhaps reflecting the relative unimportance of taxation on the latter as a source of fiscal revenue. This characteristic has not been highlighted in the previous papers, yet it could provide for a significant source of understanding of the long run trends of the RER.

Finally, the evidence on the correlation of the real exchange rate and foreign aid is, to some extent, expected. The importance of foreign aid to African, MENA and some Asian economies and its effect on the RER has been well documented before (see Adam et al., 2006). However, the negative –yet statistically insignificant— correlation found in Latin American countries is to some extent surprising.

Table 1
Sample Correlations of Selected Variables with the Real Exchange Rate
for the Median Country in each continent
1970-2004

	Terms of Trade	Government Consumption	Taxes on Traded Goods	Taxes on Non Traded Goods	Foreign Aid
Africa	0.80***	0.81***	0.61***	-0.14	0.41**
Latin America	0.76***	0.55***	0.63***	-0.40**	-0.22
Asia	0.64***	0.70***	0.67**	-0.72***	0.80***
MENA	0.63***	0.59***	0.74***	-0.52***	0.55***
OECD	0.09	0.27	-0.30*	0.21	-

Source: own elaboration. Note: ***, **,* significant at 1%, 5% and 10% respectively.

The Model

The model extends the literature of general equilibrium models of the real exchange rate to account for key characteristics of developing economies (Obstfeld and Rogoff, 1999; Hau, 2000; Chari et al., 2002; Galí and Monacelli, 2005). We define the equilibrium RER following Nurske's (1945) seminal work as "the path needed to achieve simultaneous internal and external balance by some date in the medium run future and maintain balance thereafter". This section proceeds straightforwardly: we set up the general equilibrium model[4], determine the external equilibrium, compute the internal equilibrium, and derive the path for the real exchange rate that makes external and internal equilibriums consistent.

(a) Model Setup

Assume the existence of a small-open economy producing non-traded (*N*) and traded (*T*) goods, the latter comprising exportable (*X*) and importable goods (*M*). The economy is inhabited by a representative household that maximizes its present discounted expected utility:

(1) $$max_{\{c,n,b\}}U_t = E_t\sum_{i=0}^{\infty}\beta^i\left[\log c_{t+i} + \xi g_{t+i} + \eta(1-n_{t+i})\right]$$

where E_t is the expectations operator based on information at time t, β is the discount factor, c_t is a consumption bundle described below, ξg_t is the fraction of government expenditures that is valued by consumers ($\xi \in [0,1]$), b_t stands for the stock of bonds issued by the private sector, n_t is total hours of labor effort, and η is a parameter linked to the unemployment rate (as discussed below).[5] Note that government expenditures affect household welfare but are independent of consumption and labor decisions (e.g., in-kind transfers such as publicly provided goods).

The representative household supplies homogenous labor to both non-traded and exportable sectors, so that $n_t = n_t^N + n_t^X$. The specification of the utility function follows the "lottery model" of Rogerson (1988) which assumes that each household can work a fixed number of hours $\bar{n}$ with endogenous probability *p* or none at all (i.e., is unemployed). At the aggregate level, this is consistent with an equilibrium in which a fraction *p* of the labor force is employed $\bar{n}$ hours per period while the rest is unemployed.[6]

Total consumption includes a basket of non-traded goods and a composite of internationally traded goods, which are aggregated as follows:

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4   A detailed derivation of the model is in Appendix 2.
5   The utility function assumes full separability, which fits well with the evidence that changes in private consumption, public consumption, and employment are not contemporaneously correlated.
6   In equilibrium, parameter η in equation 1 is linked to the unemployment rate *u* by the condition $u = (1-\bar{n})/(1-e^{\eta})$. See Rogerson (1988).

$$(2) \qquad c_t = \left(c_t^N\right)^{1-\alpha}\left(c_t^T\right)^{\alpha} = \left(c_t^N\right)^{1-\alpha}\left[\left(c_t^X\right)^{1-\omega}\left(c_t^M\right)^{\omega}\right]^{\alpha}$$

where parameters α and ω represent the intra-temporal elasticity of substitution between traded and non-traded goods and between importable and exportable goods, respectively.[7]

The budget constraint of the private sector in real domestic prices[8] can be expressed as:

$$(3) \qquad b_t + w_t\left(n_t^X + n_t^N\right) + \Pi_t^N + \Pi_t^X + t_t + hc_t = \left(1+\tau_t^N\right)p_t^N c_t^N + \left(1+\tau_t^X\right)p_t^X c_t^X + \left(1+\tau_t^M\right)p_t^M c_t^M + \left(1+r_t+\mu_t\right)b_{t-1}$$

where the sources of funds are bond issuing b_t, labor income $w_t(n_t^X + n_t^N)$, profits from producing non-traded goods and exports $\Pi_t^N + \Pi_t^X$, and lump-sum transfers from the government (t_t) and from overseas (hc_t) (e.g., unrequited workers remittances).[9] The use of such funds comprises the cost of consuming goods –including taxes, τ_t— and the real cost of issuing bonds: the interest rate, r_t, and a risk premium, μ_t. The latter is endogenously determined as follows: assume investors continually re-assess the probability of a default, Pr_t, on the existing stock of debt. Should the country default, investors would recover a fraction q_t of their original investment; otherwise they receive the principal and its service. The no-arbitrage condition for risk-neutral investors implies that $\left(1-Pr_t\right)\left(1+r_t+\mu_t\right)+Pr_t q_t\left(1+r_t+\mu_t\right)=\left(1+r_t\right)$ and, hence, the risk premium corresponds to:[10]

$$(4) \qquad \mu_t = \frac{Pr_t\left(1-q_t\right)\left(1+r_t\right)}{1-Pr_t+q_t Pr_t}$$

The representative consumer maximizes (1) subject to (2), (3) and (4). From the first order conditions we derive relative domestic prices as the result of intratemporal arbitrage conditions:

$$(5) \qquad \frac{p_t^M}{p_t^N} = \frac{\left(1+\tau_t^N\right)\alpha\omega C_t^N}{\left(1+\tau_t^M\right)\left(1-\alpha\right)C_t^M}$$

$$(6) \qquad \frac{p_t^M}{p_t^X} = \frac{\left(1+\tau_t^X\right)\omega C_t^X}{\left(1+\tau_t^M\right)\left(1-\omega\right)C_t^M}$$

These intratemporal arbitrage conditions indicate how consumption of different goods relocates after a change in relative prices or in taxes. The intertemporal arbitrage condition is:

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7   It is straightforward and consistent with the model to treat c^N, c^T, and c^X as a continuum of varieties, in which case they could be modeled using a CES aggregator.

8   The domestic price index P_t is found as the minimum cost of acquiring one unit of consumption:

$$P_t = \frac{\left[\left(1+\tau_t^N\right)P_t^N\right]^{(1-\alpha)}\left[\left(1+\tau_t^M\right)P_t^M\right]^{\alpha\omega}\left[\left(1+\tau_t^X\right)P_t^X\right]^{\alpha(1-\omega)}}{\left(1-\alpha\right)^{(1-\alpha)}\alpha^{\alpha}\omega^{\alpha\omega}\left(1-\omega\right)^{\alpha(1-\omega)}}$$

9   It is important to include these transfers when modeling the RER since they have become quite important in the recent years, leading to fears that they might induce RER appreciation and the Dutch disease (World Bank, 2006).

10 Note that $1+r_t+\mu_t = 1+r_t+\dfrac{Pr_t\left(1-q\right)\left(1+r_t\right)}{1-Pr_t+q_t Pr_t}=\dfrac{1+r_t}{1-Pr_t+q_t Pr_t}$.

(7) $\quad \dfrac{E_t c_{t+1}}{c_t} = E_t\left(1 + r_{t+1} + \mu_{t+1}\right)\beta$

This equation indicates that the household would postpone consumption only if she is adequately rewarded to cover the alternative cost of resources (including the risk premium) and her own impatience reflected in parameter β. This implies that two economies facing the same real expected cost of borrowing may have different consumption paths –and hence different equilibrium RER trajectories— because of different impatience levels.

The production of non-traded and exportable goods is assumed to be competitive. Firms demand labor and an exogenous, sector-specific input, z, and produce according to Cobb-Douglas technologies:

(8)
$$y_T^N = A_t^N \left(n_t^N\right)^\gamma \left(z_t^N\right)^{(1-\gamma)}$$
$$y_t^X = A_t^X \left(n_t^X\right)^\theta \left(z_t^X\right)^{(1-\theta)}$$

where A_t represents a factor productivity index for each sector. Following Prescott (1997) we assume that productivity changes are exogenous in the long run. Alexius (2005) provides evidence that productivity shocks tend to be weakly exogenous with respect to real exchange rates in developed economies, thus giving empirical support to our assumption.

The presence of sector specific inputs characterizes production of traded goods in developing economies, especially in Africa and Latin America, where exports usually concentrate in natural resources. An extensive literature documents the links between fluctuations in commodity prices and RER instability (e.g., de Gregorio and Wolf, 1994; Cashin et al., 2004). On the other hand, production of non-traded goods, such as services and retail commerce, are largely based on labor and, to a lesser extent, human capital.

