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Study on Alternative Indices (Other than NEER/REER) for Assessing Fair Value of INR

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***Abstract*:** The study examines various alternative indices other than real effective exchange rate (REER) and empirically estimates Behavioural Equilibrium Exchange Rate (BEER) for India. The results indicate that the existing REER is in line with the BEER, barring crises related episodes such as pre-global financial crisis of 2008-09, taper tantrum, US-China trade tensions and the Covid pandemic. Further, it is observed that higher productivity, favourable terms of trade, net foreign assets and higher interest rate differential cause the equilibrium real exchange rate to appreciate while, increase in gross fiscal deficit depreciates it.

I. Introduction

Exchange rate is considered to be a forward-looking indicator of the country's external competitiveness. In an uncertain environment, however, exchange rates often exhibit heightened volatility and could get delinked from economic fundamentals. This can adversely impact economic activities including cross-border trade and investment decisions. Understanding the appropriate value of a currency can help central banks to evaluate market conditions and support financial stability and monetary policy transmission. The central issue, however, is how to figure out whether the currency is fundamentally overvalued or undervalued.

The real exchange rate (RER), which considers the value of a country's goods against the basket of currencies of trading partners at the prevailing nominal

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exchange rate is a useful measure for this purpose. Over the years, several models for deriving the fair value using real effective exchange rate (REER) as the base in the estimation process, have been developed (Table 1). The Behavioural Equilibrium Exchange Rate (BEER) family of models is one of them. In this model, Clark and MacDonald (1999) propose the estimation of a reduced-form equation in order to explain the behaviour of the REER, both, in the short and medium run.

The acronym BEER is often used to indicate, a whole family of models that follow similar methodologies. These models empirically estimate the BEER by using the fitted values of a cointegration relationship between the REER and a set of fundamentals. Extension of the BEER approach is among the most popular fair value models among policy making institutions and in the financial industry.

Table 1: Alternatives Methods to REER

Method	*Variable*	*Advantage*	*Disadvantage*
Purchasing Power Parity (PPP)	Basket of goods	Oldest and simplest measure. For example, Big-mac index by the Economist	A long run concepts. Limitations due to existence of non-tradable goods and services which are not subject to cross-country arbitrage.
Behavioural Equilibrium Exchange Rate (BEER)	Considers economic fundamentals, such as productivity, interest rate differentials, net foreign assets, terms of trade, and fiscal position	Decomposes the variables that determine the real exchange rate into long-term economic fundamentals and short-term real interest rate differentials. The approach offers a way of exploiting a theoretical (real) exchange rate model to obtain a measure of the equilibrium exchange rate.	Used to be calculated for industrial countries and recently for transition countries. The approach relies critically on the assumption that a stable long-run relationship can be derived from historical data which makes the BEER approach difficult for countries that have undergone substantial structural changes or which lack historical data.
Fundamental Equilibrium Exchange Rate (FEER)	Potential Output at full employment, stable prices and the current account balance	Focuses on the long-term equilibrium level of exchange rate based on economic fundamentals. The FEER is defined as the exchange rate that is consistent with both internal and external balance simultaneously. Unlike the simple PPP approach, the FEER approach allows the equilibrium exchange rate to move as fundamentals change.	Does not specify how the exchange rate moves from the current level to the long-term equilibrium rate. The estimates often require an extensive multi-country macroeconomic model. Removes speculative capital flows from the medium-term capital account, which makes it is difficult to account for the impact of short-run changes in the interest parity condition. The approach assumes that the interest rate remains at the long-run equilibrium level, implying severe restrictions on how monetary policy can be modelled.

Method	*Variable*	*Advantage*	*Disadvantage*
Desired Equilibrium Exchange Rate (DEER)	Follows FEER approach. Variables related to internal and external balance	Considers a current account target set by policymakers as part of overall macroeconomic policy.	It is an extension of FEER.
Natural Real Exchange Rate (NATREX)	Capital, external debt, a random error (assumed to capture speculative forces), and a vector of fundamentals.	Provides the exchange rate that would prevail if speculative/ cyclical factors were removed, and unemployment is at its natural rate. For long-term equilibrium, the question of dynamic exchange rate adjustment may be addressed by the NATREX approach.	The model does not specify to what extent the real exchange rate will vary due to changes in the nominal rate and to what extent it will change due to relative prices. The exchange rate regime determines the method of adjustment.

