Real Exchange Rate and Real Effective Exchange Rate Measurement: Some Theoretical Extensions

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2012

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**Ibrahim Waheed was a Ph.D. student of Professor Jimoh Ayodele. The ideal of the exchange rate measurement in this paper was developed by him as part of Ph.D. thesis of his first ever Ph.D. Student. He is the corresponding author

ABSTRACT

The paper has provided theoretical extensions to the computations of nominal effective exchange rate and the real effective exchange rate over time. The extension took cognizance of the common base currency (USD) to which all currencies of the world is usually converted. The paper compared its computations with that of the CBN computations in attempt to provide a litmus test on the extensions. It was observed that the two computations were of preserving order with a very high correlation coefficient between the two computations. However, it was observed that the extensions perform better as it's reflects more of changes in exchange rate of Nigerian economy. The difference was attributed to the increased in the number of trading partners that was involved in the latter. At the end from the result obtained, the paper recommends that the extension should always be taken into considerations in the computations of effective exchange rate especially for the developing nations like Nigeria; also, Central banks of these countries should endeavour to include as many trading partners as possible into their computations. The paper believes that until this done, their effective rates computations may not reflect the actual changes in the exchange rate of their respective countries.

Keywords: nominal, Real, Effective rates, CBN, correlation coefficients, trading partners

1. BASIC CONCEPTS AND DEFINATIONS OF EXCHANGE RATE

The exchange rate is commonly defined in either of two equivalent ways. One of these defines exchange rate as the price of one unit of foreign currency expressed in terms of the units of home currency. For instance, N159= 1dollar, N250= 1 pound stalling etc. In this way, an increase in exchange rate represents depreciation and a decrease indicates an appreciation of the exchange rate. Alternatively, the exchange rate is defined as the price of a unit of home currency expressed in foreign currency units. For instance, N1= 0.0068 dollars, N1= 0.004 pound stalling etc. This way, an increase in exchange rate represents an appreciation while a decrease means depreciation of exchange rate.

While the exchange rate as defined in one of the two ways above defines the nominal exchange rate, behavior of economic agents are influenced or determined by real exchange rates. The real exchange rate is defined as the relative price of tradable goods to the price of non-tradable goods (Elbadawi and O'Connell, 1997:2; Sundararajan, et. al.1999:10 and Jongwanich, 2009:14).

This is written as:

$$R_t = \frac{P_{Tt}}{P_{Nt}} \quad \text{.....1}$$

Where, P_{Tt} and P_{Nt} are prices of traded and non-traded goods at time t respectively.

Most of the theoretical models that we find in economic literature are presented as if there is a single exchange rate. Yet, we know that countries actually have many trading partners. As such, for each of the partners, there is a bilateral exchange rate and if there are N trading partners there will be N bilateral rates. In a world of Z countries, there will be Z-1 bilateral rates.

Therefore, to get a measure of exchange rate equivalent to the single exchange rate in the theoretical models, the concept of "effective" exchange rate was developed. This is a weighted average of all the bilateral exchange rates.

There are two alternatives weighting methods. These are the arithmetic and the geometric weighting methods. The arithmetic method expresses the nominal effective exchange rate of a country as follows:

$$e_t = \sum_{i=1}^{n} w_{it} E_{it} \quad \text{.....2}$$

Where e_t is the nominal effective exchange rate at time t, w_{it} is the trade weight assigned to the ith trading partner at time t while E_{it} is the nominal bilateral exchange rates between home country and the ith trading partner at time t, n is the number of trading partners.

In the case of geometric weighted average method, the nominal effective exchange rate is measured and defined as below:

$$e_t = \prod_{i=1}^{n} w_{it} E_{it} \quad \text{.....3}$$

Where $\prod$ denotes the product of the real exchange rate over all the trading partners and all other variables are as defined before.

Corresponding to the effective nominal exchange rate is the "effective" real exchange rate which is a weighted average of real bilateral exchange rates.