Given this production structure, profit maximization implies that relative production in the domestic economy can be written as:

(9) $\quad \dfrac{y_t^X}{y_t^N} = \dfrac{A_t^{X\frac{1}{1-\theta}} \theta^{\frac{\theta}{1-\theta}} p_t^{X\frac{\theta}{1-\theta}}}{A_t^{N\frac{1}{1-\gamma}} \gamma^{\frac{\gamma}{1-\gamma}} p_t^{N\frac{\gamma}{1-\gamma}}} \dfrac{z_t^X}{z_t^N} w_t^{\frac{\theta-\gamma}{(1-\gamma)(1-\theta)}}$

The relative production of exportable and non-traded goods depends on relative efficiency, relative prices, the use of sector-specific inputs, and real wages (w_t). The production of exportable goods increases with an improvement in relative efficiency or if more sector specific inputs –such as the endowment of natural resources— are available for production. In this model the discovery of oil, for example, would imply a switch in relative production from non-traded goods to export industries. Note that if the labor intensity in both sectors is the same (i.e., γ=θ), the real wage does not affect the relative production.

The government collects taxes from the consumption of traded and non-traded goods. It also receives external transfers in the form of official development aid (hg_t). The government spends

these resources on non-traded (cg_t^N) and imported (cg_t^M) goods such that $g_t=(cg_t^N+cg_t^M)$; the government does not consume exportable goods. Whenever there is an imbalance, the government enacts a (positive or negative) lump-sum transfer to consumers, so as to keep its budget balanced at all times. The government does not have access to domestic or external borrowing.[11] In real terms, the government's budget constraint is:

(10) $\tau_t^N p_t^N c_t^N + \tau_t^M p_t^M c_t^M + \tau_t^X p_t^X c_t^X + hg_t = p_t^N cg_t^N + p_t^M cg_t^M + t_t$

(b)   External Equilibrium

We combine the budget constraints of the consumer and the government to derive the following expression for the current account balance:

(11) $-b_t + (1+r_t+\mu_t)b_{t-1} = p_t^N(y_t^N - c_t^N - cg_t^N) + p_t^X y_t^X - p_t^X c_t^X - p_t^M(c_t^M + cg_t^M) + h_t$

where $h_t = hc_t + hg_t$.

In equilibrium, the demand for non-traded goods must equal its supply, so that the first term of the right hand side of equation (11) drops out. For simplicity, we assume that the government demands a fraction θ_M of imports. Solving forward equation (11) and imposing the condition that the economy would hold no debt and leave no bequest in the long run[12], we obtain the present value of the external trade restriction:

(12) $(1+r_t+\mu_t)b_{t-1} + \sum_{t=s}^{\infty} R_{t,s} p_t^M c_t^M(1+\theta_M) = \sum_{t=s}^{\infty} R_{t,s} p_t^X X_t + \sum_{t=s}^{\infty} R_{t,s} h_t$

where $R_{\tau,s} = \left(\prod_{\tau=t+1}^{s}(1+r_\tau+\mu_\tau)\right)^{-1}$ is the market discount factor between dates t and s.

The left hand side of the external trade restriction is the present value of imports plus the value of the existing stock of external debt and its service. The right hand side comprises the present value of exports and the present value of foreign transfers (private and public). Using the first order condition for the accumulation of foreign assets, we obtain the sustainable level of imports:[13]

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[11] Arguably, this assumption is restrictive but it can be justified on the grounds that any government debt has to be ultimately paid in the long run by the private sector via taxes. Hence, public debt can be consolidated in private debt. Introducing public debt explicitly requires a well-defined decision rule for public debt accumulation. To our knowledge, there is no clear, simple objective function for the government.

12 The condition is $\lim_{s\to\infty} R_{s,t}b_t = 0$.

13 From equation (7), $c_{t+j} = c_t \prod_{i=1}^{j} \beta^i(1+r_{t+i}+\mu_{t+i})$. Then $\sum_{i=j}^{\infty} c_{t+j}\left[\prod_{i=1}^{j}\beta^i(1+r_{t+i}+\mu_{t+i})\right]^{-1}\frac{1-\beta}{\beta} = c_t$

(13) $\quad p_t^M c_t^M = \dfrac{1-\beta}{\beta} \dfrac{1}{\left(1+\theta_M\right)}\left[-\left(1+r_t+\mu_t\right)b_{t-1}+\sum_{t=s}^{\infty}R_{t,s}p_t^X X_t + \sum_{t=s}^{\infty}R_{t,s}h_t\right]$

Note that this *optimal* level of imports was derived imposing the restriction that in the long-run net foreign assets should be zero, i.e., the current account should be balanced in present value terms.

On the other hand, the accumulation of net foreign assets between any two periods can be written as $CA_t = b_t - b_{t-1} = -\left(r_t + \mu_t\right)b_{t-1} + p_t^X X_t - p_t^M c_t^M\left(1+\theta_M\right) + h_t$. Combining this equation with the sustainable level of imports we find:

(14) $\quad CA_t = \left(p_t^x X_t - \widetilde{p}_t^x \widetilde{X}_t\right) - \left(r_t - \widetilde{r}_t + \mu_t - \widetilde{\mu}_t\right)b_{t-1} + \left[1 - \dfrac{1-\beta}{\beta}\sum_{s=t}^{\infty}R_{t,s}\right]\left[-\left(\widetilde{r}_t + \widetilde{\mu}_t\right)b_{t-1} + \widetilde{p}_t^x \widetilde{X}_t + \widetilde{h}_t\right]$

where variables with a tilde denote the permanent values of their counterparts (see Obstfeld and Rogoff, 1996).[14]

Equation (14) indicates three reasons why a country may incur in a current-account deficit. First, a transitory decrease in exports or a drop in the terms of trade below their permanent level contributes to a current-account deficit because of consumption smoothing: since economic agents know that the shock is transitory, they would run a current account deficit in order to maintain consumption roughly constant. Second, if the economy is a net foreign debtor and the world interest rate currently exceeds its permanent level, the current account would be unusually low as, again, agents dis-save to smooth their consumption. Third, likewise a transitory decrease in foreign transfers below their permanent level contributes to a current-account deficit, again, because of consumption smoothing.

In addition, the term $\left[1 - \dfrac{1-\beta}{\beta}\sum_{t=s}^{\infty}R_{t,s}\right]$ captures the effect of differences between the market discount factor, R, and the consumer's discount factor, β. If the market discount factor exceeds the consumer's discount factor, consumption will, on average, be shrinking over time and the country will run a current-account deficit even if output, terms of trade, the real interest rate, and foreign aid are equal to their steady-state values.

(c) Internal equilibrium

Determining internal equilibrium and relative production requires solving for the endogenous wage rate, for which we use the consumer's intratemporal arbitrage condition:

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14 These are $\widetilde{p}_t^X \widetilde{X}_t = \dfrac{\sum_{s=t}^{\infty}R_{s,t}p_t^X X_t}{\sum_{s=t}^{\infty}R_{s,t}}$, $\widetilde{h}_t = \dfrac{\sum_{s=t}^{\infty}R_{s,t}h_t}{\sum_{s=t}^{\infty}R_{s,t}}$, and $\widetilde{r}_t + \widetilde{\mu}_t = \dfrac{\sum_{s=t}^{\infty}R_{s,t}\left(r_t+\mu_t\right)}{\sum_{s=t}^{\infty}R_{s,t}}$.

(15) $\quad w_t = \eta c_t^M p_t^M \dfrac{\left(1 + \tau_t^M\right)}{\alpha\omega}$

From equations (10) and (15) obtain the internal equilibrium condition:

(16) $\quad p_t^{N^{\frac{1}{1-\gamma}}} = \dfrac{\delta(1-\theta)(1-v_t)}{(1-\gamma)} \dfrac{\left[A_t^X \theta^\theta\right]^{\frac{1}{1-\theta}}}{\left[A_t^N \gamma^\gamma\right]^{\frac{1}{1-\gamma}}} \left[\dfrac{NR_t^X}{HK_t^X}\right]^{1-\delta} p_t^{X^{\frac{1}{1-\theta}}} \left[p_t^M c_t^M \dfrac{\eta\left(1+\tau_t^M\right)}{\alpha\omega}\right]^{\frac{\gamma-\theta}{(1-\theta)(1-\gamma)}}$

(d) Equilibrium Real Exchange Rate

As discussed, the equilibrium real exchange rate ERER achieves both internal and external equilibrium.[15] Consequently, we use the sustainable level of imports (eq. 13) and the internal equilibrium condition (eq. 16) to derive the ERER, which is given by the following structural expression (in logs):

(17)

$$\log ERER_t = \pi_0 + \pi_1 \log TOT_t + \pi_2 \log A_t^X - \pi_3 \log A_t^N + \pi_4 \log\left[\dfrac{z_t^X}{z_t^N}\right] + \pi_5 \log \eta_t - \pi_6 \log(1+\theta_M)$$

$$- \pi_7 \log\left(1+\tau_t^M\right) - \pi_8 \log\left(1+\tau_t^X\right) + \pi_9 \log\left(1+\tau_t^N\right)$$

$$+ \pi_{10}\log\left(\dfrac{1-\beta}{\beta}\left[-(1+r_t+\mu_t)b_{t-1} + \sum_{t=s}^{\infty} R_{t,s}\widetilde{p}_t^X \widetilde{X}_t + \sum_{t=s}^{\infty} R_{t,s}\widetilde{h}_t\right]\right)$$

where parameters π correspond to positive, linear combinations of the structural parameters of the model as described in Appendix 2. Note, moreover, that parameter π_0 is a combination of parameters governing factor intensity in production of exported and non-traded goods. In turn, this indicates the need to account for country-specific effects when estimating the econometric model using panel data.

