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What explains the real exchange rate movement for the BRICS nations? With a separate analysis for Indian economy

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Abstract. *Among all the important targets that a country wants to realize from an economic perspective, i.e. reducing current account deficit, reduction in the inflation soaring, struggle with unemployment, reduction in the debt burden of the public/fiscal deficit. The main target which underlying all these desires is economic stability. For economic stability, the exchange rate plays an important role, due to little fluctuation in exchange rates, exports, imports, domestic interest rates, debts and employment level gets affected.*
The primary objective of this study is to empirically examine the long-run relationship between the relative productivity differential (Tradable and Non-tradable goods sector) and Real exchange rate movements with the help of the Balassa-Samuelson (BS) effect.
This study uses industry-wise disaggregation provided by KLEMS database to investigate whether the more segregations of industries into non-tradable and tradable goods sector matters for real exchange rate movements across countries.
This study uses two groups, BRICS countries and the Indian economy for the period of 1991-2018 and 1981-2018 respectively. With the help of panel cointegration tests proposed by Pedroni and Kao, this paper examined the long run association between the real exchange rate and productivity differential.
Contrary to the findings of available in the literature, the study does not find any evidence of BS effect for BRICS nations, but finds the evidence of BS effect for India.

Keywords: Real Exchange Rate, Balassa-Samuelson hypothesis, BRICS, Panel unit-root, Stationarity test, Structural unit root tests, Cointegration tests and Time series analysis.

JEL Classification: E31, F00, F31, F41, C15.

1. Introduction

In the context of open economy, all countries are internationally dependent on trade and finance and one of the most recent examples in this context is BRICS. Originally founded as BRIC by former Goldman Sachs economist Jim O'Neill in 2001, it consists of four fastest growing and developing economies, namely Brazil, Russia, India and China. In 2010, South Africa became a member of the party and BRIC became BRICS.

This paper examines the real exchange rate and productivity differential movements (hereafter RER and PD respectively) in BRICS nation and analysis their relationship with the help of Balassa-Samuelson hypothesis.

Balassa-Samuelson's theory captures the divergence from purchasing power parity (hereafter PPP) arising from international disparities in relative productivity between the tradable and non-tradable goods sectors.

In contrast to a non - tradable good that cannot, a tradable good is a good that can be sold in another place usually another country, from where it was produced. Theoretically, the rule of one price that states that a product or service costs the same in any market where it would be sold should be followed by tradable goods. This price uniformity is likely to occur since any price differentiation could be used for arbitrage: goods and services could be purchased at the lowest price in the location and then sold back for profit in markets with Increased costs. This practice will continue until profit seekers push the price down by competition, so that it is the same across all locations and no opportunities for arbitrage remain. The cost of traded goods should not exceed the lowest possible price globally in any given country. Non-traded goods, on the other hand, only compete domestically and thus may have distinct prices from country to country. If all this is valid, then there should be lower inflation for goods that are traded than for goods that are not.

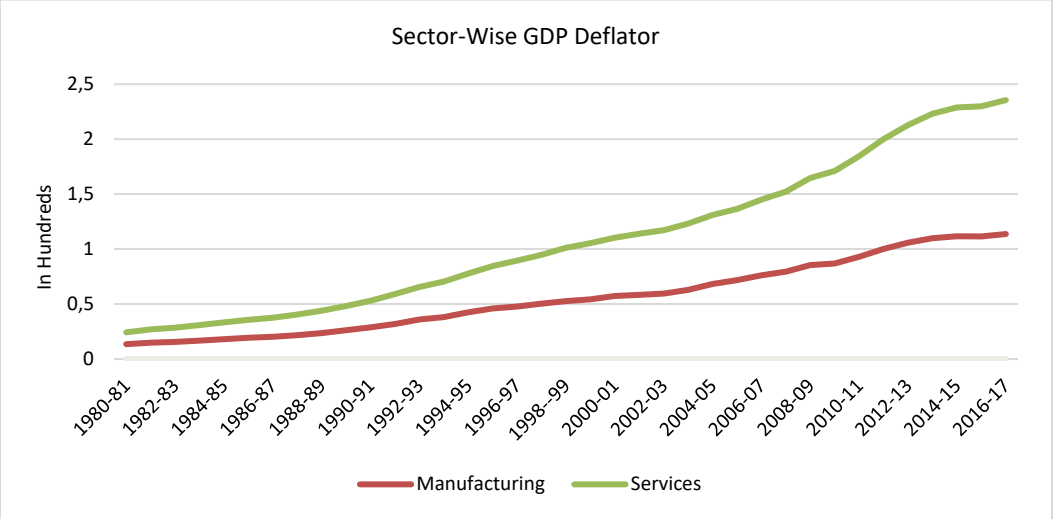
1.1. Current scenario in India(1)

India is an agriculture-based highly labour abundant economy and hence according to the international theory, it should have exported more and more labour-intensive products. But if we see the current scenario of the Indian economy the top five products(2) that India is exporting uses high-tech capital which means we are exporting more of high-tech capital-intensive products. Moreover, the Indian economy is now dominated by services, accounting for more than 55% of GDP. Figure 1(3) represents the sector-wise GDP deflator(4) for the period 1981-2016, it shows that the implicit price deflator for the services(5) sector is higher than that of the manufacturing sector.

Services is highly labour intensive in nature, as India is labour abundant country then there should be lesser prices for service sector products than for the manufacturing sector.

Here productivity plays a significant role in explaining the above situation.

Figure 1. *Sector-wise GDP Deflator*



Source: Database on Indian Economy, Reserve Bank of India.

The rise in wages of the traded sector will demand proportional wages in the non-traded sector. As a result, the relative prices of the non-traded sector will rise due to the unequal increase in wages and productivity. Due to the rise in Relative prices of non-traded, the general price level in the economy will rise resulting in an upward movement in the RER.

In this explanation two things are important first, people need to buy some non-tradable goods and second, labour is transferable between the traded and non-traded sector. Balassa-Samuelson model assumes that RER is unaffected by demand-side factors and entirely driven by the supply side, most Empirical studies draw a comparison between aggregate measures of productivity across countries, such as Per capita GDP, GDP per worker, or labour productivity in the manufacturing sector. some empirical research validates both demand and supply-side effects upon relative price fluctuations. The relative price index calculates the relative domestic cost of producing non-tradable goods and offers a proxy for the profitability of the economy on the world market. This paper is divided into eight sections. The next two sections focus on literature review and objective. Section 4 begins by discussing the basic analytical framework. Section 5 and 6, describes the data sources, tradability measures and measures of productivity. In section 7 econometric analysis is discussed and reports regression results. Section 8 concludes.

2. Literature review

The technological differences between tradable goods sector and non-tradable goods determines the prices in non-tradable goods sector, this relationship is widely known after the notable works of Bela Balassa and Samuelson in 1964.

These two papers were distinct in the sense that one used the theoretical explanation to prove the relationship and other presented the mathematical model.