Usually, countries do not announce the index they track for exchange rate monitoring except countries that follow stabilized exchange rate arrangement such as Singapore which follows nominal effective exchange rate. However, most of the advanced economies and international organisations (IMF, BIS, OECD) publish broad and narrow indices related to real effective exchange rates (Table 2).

Table 2: Country/Agency and Methods of Fair Value Assessment

Country/ Agency	*Indices/Methods Used to Assess Fair Value of Currency*	*Reference*
Monetary Authority of Singapore (MAS)	MAS utilizes the Singapore Dollar Nominal Effective Exchange Rate (S$NEER), a trade-weighted index comprising bilateral exchange rates between Singapore and its major trading partners. Weights are assigned based on the significance of trade relationships, allowing the Singapore dollar to perform collectively in relation to its major trading partners, which influences general price levels in Singapore.	"What is the S$NEER? How MAS Manages Singapore's Monetary Policy with IT" Investment Moats
European Central Bank (ECB)	The ECB employs the Euro Effective Exchange Rate (EER) indices, which include both nominal and real indices to evaluate the euro's competitiveness. The EER is calculated against a basket of major trade partner currencies, with weights assigned based on trade volumes.	"Effective exchange rates - European Central Bank" European Central Bank
People's Bank of China (PBoC)	The PBoC assesses fair value through the CFETS RMB Index, a basket-based index where the Chinese yuan is compared against a weighted basket of currencies from major trading partners. This method reflects the exchange rate's impact on the trade balance and competitiveness.	"China Foreign Exchange Trade System (CFETS) - RMB Index"
Bank of Japan (BoJ)	The BoJ calculates the Japanese Yen Effective Exchange Rate, an index weighted by trade volumes with Japan's major partners. It includes both nominal and real rates to reflect competitiveness and trade balance impacts.	"Bank of Japan - Effective Exchange Rates"

Country/ Agency	*Indices/Methods Used to Assess Fair Value of Currency*	*Reference*
Federal Reserve (USA)	The Federal Reserve uses the Trade-Weighted U.S. Dollar Index, which compares the dollar to a basket of currencies weighted by U.S. trade relationships. The Fed also publishes real and nominal indices to assess the dollar's relative value.	"Federal Reserve Economic Data (FRED) - Trade-Weighted U.S. Dollar Index"
Bank of England (BoE)	The BoE relies on the Sterling Effective Exchange Rate Index (ERI), a trade-weighted index including major trading partners. The index is used to assess the competitiveness and stability of the pound against a basket of currencies.	"Bank of England - Effective Exchange Rates"
Swiss National Bank (SNB)	The SNB uses both the Nominal and Real Trade-Weighted Indexes to assess the Swiss Franc's value. The real index adjusts for inflation, aiding in the assessment of purchasing power parity and competitiveness.	"Swiss National Bank - Exchange Rates"

In the next section, theories related to the various exchange rate models along with literature and empirical review have been discussed.

II. Theoretical and Literature Review

The starting point of exchange rate theories is purchasing power parity (PPP) which dates back to the sixteenth century in Spain and early seventeenth century in England and was revived by Gustav Cassel in 1918. The model states that exchange rate in two currencies is based on the relative price level of the two countries. PPP also called 'law of one price' theory states that arbitrage forces will lead to equalization of goods prices internationally, once the prices are measured in the same currency. It is also known as the inflation theory of exchange rate (Bulut, 2018). There are absolute or static versions of PPP. PPP based exchange rate can be expressed as a spot exchange rate in terms of relative cost of the basket in the two countries.

Rupee per dollar exchange rate = Price of a basket of commodities in India / Price of a same basket in US

For example, if a basket of goods costs Rs. 1000 in India and $ 250 in the US then PPP based exchange rate will be Rs. 4 per dollar.

