

Real Exchange Rate Fundamentals: A Synthesis of the Literature[#]

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Abstract: A general review of approaches to equilibrium real exchange rate was undertaken. The review covered most of the theoretical, methodological and empirical literatures that had been developed in the attempt to overcoming the measurement problems associated with the concept. The distinct approaches reviewed in the paper included, exchange rate equations with nominal and real disturbances, the purchasing power parity doctrine, productivity approach, macroeconomic balance, varieties of exchange rate equation models, and, behavioral equilibrium exchange rate approach. Although the models were generally theory-based and reasonably well motivated, a comprehensive evaluation of the appropriateness of some of the theoretically identified fundamentals might be a most desired status credibility check.

Keywords: International finance, open economy macroeconomics, economic growth of open economies.

1. INTRODUCTION

This review is centered on the real exchange rate (RER), the significance of which is underscored by the importance of the subject of reference. RER is an economic price with a pervading influence on other economic prices and thus is of utmost importance in the general field of international finance-cum-economics. It constitutes one of the key economic prices in respect of which conditions for optimal performance are often specified. A necessary condition is stability while proper alignment constitutes the sufficient condition. The sufficient condition presupposes a long run state at which both internal and external balances are in simultaneous equilibrium. As a result, there arises the need to ascertain when the RER is in long run equilibrium. However, being an implicit price, this task could be cumbersome and prone to errors. Consequently, various approaches to estimating and measuring the equilibrium RER had emerged in the literature.

In this paper, many of these approaches are reviewed for theoretical content, methodological applications and empirical findings. The exercise reveals that the approaches were generally theory-based with the empirical investigations supported by sound methodologies. However, there might be a cogent need to re-examine some of the approaches for credibility of associated fundamentals.

The rest of the paper is organized such that the contents are grouped under theoretical, methodological and empirical literatures as well as a concluding observation in sequential sections.

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2. THE THEORETICAL LITERATURE¹

The redefinition of the RER in terms of the relative price of tradable to nontradables (see Salter, 1959; Swan, 1956) appeared to have marked the beginning of the intense search for its determinants. However, the earliest efforts on the subject were directed at understanding only short run movements in the variable. These efforts were based on the assumption of sticky prices such that fluctuations in RER were seen as reflecting the changes in NER. Following the criticism of Meese and Rogoff (1983) on the inability of the emergent models to explain fluctuations in the exchange rate, efforts became redirected to medium and long run sources of variations in the exchange rate.

The relevant key theoretical approaches are discussed as follows.

2.1. Exchange Rate Equations with Nominal and Real Disturbances

This approach centered on the impact of nominal and real disturbances on RER determination focusing mainly on developing countries. The argument was that in the short run, both real and nominal factors were important at influencing the behavior of exchange rate; however, only the real variables mattered in the long run. These models included Khan and Montiel (1987) and Edwards (1988).

In Khan and Montiel (1987), the dynamics of real exchange rate was induced by households' asset accumulation behavior. In the model, given the current value of the real private financial wealth, the RER and

¹Part of the theoretical literature had appeared in Ogun (2019).

the real wage always adjusted to restore equilibrium in the labor and non-tradable goods market. However, the RER and real wage values that would clear the market rested on the future evolution of the economy, given the assumption of perfect foresight for economic agents. Khan and Montiel identified changes in the composition of government spending, imposition of import tariffs and export tax, terms of trade disturbances, tax-financed increase in government spending on importable goods and increase in international real interest rate (RIR) as long run determinants of RER while the nominal devaluation was the only short run determinant.

2.2. The Purchasing Power Parity Theory

According to this approach, there was the tendency for movement in the nominal exchange rate between two countries to equalize changes in the ratio of the countries' price levels, thereby leaving the RER unchanged. According to the relative version, nominal exchange rate would adjust to inflation differentials across countries. This version was more empirically tested because prices were mostly measured in indices rather than levels. It depended on arbitrage condition, which ensured that market forces would equalize prices, so that the law of one price (LOOP) held if the commodities were expressed in one currency. However, PPP's proposition that the equilibrium RER was a constant had been questioned since the fundamentals of the equilibrium real exchange rate changed as world conditions changed (Edwards, 1989), and, its inability to appropriately account for the short run movements in (real) exchange rate had been emphasized in the literature (Meese and Rogoff, 1983; Cheung *et al.* 2005; and, Kilian and Taylor, 2003).

2.3. Productivity Approach

This approach could be categorized as a flow approach as it affected RER primarily through the short run trade balance (Faruqee, 1995). In an effort to explain the deviations in absolute PPP, Balassa (1964) and Samuelson (1964) argued that productivity differential between two countries influenced movement in exchange rate. According to them, there were technological differences among countries and these differences were not the same across sectors. Technology advancement was higher in the traded goods sector than the non-traded goods sector. Therefore, by assumption, prices in the traded goods sector equaled the marginal cost. With LOOP holding, prices would equalize across countries. However, in

the non-traded goods sector where the LOOP did not hold, increased productivity in the traded goods sector would lead to rise in real wages prompting an increase in the prices of non-traded goods. Hence, all things being equal, the economy with higher productivity level in traded goods would be characterized by higher wages and prices in the non-traded goods sector generating appreciated RER (De Gregorio and Wolf, 1994; MacDonald and Ricci, 2005).