In order to effectively drive home the objective of this paper, which is to provide some theoretical extensions to the empirical computations of effective rate as stated above, the paper is further divided as follows; the next section explain the purchasing power parity approach to exchange rate computations and measurements, section three, provides the extensions to the computations and measurements of effective exchange rate, section four deals with using the extensions for computations and measurements of nominal and real effective exchange rates, in section five, the study compares the CBN computations and the new computations, while finally in the same section, the paper was concluded.

2. PURCHASING POWER PARITY(PPP) THEORY

The PPP theory which was based on the law of one price states that the nominal exchange rate should reflect the purchasing power of one currency against another. According to Qayyum et al (2004:721-735), the purchasing power exchange rate is measured by the reciprocal of one country's price level, $1/P_t$ against another, $1/P_t^*$. The purchasing power parity rate is a rate at which one country's currency is exchanged for another. It is expressed as:

$$E_t = \left(1/\ P_t^*\right) \Big/ \left(1/P_t\right) = \frac{P_t}{P_t^*} \quad \text{.....4}$$

The theory predicts that a fall in a currency's domestic purchasing power (as indicated by an increase in the domestic price level) will be associated with proportional currency depreciation in the foreign exchange market. In the same vein, PPP also suggests that an increase in the currency's domestic purchasing power will be associated with a proportional currency appreciation (Krugman and Obstfeld, 2003:421). The purchasing power parity theory has two

main variants, namely, absolute and relative purchasing power parity theories. The absolute purchasing power parity in precise terms implies that:

$P_t = E_t P^*_t$^^^^^^^^^^^^^^^^^^^^^^^^^^^^^..5

Where, E_t is the nominal exchange rate at time t, P_t and P_t* are the prices at time t in the domestic and foreign economies respectively. Accordingly:

$$E_t = \frac{P_t}{P_t^*} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Taking natural logarithm of equation 6, we have:

$\text{Log } E_t = \text{Log } P_t \; - \text{Log } P_t^*$^^^^^^^^^^^^^^^^^7

On the other hand, the relative purchasing power parity theory implies that:

$P_t = kE_t P_t^*$^^^^^^^^^^^^^^^^^^^^^^^^^^.8

Where, k is constant and other variables are as defined before. Thus, E_t is written as:

$E_t = 1/k \, (P_t/P_t^*)$^^^^^^^^^^^^^^^^^^^^^^^.9

Taking natural logarithm of equation 9:

$\text{Log } E_t = a + \text{Log } P_t \; - \text{Log } P_t^*$^^^^^^^^^^^^^.10

Where, a= 1/k

According to Isard (2007:6), the empirical validity of PPP is usually based on the relative PPP. The reason was attributed to different base years on which data on average price levels of various countries are indexed. Either variant of PPP implies a constant real exchange rate. That is, if as it

is commonly done in the empirical literature, the real exchange rate is proxied by the nominal exchange rate (E) multiplied by the relative prices of the domestic and foreign economies (P*/P). This is given as:

$$R_t = \frac{E_t P_t^*}{P_t} \quad \text{.....11}$$

3.MEASUREMENT OF REAL EXCHANGE RATE AND REAL EFFECTIVE EXCHANGE RATE

The task of deciding which measure of the exchange rate is the most appropriate is usually faced with two set of issues. According to Chinn (2002:5), the first is between the theoretically applied measures and the real world counterparts. The second one is between using the most appropriate measure conceptually and using a measure based on the most readily available data. In short, the translation from the real exchange rate theory to real- world data is not straight forward, due to the fact that, in most cases, there are usually problem in reconciling between what theory postulated and the available data to execute same. For instance, at the empirical level, due to the problem of getting data on the relative price of tradable goods to the price of non-tradable goods many authors continue to proxy the real exchange rate by nominal exchange rate adjusted for movements in the prices of foreign and domestic countries (Sundararajan, et. al., 1999:5; Jimoh, 2006:94; Jongwanich, 2009:14). That is as we have in equation 11 above.