In relative or dynamic form of PPP rate of change in exchange rate is equal to difference between the change in price level *i.e.*, inflation rate.

$$S_t = p_t - p_t^*$$

The PPP theory is based on the assumption of perfect market conditions with perfect flow of information in domestic and foreign markets. Officer (1976) argues that in practice, it may not hold due to tariff and non-tariff barriers, transport costs, autonomous capital flows, speculative forex market. Purchasing power parity assumes that trade flows dominate the foreign exchange market, but in reality, they do not; portfolio flows do. Capital flows clearly play a considerable role in driving currency prices, which purchasing power parity ignores entirely.

A basic assumption of the equilibrium exchange rate models is stationarity, *i.e.*, the exchange rate reverts to a constant mean over some time frame. However, many scholars contend that the mean reversion property, if it occurs completely, happens at a very slow rate. This slow adjustment, commonly known as "PPP Puzzle" (Rogoff, 1996), led to numerous explanations to account for the sluggish nature of the process (Taylor, 2001). Broady, two schools of thought have emerged as a response to empirically modelled equilibrium exchange rate – one, based on internal and external balance and second, a reduced form regression, based on fundamental factors that impact the exchange rate. The fundamental equilibrium exchange rate (FEER) model and the desired equilibrium exchange rate (DEER) fall into models of the first kind, whereas the behavioral equilibrium exchange rate (BEER) and NATREX (NATural Real Exchange rate) form the second school of thought.

To understand the misalignment, Williamson (1994) developed the FEER approach which focuses on exchange rate which is consistent with achievement of internal balance (full employment output with stable and low inflation) and external balance (sustainable level of BOP over a medium term). FEER approach involves judgment on estimates of potential output for domestic and major trading partner countries, components of current account balance and an optimal level of external balance over a medium term. FEER involves estimating the equilibrium exchange rate for the 'ideal macroeconomic situation' expected over the medium term, *i.e.,* a desirable medium term exchange rate. The normative nature of the approach does not explain the current disturbances but assumes an adjustment towards the equilibrium rate, without specifying the nature of adjustment (Clark and MacDonald,1998). Much focus on the normative issue of "target capital account" has been the center of controversy. FEER estimates by Artis and Taylor (1995), Barrell and Wren-Lewis (1989), Currie and Wren-Lewis (1989a and b), Edison, Williamson and Miller (1987), Williamson (1994), Frankel (1996) and Frenkel and Goldstein (1986) modelled equilibrium current account in terms of sustainable capital flows as a proportion of GDP, often arrived at, in an ad-hoc manner (Driver and Westaway, 2004).

Faruqee and Debelle (1996) and Masson (1999) addressed the issue by equating current account with net domestic savings. This approach employs a host of factors such as the demographics and government's fiscal position. However, a criticism of this approach by Mac Donald and Clark (1998) argues that since rates of return on assets do not form a part of the model, the FEER essentially models current account (and in turn capital account) as a function of savings and investment without any feedback of impact of shift in asset prices on exchange rate and thereafter the current account.

Desired equilibrium exchange rate (DEER), an extension of FEER is methodically similar to the former. However, unlike FEER, which models "target current account" under existing policies, it allows the researcher to estimate the equilibrium exchange rate driven by the "desired policy choice". Bayoumi and others (1994) estimated the DEER assuming that the targeted current account surplus was equal to 1 per cent of GDP.

Under the second school of thought, the Behavioural Equilibrium Exchange Rate (BEER) has emerged as an alternative to the FEER and DEER, which limit their usefulness to the policymaker due to their inherent subjectivity and static nature. The BEER approach disintegrates the determinants of the equilibrium exchange rate into long-term economic fundamentals and short-term interest rate differential (IMF). It is able to identify random noise, impact of transitory factors and deviation from economic fundamentals to explain cyclical and sporadic fluctuations in the exchange rate due to the prevailing economic situation unlike FEER/DEER (a medium-to-long run concept) that works on "full employment situation".