MacDonald and Ricci (2005) extended the analysis to include productivity in the distribution sector. They did not assume distribution sector acted only through the non-traded goods sector as was common in the literature. Instead, high productivity in the traded and non-traded goods sectors would appreciate and depreciate RER respectively. But, higher relative productivity in the distribution sector would appreciate the RER if the distribution sector performed a bigger role in delivering goods to the traded sector than to consumers.

2.4. Macroeconomic Balance Approach

This approach emphasized equilibrium exchange rate. It dated back to as far as Nurkse (1945) who defined equilibrium RER (ERER) as "the path needed to achieve simultaneous internal and external balance by some date in the medium run future and maintain balance thereafter".² This was also referred to as underlying balance approach. There were various versions of the approach (see e.g. Williamson, 1985 and 1994; Edwards, 1989b; Faruqee, 1995; Isard and Faruqee, 1998; Montiel, 1999). These were medium to long run RER models. The approach viewed sustainable RER as the rate that ensured simultaneous attainment of internal and external balance. Internal balance was attained when the economy was at full employment with low inflation (non-accelerating inflation rate of unemployment), while the external balance held when the underlying current account was equal to the capital account target, often described as the sustainable net flow of resources (capital) when the countries were in their internal balance.

2.4.1. Exchange Rate Equations

These were collection of theoretical models that tended to analyze the long run behavioral relationship between RER and its fundamentals, especially for developing countries. The pioneering work in this

²Cited in Soto and Elbadawi (2007).

approach for developing countries was Edwards (1989b). The other prominent contributions were Montiel (1999b) and Faruqee (1995). The three works differed in their approaches.

2.4.1.1. Flow Approach

Edwards (1989b) model was conditioned on sectoral capital flows. It employed an intertemporal framework in which the ERER did not only depend on the current value of the fundamentals but also on the expected future evolution of these variables. The central idea of the model was that the ERER responded to real disturbances. The ERER was therefore, “the relative price of tradable to nontradables that, for given sustainable (equilibrium) values of the other relevant variables such as taxes, international prices, net capital flows and technology, resulted in the simultaneous attainment of internal and external equilibrium”. Internal equilibrium held when the non-traded goods market cleared in the present period and was expected to clear in the future and external equilibrium was attained when the current account balances in the present and future periods were compatible with long run sustainable capital flows. Hence, the path that defined the ERER was a function of its current fundamentals as well as the expected future changes in these fundamentals.

2.4.1.2. Stock Approach

Montiel (1999a) argued that at one end, assumption of full adjustment in the economy’s net creditor position allowed for the conditioning of the long run equilibrium real exchange rate (LRER) on external interest rate, while at the other end, conditioning LRER on the stock of net international debt implied that the capital stock was evolving over time, though very slowly. However, while some analysts did not key into the former, they did not take the latter extreme position either but adopted the sustainable level of net capital inflow (a flow rather than a stock approach). Therefore, “the common procedure of conditioning the LRER on a ‘sustainable’ level of net capital inflows could be understood as a special case of the latter in which the adjustment in the economy’s net creditor position implied by the ongoing net capital inflow was small (in other words, the rate of adjustment of the net creditor position was slow)” Montiel (1999a:262). Hence, in contrast to Edwards, Montiel (1999b) assumed that the economy’s net creditor position had fully adjusted in the long run.

Thus, LRER was conditioned on the external interest rate rather on net capital inflow. Accordingly,

Montiel defined the LRER “as the real exchange rate that was compatible with steady-state equilibrium for the economy’s net international creditor position, conditioned on the permanent values of a variety of policy and exogenous variables”. This definition, therefore, implied that the predetermined variable, the stock of net foreign indebtedness or exogenously determined sustainable net capital inflow in some models, had fully adjusted or reached its steady state before the long run. By implication, Montiel took a different position and treated capital flow as an endogenous variable that was simultaneously determined with the short run equilibrium exchange rate. Consequently, for the external balance (defined as the current account that equaled the net capital inflow necessary to sustain the steady-state value of the economy’s net international creditor position), the model adopted the ‘stock’ rather than the ‘flow’ approach, which indicated that the economy’s net international creditor position did not appear among the set of fundamentals.

Barajas *et al.* (2011) extended the Montiel model to include worker’s remittances. They argued that, though, remittance inflow would follow the conventional view (that is, appreciating the RER), its effect would be mitigated by the share of tradable in consumption, if the remittance inflow was induced (that is, when remittance was endogenous in the model and was an inverse function of domestic households’ income).