It can be seen that the equilibrium real exchange rate depends on external variables (such as the terms of trade), endowment variables (natural resources and human capital), policy variables (such as taxes and the structure of government consumption), exogenous variables (such as productivity levels and foreign aid), and state variables (such as the stock of foreign debt).

Since the model is based on relative sector production, the intensity use of factors in production plays an important role in determining the marginal effect of some fundamentals on the ERER (e.g., government consumption, taxes or the sustainable level of the current account). Morshed and Turnovsky (2004) provide evidence that the non-traded sector is more labor-intensive than the exporting sector ($\gamma > \theta$); below, we empirically confirm this condition.

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15 Note that the prices of non-traded and exported goods can be expressed as functions of the RER as

$$p_t^X = \dfrac{\alpha^\alpha(1-\alpha)^{1-\alpha}\omega^\omega(1-\omega)^{1-\omega}}{\left(1+\tau_t^M\right)^\omega\left(1+\tau_t^X\right)^{1-\omega}\left(1+\tau_t^N\right)^{1-\alpha}} \dfrac{TOT_t^\omega}{RER_t^{1-\alpha}} \text{ and } p_t^N = \dfrac{\alpha^\alpha(1-\alpha)^{1-\alpha}}{\left(1+\tau_t^N\right)^{1-\alpha}} RER_t^\alpha \text{, where TOT is the terms of trade.}$$

Our theory encompasses two key results obtained in previous papers. According to our derivation, the ERER appreciates if production in the traded sector becomes relatively more efficient than in the non-traded sector. Increased efficiency translates into higher wages which, in turn, allow consumers to expand their demand for non-traded goods, thus leading to higher prices for non-traded goods. In this sense, the model reproduces the Balassa-Samuelson effect that has been the cornerstone of previous models (see Bergin et al., 2007). The second result relates to the terms of trade. In our model, higher permanent terms of trade raise the consumer's disposable income and, hence, the demand for non-traded goods, thereby inducing an increase in the relative price of non-traded goods. The absence of intermediate goods in our model inhibits the substitution effect in production arising from the higher cost of imported inputs. The terms of trade are, perhaps, one of the most discussed determinants of the ERER and, in general, previous empirical models tend to support the prediction of our model (Mendoza, 1995).[16]

The model also unveils issues that have been scarcely considered in the previous literature which, nevertheless, are relevant when modeling developing economies. First, it predicts the ERER to be higher in economies with a higher ratio of natural resources to human capital endowment. The intuition is straightforward. A higher relative productivity or abundance of inputs in the exportable sector means higher wages and income for the consumers. This, in turn, is consistent with higher demand for non-traded goods and a higher RER. This allows the producers of non-traded goods to meet higher wages. This relationship has been largely neglected in the literature, yet it appears as an important characteristic of the economic structure of developing countries.

The second novel element of the model is that it links the working of the labor market with the ERER. Lower unemployment rates that are associated with larger η will be congruent with higher real wages and, given the labor intensity assumption, a higher ERER. Note that if labor intensity is equal in both sectors, unemployment does not affect the ERER. This is natural because, in that case, changes in relative production will not affect relative factor prices and the demand for non-traded goods.

Third, the model provides a rich framework to analyze the effects of government expenditures and tax policies on the RER. Higher taxes on the consumption of non-traded goods (τ^N) are predicted to lead to a more depreciated ERER. This is because such taxes lower demand – and hence the relative price— of non-traded goods. Higher export taxes (τ^X) have the opposite, appreciating effect: as a result of the tax, domestic consumption switches towards the now relatively cheaper non-traded goods thus leading to an appreciation of the ERER. On the other hand, a increase in import taxes (τ^M) –by far the most used tax in developing economies— has an ambiguous effect as it operates through two channels. On one hand, it leads to an unambiguous depreciation in the ERER reflecting the pure income effect leading to reduced aggregate demand and hence lower prices of non-traded goods. On the other hand, higher import taxes lead to an unambiguous ERER appreciation as it switches demand towards the now relatively cheaper non-traded goods. The government's expenditure patterns also affect the equilibrium RER. In particular, the model predicts government consumption of non-traded goods (θ_N) to unambiguously lead to an

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16 Cashin et al. (2004) found evidence of a long-run relationship between the RER and commodity prices for about one third of the commodity-exporting countries.

RER appreciation, while the share of its expenditure on imports (θ_M) is predicted to be associated with RER depreciation, provided that the labor intensity condition holds.

Finally, a higher level of sustainable imports is predicted to lead to more appreciated ERER if the labor intensity condition holds. In terms of the individual components of this variable, a higher level of existing foreign debt would imply a lower disposable income for consumers and, hence, a lower demand for non-traded goods and a more depreciated ERER. Likewise, a higher cost of borrowing –itself the result of higher international interest rates or higher country risk— also depreciates the ERER as consumers foresee a decline in permanent income (a result of assuming a logarithmic utility function). Finally, a higher inflow of foreign transfers (aid and/or unrequited private transfers) allows for the higher sustainable current-account deficit that is congruent with higher consumption, a higher demand for non-traded goods, and a more appreciated ERER.

4.   Taking the Model to the Data

In principle, there are two ways to validate our theory: calibration and econometric estimation. Calibration is better suited to analyzing a single economy as it requires using estimates of deep parameters: these are usually not available for developing economies, in particular in low income countries. Moreover, if the interest lies on cross country comparisons, calibration is not feasible when dealing with 73 heterogeneous countries. We thus opt for econometric estimation. Before presenting the econometric results, it is useful to discuss the data (in particular the measurement of the sustainable current account), the nature of the estimation procedure, and the computation of the equilibrium RER and its misalignment.

Data issues

We test the model using annual data for 73 developing countries in the 1970-2004 period. Contrary to most RER studies, testing our model requires a set of variables that are not readily available and for which proxies are needed. First, note that the model was derived for a representative household. Hence, variables should be measured in per-worker terms: since for most developing economies unemployment is not available in comparable terms, we scale variables per working-age person. Second, to avoid measurement errors we use the data on real effective exchange rate from the IMF's Information Notice System, which adjusts for effective trade weights, instead of the customary proxy ep^*/p which is misleading in cross-country comparisons.[17] Third, with regard to the standard fundamentals (national accounts, terms of trade, exports, etc.), we use the IFS database of the IMF, complemented with data from the World Bank and from each country's Central Bank and statistical offices. Fourth, for other unavailable variables –such as productivity indices, human capital, or the endowment of natural resources— we considered several

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[17] Chinn (2005) identifies a number of elements that might mislead cross-country analysis when using ep^*/p as a measure of the RER, such as different weights in constructing price indices, traded and non-traded prices being inaccurately measured by indices, indices being computed linearly instead of geometrically.

options and chose those that matched as close as possible their analytical counterpart as well as maximize coverage in terms of number of years and countries. In particular, we used World Bank data to build a consistent measure of tax rates levied on imported and non-traded goods. Due to coverage and quality limitations, we could not build a reasonable measure on taxes levied on exported goods. We, thus, deemed reasonable to use the residual of a pooled regression of the log of exports (as percent of GDP) on the log of land size, the log average population, a dummy for oil exporters, and a dummy for countries that are landlocked. This variable has the additional advantage of controlling for specific characteristics of the economies that affect exports beyond ad-valorem taxes (e.g., profit taxes). Fifth, we proxy the share of government expenditures in imported goods (θ_M) by government consumption as ratio of imports. While less than optimal, this is a standard practice in this literature, largely motivated by restrictions of the available data on government operations in developing economies. Sixth, unemployment figures are unavailable for most developing countries in the sample period, so we were forced to drop this fundamental from the estimation.

Figure 2 presents a summary of the data employed in the estimation. We use boxplots of each variable by continent as a way to deal effectively with the large amount of information (around 2,250 observations per variable). The box portion of a boxplot represents the first and third quartiles (i.e., the middle 50 percent of the data). The median is depicted using a line through the center of the box, while vertical lines display the data normalized dispersion, measured by the range of the last data point within (or equal to) the first quartile minus 1.5*IQR and the third quartile plus 1.5*IQR (IQR is the interquartile range).