Starting point of the BEER is risk-adjusted interest parity condition, Mac Donald and Clark (1998) use the Johansen (1995) approach to model the BEER as a function of interest rate differentials, risk premium, terms of trade, Balassa-Samuelson effect and net foreign assets. BEER, by virtue of its construction, implies that the long run relationship between variables makes any departure of the actual exchange rate from the estimated BEER unsustainable and short-run dynamics will adjust to bring the exchange rate back in line with the BEER (Clark and MacDonald, 1999).

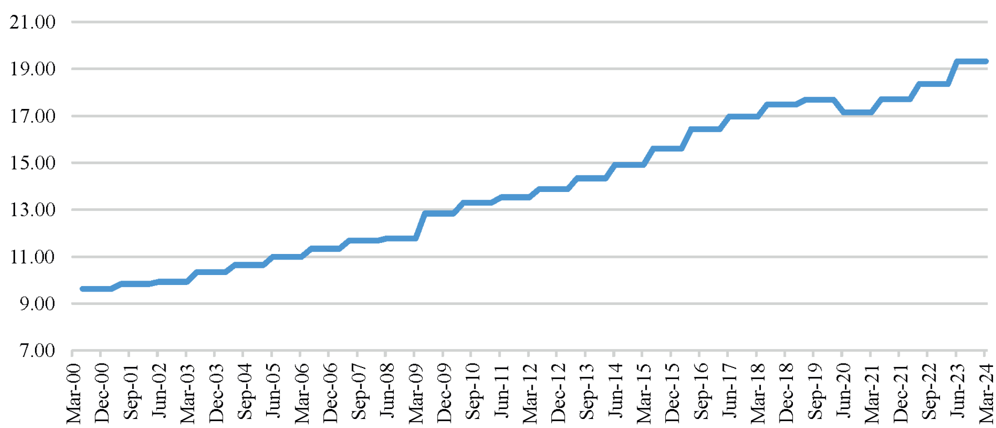
Against this background considering the theoretical and empirical review available inthe Indian context (Patra *et al.*, 2024; Raut, 2022; Kumar 2010) about the applicability and usefulness, in the next section, stylised facts about the select variables has been explained to understand and later estimate the BEER approach.

III. Stylised Facts

According to the Balassa-Samuelson (BS) effect, if productivity in the tradables sector grows faster than in the non-tradables sector compared to foreign economies, the resulting higher wages in the tradables sector will put upward pressure on wages in the non-tradables sector, resulting in a higher relative price of non-tradables. This causes an overall price increase and appreciation of the domestic real exchange rate.

In the Indian case, various studies (Banerjee and Goyal, 2021; Raut, 2022; Kumar, 2010) observed the existence of the BS effect. To understand the productivity differential, Chart 1 plots the relative per capita GDP of India. It is observed that productivity has been consistently increasing, with major shifts during GFC and Covid.

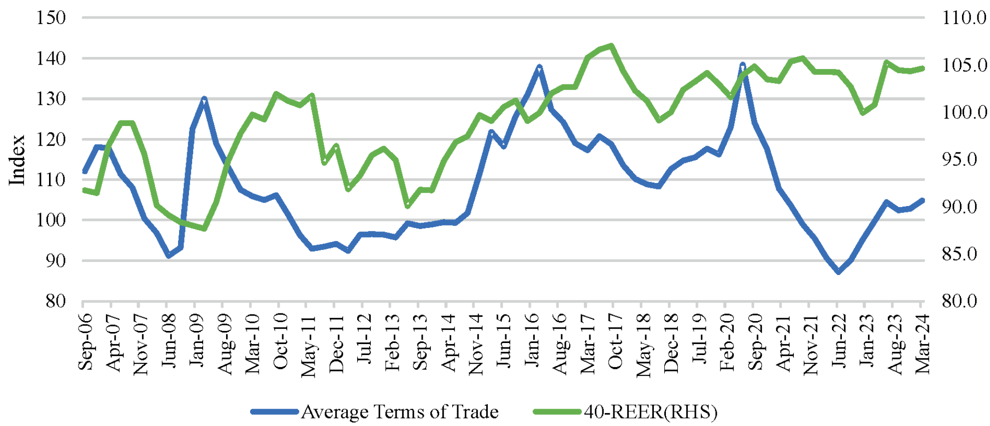
Chart 1: Relative Per Capita GDP



Source: World Bank and authors' estimation.