2.4.1.3. Stock-Flow Approach

A hybrid of the “flow” and “stock” approaches was Faruqee (1995) “stock-flow” model. It built on the asset price model of Mussa (1984). Assuming internal balance would hold in the long run, the model included stock-flow adjustment of net external position based on sustainability of current account for the external balance. The model consisted of two economies that engaged in the trade of two imperfect substitutable goods and one financial asset. Hence, it integrated the permanent structural components of current and capital accounts that underlain each country’s net trade and net assets positions as determinants of that country’s long run RER resulting in two basic types of fundamental shocks as influential to RER movement: those that affected the short run trade balance (flow shocks) and those that affected the long run net foreign asset position (stock disturbances). The trade side determinants included productivity differentials affecting the relative price of non-traded goods or commodity price shocks that affected terms of trade.

In the stock-flow model of Aglietta *et al.* (1997), they argued that, though, most studies neglected indicators of non-price competitiveness, they were important in influencing foreign trade performance. Hence, their theoretical model captured this factor as a determinant of RER.

2.4.2. Fundamental Equilibrium Real Exchange Rate (FEER)

The FEER (Williamson 1985, 1994) was based on flow rather than stock equilibrium. It was an important and the most popular concept for estimating the RER under this approach in advanced countries. The FEER, though, initially described as the current account theory of RER determination, it was subsequently referred to by Wren-Lewis as "... method of calculation of RER consistent with [macroeconomic balance]"³. Clark and MacDonald (1998) and MacDonald (2000) noted that, although, the FEER was not a theory *per se*, the in-built assumption that the actual RER would converge to FEER, had embedded in it, the theory of medium-run current account determination.

The FEER approach had two distinguishing features. First, it supposed that developed economies mostly engaged in trading in differentiated goods that were sold in imperfectly competitive markets, hence, the demand curves for individual firms and economies' products were downward sloping. As a consequence of the assumption of imperfect competitive market, the net trade was specified as a function of RER, with the RER defined in terms of output or traded goods, rather than in terms of consumer prices. Second, FEER was only a medium-term equilibrium concept. Williamson (1994) defined the FEER concept as RER that ensured simultaneous attainment of internal and external equilibria. As an underlying balance model, all variables were assumed to have reached their steady state in the medium term, except asset stock. Hence, to estimate the ERER, it utilized fundamentals at their medium-term equilibrium values (such as trend output). FEER was believed to be a normative approach.

2.4.3. Natural Real Exchange Rate (NATREX) Approach

The NATREX model (see Stein 1994, 1999) was another version of the macroeconomic balance approach that was consistent with the "stock-flow" framework based on the inclusion of stock in the flow

relationship (MacDonald, 2000). It was not a theory but like the FEER was a concept for calculating RER path. The internal balance was where the rate of capacity utilization was at its long run stationary mean, while the external balance was where the ratio of the foreign debt/GDP stabilized at their long-term level (Bouoiyour and Rey, 2005). NATREX was defined as the exchange rate that equated the current account to *ex-ante* saving and investment, where these were evaluated at the level implied by fundamentals or as the RER that was consistent with portfolio balance, so that for external equilibrium, domestic RIRs equaled world RIRs (Driver and Westaway, 2004).

In this model, the sustainable capital was assumed to be equal to the difference between social savings and planned investment. While the former implied a medium-run equilibrium, the latter indicated a long run equilibrium. MacDonald (2000) pointed out that the difference between medium-run and long run equilibrium lied in the evolution of net foreign assets and capital stock, such that in the medium-run, the current account might be non-zero to the extent that the difference between *ex ante* savings and investment were non-zero but for the long run, the NFA and the capital stock were constant and the current account was zero. However, in both the medium and long run, internal balance was assumed to hold always. Three fundamental determinants had been identified as important in the movement of key endogenous variables (investment, savings, and flows of foreign debt and capital) in the model. These were time preference given by ratio of social consumption (private and government), exogenous terms of trade and productivity.

2.5. Behavioral Equilibrium Exchange Rate (BEER)

This was a short- to medium-term framework that was premised on the behavioral relationship between real exchange rate and economic fundamentals. However, unlike the exchange rate equations discussed above, it did not assess the real exchange rate based on macroeconomic balance. Theoretically, the starting point of the analysis was the risk-adjusted uncovered interest rate parity condition. The actual real exchange rate was then related to unobservable expected real exchange rate, real interest rate differential and the risk premium. The model assumed that the unobservable expected exchange rate was basically determined by long run economic fundamentals.

³Cited in Dvornak *et al.* (2003).

3. THE METHODOLOGICAL LITERATURE

Various analytical approaches had been deployed in studying the issues of movements in RER, its fundamentals and their potency at tracking the deviation of RER from long run (equilibrium) trend and the general performance of RER determinants within a macro-model structure. In what follows, I present the application of the more prominent approaches corresponding to the distinct theoretical models discussed in section 2.

3.1. Exchange Rate Equations with Nominal and Real Variables

Ghura and Grennes (1993) specified an exchange rate equation with terms of trade, closeness of the economy, capital inflow, excess domestic credit, nominal devaluation and time index (to capture technical progress) that were estimated using instrumental variable estimation technique.