Figure 2
Descriptive Statistics of Fundamentals
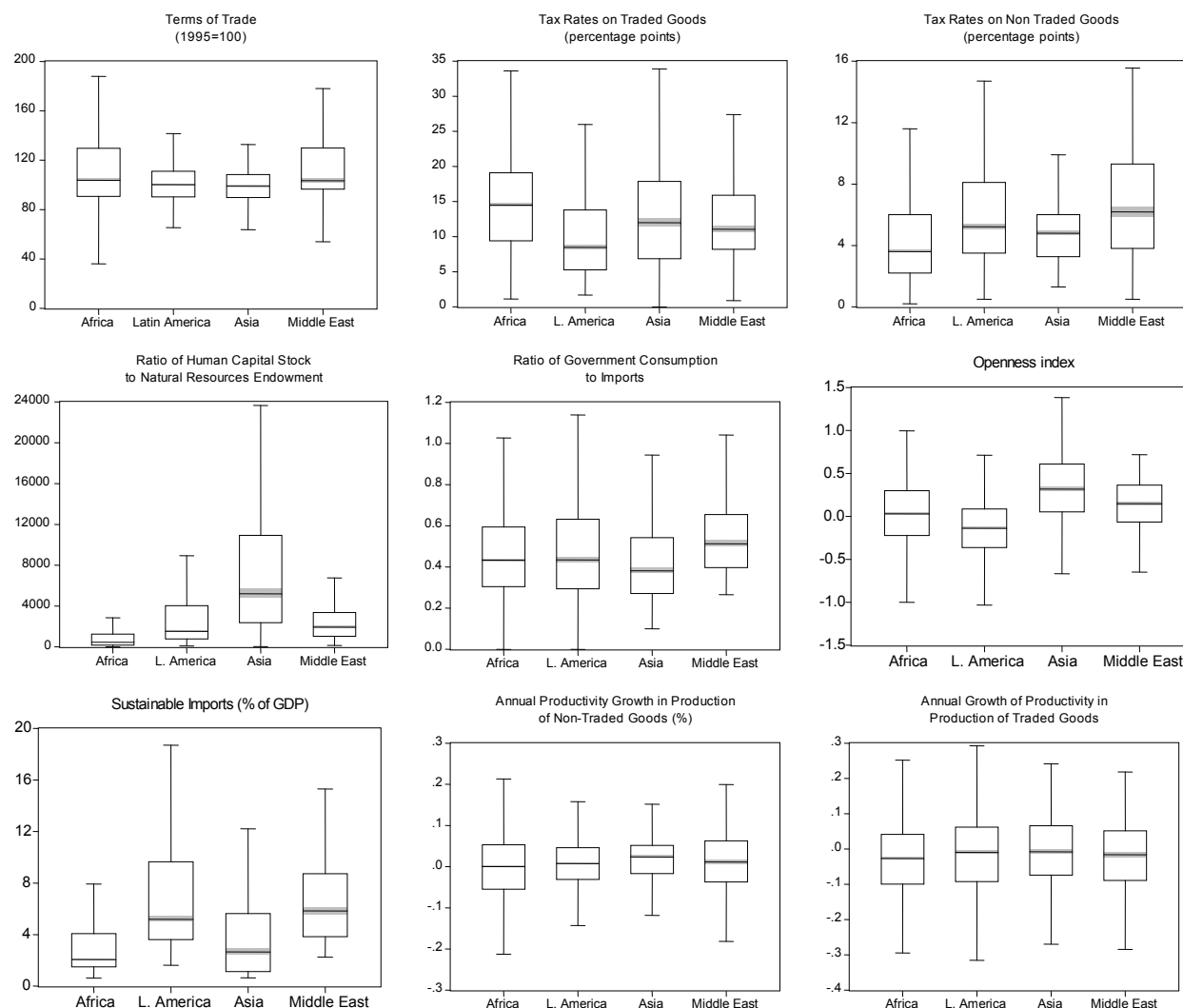
Note: The box portion represents the first and third quartiles (middle 50 percent of the data). The median is depicted using a line through the center of the box, while vertical lines shows the data dispersion, measured by the range of the last data point within (or equal to) the first quartile minus 1.5*IQR and the third quartile plus 1.5*IQR (IQR is the interquartile range).

It can be seen that there is substantial heterogeneity among countries and continents. The terms of trade in African and Middle East countries seem to be much more volatile than in Latin America and Asia, most likely as a result of their higher concentration on commodities. Government policies also display different patterns. Tax rates on non-traded goods are on average much higher in all countries. While Africa and Asia relies comparatively more on taxes on traded goods, Latin America and Middle East countries rely comparatively more on taxing non-traded goods. Dispersion in tax rates follows a similar pattern. Government consumption as ratio to imports, on the other

hand, tends to be relatively similar in Africa, Asia and Latin America and only slightly higher the Middle East. Our measure of the relative abundance of human capital vis-a-vis natural resources is consistent with intuition: Africa shows the lowest relative endowment of human capital, while Asia displays a ratio significantly higher than that in Latin America or the Middle East. Nevertheless, range intervals also reveal that the Asian countries in our sample are quite heterogeneous in terms of endowment, ranging from low income Bangladesh to the relatively affluent cases of Malaysia and Thailand. The data on trade openness replicates the conventional wisdom of Asia being the most pro-trade continent and Latin America the most protectionist. The chart on sustainable imports indicates clearly the lower capacity of African countries to import, largely the result of their high indebtedness and relatively less developed export base. Likewise, some of the Asian economies are in the same situation. Finally, we deemed more illustrative to plot productivity growth rates in both traded and non-traded sectors instead of levels which are quite dissimilar. It can be seen that continents do not differ substantially in their median values, but Latin America and Asia are less heterogeneous.

The sustainable current account

Estimating the RER model requires determining the sustainable level of the current account balance. Since it is unobservable, we build a proxy variable based on equation (14), which indicates that the optimal, intertemporal-consistent level of imports is a linear function of the long run, permanent value of exports, foreign aid, and external debt service. According to our theory, the permanent components of these variables ought to obey the long-run restriction in equation (14) for the RER model to provide a meaningful notion of the equilibrium. In econometric terms, they should to cointegrate (see Elbadawi and Soto, 1997 for details). To test this condition, we first ran a battery of panel-data unit-root tests on imports, exports, official development assistance, and debt service (all variables in real US$ per-working age person). The results are in Appendix 3. We concluded that all variables could be characterized as I(1) series, i.e., they do have permanent shocks. We then ran a GMM panel-data regression of imports on its determinants according to equation (14) and tested the residuals for cointegration using again a battery of tests. The estimated imports equation (including country specific intercepts and time trends) is:

$$\text{Im} \, ports_{it} = 0.416 + 0.953 Exports_{it} + 1.449 Aid_{it} - 0.539 Debt \, Service_{it}$$
$$\quad\quad\quad (0.114) \quad (0.015) \quad\quad\quad (0.130) \quad\quad (0.098)$$
$$\widetilde{R}^2 = 0.927 \quad\quad Observations = 2.225 \quad\quad Individual \, and \, Time \, Effects \, included$$

After securing that variables cointegrate and that a long-run relationship exists, we use the predicted value of this model as an instrument for the sustainable level of imports when estimating the RER equation. These results indicate a significant impact of foreign aid on the balance of payments: should the significant aid flows to African economies decline to the level of Latin American or Asian countries, real per-capita imports would decline permanently by 3.5%. Debt service, on the other hand, is also important but its actual effect depends on the stock of debt and

interest rates: a permanent moratorium on the highly indebted African economies would only increase per-capita imports at most by 2.3% in the long run.

Econometric estimation of the equilibrium RER model

The equilibrium RER model in equation (17) describes the long-run relationship between the real exchange rate and its fundamentals. It can be compactly stated as:

(18) $\log RER_{it} = \pi_0^i + \pi \widetilde{F}_{it} + \varepsilon_{it}$

where F_{it} is a vector of fundamentals; π is a vector of associated coefficients, which are in turn functions of the structural parameters of the model; and π_0 is the country-specific effect which corresponds to a linear combination of the deep parameters governing the structure of preferences, productions functions, and institutional restrictions.

The econometric estimation of our model is based on group-average estimators. There are three main group-average estimators. The mean group (MG) estimator of Pesaran and Smith (1995) assumes that the economies differ in their short and long-run parameters. Estimators of the coefficients are obtained by averaging individual country estimates. On the other extreme, the dynamic fixed-effects (DFE) estimator assumes that all parameters are constant across countries, except for the intercept which is allowed to vary across countries (Kiviet, 1995). The Pooled Mean Group (PMG) estimator developed by Pesaran et al. (1999) lies somewhat in between, as it restricts the parameters to be the same in the long-run model but leaves the short-run dynamics and the adjustment coefficients free to fit the data of each country. The choice between the three estimators entails a trade-off between consistency and efficiency. The DFE estimator dominates the other two in terms of efficiency if the restrictions of equality of short and long-run parameters are valid. If they are false, however, the DFE generates inconsistent estimates. The MG estimator imposes no cross-country parameter restrictions and can be estimated on a country-by-country basis, provided that the time-series dimension of the data is sufficiently large. However, it does not take into account the possibility of coefficients being the same across countries thus being less efficient. Moreover, it suffers from the classical downward coefficient bias that arises in dynamic models. The validity of using the PMG estimators against the MG or DFE estimators can be assessed using Hausman tests as discussed below.