Moreover, the empirical work exploring the relationship between technological change and relative prices of non-tradable goods has received more attention in last couple of years due to following reasons:

1) The existence of vast literature documenting the inadequacy of PPP as a theory that explains long-term exchange rate determination has led researchers to re-examine other alternative models that allow for near-perpetual changes in RERs.(6)

A significant group of these alternative models used the distinction between tradable and non-tradable goods as a theoretical instrument to break the relationship between the PPP and the One Price Law (LOOP). PPP is the extended version of the LOOP, which means that all homogeneous goods should have same price.(7) Over the decades several studies have used different approaches and studied the relationship between RER and PD.(8)

2) Another reason behind the popularity of the B-S model is the increased sectoral data availability that will further allows the composition of the better proxies for the price index for tradable and non-tradable goods sector and sector-wise productivity.

The important research in this context was because of De Gregorio, Giovannini, and Wolf (1994) (henceforth DWG), which studied both supply and demand-side components of the exchange rate that links with relative prices of non-tradable goods by using disaggregated sectoral data for 16 years starting from 1970 for 14 OECD countries.
DWG tested the relationship between the relative price of non-tradable goods and sectoral productivity differentials by taking differenced time-series and other proxies for demand-side components.

The observed literature on this topic has grown since the 1990s and early 2000s. Table 1 presents the selection of statistical techniques for estimating the Balassa-Samuelson effect in chronological order.

In the earlier studies, there were two main methods for the testing of the Balassa-Samuelson hypothesis, the single equation approach and the two-equations approach.

Balassa used the single equation approach to test his model which provides a direct relationship between productivity differential and RER.

The two-equations approach firstly examined the relationship between productivity differential and relative prices of non-tradable goods thereafter, the existence of PPP in the traded sector is to be studied. If both equations reveal the appropriate result, the RER was expected to move with relative productivity differential between tradable and non-tradable sectors between the countries.

Another class of literature used the BEER(9) approach to examined the Balassa-Samuelson model to determine the RER fluctuations.(10)

The very first econometric method was a cross-sectional OLS analysis used by "Balassa (1964)". In the early 1980s, IVs(11), and Engle-Granger co-integration techniques were used but the main technique was still OLS. In the first half of 20th century, SURE(12) analysis was used extensively but thereafter, Johanson and Juselius co-integration technique became completely popular technique for testing the Balassa-Samuelson hypothesis. After that, ARDL(13) approach was extensively used.

A first look at the estimated outcomes for the Balassa-Samuelson hypothesis shows a general asymmetry between the theoretical model and the empirically estimated outcomes and showed incomplete-transmission. As Balassa-Samuelson model is supply side model, hence the relative price of non-tradable goods is determined by the production side of the economy. Therefore, any movements in PD should, cet. par., result in equally-proportional changes in RER.

The econometric methods were varied among studies but a major group of literature used OLS (time series or panel). Longitudinal studies as a whole were specifically widespread as time series estimations suffered from short time spam. Using Pooling data into a group of countries solved this issue to some extent. Chinn (1997) provides ideal example where he estimated the Balassa-Samuelson model with both time series and longitudinal-cointegration method, results of this paper matches with the most recent paper by Drine and Rault (2002) and concluded no -cointegration among the variables but pooling the data into a panel resulted in a significant panel cointegration estimate.

After this set of work, many studies came with the models that integrated additional independent variables like government spending, ratio of M3 to GDP, trade openness, crude oil prices, ratio of export-import prices, government consumption to GDP and capital flows.

Some of them classified Capital flows into three parts, portfolio investment, FDI, and other investment flows(14).

Sjoerd Anton van der Schaar's recent work (2019) has used a new method called Olley-Pakes to calculate Total Factor Productivity and dismissed the Balassa Samuelson hypothesis.

There are mixed evidences for applicability of Balassa-Samuelson hypothesis, as it is largely depending on author based criterion like which set of countries they have examined, which techniques they have chosen, which measure of productivity they have employed and also on the time period they have considered for the analysis.

In the context of Indian economy, there are mixed evidences which shows the existence of PPP in the long-run(15).

3. Objective

This paper intends' to check what explains real appreciation for the BRICS nations with separate analysis for the Indian economy. The prime objective of this study is to empirically examine Balassa-Samuelson (BS) effect and to investigate whether the more segregations of industries into the Non-tradable and tradable goods sector matters for real exchange rate movements across countries, or in other words, whether the Balassa-Samuelson hypothesis hold or does not hold for the BRICS nations and if it does not then which one out of three assumptions violates:

1) The PD and relative prices are positively correlated.
2) RER and relative prices of non-tradable goods are positively correlated.
3) PPP is verified for tradable goods(16).

The contribution of this study is twofold. First, this study examined 23 industry-level disaggregated data for Indian economy and 6 industry-level disaggregated data for BRICS nations where the most of the studies were used aggregated, three or six-level disaggregated research for binning the non-tradable and tradable industries, and on the basis of aggregated research, many of the tradable service sectors are involved in non-tradable industries.

Second, BS effect captures the relationship between relative productivity of tradable and non-tradable sectors and given the fact that there are many service industries which are tradable in nature, and many manufacturing industries which are non-tradable. Mapping the manufacturing sector as tradable and remaining as non-tradable is not a beneficial move, as is generally acknowledged in the literature. The biggest weakness in these studies is that the mapping structure was same for all countries. In practice, however every industry in a country has a varying degree of tradability. For these purposes, this study uses the DWG methodology (extended to 23 industries) to describe tradable and non-tradable sectors.

4. Theoretical framework

Assumptions:

1) Consider a two-sector small open economy, the traded sector and nontraded sector.
2) It is assumed that there is only one traded good and one non-traded good.
3) The terms of trade (i.e. the relative price of exports in terms of imports) are determined by world conditions and are supposed to be fixed.
4) Let the traded good be numeraire(17).
5) Purchasing power parity condition holds for traded good.
6) There exists perfect competition in factor and final goods markets.
7) Constant returns to scale is assumed in production.
8) Capital is perfectly mobile internationally.
9) Labour is internationally non-transferable but perfectly transferable between two sectors.

Real exchange rate

It can be defined as the current exchange rate adjusted for inflation, in the equation term it can be written as,

$$Q = E\left(\frac{P^*}{P}\right) \quad (1)$$

Where:
Q denotes the RER.
E denotes the nominal exchange rate.
P stands for the price level in home country.
P^* reflects the price level in a foreign country.

Or in other words, it can be defined as the quantity of domestic goods needed to purchase a unit of foreign goods.

By taking the logarithmic of equation (1), we get,

$\text{Log}(Q) = \text{Log}(E) + \text{Log}(P^*) \text{ Log}(P)$

Let lower cases letter represents a logarithmic variable,

$Q = e + p^* - p$

Notations:
Assume T stands for the traded-goods sector and N stands for non-traded goods sector.
P_T denotes the price level in the home country for tradable good.
P_N denotes the price level in the home country for non-tradable good.
P_T^* denotes the price level in the foreign country for tradable good.
P_N^* denotes the price level in the foreign country for non-tradable good.
P denotes the general price level in the home country.
P^* denotes the general price level in the foreign country.
L_T denotes the labour employed in the production of domestic tradable good.
L_N denotes the labour employed in the production of domestic non-tradable good.
K_T denotes the capital employed in the production of domestic tradable good.
K_N denotes the capital employed in the production of domestic non-tradable good.
A_T denotes the technology level in the traded goods sector in the home country.
A_N denotes the technology level in the non-traded good sector in the home country.
Y_T denotes the level of output in the tradable good sector in the home country.
Y_N denotes the level of output in the non-tradable goods sector in the home country.
R denotes the rental rate of capital.
W denotes the wage rate.