Athukorala and Rajapatirana (2003) assessed the real exchange rate of 15 Latin America and Asian countries using pooled time-series annual data. The study was estimated using two stage least squares. The variables included were FDI and other capital flows, excess money supply, government expenditure, change in nominal bilateral exchange rate against the US dollars and openness.

Ok *et al.* (2010) examined the dynamic effects of real and nominal shocks on exchange rate movement in Cambodia and Lao People's Democratic Republic (Lao PDR) from January 1995 to December 2008. The study used a bivariate structural vector autoregression (SVAR) model of real and nominal exchange rates with the assumption of the long-run neutrality restriction of nominal shocks on the real exchange rate. To identify the sequence of real and nominal shocks to exchange rates, they employed the infinite moving average representation in the structural shocks. It was assumed that observed real and nominal exchange rates were subjected to two types of orthogonal shocks: the "real shock and nominal shocks".

3.2. Purchasing Power Parity

Following the PPP postulates on real exchange rate, a section of the literature on PPP concentrated on testing the stationarity of the real exchange rate using various methodologies.

Oh (1996) used a panel ADF-type test to examine the PPP validity for a group of 111 countries from 1960

to 1989. They included 23 OECD and 88 developing countries. The use of panel technique was to improve the power of the test.

However, O'Connell (1998) criticized the use of panel techniques that did not account for cross-sectional dependence among the countries because the studies were incorrectly sized. Hence, O'Connell employed the Generalized Least Squares (GLS) panel unit root test for 64 countries across Europe, Asia, South America and Africa. The use of GLS was to make the choice of the numeraire irrelevant by controlling for cross-sectional dependence.

Lee and Chou (2013) for their study adopted the panel seemingly unrelated regression ADF (SURADF) with Fourier function to account for nonlinearity and unknown smooth (structural) breaks in RER in their test for PPP validity for G20 countries.

Berka and Devereux (2010) conducted a micro-level analysis using a sample of annual price level indices (PLI's) comprising 146 consumer expenditure headings on goods and services, over 1995 and 2007, across 18 western European countries, to examine the validity of PPP. Also, for 1999-2007, they used an identical sample for 13 additional countries, mostly Eastern European. The PPP for any country and good was just the ratio of the good's price for that country to the average price of that good for the EU15. They constructed an aggregate RER for each country using the PLI's. They then compared the means of the aggregated data for different samples of countries. These were, a sample of 18 Western European countries, 12 countries in the Eurozone and a group of 6 countries with independent currencies and floating exchange rates.

3.3. Productivity Approach

Some studies had followed the line of Balassa-Samuelson model to explain the failure to validate PPP.

De Gregorio and Wolf (1994) used the seemingly unrelated regression (SUR) methodology to examine the role of productivity differential on a real exchange rate movement for 14 OECD countries from 1970-1985. They argued for the use of total factor productivity as a better proxy for productivity rather than labor productivity as was common in the literature. The regressors were total factor productivity of traded and non-traded sectors or their weighted average. Also included in the study were variables such as terms of

trade, GDP per capital and share of government expenditures.

MacDonald and Ricci (2005) examined the effect of productivity on RER for 10 countries using the dynamic OLS technique. The variables used as explanatory variables were productivity differential or productivity in the traded and non-traded sectors, productivity in the distribution sector and product market competition (the last two capture relative efficiency in the distribution sector). Others included were real interest rate differential and net foreign asset as control variables.

Berka and Devereux (2010) also attempted to explain the departure of PPP over time and across countries using relative GDP per capital. They defined relative GDP as US dollar GDP per capita relative to the EU15 average US dollar GDP per capita. So that, if real exchange rate differentials were driven mainly by differences in income per capita, countries with GDP per capita equal to the EU average should have real exchange rates at the EU average (that is, PPP should hold when compared to the EU15). Graphs and regression analysis, as well as, a simulation exercise featured in the study.

Berka *et al.* (2014) also investigated the relationship between real exchange rate and sectoral total factor productivity measures for countries in the Eurozone, both in cross-section and time series within a two-country theoretical DSGE model. The study used a good-specific PPP within the Eurozone and a sample of annual price level indices (PLI's) comprising 146 consumer expenditure headings on goods and services from 1995-2009. They applied panel regressions (pooled OLS, fixed effects, cross-sectional OLS and random effects) to the constructed sectoral real exchange rates, sectoral productivities and labor costs.

3.4. Macroeconomic Balance Approach

3.4.1. Exchange Rate Equations

Some of the studies in line with Edwards (1989) were Elbadawi and Soto (1994) and Hyder and Mahboob (2005).

Elbadawi and Soto (1994) examined the influence of capital inflow on the long-run equilibrium real exchange rate for Chile. Potential determinants of RER used were long-term capital inflow, portfolio investment, FDI, terms of trade, government expenditure, public investment and openness. The study employed the Engel and Granger two step cointegration procedure.

Hyder and Mahboob (2005), study for Pakistan also was undertaken with Engle-Granger two-step cointegration approach with OLS for estimation. The empirical model contained the real effective exchange rate as the dependent variable and the independent variables as investment to GDP ratio, government consumption, long-term capital inflow, the worker's remittance, all as percentage share of GDP. Other variables were trade openness, terms of trade and total factor productivity differential (relative to US).