Another justification for choosing group-average estimators is based on their ability to provide consistent estimates of the parameters even when variables are not stationary. Pesaran and Smith (1995) observe that the problem of spurious correlation does not appear in this context: whenever cross-section units are heterogeneous and regressors are exogenous, the MG estimator is still consistent even if the errors are non-stationary or I(1). They also show that alternative estimators (such as the fixed effects, instrumental variables or the GMM procedure by Arellano and Bover) can produce inconsistent and potentially very misleading estimates of the average parameters in dynamic panel-data models. Smith et al. (2001) show that MG estimators are unbiased even when

the error term is I(1) and also that t-tests have good size properties when the errors are I(0), I(1) or a mix of both.[18]

The model in equation (18) can be embedded in a dynamic error-correction model:

(19) $\Delta \log RER_{it} = \phi^i \left[\log RER_{it-1} - \pi_0^i + \pi \widetilde{F}_{it-1} \right] + \delta \Delta \widetilde{F}_{it} + \varepsilon_{it}$

This model is compatible with a general autoregressive, distributed lags model, ARDL(p,q,s), where the adjustment parameter ϕ as well as the long-run intercept π_0^i and the short-run coefficients (δ,υ) are allowed to vary across countries, while the long-run coefficients, π, are restricted to be the same for all economies. The PMG estimator proceeds in two stages: (1) a consistent estimate of the long-run parameters is obtained using maximum likelihood techniques for panel data under mild regularity conditions, and (2) the short term parameters and the speed of adjustment are estimated for each cross section conditional on the previously estimated long run structure.

Econometric Results

We first check the specification of our model. The PMG estimator can be seen as a restricted-model estimator, in the sense that it imposes the restriction that all countries share the long-run coefficients against the more general model that assumes that economies differ in their short and long-run parameters, i.e., the MG model. This restriction can be tested using a Hausmann test: in our case, the test was 8.82 which is not significant at the 95% level, signaling that the restriction on long-run coefficient homogeneity is not rejected by the data. On the other hand, the PMG estimator can be seen as a more general model estimator than the dynamic fixed effects model that assumes all parameters to be the same across countries. This restriction can also be tested using Hausmann tests: the null hypothesis of equality of coefficients can be rejected at the 0.1% level. Rejecting one model in favor of an alternative specification has important implications, as can be seen in Table 2 where we confront the estimators of the long-run coefficients obtained using the PMG estimator with those obtained using the DFE and MG estimators. It can be seen that most of the estimated parameters using the DFE and MG models are insignificant at conventional confidence levels. Note that, as expect, there is a downward bias of MG estimates as compared to PMG results.

With regards to the long-run coefficients, the evidence in Table 2 indicates that in general the PMG estimates are statistically significant and with the sign predicted by our theory. The point estimate of the elasticity of the RER to the terms of trade –0.06— is very similar to that found by Dufrenot and Yehoue (2005) using different econometric techniques and a sample of 64 countries in the 1979-2000 period. Our estimate –significant at 89% confidence—suggests that, while terms of trade shocks can affect the real exchange rate in the short run, their long-run impact is modest. A one-standard deviation permanent increase in the terms of trade (around 30% in the sample), would only have an impact on the equilibrium RER of about 2%. Our estimate is smaller than those found by Aguirre and Calderón (2006) and Razin and Collins (1999) which are in the 0.2-0.4 interval. One

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[18] We use a battery of panel unit-root tests on the fundamentals concluding that they are most likely stationary (see Appendix 3). Conflicting tests might be the result of the well known lack of power of these tests against near unit root processes (see Breitung and Pesaran, 2007 for a review).

explanation for the difference is that we measure only the substitution effect of terms of trade shocks, since the income effect is captured by the sustainable imports variable.

Table 2
Econometric Results: Estimated Long-run Parameters
Dependent Variable: log(RER)

	Estimation Technique		
	Pooled Mean Group	**Dynamic Fixed Effects**	**Mean group**
Terms of trade	0.04 (0.024)	0.07 (0.051)	0.13 (0.073)
Productivity in non-traded goods sector	-0.60*** (0.032)	-0.30*** (0.040)	-0.41*** (0.072)
Productivity in traded goods sector	0.62*** (0.032)	0.28*** (0.056)	0.37 (0.360)
Relative resource endowment	0.15*** (0.035)	0.02 (0.066)	-0.22 (0.165)
Share of government consumption in imports	-0.31*** (0.039)	0.03 (0.08)	-0.42 (0.328)
Taxes on imports	-0.25*** (0.103)	-0.31 (0.187)	2.05 (1.480)
Export taxes (openness)	-0.68*** (0.041)	-0.73*** (0.065)	-0.50*** (0.238)
Taxes on non-traded goods	4.34*** (0.390)	0.93 (0.632)	-0.49 (2.195)
Sustainable imports	0.31*** (0.031)	0.45*** (0.050)	-0.08 (0.256)
Adjustment coefficient (φ)	-0.296*** (0.031)	-0.284*** (0.015)	-0.769*** (0.039)
Number of Countries Observations	73 1,745	73 1,745	73 1,745
Haussman test on the equality of PMG and DFE model: 105.08 Haussman test on the equality of PMG and Mean Group model: 8.82			

Note: standard errors in parenthesis (***) and (**) significant at 99% and 95% confidence, respectively. Individual and time effects included.

The estimated response of the RER to changes in factor productivity provides interesting insights on the performance of developing countries. Sample averages indicate that average labor productivity in the non-traded sector grew at only 0.2% per year in Africa and Latin America countries in the 1970-2004 period. Using the estimated parameter of the elasticity (-0.54) it is straightforward to compute that it had only a marginal effect on the RER depreciation. On the contrary, in East Asian economies productivity grew at around 1.5% per year and the RER accumulated the equivalent to a depreciation of 43% in the same period. Changes in productivity levels in the traded-sector, on the other hand, have been similar among countries and do not contribute to explain the different trajectories observed in RERs.

To our knowledge, this paper is the first to test the role of resource endowments on the equilibrium RER. Despite the crudeness of our measure (secondary education divided by land area per capita), we obtain an estimated parameter that is significant both at the statistical and economical level. The positive coefficient suggests that a greater abundance of natural resources relative to human capital is consistent with an appreciated equilibrium RER. The estimated point elasticity indicates that the effect is sizable: for example, in a median African economy the RER would be around 12% appreciated with regards to the median developing country.

The model provides for a rich decomposition of the impact of the different components of fiscal policy on the trajectory of the equilibrium real exchange rate. We obtain the standard result that a lower fraction of government expenditures on traded goods leads to RER appreciation. Our estimate of 0.32 indicates that a one-standard deviation decrease in this share would lead to an appreciation of around 15%. A similar result is obtained by Aguirre and Calderón (2006) but Dufrenot and Yahoue (2005) and Toulaboe (2002) find much smaller estimates of around 0.10. With regards to tax rates, we obtain as expected that higher taxes on non-traded goods lead to a more depreciated exchange rate. Since the average tax rate on non-traded goods is 3.5% in developing countries, one could be tempted to conclude that the economic impact of these levies is not very significant. However, lowering tax rates on traded goods to the level of developed economies (1%) would account for a change of 12% in the RER. On the other hand, we find that taxes on imports tend to appreciate the equilibrium RER. Again the comparison of developing and developed countries provides an interesting insight on the impact of the government financing. If a median developing country would reduce its current 14% tax rate to the level of developed economies (9%), the RER would appreciate by only 2%.

The impact of openness is larger than what is usually found in the cross-country RER literature. Drine and Rault (2004) found an average value of -0.36 for a group of 45 economies in the 1975-1992 period. The above mentioned study by Dufrenot and Yehoue (2005) also report a value in the neighborhood of -0.43. These estimates, however, are not directly comparable to ours, since they use unfiltered openness measures (usually, total trade over GDP) whilst we use a filtered measure that is closer to the variable in our analytical model because it controls for country-specific endowment elements such as size, population, and geographical conditions.

With regards to the equilibrium-consistent current account we obtained a point elasticity of 0.34. This stock-flow restriction appears to be quite binding; a negative permanent shock of size one-standard deviation –which occurs 75% of the cases— would induce a 15% equilibrium depreciation of the RER on average. In turn, this indicates the need for market flexibility to avoid paying high adjustment costs. As the size of these shocks differ by continent so does their effect on

the equilibrium RER. The impact in Latin American countries is 50% larger than in Asian economies, with Sub Saharan Africa lying in between. The main contributors to the variance of equilibrium-consistent current-account shocks are exports and debt service for SSA and development aid for Latin American economies. In general, the literature does not consider stock-flow restrictions when modeling RER determinants. One exception is Lane and Milesi-Ferreti (2002) who proxy this restriction for the OECD countries with a measure of the changes in the net foreign asset position in the 1975-1998 period. Their estimated elasticity is very similar to our result, 0.32. Elbadawi (2002) takes into account the stock of net foreign income and find a semi-elasticity of 0.77 for a panel of 63 developing countries. Finding a positive, significant estimate for this parameter, in addition, confirms our assumption that the non-traded sector is more labor-intensive than the exporting sector ($\gamma > \theta$).