Terms of trade (TOT) can impact exchange rate by affecting currency demand. TOT is a ratio of country's exports to its import prices. As it is calculated by dividing the export prices by import prices and multiplied by 100, positive value indicates improvement in the TOT, while negative value shows worsening. Improved ToT increases demand for a country's exports, which increases revenue from exports. This leads to increased demand for the country's currency, which appreciates the real exchange rate through real income or wealth effect. Higher TOT is generally found to be positively associated with REER appreciation; however, the Covid pandemic seems to have broken the relationship (Chart 2).

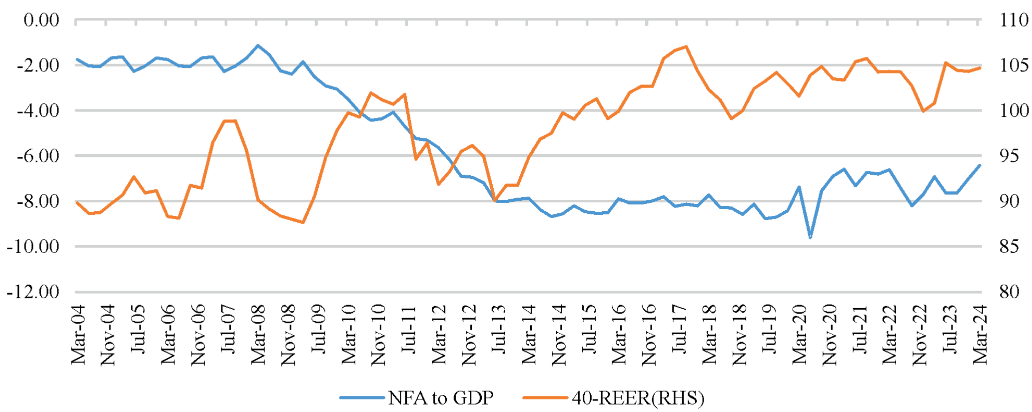
Chart 2: REER and Terms of Trade



Source: IMF and RBI.

Net foreign assets (NFA) are expected to have a positive impact over the REER of a country. This follows the simple logic that debtor countries or countries with higher liabilities than assets would need a more depreciated real exchange rate to generate the trade surpluses necessary to service their external liabilities. Conversely, economies with relatively high NFA can afford more appreciated real exchange rates - and the associated trade deficits - while remaining solvent. In the Indian case, considering the trade deficit, NFA has remained in negative territory (Chart 3).

Chart 3: REER and NFA to GDP Ratio



Source: RBI, NSO and authors' estimates.

Another factor that influences the equilibrium exchange rate is the government consumption expenditure. Higher government consumption expenditure (as a ratio to GDP) is likely to appreciate the real exchange rate to the extent that such consumption expenditure falls more on non-tradables than tradables, thereby raising the relative price of the former (Lee *et al.*, 2008). When government spends more than it earns, it creates a fiscal deficit, which can be bridged by borrowing abroad or issuing bonds in the local currency. Therefore, increase in fiscal deficit could lead to depreciation in real exchange rate, as foreign borrowing increases demand for foreign currency, while domestically raised debt decreases domestic currency value.

IV. Empirical Methodology and Estimation

As per the Johansen (1995) approach to calculate equilibrium REER through BEER is defined as below.

$$BEER = f(Interest\ rate\ differential, Risk\ Premium, Terms\ of\ Trade, Balassa - Samuelson\ effect, Net\ foreign\ assets \tag{1}$$

This equation can be reduced in the following way:

$$BEER = f(Interest\ rate\ differential, Terms\ of\ Trade, Realtive\ GDP\ per\ Capita, Net\ foreign\ assets\ to\ GDP\ Ratio) \tag{2}$$

While the NFA to GDP ratio (NFA_GDP) is expressed in per cent, relative GDP per capita and net TOT are transformed into their logarithmic forms to stabilise variances. For the empirical estimation a set of the select variables with quarterly data from 2004-05:Q1 to 2023-24:Q4 has been used. Table 1 provides details of the variables/indicators that have been used for the empirical analysis.