Lartey (2007) analyzed the influence of nominal and real variables on the real exchange rate of a sample of sub-Saharan Africa from 1980-2000 using system GMM estimator. The explanatory variables were FDI, other capital flows, official developmental aids, government expenditure share of GDP, excess money growth, openness and lag of RER.

Following the theoretical argument of Montiel (1999) was a study by Barajas *et al.* (2011).

In the study, the authors utilized the panel dynamic OLS with fixed effects and one lead and one lag of the changes in each fundamental to estimate the cointegrated vectors. They utilized real effective exchange rate as the dependent variable. In addition to workers' remittances to GDP included as independent variables were a vast number of potential fundamentals, theoretically identified in Christiansen *et al.* (2009), for 138 countries, consisting of 56 upper-middle- and high-income countries, 38 lower-middle-income countries, and as well as 44 low-income ones. These variables were official aid as a percentage of GDP, each country's net international investment position (net foreign assets, using the net present value of debt in the case of low-income countries with largely concessional debt) relative to GDP, real per capita GDP, the country's fertility rate as a proxy for its age-dependency ratio, the terms of trade, the ratio of government consumption to GDP, indexes of trade and capital account restrictions (both separately as well as in the form of the black market premium, to capture both trade and capital account restrictions), indicators of the prevalence of administered agricultural prices as well as of the severity of agricultural price intervention, and a measure of incidence of natural disasters.

For the stock-flow approach, besides Faruquee (1995), other studies included Aglietta *et al.* (1997) and Egert *et al.* (2004).

Faruquee (1995) employed the Johansen's multivariate maximum likelihood estimation method to

estimate RER long-run relationship with its fundamentals for US and Japan. The vector error correction model (VECM) had REER as the dependent variable and NFA as share of GNP, terms of trade and two measures of productivity differentials (index of labor productivity and relative price of traded to non-traded goods, both relative to trade-weighted index of G7 countries) as independent variable.

Aglietta *et al.* (1998) used Johansen and Juselius cointegration with long-run relationship between the bilateral RER with the US and the potential fundamentals estimated with OLS. The explanatory variables were ratio of prices of traded to non-traded goods, ratio of NFA to GDP and ratio of expenditure in R and D (as an indicator of non-price competitiveness). All variables were the ratios of the United States less the same ratios in the respective countries (Germany, France and Italy).

Egert *et al.* (2004) also examined the REER of 35 countries comprising OECD countries, emerging market economies of Asia and America, and transition economies of Central and Eastern Europe. They used two alternative measures of RER (consumer price index, CPI, and producer price index, PPI) against two alternative measures of productivity (industrial labor productivity and ratio of CPI-to-PPI) and NFA. After cointegration tests, long-run coefficients were obtained via (1) fixed effects OLS, (2) mean group of individual dynamic OLS, (3) mean group of individual estimates based on the ARDL, (4) pooled mean group estimator based on the ARDL.

3.4.2. Fundamental Equilibrium Exchange Rate (FEER)

Under this approach, Akram (2004) used the cointegration approach to estimate import and export equations with the FIML method. The variables employed for the estimation were home country GDP, trading partners' GDP and REER. The estimated values were used to obtain the trade balance. These estimated values were utilized in the simulation of the FEER for Norway.

3.4.3. Natural Real Exchange Rate (NATREX) Approach

Bouoiyour and Rey (2005) and Fida *et al.* (2012) were examples of studies that utilized the NATREX approach.

Bouoiyour and Rey (2005) used the cointegration technique for their study of Morocco RER. Rather than

estimating the REER relationship directly, they related the real exchange rate to exogenous terms of trade times a function of relative prices of non-traded goods. The cointegration technique was used to estimate a cointegrating equation of relative prices of traded goods (R_n) with social time preference (sum of private and government consumption as ratio of GDP) and a measure of productivity as fundamentals. Using the estimates and the three-year moving-average of the exogenous variables, the equilibrium value of R_n was obtained. The computed values of R_n with the three-year moving-average of terms of trade were used to calculate the equilibrium REER (NATREX).

Fida *et al.* (2012) also employed the cointegration technique for obtaining the NATREX for Pakistan using three fundamentals (terms of trade, government consumption, a proxy for time preference and productivity) to regress a RER equation. The estimates were inserted into the equation and used to calculate the NATREX.

3.5. Behavioral Equilibrium Exchange Rate (BEER)

Maeso-Fernandez *et al.* (2002) applied the BEER approach to examine the determinants of the real effective exchange rate of a synthetic Euro. The variables used as determinants were interest rate differential, productivity differential, real price of oil and fiscal spending. The estimation method was the Johansen cointegration technique with VECM specification.

Nilsson (2004) investigated the influence of net foreign debt, relative terms of trade, relative price of traded to non-traded goods as well as relative interest rate differentials on Swedish REER. The Johansen maximum likelihood estimator was likewise employed to examine the long-run relationship between the variables.

