Abstract

This paper develops a model of the real exchange rate derived from first principles. The model solves for a single equation framework that controls for mainstream exogenous and policy fundamentals (such as TOT, productivity, trade openness and government consumption) as well as others not frequently analyzed in the literature. These include a model-consistent proxy for ‘sustainable’ current account, which reflects the composite effects of export proceeds, debt service payments, development aid and other unrequited transfers as well as net capital inflows and change in reserves; a measure of financial development relative to the OECD frontier; and, taxes on nontradables. The model was estimated using the pooled mean group model (PMG) over 1980-2003 for a sample of 84 countries, including 37 from SSA. The PMG generates country-invariant estimates of the long-run slope parameters, while allowing for country-varying intercepts, equilibrium-correction parameters and other short-run effects. Accounting for plausible shocks to the fundamentals drawn from historical time series data suggests that productivity was the most influential fundamental, followed by current account, the combined instruments of fiscal policy, and the terms of trade, openness and financial depth. Analysis of these orders of magnitudes also suggests that a combination of expenditure restructuring, reduction of taxes on nontradables and policies for increased openness to trade could lead to an equilibrium depreciation ranging from 30 to 40%. Therefore, there appear to be an effective policy response to other influences on RER that may be driven by exogenous (TOT and aid) or less policy-responsive (productivity) fundamentals.

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I. Introduction

It is not an overstatement to suggest that the debate regarding the role of the real exchange rate (RER)\(^1\) in macroeconomic policy and long-run growth now occupies a central position in economic research and policy design in emerging as well as low-income developing economies. The pivotal role assigned to the RER should not be surprising, given that it is an economy-wide relative price signaling for intersectoral resource transfers and factor movements in the economy. Recent literature finds, first, that persistent RER overvaluation\(^2\) is a powerful predictor of currency crises (e.g. Kaminsky et al, 1998; Merrill Lynch, 1998). Second, protracted or sustained RER misalignment, especially overvaluation, has been associated with lower economic growth\(^3\). On the other hand, countries that avoided massive RER overvaluation have been associated with sustained export-led growth and substantial export diversification, with the East Asian countries, including China, and Chile providing the most notable examples (e.g. Elbadawi, 2002)\(^4\). Third, excessive fluctuations in the RER can also induce substantial uncertainty to investment decisions and, as a consequence, hamper investment and long-run growth (Caballero and Corbo, 1989). Understanding the nature of instability of the RER is an important ingredient for policy design and for a satisfactory answer to the growth problem in SSA, as discussed by Servén (1997). And, fourth, for low-income Africa, the real exchange rate has been proposed by some analysts as the centerpiece of an overall export-oriented development strategy (e.g. Williamson, 1997; Elbadawi and Helleiner, 2004).

However, despite extensive research, this literature is still in a state of flux and current research on RER modeling is fraught with conceptual and methodological problems (see, for example, Edwards and Savastano, 1999). This paper contributes to this literature by developing a dynamic general equilibrium model of the RER derived from first principles, which solves for an explicit parametric and encompassing empirical model of the RER. This model accounts for the range of the medium-run current account flow fundamentals, the longer term capital account equilibrium considerations as well as the short-run transitory changes of the fundamentals. The model is estimated using the Pooled Mean Group (PMG) estimator (see Pesaran, Shin and Smith, 1999) over a panel of 84 developing and developed countries, including most of Sub-Saharan Africa. The PMG estimator is a powerful technique that allows pooling of limited times series data across countries to estimate sample-wide long-run equilibrium RER paths; country specific intercepts, short-run effects as well as country specific convergence parameters. Therefore, we will argue, that the

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1 The RER is generically defined as the relative price of non traded goods to traded goods. More detailed empirical definition is provided in section IV.
2 According to the definition of the RER adopted here, an RER overvaluation is associated with a higher level of RER relative to its equilibrium.
3 See, for example, Edwards, 1988; Cottani et al, 1990; Ghura and Grennes, 1993; Razin and Collins, 1999; Easterly and Levine, 1997.
4 Moreover, the level of the real exchange rate affects competitiveness directly, through the return to investing in traded-goods industries, and indirectly, by affecting the use of comparative advantages. This problem has been extensively documented in the case of Africa by, among others, Elbadawi (2002), Mengistae and Pattillo (2002), and Dufrenot and Yehoue (2005).
theoretical and empirical contribution of this paper addresses most of the conceptual and methodological limitations of the current literature. Moreover, the concept of the “sustainable” current account derived naturally from this model should also motivate a more rigorous analysis of the issues regarding the computation of the equilibrium RER and RER misalignment indexes.

Though this paper covers most developing countries for which data is available, it has a special focus on Sub-Saharan Africa. There are several reasons for this. First, most African countries are small, non-diversified, low-income developing economies, where economic growth depends largely on the fate of exporting sectors. Consequently, the level of the RER and its fluctuations become a key determinant of exports, capital accumulation, and growth. Second, yet, like most other developing countries outside Latin America, very little research on RER behavior has been done so far. Third, compared to other developing regions, real exchange rate adjustment in SSA has been different, which might shed light on key policy and institutional characteristics that are specific to Africa, both in terms of timing, intensity and potential consequences. In the aftermath of the 1982 debt crisis many countries outside SSA undertook deep and relatively swift RER depreciation, consistent with reverse or declining capital inflows as well as worsening terms of trade (TOT). However, this cannot be said about SSA, where adjustment had taken much longer and, evidently, had also been more painful and costly. While, the median RER in developing countries depreciated by 40% in a course of just six years (1982-88), it took the median African country about 13 years (1982-1995) to achieve the same rate of depreciation (Figure 1). Given the precipitous decline of private capital flows, official development aid (ODA) as well as the secular decline in the TOT during the period, it is very clear that there was a need for a major equilibrium correction in the RER in the entire developing world, especially in SSA (Figures 2, 3 & 4).

Therefore, for most developing countries outside SSA massive RER overvaluation appears to have been dealt with well before the end of the 1980s. This had allowed the median developing country to pursue a much more balanced menu of policies for last 15 years or so, and was, therefore, able to also focus on RER stability while responding to the need for modest equilibrium corrections of the RER associated with the more gradual evolutions of the RER fundamentals. On the other hand, and consistent with the above preliminary story regarding Africa, recent literature has formally established that many African countries have experienced massive episodes of RER overvaluation for most of this period well into the beginning of the 1990s (e.g. Elbadawi, 2002; Elbadawi and Soto, 1997; Baffes et al, 1999). The fact that the median African country had lagged behind on this key aspect of economic reform must be associated with the disappointing performance of Africa relative to the rest of the developing world (Figure 5).

However, this is beyond the scope of this paper and will be addressed in a companion forthcoming paper (Elbadwi, Kaltani and Soto, 2005).
Figure 1: Median Real Effective Exchange Rate

Figure 2: Median Official Development Assistance Per Capita
However, Africa is obviously not monolithic, especially with regard to the diversity of the exchange rate and monetary regimes. In particular, the presence of three large monetary unions, respectively, of the West African (UMOA), the Central African (BEAC) and the Southern African monetary unions, had significantly affected the median story regarding Africa’s response to the post 1982 crisis (Figure 6). Clearly this institutional consideration suggests that failure to undertake timely and decisive reforms is only one part of the story behind the relatively limited and slow RER adjustment in SSA. Moreover, other characteristics of African are also likely to be important, including the importance of minerals and natural resources; the overall dependence on foreign aid and remittance flows from nationals working abroad; and, the small but rising number of “emerging” economies, where portfolio and capital account considerations are likely to be important. These features of the African economies must merit specific consideration in the design of the theoretical model and the empirical analysis that follows.

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6 The West African (UMOA), the Central African (BEAC) and the Southern African monetary unions, respectively, include eight, six, and three countries—which, constitutes a combined 35% of the total number of countries in Sub-Saharan Africa.
Figure 4: Median Net Capital Inflows Per Capita

- Developing Countries
- Sub-Saharan Africa

Figure 5: Median and Standard Deviation of Growth of GDP Per Capita

- Developing Countries
- Sub-Saharan Africa

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Section 2 of the paper reviews approaches to modeling of the RER, to put the concept of equilibrium and its modeling implications in perspective as well as discusses where the literature stands, including summarizing its main limitations. The section then motivates the proposed model of the paper and indicates how it might address some of the major limitations of the existing literature. Section 3 presents the theoretical model, where more detailed derivation is contained in the appendixes. Section 4 discusses data, describes the PMG estimator and analyzes the estimation results. Section 5 discusses issues related to the typology of African RER experiences and the role of institutional arrangements (e.g. exchange rate regimes), endowment, labor market characteristics, among others, in influencing the speed of convergence of the RER towards equilibrium and in determining the effectiveness of nominal devaluation and monetary policy. Section 6 concludes.
II. Approaches to Real Exchange Rate Modeling

There appears to be a wide consensus in the literature that the long-run equilibrium RER in developing countries is subject to the influence of a relatively wide range of time-varying exogenous and policy fundamentals. This view is corroborated by the failure of the PPP-based approach to explain persistent deviations of the real exchange rate from the PPP benchmark in both developed and developing countries alike (Mussa, 1986). Though the PPP model remained discredited in academic circles for decades, in the late 1990s a series of papers proposed that a weaker version of PPP could provides a meaningful benchmark for assessing RER developments over the very long term (six to seven decades). As discussed in Imbs et al. (2002), however, even in such case models based on the PPP assumption are unlikely to provide an adequate description of the misalignment at any relatively short horizon. The slow convergence of international prices towards parity makes it quantitatively difficult to ascribe the failure of PPP to temporary arbitrage impediments or sticky prices.

The implications of the more recent evidence regarding the relevance of the PPP approach to modeling of RER in developing countries is, therefore, aptly stated in Edwards and Savastano (1999: p.40-41): “A better grasp of the long-run regularities of RER behavior in developing countries, and, in particular, of the relative validity of PPP as a (very) long run benchmark for the real exchange rate, would help give the appropriate time dimension to the assessment of RER misalignment…In this regard, it is important to stress that firmer evidence of long-run convergence to PPP in developing countries (say, comparable to that available to for industrial countries) need not be incompatible with the notion of a time-varying equilibrium RER determined by the interplay of a set of foreign and domestic “fundamentals”.”

There is already an extensive literature on modeling the long-run equilibrium RER, emphasizing the role of time-varying economic fundamentals and assessing their role in explaining the departure of RER from its equilibrium. In this strand of the literature, the equilibrium RER is defined following Nurske (1945) seminal work as the level of the real exchange rate when internal and external balances are achieved. Despite the simplicity of this concept, its practical implementation offers a number of alternative, and often times sharply different, normative and methodological approaches. To better delineate the normative aspects of the definition of the concept of the equilibrium RER and the ensuing modeling and econometric issues, we follow Clark and MacDonald (1999) and distinguish between two broad classes of

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7 See, for example, Apte et al (1994). These models do not test for the proportionality and symmetry restrictions that could deliver the stronger version of PPP (Breuer, 1994) and, consequently, do not even imply that the RER is stationary, let alone be constant or unity, as claimed by the relative and absolute versions of PPP (Elbadawi and Soto, 1997).

8 See Hinkle and Montiel (1999) for a comprehensive analysis of various approaches.
models in this literature: the fundamental equilibrium RER (FEER) and the behavioral equilibrium RER (BEER).

**The Fundamental Equilibrium RER (FEER)**

The FEER is defined by Williamson (1994:p.185) as the RER path “needed to achieve simultaneous internal and external balance by some date in the medium run future and maintain balance thereafter.” Internal balance is defined as that compatible with optimal domestic and foreign output levels consistent with the “ideal” conditions of the non-accelerating inflation-rate unemployment or NAIRU (e.g. Williamson, 1994; and Bayoumi et al., 1994). On the other hand, external balance is given by the “sustainable” net flow of resources between countries, provided that internal balance is maintained. In its simplest form this model specifies a behavioral equation for the current account (CA) that depends on the real exchange rate, as its most pivotal determinant, along with potential domestic and foreign outputs. By setting the estimated CA equation equal to the negative of an exogenously given level of net capital flows in the medium run, the FEER could be simply derived as a function of “optimum” outputs and “sustainable” capital flows.

The structure of the FEER makes clear that it is based on an explicit normative concept and that it abstracts from cyclical and temporary factors and focuses on “ideal” economic fundamentals, projected or assumed to obtain in the medium-to-longer run. Since these conditions may not prevail in the future, the FEER corresponds to normative notion of equilibrium RER for assessing the compatibility of the prevailing RER with the economic policy goals assumed to be consistent with the computed FEER. This approach could, therefore, be more natural when thinking about RER in the context of the wider development strategy (Williamson, 1997).

However, several issues have been raised regarding the adequacy of the FEER approach for understanding the behavior of the RER and, hence, the usefulness of its policy implications. First, the estimation of the medium term equilibrium capital account, a key component of the FEER model, is problematic. As noted by Clark and MacDonald (1999), while the current account model and potential output for the country in question and its main trading partners could be estimated using well established theoretical and empirical procedures, the same cannot be said about the determinants of the optimum CA. Consequently, the literature has relied on sensible, albeit judgmental, approaches for calculating this variable (e.g. Williamson, 1994; Wren-Lewis and Driver, 1997; Bayoumi et al, 1994)\(^\text{10}\). Second, by focusing on three key fundamental determinants, the FEER model ignores other potentially important medium-term exogenous and policy fundamentals, such as the terms of trade, openness and trade policies, or

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\(^9\) The FEER concept was originally proposed by Williamson (1985), which subsequently spawned a rapidly growing literature. See, for example, Williamson and Miller (1987), Isard and Faruqee (1998) and Wren-Lewis and Driver (1997).