Since according to assumption (4) the price of traded-goods is 1 that is, $P_T = 1$, all these variables can be represented in terms of tradable goods.

Let the general price level in the home and foreign country follows the cobb-Douglas form:

$P = (P_T)^{\Theta} (P_N)^{(1-\Theta)}$

$P^* = (P_T^*)^{\Theta} (P_N^*)^{(1-\Theta)}$

Here the share of traded and non-tradable sector is identical for both home and foreign country, $\Theta = \Theta^*$

Now, from the equation (1) we can say that,

$$Q = E \left(\frac{P_T^{*\Theta} P_N^{*(1-\Theta)}}{P_T^{\Theta} P_N^{(1-\Theta)}} \right)$$

Now, taking logarithmic from both the sides we get,

$\text{Log } Q = \text{Log } E + \Theta \text{ Log } P_T^* + (1-\Theta) \text{ Log } P_N^* - \Theta \text{ Log } P_T - (1-\Theta) \text{ Log } P_N$

or,

$$\text{Log } Q = \text{Log } E + \Theta (\text{Log } P_T^* - \text{Log } P_T) + (1-\Theta) (\text{Log } P_N^* - \text{Log } P_N)$$

or,

$$q = e + \Theta (p_T^* - p_T) + (1-\Theta) (p_N^* - p_N)$$

or,

$$q = e + p_T^* - p_T - p_T^* + p_T + \Theta (p_T^* - p_T) + (1- \Theta) (p_N^* - p_N)$$

or,

$$q = (1-\Theta) (p_N^* - p_N) \qquad (2)$$

from assumption (4) and (5).

RER movements are thus entirely determined by the relative price of non-tradable goods.

The home country[18]

The output in both sectors are produced using Cobb-Douglas technology:

$$Y_T = A_T (K_T)^{\alpha t} (L_T)^{(1- \alpha t)}$$

$$Y_N = A_N (K_N)^{\alpha n} (L_N)^{(1- \alpha n)}$$

The traded goods firm's choice problem is to choose K_N and L_N such that profit is maximized,

$$\Pi_T = Y_T – (RK_T – WL_T)$$

or, $\Pi_T = A_T (K_T)^{\alpha t} (L_T)^{(1- \alpha t)} – (RK_T + WL_T)$

and the Nontraded-goods firm's choice problem is to choose K_N and L_N such that profit is maximized,

$$\Pi_N = P_N Y_N – (RK_N – WL_N)$$

or, $\Pi_T = P_N A_N (K_N)^{\alpha n} (L_N)^{(1- \alpha n)} – (RK_N + WL_N)$

Let $k \equiv \frac{K}{L}$ denote the capital-labour ratio.

first-order conditions are:

$$R = A_T \alpha t (k_T)^{(\alpha t - 1)} \qquad (3)$$

$$R = P_N A_N \alpha t (k_N)^{(\alpha n - 1)} \qquad (4)$$

$$W = A_T (1 – \alpha t) (k_T)^{\alpha t} \qquad (5)$$

$$W = P_N A_T (1 – \alpha t) (k_N)^{\alpha n} \qquad (6)$$

Since we have assumed that capital is mobile internationally that means R is exogenously given.

Thus, we have four equations from (3) to (6) and four unknowns (P_N, W, k_T, k_N).

From equation (3) we can obtain k_T (capital-output ratio of tradable good sector),

$k_T = \left(\frac{\alpha t\, A_T}{R}\right)^{\frac{1}{(1-\alpha t)}}$

Now, substitute this value of k_T in equation (5), we get,

$W = (1-\alpha t)\, A_T^{\{1/(1-\alpha t)\}} \left(\frac{\alpha t}{R}\right)^{\frac{\alpha t}{(1-\alpha t)}}$

Now, substitute this value of W in equation (6), we get,

$k_N = \left(\frac{(1-\alpha t)}{(1-\alpha n)} \frac{A_T^{\{1/(1-\alpha t)\}} \left(\frac{\alpha t}{R}\right)^{\{\alpha t/(1-\alpha t)\}}}{P_N\, A_N}\right)^{\frac{1}{\alpha n}}$

Finally, put the value of k_N in equation (4) to get the value for relative price of the nontraded goods.

$$P_N = \frac{(A_T)^{\frac{(1-\alpha n)}{(1-\alpha t)}}}{A_N} C\, R^{\frac{(\alpha n-\alpha t)}{(1-\alpha t)}} \quad (7)$$

Where C is positive constant.

Now, let a = Log(A), r = Log(R), and c = Log(C) and take the logarithmic version of the above equation (6),

$$p_N = \left(\frac{(1-\alpha n)}{(1-\alpha t)}\right) a_T - a_N + \left(\frac{(\alpha n-\alpha t)}{(1-\alpha t)}\right) r + c \quad (8)$$

Hence from this, we can say that the fluctuations in log(relative price of non-tradable good) depends only on the technology and the exogenously given R.

Equation (7) is the log relative price of non-tradable good for the home country the same expression can be written for a foreign country also as,

$$p_N^* = \left(\frac{(1-\alpha n)}{(1-\alpha t)}\right) a_T^* - a_N^* + \left(\frac{(\alpha n-\alpha t)}{(1-\alpha t)}\right) r + c \quad (9)$$

Now we have the expression for both p_N and p_N^*, now substitute these values in equation (2):

$q = (1-\Theta)\,(p_N^* - p_N)$

$q = (1-\Theta)\left[\left\{\frac{(1-\alpha n)}{(1-\alpha t)}\,(a_T^* - a_T)\right\} - (a_N^* - a_N)\right]$

or,

$$q = (1-\Theta)\left[(a_N - a_N^*) - \left\{\frac{(1-\alpha n)}{(1-\alpha t)}\,(a_T - a_T^*)\right\}\right] \quad (10)$$

Some reasons why the relative price of non-traded goods in terms of traded goods should increase with a country's income:

1) Assume that there is an equally-proportional technological growth between the sectors (that is, a_N and a_T increases at the same rate) and $a_N < a_T$, the production of traded goods is relatively capital-intensive, then p_N will increase over time.

2) Assume that there is a biased technological growth towards the tradable goods sector, that is a_T raises at a faster rate than a_N then p_N will increase over time.

If either of the two scenarios is correct then the economy will experience a real appreciation over time.