Also, the empirical treatment of the real effective exchange rate typically abstract from how to measure exchange rates when countries engage in transactions with a number of partners. In such a case, equation 11 can be weighted to obtain the empirical measurement of real effective exchange rate. Such that, using arithmetic weighed method as used for nominal exchange rate in equation 2 above, real effective exchange rate is measured as below:

$$REER_t = \sum_{i=1}^{n} w_{it} \frac{E_{it} P_{it}^*}{P_t} \text{.....12}$$

Where, $REER_t$ is the real effective exchange rate at time t, E_t is the nominal exchange rate, P_t is the domestic price while P^*_t is the foreign price at time t respectively, w_{it} is the weight attached to each trade partner.

Using geometric weighted method, real effective exchange rates is measured as:

$$REER_t = \prod_{i=1}^{n} w_{it} \frac{E_{it} P_{it}^*}{P_t} \text{.....13}$$

All definitions of variables are as given earlier. The trade weight (w_{it}) of the trading partners is sum to 1(Chinn, 2006:122).

The weight to be given to each bilateral rate is commonly based on the share of total imports, exports or total exports and imports. When data from only major trading partners are used for the computation, the weight to be given to the ith country's bilateral rate is computed as the country's total import and export to the domestic economy as a percentage of domestic country's total export and import from all the selected trading partners. The formula used for calculating the trade weights is given as follows:

$$w_{it} = \frac{M_{it} + X_{it}}{\sum_{i=1}^{n} X_{it} + \sum_{i=1}^{n} M_{it}} \text{.....14}$$

Where; w_{it} = time varying weight of country i in the overall trade volume of the country.

M_{it} = imports of home from country i at time t

X_{it} = exports of home to country i at time t

$\sum_{i=1}^{n} X_{it}$ = Exports of home to the n selected trading partners at time t

$\sum_{i=1}^{n} M_{it}$ = Imports of home from the n selected trading partners at time t.

Other issues involved in the measurement of effective exchange rate include the choice of price index and the choice of trade partners among others. In practice, the choice of prices to employ usually depends on the relative price that best reflect the relative price of tradable goods to non-tradable goods. The indices available are: the consumer price index (CPI), the producer price index (PPI), the wholesale price index (WPI), the export price index (EPI) and the GDP deflator (Chinn, 2006:115). The most commonly used price series are consumer price index. Although there are theoretical reasons to prefer other types of price index when measuring competitiveness (Koch, 1984:7), CPIs have the advantage of being timely and available for a wide range of countries over a long period of time. According to Chinn (2002:119), for the purposes of calculating the relative price of tradable goods, the preferred measure is the exchange rate deflated by PPIs or WPIs. One drawback of using these indices is that, there is considerably more variation in how these price series are constructed across countries, than for the corresponding CPIs (Chinn, 2002:7; 2006:120). Concerning the choice of countries to include and their relative weights, in principle, all countries that trade with a domestic country should be included. In practice, data limitations tend to restrict the number of countries that can be considered. The actual selection is determined by practical considerations, efforts are made to ensure that the currencies included account for a high proportion of total trade of the country in question (Chinn, 2006:123).

4. SOME THEORETICAL EXTENSIONS

In most cases at the empirical level the measurement of real effective exchange rate are usually done without appropriate considerations for the currency of the country for which all other currencies are based. For instance, since 1994, when special drawing right (SPR) of all countries are based on the most relatively stable currency, that is US dollar, the treatment of this country (USA) in the computations of real effective exchange rate have been not been properly done. The special treatment of this country (USA), especially when it constitutes one of the major trading partners of the concerned country, is the major theoretical extensions this paper intends to contribute to the body of economic literature. Analysis of this theoretical extension is presented below.

a. The Nominal Effective Exchange Rate (NEER)