\(^{10}\) However, a recent extension of the FEER analysis, which models the equilibrium current account as the difference between desired aggregate saving and investment at full employment, promises to address this problem and allows a more transparent method of calculation of this variable comparable to the other two inputs of the FEER model (see, for example, Faruqee, Isard and Masson, 1996).
aid and remittance flows. These, we argue, are likely to be critical for RER analysis in middle and low-income developing countries. Third, a much more important critique of the FEER model is that by being essentially a medium-term flow equilibrium model, it does not account for longer-run stock equilibrium considerations. Moreover, even in the medium-term the stock of debt could have important effects on the RER through their influence on risk premia in both developed and developing countries. Fourth, a related and equally important problem with the FEER approach is that it does not address the critical issue of the dynamics of adjustment of the RER, including the potential role of exchange rate and monetary policies in influencing the speed of convergence to the equilibrium RER.

The Behavioral Equilibrium RER (BEER)

This alternative concept of RER equilibrium, coined by Clark and MacDonald, refers to a wide class of single-equation reduced-form “behavioral” model of the RER that attempt to account for current account flow variables as well as factors influencing longer-run stock equilibrium. The underlining notion of RER equilibrium in this approach is essentially intertemporal, as the path of the equilibrium RER is assumed to be influenced not only by the current value of the fundamentals, but also by anticipations regarding the future evolution of these variables (e.g. Edwards, 1989; Elbadawi, 1994). Most contributors to this literature employ cointegration error-correction models to estimate dynamic models of the RER, to account for the implications of this notion of the equilibrium RER. In particular, Elbadawi (1994) shows that, given cointegration, the basic equilibrium RER model is adequate in this framework since it accounts for the following desirable properties: (1) it is consistent with a behavioral model specifying the equilibrium RER as a forward-looking function of the fundamentals; (2) it allows for flexible dynamic adjustments of the RER toward the equilibrium; (3) it allows for the influence in the short to medium run of macroeconomic and exchange rate policies on the RER; and, (4) the unit root stochastic nature of the fundamentals allows their time-series decomposition into permanent (sustainable) and transitory components and a relatively straightforward computation of the equilibrium RER.

However, the application of the BEER model is also subject to limitations and despite the substantial number of papers on RER analysis, research is limited in a number of areas. Edwards and Savastano (1999) survey the literature and conclude that "there are still major gaps in our understanding of the long run behavior of real exchange rates in the emerging countries". They

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11 However, though it has not been the practice, the indirect effects of the above medium-term fundamentals could presumably be accounted for in the FEER context by solving out fully specified equations for potential outputs.
13 More recently panel data econometric models, have been employed as an alternative to country-specific time series analysis, which is particularly useful when large data series are not available. For example, Nagayasu (2000) studies the long-run behavior of real exchange rates by pooling the time-series data of 16 African countries, finding support for the notion that parallel market exchange rates move consistently with the long-run PPP hypothesis, but the official rates do not. See also Chinn and Johnston (1999) and Dufrenot and Yehoue (2005). Despite the problems that characterize panel data estimates (e.g. Robertson and Symons, 1992), panel data models have become an increasingly popular alternative to single equation time series regressions.
argue that in spite of evident progress in the last years, existing models are still subject to a number of shortcomings. Chief among these is the absence of explicit intertemporal considerations in empirical applications of these models, a (still) superficial understanding of the effects of capital inflows on real exchange rates, and the lack of a general equilibrium connection between the equilibrium real exchange rate and the current account position of a particular country\textsuperscript{14} or measures of internal equilibrium, including the level of unemployment. Moreover, most of the empirical literature on the determinants of the real exchange rate does not take into account the existence of structural breaks or, when acknowledged, their econometric treatment is naive and limited (e.g., use of dummy variables).

In addition to these criticisms, one should add the following issues. First, the majority of empirical studies in the 1980s and 1990s deal with the experience of Latin American economies. Only recently, the cases of Asian economies have become under scrutiny; research on the experiences of African economies is yet to be fully developed. The Latin American experience, though valuable, cannot provide policy insights in other regions that have different economic structures and policy stance. For example, the Latin American experience with exchange rate management is tainted with the currency substitution phenomenon. As such, it does not provide for an adequate description of the African and Asian cases.

Second, an important fraction of the papers do not have an explicit solution of the theoretical model in empirical terms, i.e., the econometric specification is not based on an analytical model or its connection to the analytical framework is rather loose. The main problem, in this case, is that the interpretation of the results is controversial and that policy evaluation is not rigorous.

A third important limitation of the existing literature relates to the severe shortcomings of the econometric analysis. This comprises three brands of problems. First, researchers tend to use variables with substantial measurement errors (e.g., the classical proxy for the RER as \( p/ep^* \)), that can be affected by changes in policies (e.g., trade liberalization) and can become very misleading in the interpretation of the results of estimated models. As discussed by Hinkle and Montiel (1999), a single RER for traded goods may obscure what is happening to relative import and export prices, and calculating separate RERs should become standard practice.\textsuperscript{15} Second, the econometric analysis in a large fraction of the papers is erroneous, including inadequate analysis of the stationary of the variables, inadequate testing for the number of cointegrating vectors, unwarranted analysis of the exogeneity and causality of variables, and wrong use and interpretation of statistical tests and results.\textsuperscript{16} Third, measures of RER misalignment are, at best, given as point estimates based on the estimated parameters and the decomposition of the

\textsuperscript{14} Edwards and Savastano (1999) claim that even those studies that tried to incorporate both stock and flow considerations (such as Soto and Valdes, 1998; and, Broner et al, 1997) are, nevertheless, subject to this criticism.
\textsuperscript{15} See Sjastaad (1998) for an analytical treatment of the problem. See the first four chapters in Hinkle and Montiel(1997) for discussions and detailed empirical work.
\textsuperscript{16} Recent advances in time-series analysis provide statistical tests and econometric specifications that overcome these limitations (e.g., Diebold and Inoue, 1999; Hansen, 2003)
fundamentals. A more reasonable approach would be to recognize the statistical nature of the measurement and provide confidence intervals for the predicted misalignment.

A fourth limitation relates to the use of estimated parameters to derive policy implications. Two criticisms arise. First, researchers tend to forget that usually estimated models correspond to reduced-form specifications. This very common problem is largely the result of econometric models being loosely connected to theoretical frameworks. Second, researchers do not necessarily realize that alternative policy scenarios need to be congruent. For example, a reduction in tariffs is a once and for all change affecting the RER, but should not be treated as a policy variable that can be changed at will. Third, applying Durlauf’s (2002) criticisms on growth regressions to RER models, policy recommendations derived from real exchange rate models are usually based on the statistical significance of some regression coefficients, which does not necessarily constitute a valid evaluation of alternative policy trajectories. Moreover, the statistical significance of a parameter does not provide information on the relative merit of it for policymakers’ objectives.

The proposed model

One approach, able to address the critiques of Edwards and Savastano, is a hybrid model that estimates a behavioral equation for the RER in the context of a larger structural model that allows derivation of sustainable current account levels along the lines of the FEER approach (e.g. Elbadawi and Soto, 1997). Alternatively, general equilibrium models can be an important tool for the analysis of the dynamics of the RER, in particular when the interest lies in discussing non-normal or non-linear phenomenon (e.g., the asymmetric response of the RER to nominal devaluations or capital flows reversals). Examples of this literature include Quiroz and Chumacero (1993) and Serven and Schmidt-Hebbel (1996).

However, these models are essentially country-specific, while our main objective is to develop a framework that has wider cross-country applicability but could also account for the most salient country-specific characteristics. We, therefore, develop a general equilibrium model for a small open economy, from which we derive the RER as the relative price of traded to non-traded goods that results from the intertemporal, optimal decisions of households on consumption of different good, conditional upon government policies and external conditions. The proposed empirical framework is directly derived from this theoretical model which provides a general framework but is flexible enough to account for specific country characteristics. 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 latter is adjusted for the unemployment rate that may or may not be consistent with non-clearing labor market conditions (i.e. unemployment might be higher than the NAIRU). Moreover, specifications of the household and government budget constraints accounts for bonds and fiscal transfers, which allows for explicit derivation of portfolio and stock equilibrium variables as determinants of the RER equilibrium. Failures of RER models to

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17 Elbadawi and Soto (1997) is an exception.
account for this and to allow for unemployment (associated with frictions in the home goods market) are two fundamentals problems discussed by Edwards and Savastano (1999).

Also, in addition to accounting for the flow fundamentals, such as TOT and productivity, the production sector of the model introduces the role of natural resources and human capital as potential determinants of the equilibrium RER. This is a particularly important factor from the perspective of African economies. Finally, perhaps the most important contribution of this paper’s model is a derivation of a quantitative expression for “sustainable” current account as a key RER fundamental. The expression for “sustainable” CA is given by the discounted present values of exports proceeds plus the net returns from foreign assets (or payments for external debt service) and foreign aid and remittances flows. By providing a model-consistent measure of “sustainable” current account, the proposed model addresses one of the major critiques of the current literature.

III. The Model

The model follows the recent macroeconomic literature of general equilibrium determinants of the real exchange rate (Obstfeld and Rogoff, 1999; Hau, 2000; Chari, Kehoe and McGrattan, 2002; Galí and Monacelli, 2005). Assume the existence of a small-open economy unable to affect international prices, which we denote domestic, and a continuum of small economies which we call the rest of the world. In the domestic economy, as well as in the rest of the world, there are sectors producing non-traded (N) and traded (T) goods, the latter comprising exportable (X) and importable goods (M).

The domestic economy is inhabited by a representative household. Present discounted expected utility of the representative household is given by:

\[ U_t = E_t \sum_{i=0}^{\infty} \beta^i \left[ \log(c_{t+i}) + \xi g_{t+i} + \kappa \log(m_{t+i}) + \eta(1 - n_{t+i}) \right] \]

where \( E_t \) is the expectations operators based on information at time \( t \), \( \beta \) is the discount factor, \( c_t \) is a consumption bundle described below, \( \xi g_t \) is the fraction of government expenditures that is valued by consumers (\( \xi \in [0,1] \)), \( m_t \) represents real money holdings, and \( n_t \) is total hours of labor effort. Note that this specification assumes that households derive utility directly from the services provided by money. This is assumed for simplicity and to provide some space for including financial deepness as a determinant of the equilibrium RER. The specification is, nevertheless, consistent with other approaches to justify the existence of money in general equilibrium such as cash-in-advance restrictions or transaction costs.\(^{18}\) In addition, this utility function assumes full separability, which fits well with the evidence that changes in private

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\(^{18}\) See Soto and Mies (2002) for a discussion.
consumption, money, and employment are largely uncorrelated at time $t$. Also, note that a fraction of government expenditures affects household welfare but is independent of its consumption and labor decisions (e.g., in-kind transfers such as public goods).

The representative household supplies 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 Hansen (1985) which assumes that each household can work a fixed number of hours $n_0$ or none at all (i.e., is unemployed). At the aggregate level, this specification is consistent with an equilibrium in which a fraction of the labor force is employed $n_0$ hours per period while the rest is unemployed.

Total consumption includes a basket of non-traded goods, $c_t^N$, and a composite of internationally traded goods, $c_t^T = (c_t^X)^{1-\alpha}(c_t^M)^{\alpha}$, which are aggregated as follows:

$$c_t = (c_t^N)^{1-\alpha}(c_t^T)^{\alpha} = (c_t^N)^{1-\alpha}[(c_t^X)^{1-\alpha}(c_t^M)^{\alpha}]^\alpha$$

Parameter $\alpha$ represents the intra-temporal elasticity of substitution between traded and non-traded goods while parameter $\omega$ corresponds to the intra-temporal elasticity of substitution between importable and exportable goods.

The household holds internationally traded bonds, $b_t$, which are used to transfer wealth intertemporally, and domestic money, $m_t$. In addition, he receives every period transfers from the government ($t_t$) and from overseas ($h_t$). The latter may include official development assistance and unrequited workers remittances. Denoting real variables by small case letters, the budget constraint in real terms can be expressed as:

$$\frac{(1 + i_t + \mu_t)}{1 + \pi_t} b_{t-1} + \frac{m_{t-1}}{1 + \pi_t} + w_t (n_t^N + n_t^T) + \frac{\Pi_t^N + \Pi_t^X}{P_t} + t_t, = b_t + m_t + (1 + \tau_t^N) p_t^N c_t^N + (1 + \tau_t^M) p_t^M c_t^M + (1 + \tau_t^X) p_t^X c_t^X$$

where $P_t$ is the domestic price level (described below) and $\pi_t$ is the inflation rate. The latter is the alternative cost of holding money. The left hand side of the budget constraint represents the sources of funds of the private sector and includes the return on bonds held from previous period (earning a nominal interest rate of $i_t$ and paying a transaction cost of $\mu_t$), money balances held from the previous period, labor income (where $w_t$, the wage rate, is the same in all sectors since labor is homogeneous) and profits $\Pi$ from domestic firms operating in the traded and non traded goods sectors and owned by the representative agent. The right hand side of the budget constraint is the use of such funds, comprising the purchase of bonds, money holdings and the cost of

19 In general, separability is incompatible with a balanced growth path as discussed in Chari et al. (2002). Our specification, nevertheless, can be made compatible with balanced growth if we assume that the productivity of non-traded goods rises in line with productivity in the traded goods sector.