4.2.1. Empirical model

According to Froot and Rogoff [1994], the empirically tested model is as follows-

$$\text{Log}(\text{RER}_{it}) = \alpha_1 + \beta_{2i}\left[log\left(\frac{A_{it}^T}{A_{it}^N}\right) - log\left(\frac{A_{USA,t}^T}{A_{USA,t}^N}\right)\right] + \varphi_{it}$$

Where RER is defined as RER and in Mathematical form, RER = $\left(\frac{p}{E\ P^*}\right)$

Increase in RER is defined as the real appreciation of the home country.

A^T is defined as Labour productivity for the traded-goods sector.

A^N is defined as Labour productivity of the non-traded goods sector, and *i* is representing the country.

The sign of β_2 is supposed to be positive, suggesting that the percentage increase in relative PD is on average related to the β_2 percentage increase in the RER.

If the sign of β_2 comes out to be negative than, we will check which of the following assumption violates here.(19)

Assumption- 1 The PD and relative prices are positively correlated.

$$log(P_{it}) = \alpha_2 + \beta_{3i} log\left(\frac{A_{it}^T}{A_{it}^N}\right) + \epsilon_{1it}$$

Assumption-2 RER and relative prices of non-tradable goods are positively correlated.

$$log(RER_{it}) = \alpha_3 + \beta_{4i}\, log(P_{it}) + \epsilon_{2it}$$

Assumption-3 PPP is verified for tradable goods.

$$P_T = EP_T^*$$

5. Data sources

The BRICS countries are selected to test the Balassa-Samuelson hypothesis. The data period is from 1991 to 2018 for the analysis of BRICS and for, India it is from 1981 to 2018, the countries choice and data period are based on data availability.

For BRICS nations the data on gross value added is taken from UNSTATS and data on employment is taken from ILOSTAT, the data on exports is taken from WIOD and OECD. Here the base year is 2010 and all values are in $ i.e. base country is the USA, data on CPI is taken from OECD and data on the spot exchange rate is extracted from UNSTATS.

For INDIA and USA, the data on gross value-added, employment is taken from KLEMS, the data on exports is taken from OECD, data on CPI is taken from OECD and data on the exchange rate is taken from UNSTATS. Here the base year is 2012.

RER is measured as the ratio of CPI of the domestic country to CPI of the foreign nation (USA) multiplied by $\left({}^{1}/_{E}\right)$, where E represents nominal exchange rate. The differences in baseline years in both analyses are due to the structure of the data.

6. Tradability and productivity

Productivity is defined as the real value-added per worker keeping 2010 as a base year for panel data and 2012 as a base year for time series analysis, all values are in U.S. dollars. Thus, the value of current(gross) value added per worker is adjusted for changes in price levels over time. This study uses labour productivity, rather than further decomposing it into total factor productivity (TFP) or Solow residuals since such decomposition requires estimating each sector's capital stock and it is difficult to measure. From now, productivity stands for labour productivity, since the Balassa-Samuelson Hypothesis assumes constant returns to scale hence marginal productivity is equal to the average productivity.

Most of the empirical papers have focused on OECD countries for building productivity series for tradable and non-tradable goods sectors due to lack of data. some pieces of literature are mentioned in *annexure-1*.

For panel data analysis, we have used the data of gross and real value-added and employment at 6 sectors disaggregation. For time series analysis, we have used the data on constant, current gross value added and employment at 23 sectors disaggregation. This data is taken from KLEMS database, which gives more disaggregated data than ISIC-3, revised.

6.1. Calculating productivity of non-tradable and tradable sectors

Consider a country which made up of many sectors. An industry *j* is said to be tradable i.e. $j \in T$ if it produces tradable goods. Likely, the industry *j* is said to be non-tradable i.e. $j \in N$, if it produces goods that are not to be exported or sold abroad. The labour productivity of tradable and non-tradable sectors at time *t* is defined as,

$$A_t^T = \frac{\sum_{i \epsilon T} \left(\frac{GVA_{i,t}}{PGVA_{i,t}}\right)}{\sum_{i \epsilon T} L_{i,t}}$$

$$A_t^N = \frac{\sum_{i \epsilon N} \left(\frac{GVA_{i,t}}{PGVA_{i,t}}\right)}{\sum_{i \epsilon N} L_{i,t}}$$

Where *t* is the year, *T* is tradable goods and *N* is non-tradable goods. A_t^T and A_t^N are the labour productivity of tradable and non-tradable sectors. $GVA_{i,t}$ is the gross value added for each industry *i* at a time *t* in local currency.

$PGVA_{i,t}$ is the price index[20] of GVA of industry i at time t. $L_{i,t}$ is employment in each industry *i* at a time *t*. The USA is taken as the reference country.

7. Econometric analysis and results

This section deals with econometric analysis and results for both longitudinal and time series analysis.

7.1. Longitudinal (panel) data analysis and results

In order to test the Balassa-Samuelson hypothesis, the analysis continues to use the following procedure. After identifying and calculating tradability and productivity, we calculated the descriptive description as provided in Annexure 4.

Since this study assumes T = 28 hence data has a significant time dimension, for this purpose, this study further proceeds with testing Panel-Unit-root tests to check the order of integration. For that, this paper uses three-panel unit root test namely, Levin, Lin and Chu (2002), Im et al. (2003) and Hadri (2000), Hadri's unit-root test is used because it has a Null hypothesis of stationarity, as some times tests are biased towards the Null hypothesis. Table 1 presents the results and concludes that all variables are Non-stationary i.e. I (1),

For checking cross-sectional dependence, test for Pesaran cross-sectional independence is performed, this test does not reject the null of cross-sectional independence with a calculated-statistic value of 4.781*, significant at 1 per cent.

Evidence of non-stationarity among variables at level motivates for checking the long-run relationship between log (RER) and log (PD). For this purpose Kao's test and Pedroni's for cointegration are performed, Table 2.1 and 2.2 shows the results and concludes that there is no cointegration between the variables i.e. null hypothesis of "No cointegration" is not rejected hence we can conclude that there is no long-run relationship between log(RER) and log(PD).

Since, according to cointegration tests, there is no long-run relationship between the Balassa-Samuelson variables, to analyse the short-run relationship this study further proceeds by using standard dynamic-panel-data model i.e. Arellano-Bover/Blundell bond estimation, the results for this estimation is presented in Table 3 and concludes that a 1% rise in productivity differential leads to -0.166% RER depreciation (as the coefficient is with a negative sign).

Hence, there exists no long-run relationship between the Balassa-Samuelson hypothesis's variables for BRICS countries. This study further proceeds with checking the reasons behind the non-existence of BS effect to do so, three assumptions were tested, the results of that are shown in Tables 4, 5, 6.