On their part, Peng *et al.* (2008) examined China's RER. The analysis employed the Johansen's maximum likelihood estimator. However, the fundamentals did not include interest rate differential in the estimation. The potential determinants used were government consumption, trade openness, terms of trade (export to import as proxy), and relative productivity in traded to non-traded goods sector (proxy for the Balassa-Samuelson effect).

Bénassy-Quéré *et al.* (2009) also used the BEER approach to study equilibrium real exchange rate and macroeconomic fundamentals in a group of 15

countries that were members of G20. The sample also included sub-groups of G7 and non-G7 countries. The cointegrating relationship was estimated with the panel dynamic OLS (PDOLS) procedure. The variables involved were the real effective exchange rate estimated against the net foreign asset position in percentage of GDP, terms of trade, real interest rate differential and different measures of relative productivity differential.

Bereau *et al.* (2010), however, investigated a non-linear adjustment in equilibrium real exchange rate for the same group and sample in addition to Asian developing countries and countries that had overcome the then recent financial crisis using the panel smooth transition regression (PSTR) model. The variables utilized were the real effective exchange rate and a set of fundamentals, which were the net foreign asset position as a share of GDP, the relative CPI-to-PPI ratio as a proxy for productivity differential, terms of trade, and the interest rate differential. The parsimonious cointegrating relationship was then estimated with the PDOLS procedure. To explore the possibility of non-linearity in adjustment, the corresponding panel smooth transition regression (PSTR) error correction model was estimated.

4. THE EMPIRICAL LITERATURE

The general literature on empirical studies of the RER are summarized under distinct headings as follows.

4.1. Exchange Rate Equations with Nominal and Real Disturbances

Edwards (1988) examined the influence of economic fundamentals on RER through their effects on the changes in households demand for domestic money holdings and the rate of spread between dual nominal exchange rates. In the model, RER was affected by policy and exogenous variables. He identified the following real variables as the long run determinants of real equilibrium exchange rate: imposition of import tariffs, terms of trade disturbances, changes in government consumption of non-tradable goods and capital flows. The short run effects were exerted by nominal variables principally, domestic credit creation and nominal devaluations. One-time unanticipated increase in domestic money raised private wealth. This generated an incipient excess demand for non-traded goods, which required real appreciation to restore equilibrium. A discrete nominal

devaluation could help to speed up the adjustment as it countered the effects of excess money supply and fiscal deficit.

An empirical test of the model by Ghura and Grennes (1993) revealed that for a group of about 33 sub-Saharan African countries, macroeconomic fundamentals played vital role in real exchange rate fluctuations in the short-run. Real exchange rate appreciation was associated with capital inflow, terms of trade improvement, decrease in openness, increase in excess domestic credit as well as improvement in technology but nominal devaluation depreciated the real exchange rate.

Also, Arthukorala and Rajapatirana (2003) in their assessment of impact of capital flow and other control variables on real exchange rate in Latin America and Asia reported that while other capital flow appreciated the real exchange rate, FDI depreciated it. Increase in excess money supply and government expenditure had negative effects (appreciation), though the former's impact was not significant. Nominal devaluation and openness had significant positive effects.

Ok *et al.* (2010) findings from the impulse response function analysis showed that the response of real and nominal exchange rates to a real shock was depreciation with a persistent nature for both countries' currencies, hence, a long-run real and nominal depreciation of both currencies, with the exchange rates converging to a new long-run equilibrium level. They, also, reported that the dynamic response of nominal exchange rates to a real shock was with a similar magnitude as that of real exchange rates to a real shock, especially for Lao PDR, which implied that permanent changes in real exchange rates due to a real shock were largely due to changes in nominal exchange rates rather than through relative price levels. However, using technology as a type of real shock, the effects of a real shock on real exchange rates was discussed in the Balassa-Samuelson framework that real exchange rate movements in the long-run could be explained by productivity growth in tradable sectors, implying that technology shock will induce real appreciation in the real exchange rates in the long-run. Comparing the two countries, real shock induced relatively small response in Cambodia in the long-run while it induced relatively large responses in Lao PDR.

The effect of a nominal shock on the exchange rates of Cambodia and the Lao DPR indicated that, for

both currencies, the response of real exchange rates to a nominal shock was real appreciation at the initial stage, but it converged to zero within one year, while, the response of nominal exchange rates to a nominal shock was a permanent effect of nominal depreciation. They explained that “the non-zero response of nominal exchange rates to a nominal shock implies that a nominal shock could lead to a permanent divergence between nominal and real exchange rates so that the relative prices are permanently changing”, which relates to why nominal exchange rates are not cointegrated with real exchange rates.

4.2. Purchasing Power Parity

Oh (1996) tested the validity of PPP for 111 countries and its subsamples for 1960-1979. For the general case, the panel ADF-type test validated the PPP theory. For OECD and G7 countries, there was a strong rejection of the null hypothesis of non-stationarity during the flexible exchange rate regime but not for developing countries. The study also found contrasting result between developing and developed countries, PPP was found to hold for developing countries during the fixed exchange rate regime unlike for the OECD countries for a longer period of about 40 years (1950-1990).