20 Parameter $\eta$ is linked to the unemployment rate $U_t$ by the equilibrium condition $U_t = (1 - n_t)/(1 - e^{\eta})$.

21 It is straightforward and consistent with the model to treat $C_N$, $C_T$, and $C_X$ as types of goods for which a continuum of brands exists, in which case $C_N$, $C_T$, and $C_X$ would correspond to CES aggregates.
consumption, which includes taxes, $\tau$, to each type of good. We denote the real cost of borrowing by $1 + r_t + \mu^*_t = (1 + i_t + \mu_t) / (1 + \pi_t)$.

The consumer maximizes (1) subject to (2) and (3), from which we derive relative prices as the result of intratemporal arbitrage conditions:

$$\frac{p_t^M}{p_t^N} = \frac{(1 + \tau_i^N)}{(1 + \tau_i^M)(1 - \alpha)} \frac{c_i^N}{c_i^M}$$

$$\frac{p_t^M}{p_t^X} = \frac{(1 + \tau_i^X)}{(1 + \tau_i^M)(1 - \omega)} \frac{c_i^X}{c_i^M}$$

These arbitrage conditions indicate how the consumption of different goods will be relocated after a change in relative prices and/or taxes. From the intertemporal arbitrage condition we obtain

$$\frac{c_{t+1}}{c_t} = (1 + r_{t+1} + \mu^*_{t+1})^\beta$$

where $c_t$ denotes aggregate consumption. This equation indicates the household would postpone consumption only if adequately reward to cover the alternative cost of resources (including the risk premium) and its own impatience reflected in parameter $\beta$. Note that two economies facing the exact same real cost of borrowing may have different consumption paths—and hence RER trajectories—because of different impatience levels.

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

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

We use this index to deflate all nominal variables in the model.

**Government**

The government collects taxes from consumption of traded and non-traded goods and of inflation, and spends these resources on non-traded and imported goods (i.e., 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. In real terms, the government’s budget constraint is:

---

\(^{22}\) The detailed derivation of the model is in Appendix 1.
Production

The production of non-traded and exportable goods is assumed to be competitive. Firms in these two sectors demand labor and a sector-specific input \((z_t)\) and produce according to Cobb-Douglas technologies:

\[
y^N_t = A^N_t \left( n^N_t \right)^{\gamma} (z^N_t)^{1-\gamma} \\
y^X_t = A^X_t \left( n^X_t \right)^{\vartheta} (z^X_t)^{1-\vartheta}
\]

where \(A_t\) represents a total factor productivity (TFP) index for each sector. The presence of sector specific inputs characterizes the production of exportable goods in developing economies, especially African countries, where exports are usually dominated by natural resources. Hence, we model the sector specific input as \(z^X_t = HK_t^{1-\delta} NR_t^{\delta}\). On the other hand, production of non-traded goods, such as services and commerce, are largely based on human capital which, for simplicity, we assume to be exogenous, \(z^N_t = HK_t^{N}\). Productivity changes are also assumed to be exogenous in the long run, following Prescott (1997). Given this production structure, profit maximization implies that relative production in the domestic economy can be written as:

\[
y^X_t \left/ y^N_t \right. = \frac{A^X_t \left( n^X_t \right)^{1-\vartheta} \left[ p^X_t \right]^{\vartheta} }{A^N_t \left( n^N_t \right)^{1-\gamma} \left[ p^N_t \right]^{\gamma} } \left[ \frac{HK_t^{1-\delta} NR_t^{\delta}}{w_t \left( \frac{1-\gamma}{1-\delta} \right)} \right]^{1-\delta} \left( \frac{w_t^{1-\gamma}}{w_t^{1-\delta}} \right)
\]

The relative production of exportable goods and non-traded goods depends on relative efficiency, the relative price, the use of sector-specific inputs, and real wages. 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 share in both sectors is the same (i.e., \(\gamma = \vartheta\)), the wage does not affect the relative production.

Current Account Balance

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

\[
b_t = (1 + r, + \mu_t) b_{t-1} = p^N_t \left( y^N_t - c^N_t - c^N_t \right) + p^X_t \left( y^X_t - p^X_t c^X_t - p^M_t (c^M_t + c^M_t) \right) + h_t
\]

In equilibrium, the demand for non-traded goods must equal its supply, so that the first term of the right hand side drops out. Using the intratemporal arbitrage conditions of the
consumer optimization to express the consumption of exportable goods as a function of imports and introducing the restriction that the government demands a fraction $\theta_M$ of imports, so that $c_t^M = \theta_M c_t^M$, we obtain

$$\begin{align*}
(14) \quad b_t - (1 + r_t + \mu_t^*) b_{t-1} &= p_t^X y_t^X - p_t^M c_t^M \left[ \frac{(1 + \tau_t^M)}{(1 + \tau_t^X)} \frac{(1 - \omega)}{\omega} + (1 + \theta_M) \right] + h_t,
\end{align*}$$

Solving forward this intertemporal condition and imposing the transversality condition\(^{23}\) for the dynamic optimization problem, i.e., that in the long run the economy would hold no debts, we obtain the present value of the external trade restriction:

$$\begin{align*}
(15) \quad \sum_{s=0}^{\infty} R_{s,t} p_t^M c_s^M \phi = (1 + r_t + \mu_t^*) b_{t-1} + \sum_{s=0}^{\infty} R_{s,t} \left[p_s^X y_s^X + h_s \right].
\end{align*}$$

where $\phi_t = \left[ \frac{(1 + \tau_t^M)}{(1 + \tau_t^X)} \frac{1 - \omega}{\omega} + (1 + \theta_M) \right]$ and $R_{s,t} = \frac{1}{\prod_{\tau=t+1}^{s}(1 + r_t + \mu_t^*)}$ is the market real discount factor between dates $t$ and $s$. The left hand side of external trade restriction is the present value of net imports. The right hand side comprises the present value of the external debts and its service if the country is a net debtor (or the real rent of the stock of foreign assets if the country is a net creditor), the present value of all exports and the present value of foreign transfers. Using the first order condition for the accumulation of foreign assets, we obtain the sustainable level of imports:

$$\begin{align*}
(16) \quad p_t^M c_t^M &= \left(1 - \beta \right) \left[ (1 + r_t + \mu_t^*) b_{t-1} + \sum_{s=0}^{\infty} R_{s,t} \left[p_s^X y_s^X + h_s \right] \right]
\end{align*}$$

note that this level of imports was derived imposing the restriction that in the long run net foreign assets should be zero (the no Ponzi-game condition), i.e., in present value terms the current account should be zero.

On the other hand, the accumulation of net foreign assets between any two periods can be written as:

$$\begin{align*}
(17) \quad CA_t = b_t - b_{t-1} = p_t^X y_t^X + (r_t + \mu_t^*) b_{t-1} - p_t^M c_t^M \phi_t + h_t.
\end{align*}$$

Combining this with the sustainable level of imports we find:

$$\begin{align*}
(18) \quad CA_t = \left(p_t^X y_t^X - p_t^X y_t^X* \right) \left(\beta \right) + (r_t + \mu_t^* - \left(r_t + \mu_t^*\right)) b_t + (h_t - \tilde{h}_t) + \left[1 - \frac{1}{\beta} \sum_{s=1}^{\infty} R_{s,t} \right] \left(p_t^* y_t^X - \tilde{p}_t^* y_t^X + \tilde{h}_t \right)
\end{align*}$$

where variables with a tilde denote the permanent values of their counterparts:

\(^{23}\) The mathematical condition is $\lim_{t \to \infty} R_{s,t} b_t = 0$.\]
Equation (18) indicates, then, four reasons why a country may incur a current-account deficit. First, a decrease in the production of exportable goods or in the terms of trade below its permanent level contributes to a current-account deficit because of consumption smoothing. Since economic agents know that output or the terms of trade are transitorily below their permanent level, they would run a current account deficit in order to maintain consumption constant. Second, if the economy is a net foreign debtor and the world interest rate currently exceeds its permanent level, the current account is unusually low as, again, agents dis-save to smooth their consumption. Third, a decrease in foreign transfers \( h \) below its permanent level contributes to a current-account deficit, again, because of consumption smoothing. Fourth, \( \sum_{s} \rho_{s} r_{s} + \mu_{s} \) captures the effect of differences between the market discount factor, \( R \), and the consumer’s discount factor, \( \beta \). 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.

**Price equilibrium**

To compute the equilibrium price of non traded goods we use the intratemporal arbitrage condition between imported and non-traded goods, the budget constraint, government restrictions, and the intratemporal arbitrage condition between imported and exported goods to find:

\[
(19) \quad p_{t}^{X} y_{t}^{X} = \frac{\sum_{s} \rho_{s}^{X} p_{s}^{X} y_{s}^{X}}{\sum_{s} \rho_{s}} , \quad \bar{h}_{t} = \frac{\sum_{s} \rho_{s} h_{s}}{\sum_{s} \rho_{s}} , \quad \bar{r}_{t} = \frac{\sum_{s} \rho_{s} (r_{s} + \mu_{s})}{\sum_{s} \rho_{s}}
\]

In order to solve for the RER we need to eliminate \( y_{t}^{X} \) which comprises domestic consumption of exportable goods \( c_{t}^{X} \) and exports, i.e., imports from the rest of the world \( c_{t}^{M^*} \). The representative consumer in the rest of world faces a similar optimization problem to that of the domestic consumer. Assuming that taxes in the world economy, imports from the rest of the world are \( c_{t}^{M^*} = \left( \frac{\alpha \omega m_{t}}{\kappa \phi_{t}} \right) \left( \frac{1}{1 \cdot 1 + \mu_{t}} \right) \). Since a similar condition holds in the domestic
economy, the demand for exported goods is \( y_t^x = \frac{\alpha}{\kappa} p_t^x \left(1 - \frac{1}{1 + i_t + \mu_t} \left(\frac{(1 - \omega) m_t}{1 + \tau_t^N} + \omega m_t^*\right)\right). \)

The equilibrium real price of non traded goods is given by the following structural expression for the log of the RER:

(21)

\[
\log RER_t = \left\{ (1 - \gamma) \log \frac{A_t^x}{A_t^N} + (\gamma - \vartheta) \log \frac{A_t^N}{GDP_t} + (1 - \vartheta)(1 - \gamma) \log \frac{HK_t^x}{RN_t^N} + \omega(1 - \gamma) \log TOT_t + (\gamma - \vartheta) \log \eta \right.

- (1 - \gamma) \omega \log(1 + \tau_t^N) + \vartheta(1 - \gamma)(1 - 2\vartheta) + (\gamma - \vartheta) \log(1 + \tau_t^N) + (1 - \alpha)(\gamma - \vartheta) - (1 - \gamma)(1 - \vartheta) \log(1 + \tau_t^N)

+ (1 - \gamma)(1 - \vartheta) \log(1 + \theta_{\alpha}) - (1 - 2\vartheta + \vartheta\gamma) \left(\frac{\omega}{1 - \omega} \left(\frac{1 + \tau_t^N}{1 + \tau_t^x} \right) (1 + \theta_{\alpha}) + (1 - \vartheta)(1 - \gamma) \left(1 + i_t + \mu_t\right) \right)

- (1 - \vartheta)(1 - \gamma) \log \left[ \left(\frac{\omega}{1 - \omega} \left(\frac{1 + \tau_t^N}{1 + \tau_t^x} \right) \frac{m_t^*}{m_t}\right) - (1 - \vartheta)(1 - \gamma) \log \frac{\tau_t^N}{GDP_t} \right.

+ (1 - 2\vartheta + \vartheta\gamma) \log \left[ \frac{\bar{p}_t^x \bar{y}_t^x + (\bar{r}_t + \beta_t^\phi) b_{t-1} + \bar{h}}{GDP_t} \right] \left\} \frac{1}{(\alpha(1 - \vartheta) + (1 - \gamma)(1 - \alpha))} + \delta_0
\]

where \( \delta_0 \) is a composite term comprising all the country-specific parameters of the model \( (\alpha, \gamma, \vartheta, \omega, \kappa, \eta) \) as well as the discount term \( \frac{1 - \beta}{\beta} \sum_{s=0}^{\infty} R_{s,t} \). Note that parameter \( \delta_0 \) in equation (21) indicates the need to account for fixed effects when estimating the model using panel data.

It can be seen that the equilibrium real exchange rate depends on external variables (such as international prices and interest rates), structural variables (such as the endowment of natural resources or the intensity use of factors in production), policy variables (such as taxes, real money supply, and the structure of government consumption), exogenous variables (such as productivity levels and foreign aid), and predetermined variables, such as the stock of debt.

According to this expression, the ERER is higher (more appreciated) if the tradable sector is relatively more efficient than the non-traded sector and in terms of the structural parameters of the model, this relative productivity influence is inversely related to the labor intensity of the non-traded sector \( (\gamma) \). Also, conditional on this relative productivity effect, the model also predicts that higher absolute productivity in the latter leads to higher ERER, provided that of labor intensity in the non-traded sector is larger than the tradable sector \( (\gamma > \vartheta) \).\(^{24}\) In this sense, the model reproduces the Balassa-Samuelson effect that has been the cornerstone of several models of the RER.