A pivotal parameter in the estimation is the coefficient of the equilibrium-correction term, which measures the speed of adjustment of the real exchange rate to its equilibrium level. The sample average estimate of the adjustment parameter is -0.296, which is slightly larger than that obtained by Edwards (1989) using a partial-adjustment model for a group of 12 developing countries. Our estimate is also similar to that of the DFE model (at -0.28) but much smaller than the MG estimator (-0.77), which indicates the importance of allowing for country-specific variables when working with dynamic, heterogeneous panel data models, as suggested by our theoretical model. Figure 3 summarize the individual results by continent. It can be seen that for 21 countries the estimated speed of adjustment is not significantly different than zero at 90% of confidence, indicating that there is no adjustment whatsoever to equilibrium. Of these, nine are African economies and seven are Latin American countries. Moreover, there are an additional 30 economies where adjustment is very slow, so that it would take over ten years to dissipate 90% of a shock. This group comprises 12 African economies, 8 Latin American countries and 10 Asian and Middle East economies. In 20 countries there is prompt adjustment to equilibrium (less than five years to dissipate 90% of a shock), 14 of which belong to Africa.

The heterogeneity in the speed of adjustment to equilibrium across countries and continents is remarkable. The existence of formal exchange-rate agreements in Africa suggests it would be reasonable to explore whether the choice of exchange rate regimes is a reason for slow adjustment. Our evidence indicates that countries belonging to the BEAC, RMA, or BCEAO[19] tend to adjust to RER disequilibrium much slower than other African countries: on average, 90% of a shock in the latter countries dissipates in around four years while it takes eight years in the former. In fact, half of the countries for which we found no evidence of adjustment to equilibrium in Sub Saharan Africa (i.e., non-significant error-correction terms) belong to countries in monetary or exchange rate unions. In contrast, less than one third of the African countries in monetary unions exhibited fast adjustment to equilibrium. Finally, no country in the flexible exchange rate category exhibits inability to correct imbalances.

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[19] The BEAC (Cameroon, Central African Republic, Chad, Republic of the Congo, Equatorial Guinea, Gabon) and BCEAO (Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, Senegal, Togo) are two central and west African monetary unions comprised by French-speaking colonies, with a single currency (the CFA franc) historically linked to the French franc (and now the Euro). The Rand Monetary Area (RMA) comprises Namibia, Lesotho, and Swaziland which peg to the South African Rand.

Figure 3
Speed of adjustment to equilibrium
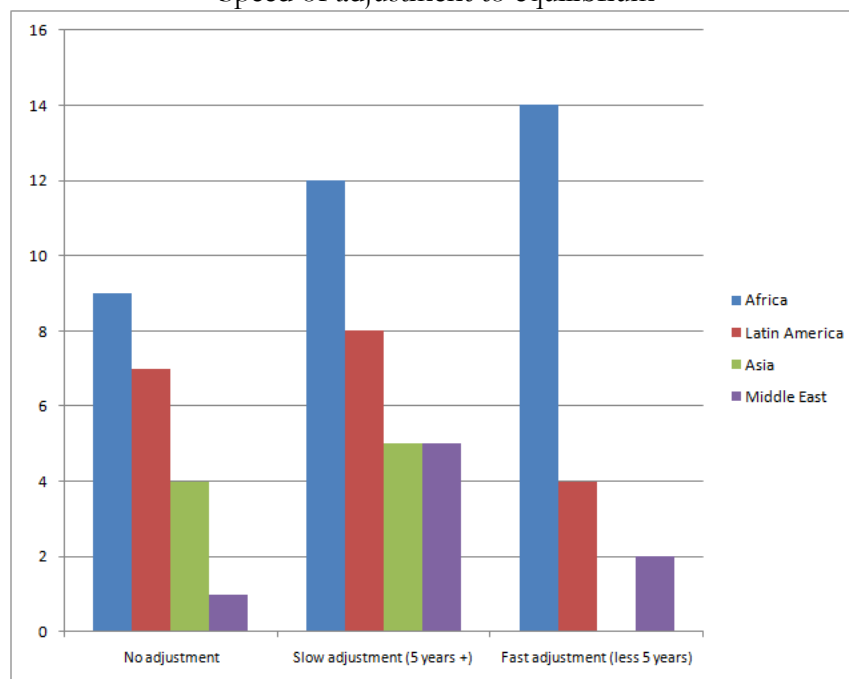
5.   Conclusions

This paper makes three contributions to the literature on the determinants of the equilibrium RER. First, it develops a general equilibrium analytical framework that extends previous models to include the labor market, foreign aid, taxes, and the endowment of natural resources as potential determinants of the equilibrium RER. In general, the standard analytical models either overlook these elements or treat them in *ad-hoc* manners. Nevertheless in empirical applications labor market considerations are at the core of those papers that use the NAIRU as a benchmark when computing the equilibrium RER. Natural resources as well as foreign aid have been blamed as inducing RER over-valuation, as is amply documented in the Dutch disease literature. Our model provides an explanation as to why one should expect the equilibrium RER to be more appreciated in economies with higher natural resources relative to human capital endowment or where the natural rate of unemployment is lower.

Second, our model provides a theoretically consistent measure of the external equilibrium (sustainable current account) as the situation where exports plus net foreign transfers balance, in present value terms, imports and the value of the existing stock of external debt. In particular, a higher level of sustainable imports is predicted to lead to a more appreciated equilibrium RER. In

this regard, we address a second limitation of the literature by explicitly linking the equilibrium RER to the long-run sustainable current account.

Third, our analytical model provides for a rich analysis of the effects of government policies on the RER. On the revenue side, we identify the channels through which three different taxes (on non-traded goods, export taxes, and import taxes) affect the equilibrium RER. On the expenditure side, the model predicts government consumption of non-traded goods to unambiguously lead to RER appreciation, but the magnitude of the effects depends on the composition of expenditures between traded and non-traded goods.

Our theoretical model generates a single-equation framework for the empirical analysis, which allows for a straightforward estimation of the elasticities of the RER with regards to the different fundamentals. An attractive feature of our model is that the empirical specification follows directly from theory, instead of being ad-hoc as is usually the case. The econometric results obtained using the PMG estimator indicate that our model is an adequate representation of the experience of 73 developing economies in the 1970-2004 period.

Among the numerous empirical results in this paper, we obtain that a greater abundance of natural resources relative to human capital stocks –which make non-traded goods relatively more expensive than resource-based exports— affects significantly the equilibrium RER. Likewise, our econometric results indicate that labor productivity growth in the non-traded had been at the core of the different observed trajectories of the RER in African and Latin American countries vis-a-vis Asian economies. High, sustained productivity gains in Asian economies have induced a significant long-term depreciation of the RER, a feature that is completely absent in other developing economies. Finally, we find that the equilibrium-consistent current account appears to be quite important. Observed shocks (of size one-standard deviation) would induce wide swings in the equilibrium RER of around 15%, indicating the need for market flexibility to avoid paying high adjustment costs.

Finally, the econometric model highlights the substantial differences among countries in the speed of adjustment to equilibrium level. In the majority of African countries the estimated speed of adjustment is extremely slow or inexistent, indicating the inability of these economies to adjust adequately to shocks. A similar situation characterizes the majority of Latin American economies. The existence of formal exchange-rate agreements in Africa suggests it would be reasonable to explore whether the choice of exchange rate regimes is a reason for slow adjustment. Our evidence indicates that countries belonging to the exchange rate arrangements (such as the CFA zone) or monetary unions (such as the Rand Monetary Area) tend to adjust to RER disequilibrium much slower than other countries. In contrast, no country with flexible exchange rate regimes exhibits inability to correct imbalances.

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Appendix 1: Countries and Data Sources and Definitions

Data Sources and Definitions

Most of the data were obtained from the IMF databases (International Financial Statistics and Government Financial Statistics) and the World Bank Database (Word Bank Development Indicators and Africa Live). Whenever necessary, missing data was completed using country sources such as the Central Bank, Bureaus of Statistics, and Ministry of the Finance.

Variable	Definition and Construction	Source
Real Effective Exchange Rate	Trade-weighted averages of the exchange rates that apply between trading partners with base 100 in 2003. An increase in the REER is an appreciation of the local currency	Author's construction based on IMF International Financial Statistics data for the 1980-2004 period, extended using World Bank
Gross domestic product and its components (public and private consumption, exports, imports, fixed capital formation, and price deflator)	Nominal, local currency units.	Author's construction based on IMF International Financial Statistics, World Bank Development Indicators, and Africa Live database
Taxes on imports	Correspond to *Taxes on international trade* (as percent of imports) net of export taxes when available.	Author's construction based on IMF Government Finance Statistics, World Development Indicators, and Africa Live database.
Taxes on non-traded goods	Correspond to *Taxes on goods and services* (as percent of GDP) net of taxes on international trade	Author's construction based on IMF International Finance Statistics, World Bank Development Indicators, and Africa Live database
Terms of Trade	Relative price of exports to imports with base 100 in 1995	World Bank Development Indicators and Loayza et al. (2005)
External debt, debt service and official development aid	Nominal data was converted to real US$ using the US wholesale price index with base 100 in 2000.	Author's construction based World Bank Development Indicators
Labor productivity in non-traded goods	Computed as (GDP-Exports)/Labor force.	Author's construction based on IMF International Finance Statistics.
Labor productivity in traded goods	Value added in agriculture and manufacturing per worker as ratio of a similar indicator in the OECD.	Author's construction based on IMF International Finance Statistics.
Population		Obtained from World Bank Development Indicators
Human Capital	Secondary education achievement	World Bank Development Indicators and Loayza et al. (2005)
Natural resource endowment	Computed as secondary education divided by area (km²) per capita	Author's construction based World Development Indicators (2006).
Openness	Residual of a regression of the log of exports (as % of GDP) on land size, population, and dummies for oil exporters and landlocked countries.	Author's construction based World Bank Development Indicators
Share of government consumption on imports	Computed as government current consumption as share of total imports in local currency.	Author's construction based on IMF International Finance Statistics.