This is measured as the weighted average of all bilateral exchange rates between home (Nigeria) and its major selected trade partners. The computation takes cognizance of US dollar to which all countries currencies are related. In this extension, NEER is computed as follows:

$$\square\square\square\square_{\square} = \square\frac{\square_{\square}}{\square_{\square\square}} - \sum_{\square\square\square}^{\square}\square_{\square}\frac{\square\square_{\square}\square_{\square}\square_{\square\square}\square}{\square_{\square\square}}\square * \square_{\square\square} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 15$$

Where;

r_j = nominal exchange rate (N/$)

r_{j0} = N/$ in the base period

E_i = Bilateral exchange rate of each trade partner per US dollar

E_{io} = Bilateral exchange rate in the base period

w_i = weight attached to each trade partner

In order to convert the above formula to index, equation 15 is written as follows:

$$\text{NEER}_t = \frac{\text{NEER}_t}{\text{NEER}_{t0}} - \sum_{i=1}^{n} w_i \frac{P_i^* P_j^*}{P_{i0} P_{j0}} * 100 \quad \ldots\ldots 16$$

All variables are as defined before for equation 15.

b. **The real effective exchange rate (REER)**

This is measured as the nominal effective exchange rate adjusted for relative price differentials between home (Nigeria) country and its major trading partners. In this study the arithmetic weighted average method is employed, this is due to its relative simplicity and it application by various authors in the field. However, the geometric approach to this extension will take the multiplicative series of the formula stated in this study. Symbolically, in this paper, the real effective exchange rate over time is defined as follows:

$$\text{REER}_t = \text{NEER}_t + \sum_{i=1}^{n} w_i \frac{P_i^* P_j^*}{P_{i0} P_{j0}} * P_{ij} \quad \ldots\ldots 17$$

Where;

$REER_t$ = Real effective exchange rate over time

$NEER_t$ = Nominal effective exchange rate over time

P_i^* = Trade partner's price index

P_{i0} = Trade partner's price index in the base period

P_j = Home country's (Nigeria) price index

P_{j0} = Home country₦(Nigeria) price index in the base period

In order to convert the above formula to index, equation 17 is written as follows:

$$\square\square\square\square_{\square} = \square\square\square\square\square\square_{\square} + \sum_{\square\square\square}^{\square} \square \frac{\square\square_{\square}^{*}\square\square_{\square\square}^{*}\square}{\square\square_{\square}\square\square_{\square\square}\square} \square * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 18$$

All variables are as defined before

5. EMPIRICAL APPLICATION OF THE EXTENSION TO NIGERIA'S DATA

This section presents typical computations of nominal and real effective exchange rate using our formula extension for Nigeria₦data from 1960 to 2011. The computation was based on 17 selected trading partners of Nigeria. The chosen countries are; United States, India, Spain, France, Italy, Brazil, Netherlands, China, Germany, United Kingdom, Belgium, Japan, Denmark, Norway, Sweden, Canada and Switzerland. The choice of trade partner countries was guided by the fact that these countries accounted for at least 80 per cent of trade with Nigeria within the period of study (IMF direction of trade statistics).

5.1 Nigeria's Exchange Rate and the Computed Effective Rates

Table 5.1 presents the dollar exchange rates of Nigeria₦currency and the corresponding effective exchange rates (Nominal effective exchange rate and the real effective exchange rates) in some selected periods. The first column in Table 5.1a shows the nominal exchange rates of naira per dollar while the second and the third columns indicate the computed nominal effective exchange rates and real effective exchange rates respectively.

The data indicates that Nigeria's official exchange rate appreciated between 1975 and 1980 and depreciated between 2000 and 2005; it recorded minor appreciations between 2005 and 2008. However, in 2009, 2010 and 2011 it recorded major depreciation. In terms of effective nominal rate, it recorded appreciation between 1960 and 1975; depreciated between 1975 and 2005 and appreciated between 2006 and 2008. It however, depreciated in 2009, 2010 and 2011. In terms of real effective rate, it depreciated between 1960 and 1965; appreciated between 1965 and 1980; depreciated between 1980 and 2005; it appreciated between 2005 and 2008; and depreciated in 2009, 2010 and 2011. Hence, on account of all measures, there were depreciations in 2009, 2010 and 2011 respectively.