The model also predicts the ERER to be higher for economies with higher natural

---

\(^{24}\) Given that this assumption is likely to be corroborated by empirical evidence, it will be maintained throughout in the discussion of the theoretical predictions of the model, hereafter, “the labor intensity assumption”.
resources relative to human capital endowment. The intuition is straightforward. A higher relative productivity or relatively abundant inputs $z^X$ in the tradable sector means higher wages and income for the consumer. This, in turn, is consistent with higher demand for non-traded goods and a higher ERER. This allows the producers of non-traded goods to meet higher wages. Moreover, if the above labor intensity assumption is maintained (i.e. production in the non-traded sector is more intensive in the use of labor $\gamma > \vartheta$) then higher unemployment rates that are associated with larger $\eta$ will be congruent with higher real wages and, hence, a higher ERER. The relationship between the endowment of natural resources and the RER has been largely neglected in the literature, yet it is an important characteristic of the economic structure of developing countries.

Higher permanent terms of trade—reflected in higher real prices for exports—raise the consumer’s disposable income and, hence, the demand for non-tradable goods, thereby inducing an increase in the relative price of non-tradable goods. As noted before, in this model the substitution effect in production, arising from the higher cost of imported inputs, is neglected. The effect of the terms of trade is, perhaps, one of the more discussed determinants of the equilibrium RER and, in general, empirical models tend to support this assumption.

The impact of fiscal policy, including taxes and composition of government expenditure, provides for a rich, if mostly undetermined, channels of policy levers on the ERER. First, when the weight of the traded goods in domestic consumption is higher than labor intensity in the non-traded sector $(\gamma > \vartheta)$, higher taxes on non-traded goods ($\tau_N$) are predicted to lead to a more depreciated (lower) equilibrium RER. This is because such taxes lower demand—and hence price—of non-traded goods. Second, a tax on exports or imports—by far the most used tax in developing economies—operates through two channels. First, higher import taxes lead to unambiguous ERER depreciation reflecting a pure income effect leading to reduced aggregate demand and hence lower prices of non-traded goods. This predicted effect is consistent with this model, in which the substitution effect, arising from the higher cost of imported inputs, is zero. Third, higher export taxes are predicted to have an ambiguous effect because both substitution and income effects are at work, though their effect is likely to be one of appreciation.\(^{25}\)

However, the full impact depends on the government’s expenditure patterns ($\theta_N$ and $\theta_M$) as well as the real monetary stocks associated with the demand for exports. As expected, the model predicts government consumption of the non-traded goods to unambiguously lead to RER appreciation, while the share of its expenditure on imports is predicted to be associated with RER depreciation, provided that the “labor intensity’’ condition holds.

The influence due to the demand for home exports domestically and abroad is reflected through three channels, all leading to unambiguous RER depreciation because in equilibrium these leads to higher production of exported goods. First, there is interest rate and transaction cost channel for holding real money balances; second the effect of real foreign money stock relative to domestic money, weighted by the tax rate on exports and the relative weight of exports

\(^{25}\) Under the plausible assumption of $\vartheta < 0.5$ in addition to the labor intensity condition, the coefficient of $\log(1 + \tau^X \vartheta)$ in equation 21 will be positive.
to imports in the consumption of tradable goods; and, third, an additional channel for the domestic real monetary stock. The relative monies condition can be understood more intuitively as signaling for the role of financial depth: economies with lower levels of financial development will display a more depreciated RER in equilibrium.

Finally, the model permits derivation of a quantitative concept of “sustainable current account level”, where a higher level of sustainable imports is predicted to lead to more appreciated ERER, provided that 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 the demand for non tradable goods and a more depreciated ERER. Likewise, for a net debtor 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. The opposite verifies if the country is a net creditor. Finally, a higher inflow of foreign transfers, i.e. aid or unrequited private transfers, allows for the higher sustainable current-account deficit that is congruent with higher consumption and, hence, with a higher demand for non tradable goods and a more appreciated ERER.

IV. Taking the Model to the Data

Before presenting the data and econometric results, it is important to discuss the nature of the estimation procedure. The above RER model can be compactly stated for expositional purposes as follows:

\[ \log RER_{it} = \delta_0 + \delta' \log F_{it} + \epsilon_{it} \]

where \( F_{it} \) is a vector of the right hand side variables of equations (21) which we call the RER fundamentals; \( \delta \) is a vector of the associated coefficients, which are in turn functions of the structural parameters of the model; and the term \( \delta_0 \) 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 (\( \alpha, \omega, \eta, \theta, \) and \( \lambda \)). As mentioned, equation (21) suggests that in the context of panel data analysis, it is important to allow this country-specific structural parameter (intercept) to vary across countries, since it is very likely that economies will differ in such parameters.

Recent literature (e.g., Pesaran and Smith. 1997) suggests that the existence of the above long-run relationship is not contingent upon co-integration and can be embedded in a dynamic error-correction model of the form:
\[(23) \Delta \log RER^i_t = \phi^i (\log RER^i_{t-1} - \delta^i_0 - \delta^i F^i_{t-1}) + \sum_{j=1}^{p} \gamma^i_j \Delta \log RER^i_{t-j} + \sum_{j=1}^{q} \lambda^i_j \Delta F^i_{t-j} + \sum_{j=1}^{s} \xi^i_j \Delta M^i_{t-j} + \epsilon^i_t \]

where \( M^i_t \) is a vector of variables that may affect the RER in the short-run but have no permanent effects. This model is compatible with a general autoregressive, distributed lags model, ARDL(p,q,s), with the restriction that the long-run coefficients of \( M^i_t \) are equal to zero. Notice that the adjustment parameter as well as the long-run intercept and short-run coefficients \((\phi^i, \delta^i_0, \lambda^i, \xi^i)\) are allowed to vary across countries, while the long-run coefficients, \( \delta^i \), are the same for all economies.

The econometric technique for estimating the model in equation (23) is provided by the Pooled Mean Group (PMG) estimator developed by Pesaran, Shin, and Smith (1999), hereafter PSS. This estimator has several attractive features in terms of generality and flexibility, which makes it useful when estimating the above theoretical model in panel data context. These include allowing (1) the long–run RER to be influenced by fundamentals of varying degree of integration, including stationary country-specific fundamentals, (2) the intercept \((\delta^i_0)\) of the estimated long-run ERER to vary across countries, accounting for differences in country-specific deep parameters, (3) the short-run effects of the fundamentals and other variables to vary across countries, and (4) the equilibrium correction parameter \((\phi^i)\) to vary across countries, which permits identifying differences in the speed at which countries adjust to new equilibria.

Estimation of equation (23) is performed directly using maximum likelihood techniques, under the following assumptions. First, in order to have consistent estimates of the short-term coefficients, residuals and regressors should be independently distributed. For long-run coefficients, dependency is not a problem as long as regressors have finite AR representations. Second, the order of integration of the RER is at most equal to that of fundamentals. This ensures the existence of the long-run specification of the model. Third, the long-run coefficients are the same across countries. Fourth, if fundamentals are stationary, they satisfy the Grenander conditions; while if they are not stationary, they should not cointegrate by themselves (otherwise there is a problem of non-invertibility of the regressors matrix due to perfect colinearity). Fifth, country specific factors should be accounted for. We allow for fixed country-specific intercepts using dummy variables and also for time-specific worldwide factors affecting all economies. The latter can be dealt with using dummy variables but we deemed reasonable to use the alternative procedure of demeaning the data every period by removing the cross-country mean for that year. Sixth, in order to have a meaningful long run relationship between the RER and its fundamentals, the equilibrium correction coefficient should be negative and contained in the unit circle (i.e. its absolute value should be less than 2).

We test the model using a sample of 84 countries –which we describe in detail in Appendix B— in 1980-2003. The total number of RER observations is 1,744. The sample comprises 17 developed economies and 67 developing economies with an adequate regional balance considering our interest in African economies (37 African countries, 16 Latin American economies, and 14 Middle East, Asian, and East Asian economies). Since the efficiency of the PMG estimator relies on residuals being uncorrelated, we included one lag of the fundamentals
and drop those that were not significant. We did not expand the lag structure any further to avoid small sample biases arising in the estimation of country specific parameters.

Contrary to most RER studies, the model described above requires a specific set of variables that is difficult to obtain and for which proxies are needed. First, note that the above model is for a representative consumer. Hence, all variables should be measured in per working-age person terms: since for most economies this variable is not readily available in comparable terms, we scale variables per capita. Second, in order to avoid measurement errors in the RER we used a recent data base on real effective exchange rate from the IMF’s Information Notice System. The effective real exchange rate index, as opposed to the customary measure $eP^*/P$ which can be misleading. Third, with regards to the standard fundamentals (national accounts, terms of trade, money, etc), we used the IFS database of the IMF, complemented with data from the World Bank, and each country’s Central Bank and statistical offices. Fourth, for non-standard variables such as productivity indices, human capital, natural resources, etc. we considered several options and chose those that match as close as possible their analytical counterpart as well as maximize coverage in terms of number of years and countries. In particular, we proxied $m_t^r$ with the yearly average of M1 per capita in 19 OECD countries expressed in US$. We used World Bank data to build a consistent measure of taxes levied on imported and non-traded goods. Due to coverage and quality limitations, we could not build a reasonable database on taxes levied on exported goods. We were, thus, forced to drop taxes on exports from the econometric model. Fifth, we proxied the share of government expenditures in imported and non-traded goods ($\theta_M$ and $\theta_N$) by public investment and government consumption as share of GDP, respectively. 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, computational restrictions when using the PMG estimator precluded us from using more than eight regressors; we, thus, deemed reasonable to use the residual of a pooled regression of the log of foreign trade (as % 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—which is called filtered openness—has the additional advantage of controlling for specific characteristics of the economies that affect trade levels beyond trade taxes. This is an important feature because it implicitly accounts for the role of natural resource endowment that our theoretical model takes into account but was not found in the data to be directly associated with the RER. Finally, the model requires determining the sustainable level of the current account balance. To do this, we use an instrumental procedure in two stages: we first run a panel regression of imports (as share of GDP and weighted by the tax rate on imports) on exports, official development assistance, debt service, and change in

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26 The construction of the REER is based consumer price indices for the majority of the countries in the sample and unit labor costs for a group of the industrial countries. The weights used are based on partner countries for both direct and third market competition. See Zanello and Desruelle (1997) for further clarifications.


28 Countries are Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, Greece, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Portugal, and the USA.

29 See Frankel and Rose (2002) for the effect on foreign trade of elements such as currency unions, common currencies, isolation, endowment of resources, etc.
foreign debt. We next use the predicted value as an instrument when estimating the RER equation.

The results of the PMG estimation of equation (23) are extensive as they involve estimating one common set of parameters for long-run coefficients for all countries and one set of short-term coefficients for each country. We then summarized the main results and presented them in Tables 1 and 2. Prior to discussing the results, some description of the estimation procedures is necessary. The PMG estimation is performed using maximum likelihood techniques. Optimal lags were determined using Akaike’s criterion and parameters were estimated using the Newton-Raphson optimization method (see Pesaran et al. (1999) for details).

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. 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 individual-effects panel-data model that assumes all parameters to be the same across countries. This restriction can also be tested: the null hypothesis of equality of coefficients can be rejected at the 0.01% level. Rejecting one model in favor of an alternative specification has important implications, as can be seen in Table 1 where we confront the estimators of the long-run coefficients obtained using the PMG estimator with those obtained using the dynamic, fixed-effects panel data estimator and the mean-group model estimator. We discuss in turn the long-run coefficients, the speed of adjustment coefficient, and the short-run estimated parameters. Nevertheless, we acknowledge that estimated elasticities and statistical significance are not the best assessment of our results since we are interested in the economic impact of changes in fundamentals on the RER. We thus include an estimation of the economic effect of such changes in a separate sub-section below.

**Econometric Results**

With regards to long run coefficients, it can be seen that all parameters estimated using the PMG estimator are highly significant (over 99% confidence) and display the expected sign according to the theoretical model of section 3. When comparing these results with the alternative estimators, we confirm that the PMG estimator provides a better match of the data and our theoretical model. It can be seen that, as expected after Hausman’s tests, the very restrictive mean-group estimator is not consistent with the data: the estimated parameters are not significant at the 90% confidence level. Point estimates also display a negative sign for productivity and sustainable equilibrium-consistent current account level. On the contrary, the estimated coefficients, obtained using the dynamic panel-data model, are more in line with the theoretical model, in the sense that they display the expected signs. Yet, they are not significant at conventional significance levels in most cases. We thus conclude in favor of the estimated PMG model.