O’Connell (1998), however, invalidated the outcome of these panel studies that found stationarity of real exchange rate after controlling for cross-sectional dependence among the countries used for panel investigation.

Using monthly data, Lee and Chou (2013), confirmed validity of PPP for G20 countries for the period January, 1994 to April, 2010. The result also showed the existence of non-linearity and structural breaks in the real exchange rate of these countries.

Berka and Devereux (2010) found out that within the Eurozone, and particularly outside the zone, there was a large and continued departure from PPP in the aggregated data. The study noted that, although there was some tendency for price differentials across countries to narrow over time, the fall in dispersion across countries was very small relative to the departures from overall PPP. Decomposition of real exchange rates and price dispersion separately into tradable and non-tradable goods showed that in terms of deviation from EU average, even traded goods exhibited substantial and continued departure from PPP in both directions. For the non-traded goods

categories, it was similar, except that the magnitude of departures from PPP were substantially greater for the countries both above and below the EU average.

4.3. Productivity Approach

De Gregorio and Wolf (1994) conducted a test of the model and their results for 14 OECD countries showed that increase in productivity differential was highly influential in the movement of RER resulting in appreciation as equally did terms of trade improvement. Other variables included to capture demand side effects: GDP per capita and government expenditure also appreciated the real exchange rate.

Similarly, MacDonald and Ricci (2005) findings underscored the importance of productivity in the 10 countries studied; not even the inclusion and exclusion of the control variables (interest rate differential and NFA) one at a time or simultaneously in the basic model could change the size or alter the sign of the Balassa-Samuelson term (productivity differential) or its components (productivity in traded and non-traded sectors). They interpreted this outcome to mean that macroeconomic variables were less significant than real variables capturing Balassa-Samuelson effect. Besides, NFA and real interest rate differential did not exhibit evidence of cointegration with real exchange rate without productivity and distribution effects, further underlying the importance of these variables. Also, the extension of the basic model to include productivity in the distribution sector and product market competition (to capture relative efficiency in the distribution sector) did not affect the size, sign or significance of the Balassa-Samuelson term. However, the coefficients of the additional variables indicated that improvement in them significantly appreciated the RER, implying that the distribution sector influenced the RER as traded sector rather than as a non-traded sector earlier assumed in the literature.

Berka and Devereux (2010) graphical analysis suggested that the relationship between GDP per capita and real exchange rates was close both across countries and over time, even within countries. Movements in relative GDP per capita were associated with movements in real exchange rates in the same direction. The OLS regression results of country level real exchange rate on relative GDP, distance (proxy for trade cost) and Euro membership dummy, also suggested similar findings with the effect of relative GDP being highly significant in all goods, traded and non-traded, for Western and Eastern Europe. The

elasticity of real exchange rate to relative GDP per capita was equal to 0.35 on average within countries. Simulating a general equilibrium model using the historical relative GDP per capita for each country, showed that for most (not all) countries, there was a very close fit between the actual and simulated real exchange rate.

Berka *et al.* (2014) findings showed that the relationship between the real exchange rate and the traded and non-traded total factor productivity and unit labor costs had the expected signs and were significant at 5 percent level in all four empirical approaches, except non-traded TFP that was marginally insignificant in the cross-sectional regression. An increase in traded productivity increased a country's overall consumer price level (relative to the price level of the EU as a whole). An increase in non-traded productivity, on the other hand, was associated with a real depreciation. Also, holding productivity constant, an increase in unit labor costs raised the country's relative consumer price level.

4.4. Macroeconomic Balance Approach

4.4.1. Exchange Rate Equations

The different findings under this subhead were discussed in sections as follows.

4.4.1.1. Flow Approach

Elbadawi and Soto (1994) test of the model showed that short-term capital flows and portfolio investment had no effect on the ERER (although they could affect the RER in the short run). For contrast, long-term capital inflows and FDI had a significant appreciating effect on the ERER. Other significant fundamentals in the study included, degree of openness and terms of trade (TOT) (both depreciating the RER), and, ratio of government expenditure to GDP (appreciating). However, the TOT outcome was a departure from convention.

Furthermore, Hyder and Mahboob (2005) study revealed that, on the contrary, increase in net capital inflows, increase in government expenditure and an increase in total factor productivity differential relative to trading partners as well as an increase in trade openness were associated with a depreciation of real effective exchange rate (REER). Also, an increase in workers' remittances, improvement in terms of trade led to appreciation of REER. However, Lartey (2007) study of a sample of SSA countries produced contrary result for capital inflow. The FDI was found to

appreciate RER while other capital flows depreciated it, though, not significantly. Also, official development aids had an appreciating influence greater in magnitude than FDI. In terms of other fundamentals, greater openness and increased government expenditure had the expected signs while excess monetary growth was found not to be insignificant.