Table 1

	Lm, Pesaran, Shin		Hadri		Levin, Lin, Chu	
Variables	At-Level	At-First-difference	At-Level	At-First-difference	At-Level	At-First - difference
log (RER)	-0.56261	-14.8771*	2.28589*	0.07103	1.27593	-20.1097*
log (Productivity differential)	-0.03658	-6.75346*	5.99338*	0.54829	-1.04066	-6.32378*
log (Relative price of Traded goods)	1.07848	-7.60327*	3.58822*	-0.47615	0.21885	-8.64374*
Exchange rate	1.39956	-6.63212*	6.60488*	-0.93409	0.28093	-8.04984*
The relative price of traded goods	1.686	-7.07255*	4.05715*	-0.42529	0.15077	-8.05471*

Note(s): This table presents the stationarity properties of the variables. Unit root tests of "lm, Pesaran, Shin (IPS) (2003), Hadri (2000) and Levin, Lin and Chu (2002)" are reported. The Null hypothesis of these tests except the Hadri (2000) is that panel contains a unit root. The Akaike information criterion (AIC) is used in choosing the optimal lag lengths. "Asterisks (*) and (**) denotes statistical significance at 1 and 5 per cent level". Results reported are those with Individual intercept only, the first difference of I (1) series are reported stationary,

Table 2.1

Kao test for cointegration		
Test statistic	Statistic	Computed- p-value
ADF	1.42836	0.08

Note(s): Table shows the Kao test for cointegration, which is not significant at the 5 per cent level with the "Null hypothesis of no cointegration".

Table 2.2

Pedroni's test for cointegration		
Test statistic	Calculated-Statistic	Computed- p-value
Panel v-Statistic	-0.90466	0.8172
Panel rho-Statistic	0.624972	0.734
Panel PP-Statistic	-0.01313	0.4948
Panel ADF-Statistic	-0.28649	0.3873
Between-dimension		
Group rho-Statistic	1.611545	0.9465
Group PP-Statistic	0.831653	0.7972
Group ADF-Statistic	-0.32601	0.3722

Note(s): Table shows the Pedroni's test for cointegration between log (RER) and log (Productivity differential) with "Null hypothesis of No cointegration".
"Asterisks (*) and (**) denotes statistical significance at 1 and 5 per cent level".

Table-3

Dependent variable log (RER)	Coefficient	Standard error	z-statistic
lag 1	0.8579829	0.493267	17.39*
log (Productivity differential)	-0.165718	0.536123	-3.09*

Note(s): This table shows the short-run relationship between log (RER) and log (Productivity differential) with significant AR (1) component of dependent variable namely lag1, Asterisks (*) represents 1per cent level of significance.

Table 4 presents the Pedroni's cointegration test between log (Relative price of Tradable-goods) and log (productivity differential), the result shows the "acceptance of null hypothesis of no-cointegration" and concludes that there exists no long-run relationship between these two- variables at 1% level of significance.

Table 4 shows the Pedroni's cointegration test between log (RER) and log (Relative price of Tradables), the result shows the "rejection of the null hypothesis of no-cointegration"

and concludes that there exists a long-run relationship between these two-variables at 1% level of significance.

Table 5 shows the cointegration test for PPP between tradable goods and concludes nonexistence of the assumption-3 at 1% level of significance.

Table 4

Pedroni's test for cointegration		
Test statistic	Calculated-Statistic	Computed- p-value
Panel v-Statistic	0.552109	0.2904
Panel rho-Statistic	-0.33513	0.3688
Panel PP-Statistic	-0.85881	0.1952
Panel ADF-Statistic	-1.55825	0.0596
Between-dimension		
Group rho-Statistic	0.312921	0.6228
Group PP-Statistic	-0.81164	0.2085
Group ADF-Statistic	-1.68174**	0.0463

Note(s): Table shows the Pedroni's test for cointegration between log (Relative price of Traded-goods) and log (Productivity differential) with "Null hypothesis of No cointegration". Asterisks (*) and (**) denotes statistical significance at1 and 5 per cent level.

Table 5

Pedroni's test for cointegration		
Test statistic	Calculated-Statistic	Computed- p-value
Panel v-Statistic	4.4789*	0.0000
Panel rho-Statistic	-7.1481*	0.0000
Panel PP-Statistic	-17.8914*	0.0000
Panel ADF-Statistic	-0.7818	0.2172
Between-dimension		
Group rho-Statistic	-0.2358	0.4068
Group PP-Statistic	-4.6143*	0.0000
Group ADF-Statistic	-0.2311	0.4086

Note(s): Table shows the Pedroni's test for cointegration log (Relative price of Tradables) and log (RER) with the Null hypothesis of no cointegration. Asterisks (*) and (**) denotes statistical significance at 1 and 5 per cent level.

Table 6

Pedroni's test for cointegration		
Test statistic	Calculated- Statistic	Computed- p-value
Panel v-Statistic	-1.106588	0.8658
Panel rho-Statistic	0.45685	0.6761
Panel PP-Statistic	0.203588	0.5807
Panel ADF-Statistic	-0.95702	0.1693
Between-dimension		
Group rho-Statistic	1.531269	0.9371
Group PP-Statistic	0.649918	0.7421
Group ADF-Statistic	-1.158628	0.1233

Note(s): Table shows the Pedroni's test for cointegration between Exchange rate and Relative price of Tradables with "Null hypothesis of No cointegration". Asterisks (*) and (**) denotes statistical significance at1 and 5 per cent level.

7.2. Time series analysis

In the last section, panel data analysis for checking the existence of Balassa- Samuelson hypothesis was presented and concluded that hypothesis does not exist in the case of BRICS nations, this section proceeds with further analysing the BS hypothesis for Indian economy by taking the USA as a reference country for the period 1981-2018.

Firstly, time properties of the variables are analysed by checking unit root tests namely, ADF, DF-GLS, PP and KPSS. Since these tests does not consider structural breaks as pointed out by Perron (1989), a series may have structural breaks due to policy changes and/or any external shock. In the presence of such breaks in the series, standard unit root tests may wrongly conclude a stationary series to be non-stationary. Thus, in order to avoid such misleading conclusions, Zivot-Andrews unit root test (1992) with a single endogenously determined structural break is performed, under this test, the structural break is endogenously defined by taking dummy variables for the break date. Results for both with and without structural break unit root tests are mentioned in *annesure-5* and concludes that if we use unit root tests without considering the structural break then the variables are non-stationary of the mixed order, but for Zivot and Andrew test it is found that all series are stationary, I(0).

KPSS unit-root test is used because it has a Null hypothesis of stationarity, as some times tests are biased towards the Null hypothesis.

Since according to Structural unit root test, all series are stationary. Thus, the least-square estimate is appropriate for checking BS hypothesis. Table 7 shows the results and conclude that the Balassa-Samuelson hypothesis exists in case of India and with a 1% rise in productivity differential leads to 0.29% RER appreciation, as the coefficient is with a positive sign.