The PMG results for the classical determinants of the RER are in line with those of the existing literature in several cases; yet the extended specification provides additional insights on
the dynamics of the RER. We estimated that a one percent increase in total productivity in the traded sector beyond that in the non-traded sector signals for an appreciation of the RER of around one half of a percentage point. This value is similar to that found by Chinn (1997), who estimated a value of 0.45 for a panel of 14 developed economies in the 1970-1991 period, and de Gregorio and Wolff (1994) who estimated a value between 0.36 and 0.52 for a group of 14 OECD economies in 1970-1985 period.
Table 1. The Long-and-Short-Run Determinants of the Real Exchange Rate
Estimator: Pooled mean group, Mean group all controlling for country and time effects
Dynamic Specification: ARDL(1,1,0,1,0,1,0,1)
Sample: annual data 1980-2003

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<th>Variables</th>
<th>Pooled Mean Group</th>
<th>Mean Group</th>
<th>Hausman Tests</th>
<th>Dynamic Fixed Effect</th>
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<td>0.013</td>
<td>-16.502</td>
<td>16.524</td>
</tr>
<tr>
<td>Government Consumption/GDP</td>
<td>2.443</td>
<td>0.195</td>
<td>-104.348</td>
<td>105.587</td>
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<tr>
<td>Taxes on non-traded goods</td>
<td>3.127</td>
<td>0.263</td>
<td>464.382</td>
<td>459.118</td>
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<tr>
<td><strong>Error Correction Coefficients</strong></td>
<td>-0.194</td>
<td>0.024</td>
<td>-0.710</td>
<td>0.053</td>
</tr>
<tr>
<td>Phi</td>
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<table>
<thead>
<tr>
<th>Variables</th>
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</tr>
<tr>
<td>Sustainable Current Account</td>
<td>0.058</td>
<td>0.088</td>
<td>0.065</td>
<td>0.130</td>
<td>-0.016</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>0.028</td>
<td>0.044</td>
<td>-0.071</td>
<td>0.048</td>
<td>-0.007</td>
<td>0.024</td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>0.366</td>
<td>0.039</td>
<td>0.110</td>
<td>0.055</td>
<td>0.285</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>M*/M</td>
<td>-0.129</td>
<td>0.029</td>
<td>-0.031</td>
<td>0.032</td>
<td>-0.167</td>
<td>0.016</td>
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<tr>
<td>Government Consumption/GDP</td>
<td>-0.088</td>
<td>0.322</td>
<td>0.027</td>
<td>0.329</td>
<td>-0.233</td>
<td>0.157</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.052</td>
<td>0.040</td>
<td>0.065</td>
<td>0.130</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No. Observations</td>
<td>1744</td>
<td></td>
<td>1744</td>
<td>1744</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: standard errors in parenthesis.

The estimated effect of permanent terms of trade shocks (0.331) is also in line with those found in other papers in this literature. For example, Elbadawi and Soto (1997) found mixed results for eight developing economies (4 African), with an average value of around 0.2. Drine and Rault (2004) found an average value of 0.5 for a group of 45 developing economies in the 1980-1996 period. However, these estimates are much larger than those of Clark and McDonald (1998) who found a 0.08 parameter for G3 countries in the 1960-96 period. This comes as no surprise given the evidence that changes in terms of trade are much larger for developing economies (in particular African countries) than for developed economies.30

The impact of trade liberalization, as reflected in the -0.41 coefficient of filtered openness, is slightly larger than what is usually found in the cross-country literature. The abovementioned study by Drine and Rault (2004) found an average value of -0.16. Dufrenot and

30 In our simple of countries, the variance of the terms of trade of African economies is seven times larger than that of developed economies.
Yehoue (2005) also report a value in the neighborhood of -0.2 for a group of 70 economies in the 1979-2000 period. These estimates, however, are not directly comparable to ours, since they use unfiltered openness measures (usually, total trade over GDP) whilst, as mentioned, 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 government consumption on non-traded goods, the point estimate of the coefficient is 2.44. However, the estimated coefficient is for log (1+government consumption as share of GDP); hence in order to have a meaningful comparison with the previous literature we transform this estimate to obtain an elasticity of 2. This value is much higher than that found in the abovementioned study by Dufrenot and Yehoue (0.083). But it is closer to those reported for 7 individual countries by Elbadawi and Soto (1997)—in the 1.6 range—and for the Euro area by Maeso-Fernandez et al. (2002), in the 1.0 to 1.7 range.

With regards to the equilibrium-consistent current account we obtained a point elasticity of 0.37. In general, the literature does not consider stock-flow restrictions when modeling RER determinants. One exception is Lane and Milesi-Ferreti (2000) 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. They estimated elasticity very similar to our result, 0.32. Another exception is Maeso-Fernandez et al. (2002), who use the cumulative change in the net foreign asset position. Their choice is, however, not optimal since this is a stationary variable which is used in the context of a cointegrating vector. Their point estimate for this parameter using data for 65 countries in the 1975-1997 period is 1.33, substantially larger than our result. Two further studies account for the stock of net foreign income and estimate semi elasticities of 0.77 for a panel of 63 developing countries (Elbadawi, 2002) and 1.82 for Argentina (Alberola at al, 2004).

Two results are new to the BEER literature. First, the estimated effect of relative monies, which in this paper proxies for the degree of financial development relative to that of developed economies, indicates a small yet important effect. The median value for this variable in developing countries is 3.22, indicating that on average developing economies have a financial sector of around 1/3 that of OECD economies. In Africa the median for this indicator is 4.5. An increase in financial depth that would take the median African economy to the level of the median developing country would induce an appreciation of around 10% (R: Is this right: I thought it should be 2%, pls check) of the RER. Second, the impact of taxes on non-traded goods is substantial. The transformed elasticity is around 0.9. Since the median value for these taxes is around 4.7% in non African economies, while it is 4% in African economies, a raise towards developing country levels would induce an appreciation in the RER of around 20%.

**Economic Impact of Fundamentals on the RER**

As discussed, estimated elasticities and statistical significance are not the main interest for economic analysis, in particular when thinking about the effects of alternative policies on the RER. The main reason is that the implied changes in elasticities need not be of significant economic meaning. For example, according to our estimation, a 10 percent increase in
**Table 2: Net Effects of PMG Variables by Groups**

**Sample with 84 Countries**

<table>
<thead>
<tr>
<th>Country Group</th>
<th>Coefficient</th>
<th>Standard Deviation</th>
<th>Implied Net Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CFA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>0.33</td>
<td>26.32%</td>
<td>8.71%</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.51</td>
<td>64.84%</td>
<td>32.76%</td>
</tr>
<tr>
<td>Filtered Openness (% of GDP)</td>
<td>-0.41</td>
<td>29.91%</td>
<td>-12.11%</td>
</tr>
<tr>
<td>Government Consumption (% GDP)</td>
<td>2.44</td>
<td>3.36%</td>
<td>8.54%</td>
</tr>
<tr>
<td>$\frac{M}{M}$</td>
<td>-0.05</td>
<td>91.06%</td>
<td>-4.80%</td>
</tr>
<tr>
<td>Taxes on Non-traded Goods</td>
<td>3.13</td>
<td>2.20%</td>
<td>7.12%</td>
</tr>
<tr>
<td>Eq-consistent Current Account</td>
<td>0.37</td>
<td>22.61%</td>
<td>8.40%</td>
</tr>
<tr>
<td><strong>RMA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>0.33</td>
<td>12.80%</td>
<td>4.23%</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.51</td>
<td>57.81%</td>
<td>29.20%</td>
</tr>
<tr>
<td>Filtered Openness (% of GDP)</td>
<td>-0.41</td>
<td>7.91%</td>
<td>-3.20%</td>
</tr>
<tr>
<td>Government Consumption (% GDP)</td>
<td>2.44</td>
<td>3.05%</td>
<td>7.74%</td>
</tr>
<tr>
<td>$\frac{M}{M}$</td>
<td>-0.05</td>
<td>43.73%</td>
<td>-2.30%</td>
</tr>
<tr>
<td>Taxes on Non-traded Goods</td>
<td>3.13</td>
<td>2.10%</td>
<td>6.79%</td>
</tr>
<tr>
<td>Eq-consistent Current Account</td>
<td>0.37</td>
<td>12.58%</td>
<td>4.68%</td>
</tr>
<tr>
<td><strong>Rest of SSA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>0.33</td>
<td>37.76%</td>
<td>12.50%</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.51</td>
<td>104.48%</td>
<td>52.78%</td>
</tr>
<tr>
<td>Filtered Openness (% of GDP)</td>
<td>-0.41</td>
<td>45.36%</td>
<td>-18.37%</td>
</tr>
<tr>
<td>Government Consumption (% GDP)</td>
<td>2.44</td>
<td>5.45%</td>
<td>14.24%</td>
</tr>
<tr>
<td>$\frac{M}{M}$</td>
<td>-0.05</td>
<td>118.10%</td>
<td>-6.22%</td>
</tr>
<tr>
<td>Taxes on Non-traded Goods</td>
<td>3.13</td>
<td>2.62%</td>
<td>8.53%</td>
</tr>
<tr>
<td>Eq-consistent Current Account</td>
<td>0.37</td>
<td>42.89%</td>
<td>15.94%</td>
</tr>
<tr>
<td><strong>Developing-Fixed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>0.33</td>
<td>35.05%</td>
<td>11.60%</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.51</td>
<td>101.87%</td>
<td>51.47%</td>
</tr>
<tr>
<td>Filtered Openness (% of GDP)</td>
<td>-0.41</td>
<td>41.19%</td>
<td>-16.68%</td>
</tr>
<tr>
<td>Government Consumption (% GDP)</td>
<td>2.44</td>
<td>5.25%</td>
<td>13.68%</td>
</tr>
<tr>
<td>$\frac{M}{M}$</td>
<td>-0.05</td>
<td>128.49%</td>
<td>-6.77%</td>
</tr>
<tr>
<td>Taxes on Non-traded Goods</td>
<td>3.13</td>
<td>2.10%</td>
<td>6.80%</td>
</tr>
<tr>
<td>Eq-consistent Current Account</td>
<td>0.37</td>
<td>51.48%</td>
<td>19.13%</td>
</tr>
<tr>
<td><strong>Developing-Flexible/Intermediate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>0.33</td>
<td>21.02%</td>
<td>6.96%</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.51</td>
<td>91.58%</td>
<td>46.26%</td>
</tr>
<tr>
<td>Filtered Openness (% of GDP)</td>
<td>-0.41</td>
<td>43.05%</td>
<td>-17.44%</td>
</tr>
<tr>
<td>Government Consumption (% GDP)</td>
<td>2.44</td>
<td>3.81%</td>
<td>9.74%</td>
</tr>
<tr>
<td>$\frac{M}{M}$</td>
<td>-0.05</td>
<td>92.94%</td>
<td>-4.90%</td>
</tr>
<tr>
<td>Taxes on Non-traded Goods</td>
<td>3.13</td>
<td>2.39%</td>
<td>7.77%</td>
</tr>
<tr>
<td>Eq-consistent Current Account</td>
<td>0.37</td>
<td>53.89%</td>
<td>20.02%</td>
</tr>
<tr>
<td><strong>Industrial</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terms of Trade</td>
<td>0.33</td>
<td>9.92%</td>
<td>3.28%</td>
</tr>
<tr>
<td>Productivity</td>
<td>0.51</td>
<td>38.42%</td>
<td>19.41%</td>
</tr>
<tr>
<td>Filtered Openness (% of GDP)</td>
<td>-0.41</td>
<td>31.85%</td>
<td>-12.90%</td>
</tr>
<tr>
<td>Government Consumption (% GDP)</td>
<td>2.44</td>
<td>3.13%</td>
<td>7.94%</td>
</tr>
<tr>
<td>$\frac{M}{M}$</td>
<td>-0.05</td>
<td>31.75%</td>
<td>-1.67%</td>
</tr>
<tr>
<td>Taxes on Non-traded Goods</td>
<td>3.13</td>
<td>3.82%</td>
<td>12.70%</td>
</tr>
<tr>
<td>Eq-consistent Current Account</td>
<td>0.37</td>
<td>44.19%</td>
<td>16.42%</td>
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</tbody>
</table>
government expenditures (as % of GDP) would lead to an appreciation of 20% of the RER. While these magnitudes are plausible, they are not typically observed in real life. Likewise, a 25% change in terms of trade—which would lead to a 9% change in RER—may appear as an excessively large foreign shock for most observers, yet it occurs frequently in Africa. In 1980-2003 there were 187 episodes of annual fluctuations in terms of trade above 25%; 143 of them occurred in African economies.

We thus measure the implied economic effect of fundamentals on the RER multiplying the estimated long-run elasticity by the standard deviation of the variables in the sample. A one standard deviation change in the level of a variable reflects a typical shock for an economy (in fact, if the distribution of the variable is normal it would correspond to 68% of the cases). The results are presented in Table 2, where countries were grouped according to relative degree of economic development and exchange rate systems.

In general, the main economic determinants of the long run evolution of the RER are productivity changes. This is, naturally, the expected result of the Balassa-Samuelson effect and it verifies in all economies, notwithstanding the fact that it is more pronounced in developing economies. It is striking, also, that this effect is rather small in CFA and RMA economies, whilst in the rest of African economies the impact is similar to that of other developing economies. The productivity lag of African economies is significant when compared to other developing economies. This indicates that, as African economies catch-up on productivity levels, the impact of productivity changes on the long run RER will likely increase.