4.4.1.2. Stock Approach

According to Barajas *et al.* (2011), investigation of the effect of remittances depended on the particular country being studied and to a lesser extent on the set of fundamentals included in the study. The richer the country and the more trade and financially restricted the economy was, the more conventional was the result. Also, while the Middle-East and the North African countries tended to have significant appreciation of the RER for a permanent increase in remittance inflow, the Asian countries had significant depreciation of their RER. In Latin America, the results from the various regressions were mixed with mostly insignificant real depreciations. For the non-remittance fundamentals, the study found that net foreign assets (NFA), government consumption to GDP, fertility, black market premium, all, appreciated the REER while aid to GDP, administered agricultural prices, natural disasters, productivity (real GDP per capita) were associated with real depreciation. Besides NFA, black market premium and natural disaster that were regressed only in level, others were estimated both at levels and relative to trading partners. Increased trade restrictions, however, showed contrasting results. Regression at level depreciated the REER while it appreciated the REER when estimated relative to trading partners.

4.4.1.3. Stock-Flow Approach

Using the data of the United States of America (USA), Faruquee (1995) Faruquee (1995) showed that the included fundamentals principally, NFA, the two measures of productivity differential and TOT had the correct signs, however, only NFA and productivity differentials were important in long-run determination of the REER (LREER) based on test of exclusion. Also, for Japan, productivity differential was the major determinant of LREER as it was rejected in every exclusion test while the test for NFA and TOT might or might not be rejected depending on the lag length specification.

For contrast, Aglietta *et al.* (1997) revealed that in the case of Germany, France and Italy both individually

and simultaneously, productivity differentials significantly depreciated the bilateral RER with the dollar but NFA and the non-price competitiveness indicator appreciated the exchange rate.

The result of Egert *et al.* (2004) using consumer price index (CPI)-based REER showed that for OECD countries, both labor productivity and the ratio of CPI-to-PPI appreciated the REER, but the size of the latter was high in absolute value; this they argued to mean that the CPI-to-PPI ratio conveyed different information. Hence, it was not a good proxy for productivity. In the model, labor productivity also captured the effects of non-price competitiveness. For the emerging economies, increase in both measures of productivity also appreciated the REER. NFA result was inconsistent. For the transition economies, productivity differentials significantly appreciated the RER but the NFA had significant depreciating effect. Using the PPI-based REER, they reported for OECD countries that productivity variables and NFA significantly depreciated and appreciated the REER, respectively. However, for the transition and emerging economies, increase in productivity variables had an appreciating effect while the NFA was associated with depreciation. Further analysis, revealed that when labor productivity was used along with NFA, the NFA showed a positive relationship (depreciation) with the REER but if regressed with CPI-to-PPI ratio was negatively related to REER for emerging economies. When both measures were included simultaneously in the model, in most cases, both variables were significant. For the OECD countries, they had opposite signs (positive for labor productivity and negative for CPI-to-PPI ratio).

4.4.2. Fundamental Equilibrium Exchange Rate (FEER)

Akram (2004) showed through simulation that the equilibrium real exchange rate of Norway would depreciate overtime as a result of economic growth induced increase in the import level relative to permanent income.

4.4.3. Natural Real Exchange Rate (NATREX) Approach

For this approach, Bouoiyour and Rey (2005) deduced the impact of fundamentals on REER from their influence on the relative price of non-traded goods from which the REER was computed. The result showed that government consumption per GDP appreciated the relative price of non-traded goods while private consumption per GDP was associated with depreciation. In addition, increase in productivity

depreciated this relative price. However, based on a direct estimation from which the NATREX was computed, Fida *et al.* (2012) reported that government consumption (the only proxy for time preference) and terms of trade had significant appreciating effects on the RER while productivity had an insignificant appreciation on the exchange rate.

4.5. Behavioral Equilibrium Exchange Rate (BEER)

Maeso-Fenandez *et al.* (2002) found evidence of EREER appreciation for increase in domestic country's interest rate, government expenditure, NFA, and price of oil for the synthetic Euro.

Nilsson (2004) result showed that productivity improvement, increase in NFA depreciated the EREER of Sweden. RER appreciation was associated with improvement in terms of trade.

However, Peng *et al.* (2008) reported that productivity differential, improvement in terms of trade and government expenditure appreciated RER but trade openness depreciated RER for China. Similarly, Bénassy-Quéré *et al.* (2008) and Bureau *et al.* (2010) found that appreciation of the RER was associated with increase in productivity differential, NFA and improvement in terms of trade. However, both studies omitted interest rate differential after it was found stationary.

CONCLUDING OBSERVATION

The proliferation of RER models/theories appeared to have been greatly influenced by the perceived need to reduce to the barest minimum, errors in the estimation of EREER and by extension, RER misalignment series. In this respect, successive models tended to lay claim to some degree of superiority over earlier models. However, as noted in the introductory section of this paper, efforts in this endeavor appeared to have been beleaguered by the implicit nature of RER. Hence, considerable amount of care was required in conceptualizing the effect and measurement of the variables deemed qualify for inclusion in the models.

Future studies could contribute to the literature on this subject by conducting comprehensive tests of the relative effectiveness of the various models within the context of EREER estimation. Such studies would constitute status credibility checks and could inform the choice of particular variables as fundamentals in RER analysis.

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