To check the time series properties of the variables, standard unit root tests are conducted. It is found that the select variables are stationary at level or at first difference (Annex table 1). Therefore, following Patra *et al.*, (2024) an Auto regressive distributed lag (ARDL) model is used. The ARDL model examines the relationship between a dependent variable and one or more independent variables while capturing both short-run dynamics and long-run equilibrium relationships. This makes it highly suitable for time-series data with potential lags in effects. The model includes lags of both dependent and independent variables

Table 1: Variables and Description

Variable	*Indicator*	*Data Description*	*Source*
NFA to GDP	Net foreign assets to GDP ratio	Ratio of net foreign assets to the nominal GDP.	RBI, NSO
GFD to GDP	Central government's gross fiscal deficit as a ratio to the GDP	Difference between the total expenditure and the total non-debt capital receipts. It indicates the total borrowing requirements of the government	RBI DBIE
Relative Per Capita GDP	Relative real per capita GDP	A ratio of domestic to world real GDP per capita	World Bank
Terms of Trade	Annual/ IMF database (Gruss and Kebhaj 2019).	Log of terms of trade index (June 2012=100) is the commodity net export price index (weighted by net exports to total commodity trade).	IMF
REER	40-currency trade based REER	40-currency trade based REER (base year 5015-16) captures 88 per cent of India's trade	RBI DBIE
Interest Rate Differential	Difference between UST and 10 year Gsec.	Higher interest rates attract foreign investors, which increases demand for and the value of a country's currency. This leads to an increase in exchange rates.	https://fred.stlouisfed.org/ and CEIC

to capture the dynamic relationships over time. The model will assess how these macroeconomic variables influence the real exchange rate both in the short run and the long run.

The results indicate that in line with the theory, the fundamental determinants of BEER are statistically significant with expected signs in the case of India. It shows that relative GDP per capita, a proxy for the productivity differential, NFA to GDP ratio, terms of trade and net interest differential positively impact the BEER while GFD to GDP ratio negatively impact the BEER. The Error Correction terms (ECT) is negative with an associated coefficient estimate of -0.50 which is highly significant. The bounds test confirms the existence of long-term relationship between the variables (Table 2).

Table 2: ARDL Results of BEER Estimation

Variable	*Coefficient*	*T-Statistics*	*P-value*
ECT_{t-1}	-0.50***	-6.981	0.00
$Ln(Relative\ GDP\ Per\ Capita)_t$	0.28*	1.695	0.09
$Ln(Net\ Terms\ of\ Trade)_t$	0.08***	2.579	0.01
Net Foreign $Assets$ to GDP Ratio_{t-2}	0.01*	1.892	0.06
$Ln(Interest\ Rate\ Differential)_t$	0.08***	2.986	0.00
$Ln(GFD\ to\ GDP)_{t-3}$	-0.05***	-3.213	0.00
C	1.04**	6.998	0.01
Residual Diagnosis			
Adjusted R^2	0.89	AIC:	-4.91
F-statistic	31.87	DW:	2.21
Breusch-Godfrey Serial Correlation LM Test:		Prob. F (2, 53) = 0.33	
Heteroskedasticity Test: Breusch-Pagan-Godfrey		Prob. F (22, 55) = 0.26	
Bound Test Results			
F-statistic: 7.44; 1 per cent Lower Bound: 3.93; 1 per cent Upper Bound:5.23			

Note: ***, ** and * denote significance at 1 per cent, 5 per cent and 10 per cent level.
Source: Authors' estimates.