Table 7

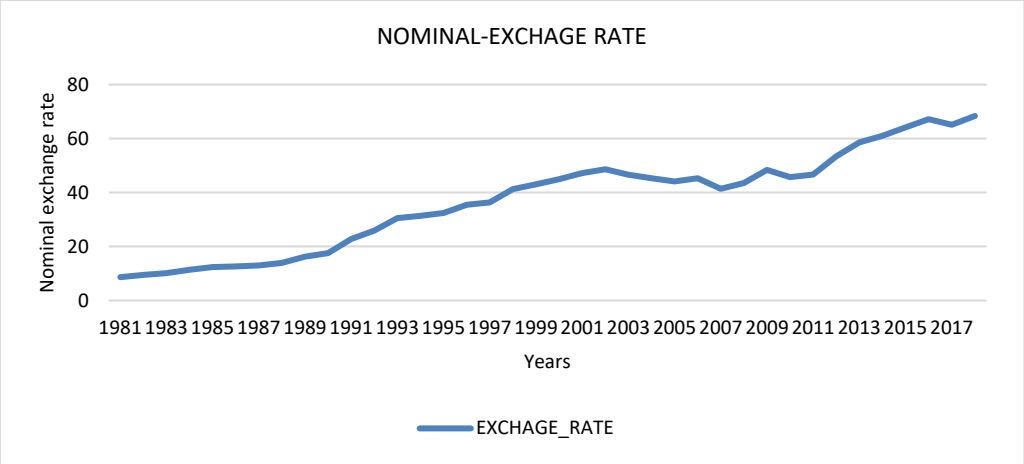
Dependent variable log (RER)	Coefficient	t-statistic	p-value
Constant	-4.516993	-23.04665	0
log (Productivity differential)	0.29025	2.455209	0.019

Note(s): This table shows the least square estimate between log (RER) and log (Productivity differential) with significant constant and slope coefficient.

Zivot and Andrew's unit root test reported the different break periods for all the variables, below represents the individual figures (2.1, 2.2 2.3 and 2.4) of the variables with the possible explanation regarding the break periods.

Exchange rate graph shows a break period of 2003, this might be because consecutive four terrorist attack (9/11), due to which both trade and stock market hampered.

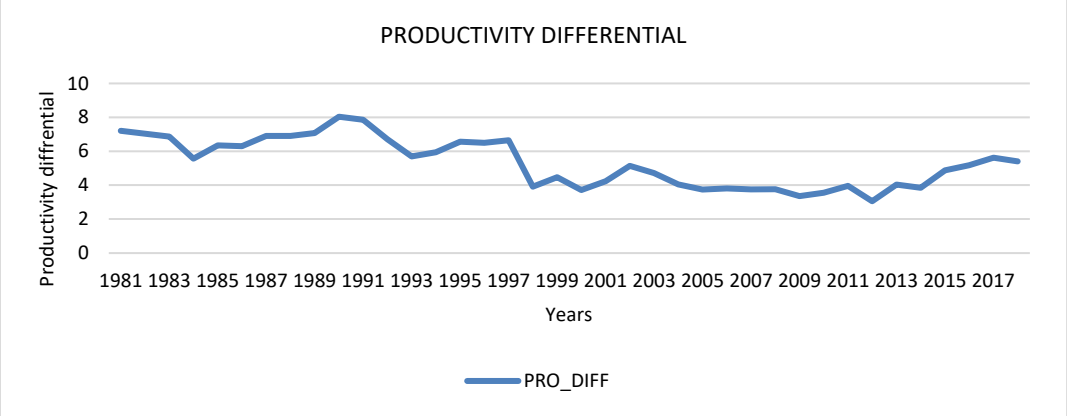
Figure 2.1. *Nominal exchange rate*



Source: UNSTAT.

Productivity differential's graph depicted the break period of 1998, this might be because of Asian crises and also at the backdrop of high fiscal slippage during the late 1990s, the government decided in this period to rationalize the tax structure (for both direct and indirect taxes) and composition of expenditure to control the deteriorating government budget deficit. Also, during this period, India's terms of trade dipped as a consequence of depressed export prices and increased oil prices.

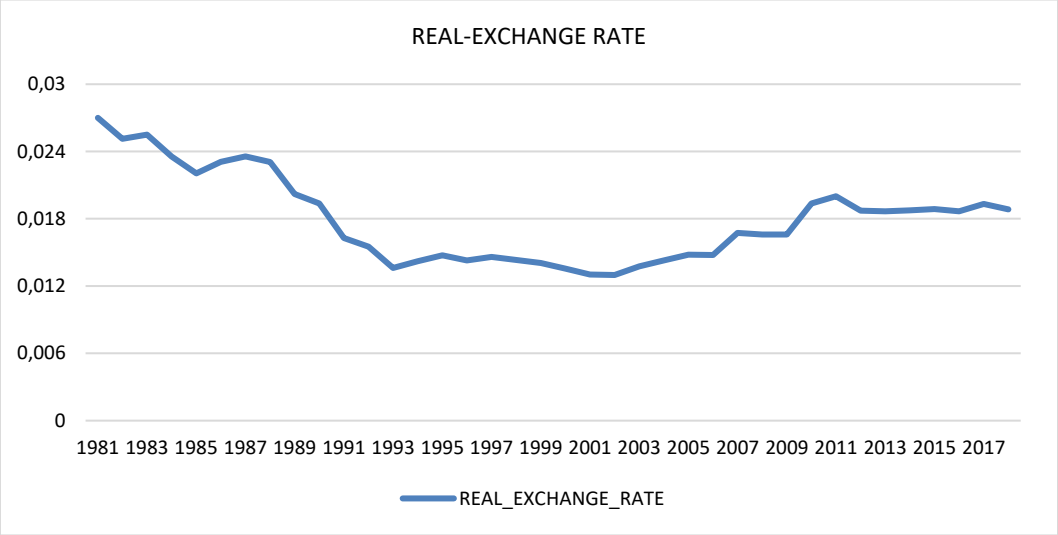
Figure 2.2. *Productivity differential*



Source: Author's own calculation with the help of E-Views.

The real exchange's graph shows a break period as 1989, this might be due to the savings and loan crises which resulted in the closure of 1000 banks.

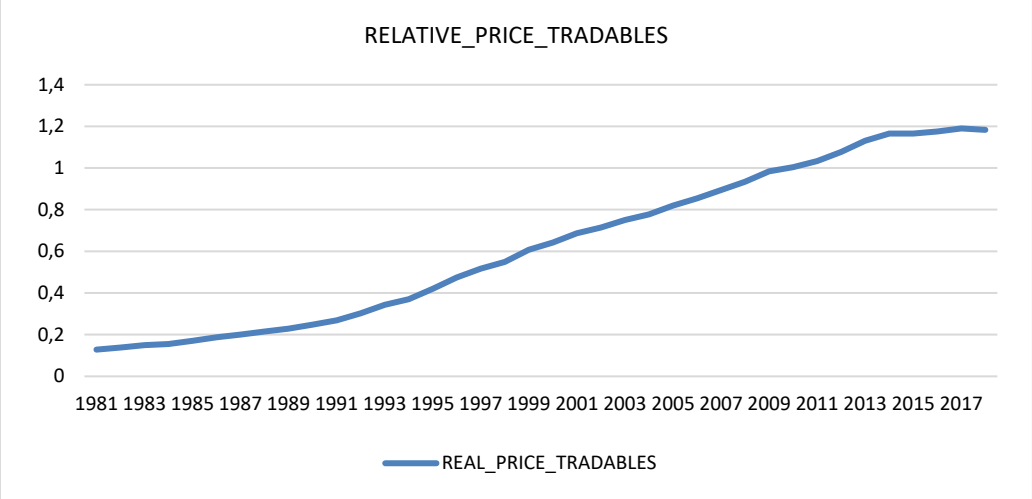
Figure 2.3. *Real exchange rate*



Source: Author's own calculation with the help of E-Views.