Table 5.1: Nominal Exchange Rate and Effective Rates in Some Selected Years

Year	Nominal Exchange Rate(N/$) (a)	NEER(N/$) (b)	REER(N/$) (c)
1960	0.714	0.714	0.509
1965	0.714	0.677	19.461
1970	0.714	0.479	5.460
1975	0.616	0.568	2.228
1980	0.546	2.310	2.231
1985	0.894	3.421	3.049
1986	2.021	4.312	3.684
1990	8.038	21.318	15.428
1994	21.886	44.091	31.536
1995	21.886	45.377	32.432
2000	102.105	207.143	147.92

2005	132.147	265.418	189.518
2006	128.652	262.870	187.702
2007	125.853	253.881	181.281
2008	118.567	247.727	176.887
2009	152.340	307.030	219.229
2010	167.32	325.765	236.213
2011	160.45	354.742	276.52

Sources: (a) CBN Statistical Bulletin (various issues)

(b) and (c) are Author's Computations

Table 5.2 presents the Nominal effective exchange rate as computed in this study together with the corresponding figures published by Central Bank of Nigeria (CBN) for some selected years.

Table 5.2: CBN Nominal Effective Exchange Rate and the Computed NEER

Year	CBNNEER(INDEX) (a)	NEER (INDEX) (b)
1960	-	79.88
1965	-	74.75
1970	99.9	47.05
1975	100.4	67.67
1980	106.3	73.67
1985	100	100
1986	51.9	49.78
1990	7.7	1.87

1994	3.0	0.75
1995	0.7	4.00
2000	0.2	0.65
2005	106.6	108.7
2006	105.0	120.0
2007	106.41	124.0
2008	100.31	119.6
2009	121.54	121.0
2010	130.51	137.80
2011	134.11	140.67

Sources: (a) CBN Statistical Bulletin (various issues)

(b) Author's Computations

The CBN started publishing Nigeria's nominal effective exchange rate in 1970. The first column(a) of Table 5.2 indicates the nominal effective exchange rate index (base 1985) as computed by the CBN, while the second column (b) shows the index of nominal effective exchange rate as computed in this study (base 1985). To determine whether or not the two indices are order preserving, the study computed simple correlation coefficient and the result obtained was 0.93. Therefore, a high value of correlation coefficient such as this can make us conclude that the two computations are order preserving.

The difference observed between the two indices may be attributed to a number of reasons as identified in the literature (Chinn, 2006:175). The major reason that may be responsible is the number of trade partners included in the computation process. For instance, while CBN uses six major Nigeria's trade partners (United States, United Kingdom, Germany, Japan, France, and Netherlands) in its computation, this study extended its coverage to include seventeen countries that accounted for about 80 per cent of Nigeria total trade during the study period. Therefore, it is to be expected that the increase in the number of trade partners included

in the computation process would produce effective rates that more correctly reflect changes in the exchange rate of an economy.

5.2 CONCLUSION

The paper has provided theoretical extensions to the computations of nominal effective exchange rate and the real effective exchange rate over time. The extension took cognizance of the common base currency (USD) to which all currencies of the world is usually converted. The paper compared its computations with that of the CBN computations in attempt to provide a litmus test on the extensions. It was observed that the two computations were of preserving order with a very high correlation coefficient between the two computations. However, it was observed that the extensions perform better as it reflects more of changes in exchange rate of Nigerian economy. The difference was attributed to the increased in the number of trading partners that was involved in the latter. At the end from the result obtained, the paper recommends that the extension should always be taken into considerations in the computations of effective exchange rate especially for the developing nations like Nigeria; also, Central banks of these countries should endeavour to include as many trading partners as possible into their computations. The paper believes that until this done, their effective rates computations may not reflect the actual changes in the exchange rate of their respective countries.

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