A second main determinant of the long run evolution of the RER is the equilibrium-consistent current account level. In non-African developing economies, as well as in OECD countries, fluctuations in this variable account have a significant impact on the RER. In African economies this replicates only in those economies that are not part of a monetary agreement; in the latter, changes in the equilibrium current account are much less important. Since long run elasticities are the same for all countries, differences lie on the levels and standard deviations of the components (exports, debt service, unrequited transfers in the form of aid an workers remittances as well as net capital flows and change in reserves). However, in the four groups of developing countries the share of exports in GDP is roughly equivalent (30%) and the group variances are also very similar. Likewise, foreign debt service is relatively small (on average, 3 to 4% of GDP) and its standard deviation does not differ significantly among African economies. Consequently, the observed differences in the impact of the equilibrium-consistent current account level are the result of differences in the unrequited transfers. Nevertheless, aid flows are of similar magnitude in CFA, RMA and the rest of the African economies. Hence, it is the fluctuations in foreign aid what accounts for the observed differences in the impact on the RER.

As mentioned, there are substantial differences in the effects of terms of trade on the RER in the different country groups. It can be seen in column 2 of Table 3 that the variability of the TOT in CFA and RMA countries is much smaller than in the rest of the African economies i.e., these economies face smaller terms of trade shocks. Consequently, in the former economies the evolution of the RER has been less dependent on TOT fluctuations. In the rest of the African
Table 3: Error Correction Coefficients by Exchange Rate Regime and Region/Development

<table>
<thead>
<tr>
<th>SSA-Flexible Exchange Rate Regime</th>
<th>Error Correction Coefficient</th>
<th>Rigid Labor Market</th>
<th>Flexible Labor Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>-0.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burundi</td>
<td>-0.08</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Botswana</td>
<td>-0.18</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>-0.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gambia</td>
<td>-0.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Madagascar</td>
<td>-0.17</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Mauritania</td>
<td>-0.08</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Malawi</td>
<td>-0.11</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>-0.16</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>-0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>-0.16</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Congo, Dem. Rep.</td>
<td>-0.61</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>No. of Countries</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Countries with Flexible Labor Markets</td>
<td>27%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SSA-Fixed Exchange Rate Regime</th>
<th>Error Correction Coefficient</th>
<th>Rigid Labor Market</th>
<th>Flexible Labor Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>-0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>-0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chad</td>
<td>-0.28</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Cote d’Ivoire</td>
<td>0.09</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Gabon</td>
<td>-0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guinea Bissau</td>
<td>-0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesotho</td>
<td>-0.10</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Senegal</td>
<td>-0.18</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Swaziland</td>
<td>-0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Togo</td>
<td>-0.83</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>No. of Countries</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Countries with Flexible Labor Markets</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Developing Countries-Flexible Exchange Rate Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>No. of Countries</td>
</tr>
<tr>
<td>% of Countries with Flexible Labor Markets</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Developing Countries-Fixed Exchange Rate Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>No. of Countries</td>
</tr>
<tr>
<td>% of Countries with Flexible Labor Markets</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industrial Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>No. of Countries</td>
</tr>
<tr>
<td>% of Countries with Flexible Labor Markets</td>
</tr>
</tbody>
</table>

Notes:
Countries included are those with the t-ratio for the error correction coefficient greater than 1 in absolute value.
Countries are considered to have a flexible labor market when they are in the bottom 25th percentile of their sample for the labor market indicator. The labor market rigidity variable comes from Doing Business and ranges between 22 and 79, and the threshold value used to classify countries as rigid or flexible is 43.

Economies terms of trade shocks are of similar size to those in developing countries without hard pegs. One explanation for this could be that most RMA and some of the large CFA countries are likely to have more diversified economies. This pattern can also be found in the effects of changes in government consumption on the RER. In the CFA countries, as well as in developing economies without hard pegs, the impact of government expenditures on the RER is much smaller than in the rest of Africa and the developing economies with fixed exchange rates. It is not surprising that the swings in fiscal policy are less pronounced in the CFA compared to other.
SSA, because of the inherent fiscal discipline imparted by the monetary union.

In terms of openness it is striking to observe the differences between RMA countries and the rest of the economies, both developed and developing. RMA countries show much less sensitivity of the RER to changes in openness. The reason for this difference is that RMA countries are more homogenously opened to trade than the rest of the economies. Hence, deviations tend to be smaller.

Finally, there are virtually no differences in the impact of taxes levied on non-traded goods on the RER in developing economies. As expected, the RER in developed economies shows more sensitivity to changes in tax rates. On the contrary, the economic effects of changes in relative monies (that in this model are a proxy of financial services) are very different in the different groupings. Since this variable is measured against the average of OECD countries, its contribution to RER fluctuations in the developed economies is naturally nil. In the developing economies the results are mixed, being difficult to justify without more detailed institutional background. In non-African economies, shocks to money markets in countries with fixed exchange rates are much larger and have a larger impact on the RER. In African economies it is exactly the opposite: the CFA and RMA display the lower standard deviation, and thus the smaller effect, of changes in the RER.

**Short-Run Dynamics**

With regards to the speed of adjustment and the short term elasticities, the results in Table 1 show that there are marked differences among estimating techniques. As discussed in the methodology section, the PMG estimator does not restrict coefficients to be the same among countries. Contrary to the estimation of the long run coefficients, for these parameters we are quite restricted by the available sample size in each country. On average, we have around 20 years of data for each country. This leaves very little degrees of freedom for estimating short run coefficients and the speed of adjustment.

The concerns about the small sample properties of these estimates aside, and starting with the fundamentals, we find that only productivity and the ratio of money stocks have had significant short-run effects, and for both variables the short and long-run coefficients have the same signs. Therefore, positive transitory shocks to each variable would lead to short-run real exchange rate appreciation for the case of productivity and depreciation for the case of relative monetary stocks. Not surprisingly, the PMG results were very similar to the ones generated by the dynamic fixed-effects, while only productivity was found to have a significant short-run effect in the MG model.

The most pivotal parameter in the estimation of short-run dynamics is the coefficient of the equilibrium-correction term, which measures the speed of adjustment of the real exchange rate to its equilibrium level. The estimated average adjustment parameter was -0.19, which is exactly equal to the one obtained by Edwards (1989) using a partial adjustment model for a group of 12 developing countries. This PMG estimate is, however, smaller than the dynamic fixed-effect model (at -0.25) and much smaller compared to the MG estimate of -0.71. The PMG estimate is also much smaller if compared to estimates obtained from time series models. This suggests
that, like other panel regressions, the PMG model might have understated the true level of the convergence parameter because it fails to capture short-run heterogeneity across countries. However, unlike other panel regression models, the possible failure of the PMG to account for short-run country heterogeneity is likely to be because of inadequacy of the time series dimension of the data, since the model does not impose restrictions on short-run parameters. In fact, for a non-negligible number of countries the convergence parameter estimate was not statistically significant. This makes it difficult to draw meaningful comparisons across countries or group of countries.

However, and notwithstanding the admittedly limited success of our model so far with the estimation of the short-run effects, the sub-regional and country by country analysis reveals some interesting findings (Table 3). For example, the mean and median estimates of the convergence parameter for SSA are marginally lower than other developing countries and much lower compared to those for industrial countries; and within SSA, the fixed-exchange rate regime countries (CFA & RMA) have had lower mean and median adjustment parameter estimates than the rest of Africa. Economies with inflexible exchange rate regimes and rigid labor markets are likely to be characterized by nominal rigidities, which in turn, should dampen their automatic adjustment towards the equilibrium RER (e.g. Baffes et al, 1999). Though the differences are small between these estimates they appear consistent with the difficult adjustment experienced by SSA relative to other regions. For country-specific results there are implausible results, where very high adjustment parameters were estimated for countries with rigid labor markets and inflexible exchange rate regimes and vice versa (e.g. Togo & Botswana, Uganda). However, there are other plausible estimates, including for the cases of Ethiopia (-0.47) and South Africa (-0.37) as well as Cote d’Ivoire (-0.09) and Chad (-0.28). The latter two estimates are consistent with the received literature, which find that adjustment had been particularly difficult in large CFA economies, like Cote d’Ivoire, and relatively fast in smaller and less rigid economies of the zone, such as Chad (e.g. Baffes et al, 1999; Elbadawi and Soto, 1997).

V. Conclusions

The real exchange rate is an important economy-wide relative price closely watched and analyzed by policy makers and academic researchers alike. Depending on whether it was highly volatile or stable, grossly overvalued or close to its ‘equilibrium’ level, this variable has been at center stage in almost all major economic crises or stellar successes. For example, the literature suggests that currency crises have usually been preceded by persistent RER overvaluation. On the other hand, there is little evidence that sustained export-led growth or substantial export diversification has been achieved without stable and well-aligned currencies. It is natural, therefore, that there is wide policy and academic interest in understanding the long-run behavior of the RER as well as its short-run dynamics. However, due to the difficulties of implementing the concept of the ‘equilibrium’ RER in empirical models of the RER, this literature remains in a state of flux and is fraught with theoretical and econometric problems. Nevertheless, there appears to be a general consensus in this literature that, at least for developing countries, the long-run equilibrium RER is not a fixed, immutable
number; and should, therefore, be determined by time-varying exogenous and policy fundamentals. This constitutes a major departure from the traditional PPP model, which dominated the theory and practice of real exchange rate modeling for so long.

There are two main approaches to modeling this equilibrium concept, both of them define the equilibrium RER as that level of RER consistent with the joint achievement of internal balance and ‘sustainable’ current account position. However, the two approaches differ in terms of the concept of ‘sustainability’ of fundamentals that underlie the equilibrium RER; the range of the fundamentals considered; and attention to short-run disequilibrium behavior of the RER. The Fundamental Equilibrium Exchange Rate (FEER) is based on an explicit normative concept and abstracts from cyclical and temporary factors and develops a set of projected (or assumed) ‘ideal’ economic fundamentals to derive the FEER. While the projected/assumed fundamentals may or may not prevail in the future, they are more suited to a wider development strategy that is linked to plausible development targets, such as growth, exports and associated imports and capital account targets. On the other hand, the Behavioral Equilibrium Exchange Rate (BEER) estimates dynamic single-equation models that controls for a wider class of current account flow and longer-run stock fundamentals. The BEER equilibrium is essentially intertemporal, as the path of the RER equilibrium is assumed to be influenced by current as well as future anticipated values of the fundamentals. Cointegration and error-correction allows estimation of long-run as well as short-run effects of the RER fundamentals.

Aside from neglecting short-run dynamics and the limited range of its fundamentals, the FEER approach is based on a ‘judgmental’ approach that requires considerable country-specific insight. As such, the FEER approach is not suitable for this paper, which is aimed at analyzing the behavior of the RER for a large sample of African and non-African countries. Instead, this paper follows the BEER tradition by developing a dynamic general equilibrium model of the RER derived from first principles, which solves for an explicit parametric and encompassing empirical model of the RER. However, the BEER approach is also subject to major conceptual and econometric criticisms. It is interesting to focus on two major critical issues due to Edwards and Savastano (1999). First, they argue that models applying the BEER approach only account for intertemporal considerations in a superficial fashion because they suffer from the lack of a general equilibrium connection between the equilibrium RER and the notion of ‘sustainable’ current account. Second, they suggest that the same criticism also applies for the case of departure from internal equilibrium, especially with regard to the level of unemployment. Perhaps the most important contribution of our model, we will argue, was that it addresses the first Edwards-Savastano critique by explicitly linking the equilibrium RER to an empirical index of ‘sustainable’ current account that derives from the general equilibrium model. This index provides a proxy for empirical estimation and will be used for computing the equilibrium RER index in a subsequent companion paper (Elbadawi, Kaltani and Soto, 2005). With regard to the other Edwards-Savastano critique, our model is also compatible with higher than NAIRU levels of unemployment, though we were unable to test this empirically due to data limitations.
**Estimation and Summary of the Main Results:**

The theoretical model of this paper generates a single equation empirical framework that controls for mainstream exogenous and policy fundamentals (e.g. TOT, productivity, taxes openness, government expenditure). In addition, this model also accounts for the no so standard equilibrium-consistent CA variable, which is an empirical proxy for the concept of ‘sustainable’ CA and reflects the composite effects of export proceeds, debt service payments, development aid and other unrequited transfers as well as net capital inflows and change in reserves. Another nontraditional fundamental is the ratio of foreign relative to domestic stocks of money, which is a measure of financial development relative to the OECD frontier. Moreover, the model also accounts for unemployment and the natural resource endowment relative to human capital. This latter country-specific effect is particularly important for SSA and has been a key variable studied in recent literature analyzing the problems of Africa’s lack of economic diversification and its inability to penetrate the global market of labor-intensive manufactures (e.g. Wood, 1997; Elbadawi, 1999). However, either due to lack of data or inadequacy of the proxy used both of the latter effects could not be estimated.

The econometric strategy for estimating the model was guided by the objective of generating robust long-run relationship that could approximate the long-run behavior of the RER for a wide class of countries, while allowing for country-specific characteristics through country-varying intercepts. This latter feature is particularly important for computing country-specific indexes of equilibrium RER and RER misalignment\(^{31}\). A second objective is assessing country-specific short-term behavior of the RER, especially the equilibrium-correction convergence characteristics of the RER. Country by country time series based regressions is not likely to be promising because of the limited time dimension of the data, especially for the SSA countries. This leaves the option of dynamic panel analysis, which employs a menu of models. For example, the dynamic, fixed-effect model estimates country-invariant longer-run and short-effects, including the convergence parameter but allows for country-specific intercept; while the mean group estimator (MG) estimates are all constant across countries. On the other extreme of the MG is the fully heterogeneous-coefficient model, which imposes no cross country restrictions. The latter cannot be implemented in our context because it requires large time series dimension. On the other hand, the other two approaches do not allow for short-run cross country heterogeneity. This leaves the more recently developed pooled mean group estimator (PMG) as the most ideal model for our purpose. This model restricts the long-run coefficients of fundamentals to be the same for all countries but allows the intercepts, the equilibrium correction parameter as well as all other short-run coefficients to vary across countries.