The relative price of Traded-goods shows 2005 as a break period this might be because of the *world risk global recession*. Whereas log form shows a break period as 1992, which might due to the *BOP crises*. And after that Indian economy introduced LPG policy, to support their international stability.

Figure 2.4. *Relative price of tradable goods*



Source: Author's own calculation with the help of E-Views.

8. Conclusion and policy implication

The primary objective of this paper was the re-examination the Balassa-Samuelson hypothesis using the approach used by DWG, the second purpose of this analysis was to examine whether the classification of industries matters for BS-effect.

The evidence from BRICS nations indicates the nonexistence of cointegrating relationship between log (RER) and log (PD), one of the possible reasons behind this is the failure of the assumptions B-S hypothesis.

After checking for the above-mentioned assumptions, Results conclude that assumption 1 and 3 are violated i.e. that assumption of correlation between log (relative prices of Tradable-goods) and log (PPP) and the PPP in Tradable goods sector.

Possible reasons why the Balassa-Samuelson Hypothesis does not hold are:
1) There are additional variables which may impact the real exchange rate.
2) Since that reference country is USA which is a Large country in comparison to BRICS, therefore BRICS does not impact prices too much.
3) The non-existence of assumption- 3 of PPP in tradable goods sector could be a reason, PPP formulation has been subject to different-different interpretations, because in real life PPP does not hold because of the following reasons:
   A) PPP undertakes that there are “no transaction costs” and “no trade restrictions”.
   B) An assumption about perfect information about the market leads to the violation of PPP theory.
4) This paper considered only the supply-side model, but Tradable goods can be influenced by demand-side-factors also.
5) Different exchange rates mechanisms could be one of the reasons, as China has the fixed exchange rate system and other BRIS countries has flexible exchange rate system

Then by analysing time series, the validity of BS hypothesis is checked and found to be positive.

From the policy standpoint of view, these findings provide, useful framework for analysis appropriate thresholds based on relative productivity to understand the long-lasting behaviour of RER.

In addition, from the above study, two important conclusions arise. First, factors other than differential productivity growth in BRICS nations may tend to have been primarily responsible for higher inflation. Second, the empirical evidence that faster productivity growth in tradable industries leads to increasing relative prices of non-tradables must be carefully differentiated (and hence domestic inflation). While the effects in India have been present and are very small, and hence the Claims that the Balassa-Samuelson effect is a significant determinant of inflation in the BRICS countries therefore tend to have weaker empiric foundations.

Even after incorporating industry-wise classification there are a few questions unanswered and might become the future scope of this study.
1) Demand-side-factors can be incorporated.
2) Panel-unit root test with structural break could be used for robust results. In addition like dynamic panel data models, dynamic time series models could be used for the robust results.

3) More disaggregate database for BRICS nations can be used to analyse the Balassa-Samuelson hypothesis.
4) Future research in this area can be considered by employing alternative strategies for the classification of Traded and non-Traded sectors.

Note

(1) Country of interest.
(2) Top five Exporting products are Petroleum, Pharmaceuticals, chemicals, jewellery and precious stones and leather products.
(3) The series for GDP-deflator is constructed At Constant/Current Prices by taking 2012 as Base Year for the period 2004-2005 to 2018-2019.
(4) GDP deflator/Implicit price deflator for GDP measures the level of prices of all final goods and services produced domestically.
(5) According to India-stat, services comprise following-
   a) Constructions.
   b) Hotels, Transports, communications and broadcasting services.
   c) Finance, Insurance, Business Services and Real estate.
   d) Quasi-government services, Public administration and Defence.
(6) As some researchers documented that RER is unit root stationary that means in the long run PPP does not hold (Corbae and Ouliaris (1988), Baillie and McMahon (1989) with several others).
(7) Commodity baskets should be exactly same between the countries.
(8) Hsieh (1982), Jones and Purvis (1983), Backus and Smith (1983), Marston (1987) and Neary (1988), Bergstrand (1991), Rogoff (1992), Obstfeld (1993), De Gregorio, Giovannini, and Wolf (1994), among others, the vast literature makes it difficult to cite all the relevant papers.
(9) BEER refer as the Behavioural Equilibrium Exchange rate.
(10) The fundamentals were assumed to be the key determinant of the RER for the countries which had taken into account either trade reforms or economic reform.
(11) Shorthand for Instrumental variables.
(12) Shorthand for seemingly unrelated regression technique.
(13) Shorthand for autoregressive distributed lag models.
(14) Chinn (1998), Broeck and Slok (2001), Sonora and Tica (2007) and Jongwanich (2010)
(15) Purna Chandra Parida et al. (2001), Sirajul Islam (2013).
(16) These assumptions are taken from the Base paper, “Does Balassa-Samuelson hypothesis hold for Asian countries?” (Drine and Rault, 2002).
(17) Global trade is supposed to equalize the price of tradable goods across nations.
(18) Since we have more focused towards the long run, hence, omitting the time subscripts.
(19) Assumptions are already discussed in the section: 3
(20) $PGVA_{i,t}$ can be thought of as a Price deflator.

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Annexure

1) Collection of some of the important literature on Balassa-Samuelson hypothesis.

Author(s)	Year	Investigated Country(s)	Time-Period	Econometric Technique	Sector-wise classification		BS effect-Result
					Traded-sector	Non-traded sector	
P.A. David	1972	12	1950, 1955, 1965	OLS	Aggregate analysis		Positive
Balassa	1973	12	1960	OLS	Aggregate analysis		Positive
P.A. David	1973	18	1960-1962	OLS	Aggregate analysis		Positive
Lawrence H. officer	1976	15	1950-1973	OLS	Agriculture, Mining, Manufacturing	All other Industries	Mixed
Rogoff	1992	2	1975-1990	OLS	Aggregate analysis		No effect
De Gregorio and Wolf	1994	14	1970-1985	SUR	Agriculture, Mining, Manufacturing and Transportation	All other Industries	Positive
Chinn' and Johnston	1996	14	1970-1991	Non-linear least square time-series estimate and SUR	Agriculture, Mining, Manufacturing and Transportation	Services	Positive
Chinn et al.	1997	14	1970-1991	EG, ECM	Manufacturing	Services	Mixed
Rother	2000	1	1993-1998	OLS time series	Manufacturing except for Agriculture	Services	Positive
Chinn	2000	10	1972-1992	OLS, NLS, GLS	Agriculture, Mining, Manufacturing and Transportation	All other Industries except Public administration, Defense and Social services	Negative
Halpern and Wyplosz	2001	12	1991-1999	GLS Panel ESTIMATION	Industry	Services	Positive
Macdonald and Ricci	2001	10	1970-1992	DOLS	Manufacturing, Mining, Transportation and Agriculture	Utilities, Construction and Services	Mixed
Taylor et al.	2001	9	1992-1997	Johansen-VAR, NLS, ESTR	Aggregate analysis		Positive
De 'Broeck et al.	2001	25	1991-1999	OLS, ARDL, ECM	Manufacturing and Construction	All other Industries except Agriculture	Positive
Imed Drine and Christophe rault	2002	6	1983-1998	Panel data Cointegration and Dynamic models	Agriculture, Manufacturing, Forestry, Fishing and Hunting,	Transport, Storage, communication, Insurance, Finance, 'Real Estate and 'Business services	Mixed
Egert, Imed drine et al.	2002	9	1995-2000	Panel data Cointegration	1) Agriculture and Industry except Construction 2) Without agriculture	All other Industries	mixed