Countries included in the sample

Africa (36 countries)	Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Dem. Rep. Congo, Rep. Congo, Cote d'Ivoire, Ethiopia, Gabon, The Gambia, Ghana, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.
Latin America (19 countries)	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela.
Asia (10 countries)	Bangladesh, India, Indonesia, Korea, Malaysia, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand.
Middle East and North Africa (8 countries)	Algeria, Arab Rep. Egypt, Islamic Rep. Iran, Jordan, Morocco, Syrian Arab Republic, Tunisia, Turkey.
OECD (21 countries)	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Note: OECD countries not included in the model estimation.

Appendix 2: Model Solution

The model assumes a three sector economy (exportable, importable, and non-traded goods) and a representative household that chooses consumption and leisure so as to maximize its welfare. The government taxes consumption and profits in the exportable sector at rates τ^X, τ^M, τ^N, and ν respectively.

The Representative Consumer

The consumer problem in real terms (deflated by the general price index) is:

$$max_{\{c,n,b\}} U_t = E_t \sum_{t=0}^{\infty} \beta^i [\log c_{t+i} + \xi g_{t+i} + \eta(1-n_{t+i})] \quad \text{subject to}$$

$$c_t = \left(c_t^N\right)^{1-\alpha} \left(c_t^T\right)^{\alpha} = \left(c_t^N\right)^{1-\alpha} \left(c_t^X\right)^{\alpha(1-\omega)} \left(c_t^M\right)^{\alpha\omega} \quad \text{and}$$

$$b_t + w_t\left(n_t^X + n_t^N\right) + \Pi_t^N + \Pi_t^X + t_t + hc_t = \left(1+\tau_t^N\right)p_t^N c_T^N + \left(1+\tau_t^X\right)p_t^X c_T^X + \left(1+\tau_t^M\right)p_t^M c_T^M + \left(1+r_t+\mu_t\right)b_{t-1}$$

Let $n_t = n_t^X + n_t^N$, then the optimization problem is:

(A.1)
$$H_t = \beta^t [\log\left(c_t^N\right)^{1-\alpha} \left(c_t^X\right)^{\alpha(1-\omega)} \left(c_t^M\right)^{\alpha\omega} + \xi g_{t+i} + \eta(1-n_{t+i})]$$
$$+ \lambda \left[b_t + w_t n_t + \Pi_t + t_t + h_t - \left(1+r_t+\mu_t\right)b_{t-1} - \sum_{j=X,M,N}\left(1+\tau_t^j\right)p_t^j c_T^j \right]$$

The first order conditions are:

(A.2) $\frac{\partial H_t}{\partial c_t^N} = (1-\alpha)\frac{1}{c_t^N} - \lambda_t p_t^N (1+\tau_t^N) = 0$

(A.3) $\frac{\partial H_t}{\partial c_t^X} = \alpha(1-\omega)\frac{1}{c_t^X} - \lambda_t p_t^X (1+\tau_t^X) = 0$

(A.4) $\frac{\partial H_t}{\partial c_t^M} = \alpha\omega\frac{1}{c_t^M} - \lambda_t p_t^M (1+\tau_t^M) = 0$

(A.5) $\frac{\partial H_t}{\partial n_t} = w_t\lambda_t - \eta = 0$

(A.6) $\frac{\partial H_t}{\partial b_t} = \lambda_t - \beta\lambda_{t+1}(1+r_t+\mu_t) = 0$

Risk Premium

Assume foreign investors continually reassessing the probability of a default, *Pr*, on the existing stock of debt. Should the country default, the investor would recover a fraction *q* of the original investment; otherwise it could receive the principal and the real service including the risk premium, μ. The no-arbitrage condition for risk-neutral investors implies:

(A.8) $(1 - Pr_t)(1 + r_t + \mu_t) + Pr_t q_t (1 + r_t + \mu_t) = (1 + r_t)$

hence, the risk premium corresponds to:[20]

(A.9) $\mu_t = \frac{Pr_t(1-q_t)(1+r_t)}{1-Pr_t+q_t Pr_t}$

General Price Index

The general price index P_t is obtained as the solution to the minimization problem:

(A.10) $min(1+\tau_t^N)P_t^N c_t^N + (1+\tau_t^M)P_t^M c_t^M + (1+\tau_t^X)P_t^X c_t^X$ subj. to $P_t\left(c_t^N\right)^{1-\alpha}\left(c_t^X\right)^{\alpha(1-\omega)}\left(c_t^M\right)^{\alpha\omega} = 1$

The first order conditions are:

(A.11) $P_t^N = P_t \frac{c_t}{c_t^N} \frac{(1-\alpha)}{(1+\tau_t^N)}$

(A.12) $P_t^M = P_t \frac{c_t}{c_t^M} \frac{(\alpha\omega)}{(1+\tau_t^M)}$

(A.13) $P_t^X = P_t \frac{c_t}{c_t^X} \frac{\alpha(1-\omega)}{(1+\tau_t^X)}$

Replacing equations A.11 to A.13 in $P_t\left(c_t^N\right)^{1-\alpha}\left(c_t^X\right)^{\alpha(1-\omega)}\left(c_t^M\right)^{\alpha\omega} = 1$, the price index is found to be:

(A.14) $P_t = \frac{[(1+\tau_t^N)P_t^N]^{(1-\alpha)}[(1+\tau_t^M)P_t^M]^{\alpha\omega}[(1+\tau_t^X)P_t^X]^{\alpha(1-\omega)}}{(1-\alpha)^{(1-\alpha)}\alpha^\alpha \omega^{\alpha\omega}(1-\omega)^{\alpha(1-\omega)}}$

Likewise, the price of traded goods can be found as:

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[20] Note that $1+r_t+\mu_t = 1+r_t + \frac{Pr_t(1-q)(1+r_t)}{1-Pr_t+q_t Pr_t} = \frac{1+r_t}{1-Pr_t+q_t Pr_t}$.

(A.15) $\quad P_t^T = \dfrac{[(1+\tau_t^M)P_t^M]^\omega [(1+\tau_t^X)P_t^X]^{(1-\omega)}}{\omega^\omega (1-\omega)^{(1-\omega)}}$

Note that the following results can be obtained:

(A.16) $\quad p_t^N = \dfrac{P_t^N}{P_t} = \dfrac{\alpha^\alpha (1-\alpha)^{(1-\alpha)}}{(1+\tau_t^N)^{(1-\alpha)}} RER_t^\alpha$

(A.17) $\quad p_t^T = \dfrac{P_t^T}{P_t} = \dfrac{\alpha^\alpha (1-\alpha)^{(1-\alpha)}}{(1+\tau_t^N)^{(1-\alpha)}} RER_t^{(\alpha-1)}$

(A.18) $\quad p_t^X = \dfrac{(P_t^X / P_t^T)}{(P_t / P_t^T)} = \dfrac{\alpha^\alpha (1-\alpha)^{(1-\alpha)} \omega^\omega (1-\omega)^{(1-\omega)}}{(1+\tau_t^M)^{(\omega)}(1+\tau_t^X)^{(1-\omega)}(1+\tau_t^N)^{(1-\alpha)}} \dfrac{TOT_t^\omega}{RER_t^{(1-\alpha)}}$

(A.19) $\quad p_t^M = \dfrac{(P_t^M / P_t^T)}{(P_t / P_t^T)} = \dfrac{\alpha^\alpha (1-\alpha)^{(1-\alpha)} \omega^\omega (1-\omega)^{(1-\omega)}}{(1+\tau_t^M)^{(1-\omega)}(1+\tau_t^X)^{(1-\omega)}(1+\tau_t^N)^{(1-\alpha)}} \dfrac{TOT_t^{(1-\omega)}}{RER_t^{(1-\alpha)}}$

Solving for domestic production

Use the production function of the firms to derive the demand for labor:

(A.20) $\quad n_t^N = \dfrac{p_t^N y_t^N}{w_t}$

(A.21) $\quad n_t^X = \dfrac{\theta p_t^X y_t^X}{w_t}$

To solve for the real wage, use the first order conditions (A.2) and (A.5) of the consumer to obtain:

(A.24) $\quad w_t = \eta c_t^M p_t^M \dfrac{(1+\tau_t^M)}{\alpha\omega}$

Finally, express relative production as:

(A.25) $\quad \dfrac{y_t^X}{y_t^N} = \dfrac{[A_t^X \theta^\theta]^{\frac{1}{1-\theta}}}{[A_t^N \gamma^\gamma]^{\frac{1}{1-\gamma}}} \dfrac{z_t^X}{z_t^N} \dfrac{p_t^{X\frac{\theta}{1-\theta}}}{p_t^{N\frac{\gamma}{1-\gamma}}} \left[\eta c_t^M p_t^M \dfrac{(1+\tau_t^M)}{\alpha\omega} \right]^{\left(\frac{\gamma}{1-\gamma} - \frac{\theta}{1-\theta}\right)}$