This model fits the purpose of this paper and is consistent with the underlying data generating processes. The PMG and the other two rival models are estimated using a data field of 84 countries over 1980-2003. A Hausman specification test could not reject the

\(^{31}\) Such computations are beyond the scope of this paper but will be undertaken in a forthcoming companion paper (Elbadawi, Kaltani and Soto, 2005).
long-run restriction of the PMG against the more flexible alternative, while it rejects the more restrictive dynamic, fixed-effects and MG model in favor of the PMG. Moreover, the more than 1700 observations generated by the panel appear to be sufficient for estimation of the long-run country-invariant coefficients. Focusing on the PMG results, all the estimated parameters are consistent with the theoretical predictions of the model and highly significant (at a marginal significant level of over 99 percent). However, the same could not be said about the country-specific short-run estimates, for which the small sample properties depend on the time series dimension of the data, which is rather limited in this sample.

The estimated elasticity-equivalent coefficients for the standard fundamentals (TOT, productivity, and government consumption) are, respectively, equal to about (0.3, 0.5, and 2.0). Though the estimated elasticity for government consumption is on the high side, all three estimates are broadly comparable to others in the literature. There are four more other fundamentals not directly comparable to others in the literature. First, the policy-oriented openness has an estimated elasticity of -0.41, which is much larger than the elasticity estimate for the unadjusted measure of openness. This suggests that economies that are more open relative to their ‘natural’ level of openness require substantial equilibrium depreciation. Second, the equilibrium-consistent CA metric has an estimated elasticity 0.37. As a stock-flow metric, this fundamental is not commonly modeled in the literature, though its estimated elasticity appears to be in line with the one or two studies that estimate a comparable variable. Third, the model generates two more fundamentals that have no parallels in the literature: taxes on nontradables, with a substantial estimated elasticity of about 0.9 and relative foreign to domestic money stocks, with a modest elasticity of -0.05.

As for the short-run estimates, the average equilibrium correction parameter estimate was low at -0.19, which is comparable to other panel data estimates. However, it is on the low side if compared to estimates obtained from time series models. Moreover, the inadequacy of the time series dimension of the data appears to have affected the robustness of these estimates and, hence, limited the scope for detailed country by country or cross regional analysis. Extending this dimension of the data base should, hopefully, permit better estimates in a future revised version.

**Some Policy Implications:**

By multiplying the estimated long-run elasticity estimates with the assumed permanent shocks to the fundamentals we generate the policy-relevant orders of magnitude of the ensuing long-run impacts on the RER. These calculations reveal that productivity was the most influential fundamental, followed by CA, the combined instruments of fiscal policy, the terms of trade, openness and financial depth. For example, a perfectly plausible negative shock to productivity could require staggering 30 to 50% equilibrium RER depreciation. The implication of this finding is that stagnant and non-modernizing economies cannot sustain stronger currencies. Likewise, the stock-flow restriction of the CA appears to be quite binding, with a plausible negative shock leading to 15 to 20% equilibrium depreciation for most developing countries, including those SSA countries with flexible exchange rate
regimes. For the CFA and especially the RMA countries, the shocks to this variable were of much smaller magnitude, leading to smaller effects of 8 and 5%, respectively. The main contributors to the overall CA shocks are development aid for SSA and capital flows for other developing economies. Therefore, it is not surprising that the destabilization effect of aid volatility is so substantial for aid dependent SSA.

Terms of trade also has a substantial effect, especially in the flexible exchange rate economies of SSA, where a typical negative TOT shock would require more than 12% equilibrium depreciation. However, the effect of TOT for the CFA, and especially the RMA, was much less, possibly reflecting that fact that these economies are relatively more diversified.

In terms of the policy fundamentals, the results suggest that fiscal policy and policy-oriented openness can be important policy instruments for restoring RER equilibrium or engineering an RER-led export promotion strategy. For example, a combination of expenditure restructuring away from government consumption, reduction of taxes on nontradables and policies for increased openness to trade could lead to an equilibrium depreciation ranging from 30 to 40%. To the extent that the assessed magnitude of the policy correction is plausible, which any way is consistent with the range of shocks experienced by the three fundamentals, there appears to be an option for effective policy response to other influences on RER that may be driven by exogenous (TOT and aid) or less policy-responsive (productivity) fundamentals. The effect due to financial development is important despite its relatively limited computed impact. This is because the scope for achieving further financial depth is large in SSA and other developing countries.

Finally, it is pertinent to note that for the advanced industrial countries, though productivity and the capital account restrictions are by far the most important fundamentals affecting the long-run behavior of the RER, other fundamentals are important as well. These include fiscal policy and policy-oriented openness. This finding would suggest that the tradition of excluding policy fundamentals from the analysis of RER for industrial countries may not be justified.

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Appendix 1: Model Solution

The consumer problem is

$$\max \ U_i = \sum_{t=0}^{\infty} \beta [\log(c_{t+1}) + \xi_{t+1} + \kappa \log(m_{t+1}) + \eta (1-n_{t+1})] \quad \text{subject to}$$

$$\frac{(1+i_t+\mu_t)}{1+\pi_t} b_{t-1} + \frac{m_{t-1}}{1+\pi_t} + w_i n_i + w_i^T n_i + \frac{\Pi_t^N}{P_t} + \frac{\Pi_t^T}{P_t} + t_t + h_t = b_t + m_t + (1+\tau_i^N) p_i^N c_i^N + (1+\tau_i^M) p_i^M c_i^M + (1+\tau_i^X) p_i^X c_i^X$$

$$c_i = (c_i^N)^{-\alpha}(c_i^T)^{\alpha}$$

$$c_i^T = (c_i^X)^{-\alpha}(c_i^M)^{\alpha}$$

Let

$$H = \sum_{t=0}^{\infty} \beta [\log((c_i^N)^{-\alpha}(c_i^X)^{-\alpha}(c_i^M)^{\alpha}) + \xi_{t+1} + \kappa \log(m_{t+1}) + \eta (1-n_{t+1})]$$

$$+ \lambda \left( \frac{(1+i_t+\mu_t)}{1+\pi_t} b_{t-1} + \frac{m_{t-1}}{1+\pi_t} + w_i n_i + w_i^T n_i + \frac{\Pi_t^N}{P_t} + \frac{\Pi_t^T}{P_t} + t_t + h_t - b_t - m_t - (1+\tau_i^N) p_i^N c_i^N - (1+\tau_i^M) p_i^M c_i^M - (1+\tau_i^X) p_i^X c_i^X \right)$$

The consumer's first order conditions are:

(A2) \( \frac{\partial H}{\partial c_i^N} = \frac{1}{c_i} \frac{\partial c_i}{\partial c_i^N} - \lambda_i p_i^N (1+\tau_i^N) = 0 = (1-\alpha) \frac{1}{c_i^N} - \lambda_i p_i^N (1+\tau_i^N) \)

(A3) \( \frac{\partial H}{\partial c_i^X} = \frac{1}{c_i} \frac{\partial c_i}{\partial c_i^X} - \lambda_i p_i^X (1+\tau_i^X) = 0 = \alpha (1-\omega) \frac{1}{c_i^X} - \lambda_i p_i^X (1+\tau_i^X) \)

(A4) \( \frac{\partial H}{\partial c_i^M} = \frac{1}{c_i} \frac{\partial c_i}{\partial c_i^M} - \lambda_i p_i^M (1+\tau_i^M) = 0 = \alpha \omega \frac{1}{c_i^M} - \lambda_i p_i^M (1+\tau_i^M) \)

(A5) \( \frac{\partial H}{\partial n_i} = w \lambda_i - \eta = 0 \)

(A6) \( \frac{\partial H}{\partial b_t} = -\lambda_t + \beta \left( \frac{1+i_{t+1}+\mu_{t+1}}{1+\pi_{t+1}} \right) \lambda_{t+1} = 0 \)

(A7) \( \frac{\partial H}{\partial m_t} = \frac{m_t}{\kappa} - \lambda_i + \frac{\beta \lambda_{t+1}}{(1+\pi_{t+1})} = 0 \)
Prices Indices

Price indices are obtained as the solution to the minimization problem:

(A8) \[ \min \ (1 + \tau_i^N) P_i^N c_i^N + (1 + \tau_i^M) P_i^M c_i^M + (1 + \tau_i^X) P_i^X c_i^X \quad \text{s.t.} \quad P_i^{\omega \alpha} \left[ c_i^M \right]^{\omega \alpha} \left[ c_i^X \right]^{1-\omega} = 1 \]

The first order conditions are:

(A9) \[ P_i^N = P_i \frac{c_i}{c_i^N} \frac{(1 - \alpha)}{(1 + \tau_i^N)} \quad P_i^M = P_i \frac{c_i}{c_i^M} \frac{\alpha \omega}{(1 + \tau_i^M)} \quad P_i^X = P_i \frac{c_i}{c_i^X} \frac{(1 - \omega)}{(1 + \tau_i^X)} \]

Replacing these conditions in \( P_i^{\omega \alpha} \left[ c_i^M \right]^{\omega \alpha} \left[ c_i^X \right]^{1-\omega} = 1 \), the domestic price index is found to be

(A10) \[ P_i = \frac{\left[ (1 + \tau_i^N) P_i^N \right]^{1-\alpha} \left[ (1 + \tau_i^M) P_i^M \right]^{\alpha \omega} \left[ (1 + \tau_i^X) P_i^X \right]^{\omega \alpha}}{(1 - \alpha)^{1-\alpha} (\alpha \omega)^{\alpha \omega} (\alpha (1 - \omega))^{\alpha (1-\omega)}} \]

Likewise, the price index for tradable goods is found to be

(A11) \[ P_i^T = \frac{\left[ (1 + \tau_i^M) P_i^M \right]^{\alpha \omega} \left[ (1 + \tau_i^X) P_i^X \right]^{1-\omega}}{\omega^\alpha (1 - \omega)^{1-\omega}} \]

Note that

(A12) \[ P_i = \frac{\left[ (1 + \tau_i^N) P_i^N \right]^{\alpha \omega}}{(1 - \alpha)^{1-\alpha} \alpha^\alpha} \quad \text{and} \]

(A13) \[ P_i^N = \frac{P_i^N}{P_i} = \frac{P_i^N}{\left[ (1 + \tau_i^N) P_i^N \right]^{\alpha \omega} P_i^{T \alpha}} = \frac{\alpha^\alpha (1 - \alpha)^{1-\alpha} \left( P_i^N \right)^{\alpha \omega}}{(1 + \tau_i^N)^{1-\alpha} \left( P_i^T \right)^{\alpha \omega}} = \alpha^\alpha (1 - \alpha)^{1-\alpha} - RER_i^\alpha \quad \text{and} \]

(A14) \[ \frac{P_i}{P_i^T} = \frac{\left[ (1 + \tau_i^N) P_i^N \right]^{\alpha \omega} P_i^{T \alpha}}{(1 - \alpha)^{1-\alpha} \alpha^\alpha P_i^{T \alpha}} = \frac{\left[ 1 + \tau_i^N \right]^{1-\alpha} \left( P_i^N \right)^{1-\alpha}}{(1 - \alpha)^{1-\alpha} \alpha^\alpha \left( P_i^T \right)^{1-\alpha}} = \frac{1 + \tau_i^N}{(1 - \alpha)^{1-\alpha} \alpha^\alpha} RER_i^{1-\alpha}, \text{ thus} \]
Solving the domestic production

From the firms’s profit maximization conditions derive the demand for labor:

(A16) \[ n_i^N = \frac{\mathcal{P}_i^N y_i^N}{\omega_i^N} \]

(A17) \[ n_i^X = \frac{\omega_i^X y_i^X}{\omega_i^X} \]

Profits, i.e., the residual payments to sector-specific inputs, correspond to:

(A18) \[ (1 - \gamma) p_i^N y_i^N = \frac{\Pi_i^N}{P_i} \]

(A19) \[ (1 - \vartheta) p_i^X y_i^X = \frac{\Pi_i^X}{P_i} \]

Supply prices are:

(A20) \[ p_i^N = \frac{w_i}{\gamma} \left[ \frac{\left( y_i^N \right)^{1-\gamma}}{A_i^N \left( z_i^N \right)^{1-\gamma}} \right]^{\frac{1}{\gamma}} \]

(A21) \[ p_i^X = \frac{w_i}{\delta} \left[ \frac{\left( y_i^X \right)^{1-\vartheta}}{A_i^X \left( z_i^X \right)^{1-\vartheta}} \right]^{\frac{1}{\vartheta}} \]

To solve out for the real wage, use the first order conditions from the consumer’s optimization problem and express real wages as:

(A22) \[ w_i = \eta c_i^N p_i^N \left( 1 + \tau_i^N \right) \frac{1}{1 - \alpha} \]
Hence

\[
\frac{y_i^X}{y_i^N} = A_i^{\frac{1}{1-\delta}} \theta^{\beta \delta} \left[ p_i^X \right]^{\delta \gamma} \left[ \begin{array}{c} \eta_{c_i}^N \frac{1 + \tau_i^N}{(1 - \alpha)} \\
\frac{H}{N} \end{array} \right] \left( \frac{\gamma}{1-\gamma} \right)^{\delta}.
\]