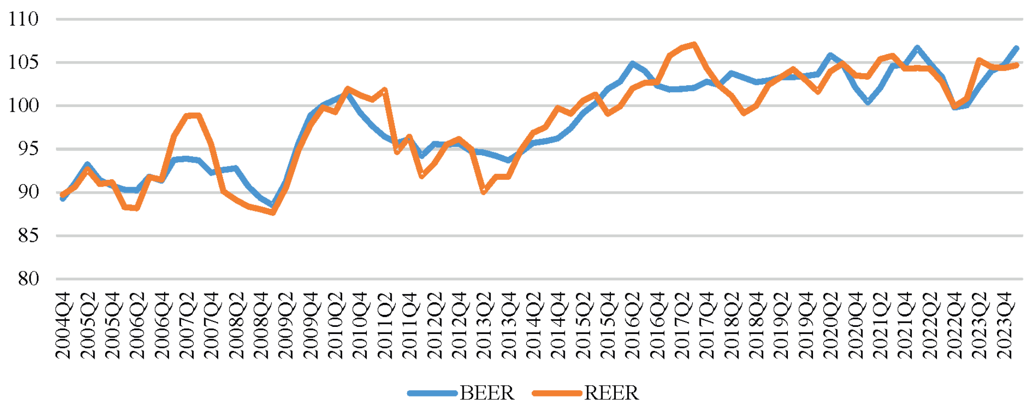
The rising productivity within the tradable goods sector has played a significant role in the sustained trend of appreciation in REER (Patra, et al., 2024). In the similar vein, BEER estimation results also confirm the same, as the coefficient is statistically significant with a positive sign. GFD to GDP is also statistically significant with expected sign, indicating that increase in government fiscal deficit to GDP ratio leads to depreciation in BEER. The fiscal deficit increases when a government spends more than it earns. To finance the deficit, the government may borrow from abroad or print money. Borrowing from abroad increases demand for foreign currency, which reduces the value of the domestic currency. On the other hand, domestic borrowing increases the supply of domestic currency, which lowers its value.

Terms of trade has a positive relation with currency's strength as seen in the developed countries' currencies. When a country's TOT improves, it can buy more imports with the same quantity of exports. This can lead to increased demand for the country's currency, which increases the value of the currency.

Higher interest rates attract foreign investors, which increases demand for and the value of a country's currency. This leads to an appreciation in the domestic exchange rates. Our findings are in line with the theory related to interest rate parity and empirical studies.

Furthermore, the comparison of BEER and existing REER depicted, both, periods of overvaluation and undervaluation (Chart 4). In the initial period of global financial crisis, REER witnessed a sharp correction in the overvaluation and went below the BEER. During the post GFC years and especially after the taper tantrum episode (2013), REER was able to rectify its previous misalignments in a sustained manner.

Chart 4: BEER v/s REER



Source: Authors' estimates.

Thus, the empirical analysis finds that global events like the GFC, taper tantrum and Covid influence the REER, with the turning points taking place post such events. This is also in consonance with other studies stating that pre-crisis years have been associated with REER over-valuations (Catao, 2018).

V. Conclusion

Understanding the appropriate value of a currency is the central issue for markets and policymakers. However, in this area, the economics profession itself lacks a foolproof method of establishing when a currency is properly valued. The study attempts to analyse various alternatives of estimating fair value of the Rupee based on existing theoretical and empirical literature. Among the various methods of estimating fair value, an attempt has been made to evaluate the INR by BEER method with using quarterly data and ARDL techniques.

Furthermore, it is found that the existing REER movements and the BEER movements are in line in long run, and the REER is able to capture the fair value of INR in normal conditions. However, during crisis episodes, there have been misalignments in the REER. The findings are in line with the earlier studies focused on India such as Patra et al., (2024), Raut (2022), Kumar (2010) and Banerjee and Goyal (2021).

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Annex

Table 1a: Unit Root Test

Variables	*Augmented Dickey Fuller (ADF) Test Statistic*		*Phillips–Perron Unit-Root Test Statistic Z(rho)*	
	X	ΔX	X	ΔX
$Ln(REER)_t$	-1.3364	-5.8529***	-1.8162	-7.9187***
$Ln(Relative\ GDP\ Per\ Capita)_t$	-0.2957	-3.5202***	-0.2301	-23.3465***
$Ln(Net\ Terms\ of\ Trade)_t$	-2.3542	-7.6816***	-2.1813	-7.4953***
Net Foreign $Assets$ to GDP $Ratio_t$	-1.6368	-2.9515**	-1.4807	-10.7631***
$Ln(Interest\ Rate\ Differential)_t$	-1.6813	-4.0958***	-1.9584	-10.0619***
$Ln(GFD)_t$	-2.4584	-9.7473***	-2.5684	-9.7474***

Note: ***, **, and * indicate significance at 1 per cent, 5 per cent, and 10 per cent levels, respectively.
Source: Authors' estimates.