Use (A.23) to obtain

(A.26) $\quad p_t^{N^{\frac{1}{1-\gamma}}} = \frac{(1-\theta)(1-\nu_t)\delta}{(1-\gamma)} \frac{[A_t^X \theta^\theta]^{\frac{1}{1-\theta}}}{[A_t^N \gamma^\gamma]^{\frac{1}{1-\gamma}}} \left[\frac{z_t^X}{z_t^N}\right] p_t^{X^{\frac{1}{1-\theta}}} \left[\frac{\eta(1+\tau_t^M)}{\alpha\omega}\right]^{\frac{\gamma-\theta}{(1-\gamma)(1-\theta)}} \left[c_t^M p_t^M\right]^{\frac{\gamma-\theta}{(1-\gamma)(1-\theta)}}$

Let $\quad k_1 = \frac{(1-\theta)(1-\nu_t)\delta}{(1-\gamma)} \frac{[A_t^X \theta^\theta]^{\frac{1}{1-\theta}}}{[A_t^N \gamma^\gamma]^{\frac{1}{1-\gamma}}} \left[\frac{z_t^X}{z_t^N}\right] \left[\frac{\eta(1+\tau_t^M)}{\alpha\omega}\right]^{\frac{\gamma-\theta}{(1-\gamma)(1-\theta)}}$. Then:

(A.27) $\quad p_t^N = k_1^{(1-\gamma)} p_t^{X^{\frac{(1-\gamma)}{(1-\theta)}}} \left[c_t^M p_t^M\right]^{\left(\frac{\gamma-\theta}{1-\theta}\right)}$

Solving for the current account

To obtain the economy-wide budget constraint, obtain government transfers as:

(A.28) $\quad t_t = \tau_t^N p_t^N c_t^N + \tau_t^M p_t^M c_t^M + \tau_t^X p_t^X c_t^X + hg_t - p_t^N cg_t^N - p_t^M cg_t^M$

Introducing this restriction in the consumers budget constraint and using the fact that production in non-traded goods and exportable goods must equal payments to labor and other factors, we obtain the economy-wide (or consolidated) budget constraint:

(A.29) $\quad -b_t + (1+r_t+\mu_t)b_{t-1} = p_t^N\left(y_t^N - c_t^N - cg_t^N\right) + p_t^X y_t^X - p_t^X c_t^X - p_t^M\left(c_t^M + cg_t^M\right) + h_t$

Use the fact that in equilibrium the demand and supply of non-traded goods must equalize, note also that exports correspond to $y_t^X - c_t^X = X_t$, and assume that $cg_t^M = \theta_M c_t^M$ to obtain:

(A.30) $\quad -b_t + (1+r_t+\mu_t)b_{t-1} = p_t^X X_t - p_t^M c_t^M(1+\theta_M) + h_t$

Solving forward

(A.31) $\quad (1+r_t+\mu_t)b_{t-1} + \sum_{t=s}^\infty R_{t,s} p_t^M c_t^M(1+\theta_M) = \sum_{t=s}^\infty R_{t,s} p_t^X X_t + \sum_{t=s}^\infty R_{t,s} h_t$

where $\quad R_{s,t} = \frac{1}{\prod_{\tau=t+1}^s (1+r_\tau+\mu_\tau^*)}$

Use the intertemporal arbitrage condition and solve forward for the sustainable level of imports:[21]

$$(A.32) \quad p_t^M c_t^M = \frac{1-\beta}{\beta} \frac{1}{(1+\theta_M)} \left[(1+r_t + \mu_t)b_{t-1} + \sum_{t=s}^{\infty} R_{t,s} p_t^X X_t + \sum_{t=s}^{\infty} R_{t,s} h_t \right]$$

Solving for the equilibrium real exchange rate

Use equations (A.27) and (A.32) and take logs to obtain

$$(A.33) \quad \begin{array}{l} \log p_t^N = (1-\gamma)\log k_1 + \frac{(1-\gamma)}{(1-\theta)}\log p_t^X \\ + \left(\frac{\gamma-\theta}{1-\theta}\right)\log\left(\frac{1-\beta}{\beta}\frac{1}{(1+\theta_M)}\left[-(1+r_t+\mu_t)b_{t-1} + \sum_{t=s}^{\infty} R_{t,s} p_t^X X_t + \sum_{t=s}^{\infty} R_{t,s} h_t\right]\right) \end{array}$$

Replace   by equations (A.16) and (A.18) to obtain:

(A.34)

$$\log RER_t = \frac{1}{\alpha(1-\theta)+(1-\gamma)(1-\alpha)} \left[\begin{array}{c} \delta_0 + (1-\gamma)\omega\log TOT_t + (1-\gamma)\log\left[\frac{z_t^X}{z_t^N}\right] + (1-\gamma)\log A_t^X - (1-\theta)\log A_t^N + (\gamma-\theta)\log\eta \\ -(\gamma-\theta)\log(1+\theta_M) + (1-\gamma)\log(1-v_t) + (\gamma-\theta-\omega(1-\gamma))\log(1+\tau_t^M) - (1-\gamma)(1-\omega)\log(1+\tau_t^X) \\ +(\gamma-\theta)(1-\alpha)\log(1+\tau_t^N) + (\gamma-\theta)\log\left(\frac{1-\beta}{\beta}\left[-(1+r_t+\mu_t)b_{t-1} + \sum_{t=s}^{\infty} R_{t,s} p_t^X X_t + \sum_{t=s}^{\infty} R_{t,s} h_t\right]\right) \end{array} \right]$$

where $\delta_0 = \log\left[\frac{1-\alpha}{\alpha}\right]^{(\theta-\gamma)(1-\alpha)} + \log\left[\omega^\omega(1-\omega)^{1-\omega}\right]^{1-\gamma}\omega^{(\theta-\gamma)} + \log\left[\frac{(1-\theta)\delta}{(1-\gamma)}\right]^{1-\gamma}\frac{\theta^{\theta(1-\gamma)}}{\gamma^{\gamma(1-\theta)}}.$

Under the assumption that the non-traded sector is more labor-intensive than the exporting sector (i.e., $\gamma > \theta$), the sign of the elasticities can be directly obtained for all fundamentals, with the only exceptions of import taxes.

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[21]Since $c_{t+1} = c_t\beta(1+r_t+\mu_t^*)$ then $c_{t+j} = c_t\prod_{i=1}^j \beta^i(1+r_{t+i}+\mu_{t+i}^*)$ then

$\sum_{i=j}^{\infty} c_{t+j}\left[\prod_{i=1}^j \beta^i(1+r_{t+i}+\mu_{t+i}^*)\right]^{-1} = c_t\sum_{i=j}^{\infty}\beta^i = c_t\frac{\beta}{1-\beta}$.

Appendix 3: Econometric Results

Unit Roots Tests for Variables in the Sustainable Current Account Model
Panel Unit Root Tests
1970-2004, 73 countries

Variable	Null hypothesis of a common unit root		Null hypothesis of an individual unit root	
	Levin Lin	Breitung	Im et al.	PP-Fischer
Real Imports (in US$ per capita)	3.69	2.99	-0.32	217.80
Real Exports (in US$ per capita)	7.30	5.15	2.13	184.16
Foreign Aid (in US$ per capita)	0.75	0.03	-1.53*	171.30
Debt Service (in US$ per capita)	2.46	-1.74**	-0.71	146.27
Residual Cointegration Test	-9.68***	-7.09***	-9.77***	317.79***

*Notes: *,**,*** rejects the null hypothesis at 10%, 5% and 1%, respectively. Exogenous variables: Individual effects, individual linear trends, maximum lags=3, automatic selection of lags based on SIC, Newey-West bandwidth selection using Bartlett kernels.*

Unit Roots Tests for Variables in the RER Model
Panel Unit Root Tests
1970-2004, 73 countries

Variable	Null hypothesis of a common unit root		Null hypothesis of an individual unit root	
	Levin Lin	Breitung	Im et al.	PP-Fisher
Real Exchange Rate	-3.11***	-0.54	-4.25***	158.1
Terms of trade	-8.03***	1.42	-8.35***	315.2***
Productivity in non-traded sector	-4.61***	-0.02	-3.42***	183.4***
Productivity in traded sector	-1.98**	0.77	-1.79**	129.6
Resource endowment	-7.25***	-2.01**	-12.45***	451.3***
Share of government consumption in imports	-6.40***	-4.14***	-6.57***	217.4***
Taxes on imports	-8.43***	-1.82*	-7.70***	316.7***
Export taxes (openness)	-7.47***	-6.00***	-7.86***	296.2***
Taxes on non-traded goods	-2.68***	1.08	-2.63***	216.2***
Sustainable imports	-1.35*	0.82	-3.97***	215.7***

*Notes: *,**,*** rejects the null hypothesis at 10%, 5% and 1%, respectively. Exogenous variables: Individual effects, individual linear trends, automatic selection of lags based on SIC, Newey-West bandwidth selection using Bartlett kernel.*