Author(s)	Year	Investigated Country(s)	Time-Period	Econometric Technique	Sector-wise classification		BS effect-Result
					Traded-sector	Non-traded sector	
Vikas Kakkar	2003	14	1970-1998	Panel data Cointegration and Dynamic models	Agriculture, Mining, Manufacturing, Retail and Transportation	Electricity, Gas, Water, Finance, Insurance, Real Estate, Private and Government services	Positive
Choudhri and Khan	2004	16	1976-1994	Pedroni, DOLS	Agriculture and Manufacturing	All other Industries	Positive
Renu Kohli and Sudip Mohapatra	2007	1	1980-2002	OLS and IV	Food products, Beverages, Tobacco, Textile group, Leather and Fur products, Chemicals, Metal and Non-metallic products, Transport, Insurance, Communication Services, Legal Services, Business services	Electricity, Gas and Water supply, Construction, Trade, Hotels and restaurants, Railway transport and 'Storage, 'Banking, Real 'Estate Dwellings and 'Business services, 'Community and personal services	Positive
Jose Garcia-Solanes and Fernando Torrejon-Flores	2009	32	1991-2004	Panel Cointegration and Nonparametric Bootstrapping Technique	Manufacturing, Transportation, Storage, Communication, Mining and Quarrying	Electricity, Gas, Water supplies, Wholesale and 'Retail trade, 'Hotels and 'Restaurants, Finance, 'Real Estate except 'Public Services	Mixed

2) Classification of industries into Tradable (T) and Non-tradable (NT) sector for Time-series analysis*).

Industry code	KLEMS Industry Description	India	United States
A- B	Agriculture, Hunting, Forestry and Fishing	NT	T
C	Mining and Quarrying	T	NT
15 – 16	Food Products, Beverages and Tobacco	T	T
17 –19	Textiles, Textile Products, Leather and Footwear	T	T
20-22	Wood and Products of Wood and Pulp, Paper, Paper Products, Printing and Publishing	T	T
23	Coke, Refined Petroleum Products and Nuclear fuel	T	T
24	Chemicals and Chemical Products	T	T
25	Rubber and Plastic Products	T	T
27-28	Basic Metals and Fabricated Metal Products	T	T
29	Machinery, Not elsewhere classified	T	T
30- 33	Electrical and Optical Equipment	T	T
34- 35	Transport Equipment	T	T
36- 37	Manufacturing recycling	T	T
E	Electricity, Gas and Water Supply	NT	NT
F	Construction	NT	NT
G	Trade	NT	NT

Industry code	KLEMS Industry Description	India	United States
60- 63	Transport and Storage	NT	T
J	Financial Services	NT	NT
71- 74	Business Service	T	NT
L	Public Administration and Defense; Compulsory Social Security	NT	NT
M	Education	NT	NT
N	Health and Social Work	NT	NT
70+ O+ P	Other services	T	NT

*) For aggregation purpose code 19 is merged with 17-18, code 20 is merged with 21-22, code 70, O, P are merged, codes 60, 61, 62, 63 are merged, codes 50, 51, 52 represents as new code G. I8 industries are come out to be same in both the countries rest are different.
Source: Author's own calculation.

3) Classification of industries into Tradable (T) and Non-tradable (NT) sector for Panel-data analysis

Description/Country	Brazil	Russia	India	China	South Africa	United States
Services	*NT*	*NT*	*NT*	*NT*	*NT*	*T*
Agriculture; forestry and fishing	*T*	*NT*	*NT*	*NT*	*NT*	*NT*
Construction	*NT*	*NT*	*NT*	*NT*	*NT*	*NT*
Manufacturing	*T*	*T*	*T*	*T*	*T*	*T*
Mining and quarrying	*T*	*T*	*T*	*NT*	*T*	*NT*
Utilities	*T*	*T*	*T*	*T*	*T*	*T*

Source: Author's own calculation.

4) Descriptive summary

Variables	Mean	Maximum	Minimum	Std. Dev.	Observations
Exchange rate	2.009698	4.225341	-8.645246	1.91723	140
The relative price of tradable goods	-0.36068	0.142022	-1.338784	0.296224	140
Productivity differential	0.380532	0.986559	-0.495753	0.4012	140
Real exchange rate	-2.51466	-0.481341	-4.302176	1.205128	140

Note(s): This table presents descriptive statistics. The statistics of mean, stand. deviation, minimum and maximum are reported. All the variables are in log form.
Source: Author's own calculation.

5) Results of unit root tests

	ADF		DF-GLS		PP		KPSS	
Variables	At-Level	At- FD	At-Level	At -FD	At-Level	At-FD	At- Level	At- FD
log (RER)	-3.04642**	-4.839251*	-1.0392*	-	-2.07165	-4.908047*	0.255005*	0.45601*
log (Productivity differential)	-1.90973	-7.569326*	-1.5932*	-	-1.82209	-7.786526*	0.52383*	-
log (Relative price of Traded-goods)	-4.8980*9	-	-1.9206*	-	- 3.13461**	-	-0.720349*	0.540426*
Exchange rate	-0.04365	-5.019033*	-0.1768*	-	-0.16053	-5.05645*	0.7146*	0.08225
Relative price of Traded-goods	-0.67079	-2.35851	-2.7687	-2.233911*	0.29668	-2.585162	-2.333669*	0.22491*

Note(s): This table presents the stationarity properties of the variables without considering structural breaks. Unit root tests results are reported, Lag Length selection is based on AIC for ADF and DF-GLS, for KPSS Newey-West bandwidth criterion is used, In ADF test the reported values are with the constant term, Asterisk (*) and (**) shows 1 and 5 per cent level of significance, FD denotes "First difference".

Zivot-Andrews's Unit Root Test				
Variables	Statistic	Break-period	Lag length	Results
log (RER)	-3.930964	1989	0	"Series is stationary i.e. I (0)".
log (Productivity differential)	-4.146898	1998	0	"Series is stationary i.e. I (0)".
log (Relative price of Traded-sector)	-0.000587	1992	1	"Series is stationary i.e. I (0)".
Exchange rate	-3.91341	2003	3	"Series is stationary i.e. I (0)".
The relative price of traded-sector	-2.333669	2005	4	"Series is stationary i.e. I (0)".

Note(s): This table presents the time-properties of the variables after considering structural breaks. Zivot Andrews-Unit root test's result is reported, "asterisk (*) and (**) shows 1 and 5 per cent level of significance".
Source: Author's own calculation.