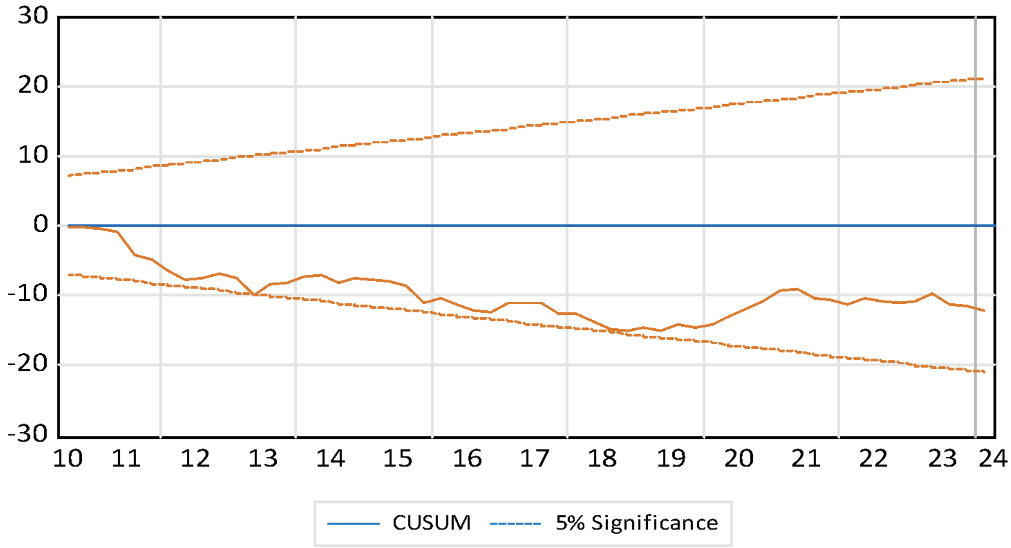

Chart 1a: Stability Test CUSUM Test

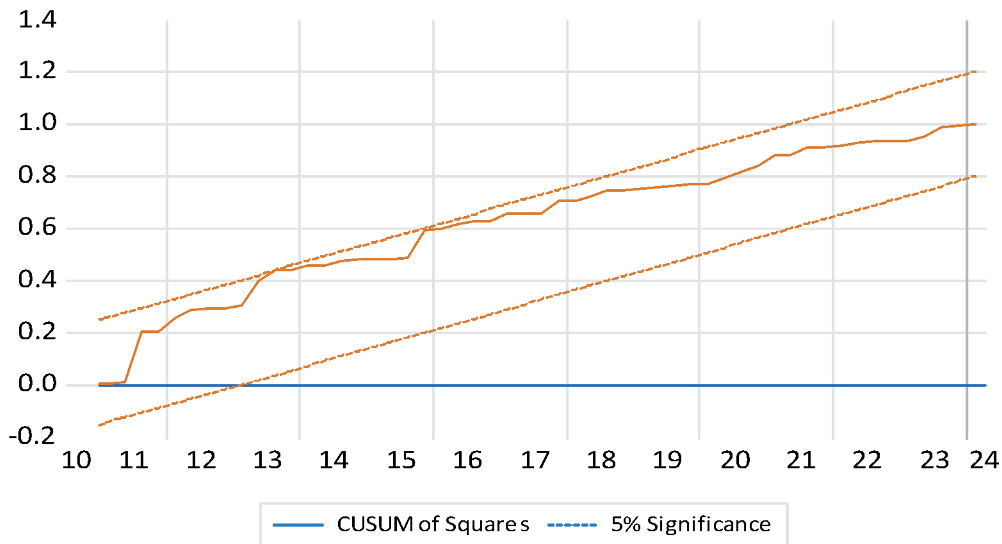

Chart 1b: Stability Test CUSUM Squares Test