**Economy-wide budget constraint**

From the government budget equation we obtain transfers as

\[
m_i = \frac{m_{i-1}}{1 + \pi_i} + \tau_i^N p_i^N c_i^N + \tau_i^X p_i^X c_i^X + \tau_i^M p_i^M c_i^M - p_i^N c_g^N - p_i^M c_g^M = t_i
\]

Introducing this restriction in the consumer’s 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 consolidated budget constraint:

\[
b_i - (1 + r_i + \mu_i) b_{i-1} = p_i^X (y_i^X - c_i^X) - p_i^X c_i^X - p_i^M (c_i^M + c_g^M) + h_i.
\]

**Solving the sustainable current account**

In equilibrium, the demand and supply of non-traded goods must equal, so that

\[
b_i - (1 + r_i + \mu_i) b_{i-1} = p_i^X y_i^X - p_i^X c_i^X - p_i^M (c_i^M + c_g^M) + h_i.
\]

Introducing the restriction \( c_g^M = \theta c_i^M \)

\[
b_i - (1 + r_i + \mu_i) b_{i-1} = p_i^X y_i^X - p_i^X c_i^X - p_i^M c_i^M (1 + \theta_M) + h_i.
\]

From the first order conditions of the consumer’s optimization problem, we can express \( c_i^X \) as a function of imports:
(A28) \[ \frac{p_t^M c_t^M}{p_t^X} \frac{1 - \omega}{\omega} \left(1 + \tau^M_t\right) = c_t^X \] hence
\[ b_t - (1 + r_t^i + \mu_t^i) b_{t-1} = p_t^X y_t^X - p_t^M c_t^M \left(1 - \omega\right) \left(1 + \tau^M_t\right) - p_t^M c_t^M \left(1 + \theta_M\right) + h_t \]
\[ = p_t^X y_t^X - p_t^M c_t^M \left[\frac{1 - \omega}{\omega} \left(1 + \tau^M_t\right) + (1 + \theta_M)\right] + h_t \]

Solving forward
\[ \sum_{t=1}^{\infty} R_{t+1} p_t^M c_t^M \left[\frac{1 - \omega}{\omega} \left(1 + \tau^M_t\right) + (1 + \theta_M)\right] = (1 + r_t^i + \mu_t^i) b_t + \sum_{t=0}^{\infty} R_{t+1} p_t^X y_t^X + \sum_{t=0}^{\infty} R_{t+1} h_t \]

Using the intertemporal arbitrage condition and solving forward for the level of imports\(^{32}\):
\[ p_t^M c_t^M = \frac{1 - \beta}{\beta} \left[\frac{1 - \omega}{\omega} \left(1 + \tau^M_t\right) + (1 + \theta_M)\right] \left[(1 + r_t^i + \mu_t^i) b_t + \sum_{t=0}^{\infty} R_{t+1} p_t^X y_t^X + \sum_{t=0}^{\infty} R_{t+1} h_t\right] \]

From (A27), the change in foreign assets (or liabilities) is
\[ b_t - b_{t-1} = CA_t = (r_t + \mu_t^i) b_{t-1} + p_t^X y_t^X - p_t^M c_t^M \left[\frac{1 - \omega}{\omega} \left(1 + \tau^M_t\right) + (1 + \theta_M)\right] + h_t \]

Using expression (A32) for imports then
\[ CA_t = (r_t + \mu_t^i) b_{t-1} + p_t^X y_t^X + h_t - \frac{1 - \beta}{\beta} \left[(1 + r_t^i + \mu_t^i) b_t + \sum_{t=0}^{\infty} R_{t+1} p_t^X y_t^X + \sum_{t=0}^{\infty} R_{t+1} h_t\right] \]

This is the sustainable level of the current account. Deviations from this equilibrium condition can be written as:

\(^{32}\) Since \( c_{t+1} = c_t (1 + r_{t+1} + \mu_{t+1}) \beta \) then \( c_{t+j} = c_t \prod_{i=1}^{j} (1 + r_{t+i} + \mu_{t+i}) \beta^i \). Hence,
Solving for the equilibrium real exchange rate.

From equation (A23) we use the restriction that \( c^N_t = \theta_N c^N_t \) to obtain:

\[
\frac{y^X_t}{y^N_t} = \frac{A^X_t}{A^N_t} \frac{1}{1-\gamma} \left[ \frac{p^X_t}{p^N_t} \right]^\gamma \left( \frac{HK_t}{NR} \right)^{\gamma-\delta} \left( \frac{\eta(1+\tau^N_t)}{(1-\alpha)(1+\theta_N)} \right)^{\frac{\gamma-\theta}{1-\gamma(1-\theta)}} \left[ \frac{p^N_t y^N_t}{p^N_t} \right]^{\frac{\gamma}{1-\gamma}}
\]

Let \( k_1 = \frac{A^X_t}{A^N_t} \frac{1}{1-\gamma} \frac{1}{\gamma} \left[ \frac{HK_t}{NR} \right]^{\gamma-\delta} \left( \frac{\eta(1+\tau^N_t)}{(1-\alpha)(1+\theta_N)} \right)^{\frac{\gamma-\theta}{1-\gamma(1-\theta)}} \), then

\[
\frac{y^X_t}{y^N_t} = k_1 \left[ \frac{p^X_t}{p^N_t} \right]^\gamma \left[ \frac{p^N_t y^N_t}{p^N_t} \right]^{\gamma-\theta} \left( \frac{\eta(1+\tau^N_t)}{(1-\gamma)(1-\theta)} \right) = k_1 \left[ \frac{p^X_t}{p^N_t} \right]^\gamma \left[ y^N_t \right]^{\gamma-\theta} \left( \frac{\eta(1+\tau^N_t)}{(1-\gamma)(1-\theta)} \right) = k_1 \left[ \frac{p^X_t}{p^N_t} \right]^\gamma \left[ y^N_t \right]^{\gamma-\theta} \left( \frac{\eta(1+\tau^N_t)}{(1-\gamma)(1-\theta)} \right)
\]

To eliminate \( y^N_t \) we use the current account definition and the first order condition from the optimization of the consumer:

\[
c^M_t = \frac{p^X_t y^X_t + (r_t + \mu_t^t) b_{t-1} + h_t - CA_t}{\phi p^M_t}
\]

Use the first order condition \( \frac{p^M_t}{p^N_t} = \frac{1+\tau^N_t}{1+\tau^M_t} \frac{\alpha \omega c^N_t}{1-\alpha c^M_t} \), the restriction \( c^N_t = \frac{y^N_t}{1+\theta_N} \) and collect all terms that do not reflect the equilibrium in the non-traded goods market to get:

\[
\frac{(1-\alpha)(1+\tau^M_t)(1+\theta_N)\left[ p^X_t y^X_t + (r_t + \mu_t^t) b_{t-1} + h_t - CA_t \right]}{\alpha \omega (1+\tau^N_t) \phi p^N_t} = y^N_t
\]
Let \( k_2 = \frac{(1 - \alpha)(1 + \tau_t^M)}{\alpha \omega (1 + \tau_t^N)} \) hence

\[
y_t = \frac{k_2}{p_t^N}
\]

Replacing (A39) in (A38) we obtain

\[
\left[ p_t^N \right]^{1-\gamma} = \frac{k_1}{y_t^X} \left[ p_t^X \right]^{\alpha - \beta} \left[ k_2 \right]^{\frac{\alpha}{(1-\gamma)(1-\beta)}} p_t^N^{\frac{\alpha}{1-\gamma}} \text{ hence:}
\]

\[
\left[ p_t^N \right]^{1-\gamma} = \frac{k_1}{y_t^X} \left[ p_t^X \right]^{\alpha - \beta} \left[ k_2 \right]^{\frac{\alpha}{1-\gamma}}
\]

In order to solve for the RER we need to eliminate \( y_t^X = c_t^X + Exp_t = c_t^X + c_t^{M*} \) where \( Exp \) are exports and \( c_t^{M*} \) are the imports from the rest of the world, which is denoted by \( * \). The representative consumer for the rest of world faces a similar optimization problem to that of the domestic consumer. From her first order conditions we obtain \( \frac{\kappa}{m_t} = \lambda_t \left( 1 - \frac{1}{1+i_t + \mu_t} \right) \), and

\[
\lambda_t = \left( \frac{\alpha \omega}{(1 + \tau_t^{M*}) p_t^{M*} c_t^{M*}} \right). \text{ Assuming that taxes in the world economy are zero, we solve for the imports of the rest of the world as:}
\]

\[
c_t^{M*} = \left( \frac{\alpha \omega m_t^{M*}}{\kappa p_t^{M*}} \right) \left( 1 - \frac{1}{1+i_t + \mu_t} \right).
\]

Similarly, in the domestic economy, \( c_t^M = \left( \frac{\alpha \omega m_t}{\kappa p_t^M (1 + \tau_t^{M*})} \right) \left( 1 - \frac{1}{1+i_t + \mu_t} \right) \). Using the intratemporal arbitrage condition to express imports as a function of exports

\[
\frac{p_t^M}{p_t^X} = \frac{(1 + \tau_t^X)}{(1 + \tau_t^M)(1 - \omega)} \frac{c_t^X}{c_t^M} \text{ we have}
\]

\[
c_t^X = \frac{\alpha(1 - \omega)}{\kappa (1 + \tau_t^X)} \frac{m_t}{p_t^X} \left( 1 - \frac{1}{1+i_t + \mu_t} \right)
\]
Finally, recalling that $p_t^{M^*} = p_t^X$ we obtain the demand for exportable goods as:

\[
y_t^X = \frac{\alpha (1-\omega) m_t}{\kappa (1+\tau_t^X)} \frac{1}{p_t^X} \left( 1 - \frac{1}{1+i_t + \mu_t} \right) + \left( \frac{\alpha \omega m_t^*}{\kappa p_t^X} \right) \left( 1 - \frac{1}{1+i_t + \mu_t} \right)
\]

(A42)

\[
y_t^X = \frac{\alpha}{\kappa p_t^X} \left( 1 - \frac{1}{1+i_t + \mu_t} \right) \left( \frac{(1-\omega)m_t}{1+\tau_t^X} + \omega m_t^* \right)
\]

The equilibrium real price of non traded goods is:

\[
[p_t^N]_{1-\gamma} = \frac{\alpha}{\kappa p_t^N} \left( 1 - \frac{1}{1+i_t + \mu_t} \right) \left( \frac{(1-\omega)m_t}{1+\tau_t^X} + \omega m_t^* \right) [p_t^X]_{1-\gamma} \left[ k_1 \right]_{1-\gamma} \left[ k_2 \right]_{1-\gamma}
\]

(A43)

Note that $p_t^N = \frac{\alpha^\alpha (1-\alpha)^{1-\alpha}}{(1+\tau_t^N)^{1-\alpha}} RER_t^\alpha$ and $p_t^X = \frac{\alpha^\alpha (1-\alpha)^{1-\alpha} \omega^\omega (1-\omega)^{1-\omega}}{[1+\tau_t^M]^\alpha [1+\tau_t^X]^\omega [1+\tau_t^N]^\alpha} TOT_t^\omega$

hence

\[
RER_t^{(1-\gamma)(1-\alpha)} = \frac{\alpha^\alpha (1-\alpha)^{1-\alpha} \omega^\omega (1-\omega)^{1-\omega}}{(1+\tau_t^N)^{1-\gamma} \alpha^{(1-\gamma)(1-\alpha)}} k_1 \left[ \frac{\alpha^\alpha (1-\alpha)^{1-\alpha} \omega^\omega (1-\omega)^{1-\omega}}{[1+\tau_t^M]^\alpha [1+\tau_t^X]^\omega [1+\tau_t^N]^\alpha} TOT_t^\omega \right]_{1-\gamma} \left[ k_2 \right]_{1-\gamma} \left[ k_2 \right]_{1-\gamma} \left[ k_2 \right]_{1-\gamma}
\]

(A44)

from which equation (21) in the text obtains. The country fixed effect is:

\[
\delta_0 = \frac{1}{(1-\alpha)[\alpha(1-\omega) + (1-\gamma)(1-\alpha)]} \left[ (\varphi(1-\gamma) - (1-\varphi))(1-\alpha) - \alpha^\gamma (1-\varphi)(1-\gamma) \right] \log \alpha
\]

\[
+ \left[ (1-\gamma) - (1-\alpha) \right] \log \omega
\]

\[
+ [1-\omega] (1-\alpha) \left( (1-\gamma) - (1-\varphi)(1-\alpha) \right] \log \omega
\]

\[
+ [1-\omega] (1-\alpha) \left( (1-\gamma) - (1-\varphi)(1-\alpha) \right] \log \omega
\]

\[
+ [1-\omega] (1-\alpha) \left( (1-\gamma) - (1-\varphi)(1-\alpha) \right] \log \omega
\]

\[
+ [1-\omega] (1-\alpha) \left( (1-\gamma) - (1-\varphi)(1-\alpha) \right] \log \omega
\]

\[
(A45)
\]
### Appendix 2: Definitions and Sources of Variables Used in Regression Analysis

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