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# Foreign Direct Investment, Aggregate Demand Conditions and Exchange Rate Nexus: A Panel Data Analysis of BRICS Economies

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**Abstract:** In this study, we attempt to provide underlying theoretical and empirical explanations for exchange rate appreciation due to foreign capital influx and aggregate demand conditions in the BRICS economies. The empirical analysis is based on a panel dataset of BRICS countries over the time period 1992–2013 to substantiate our theoretical findings. For panel co-integration, Pedroni and Johansen-Fisher panel co-integration tests are conducted to compare co-integration among panel countries. We also analyze the results from Dumitrescu-Hurlin panel causality test among variables and use Granger Causality to test for the causal patterns in each of the individual countries. Our findings showed that the exchange rate volatility is directly affected by the flows of FDI, GDP per capita, Capital formulation and House hold consumption. The results have profound implications in terms of exchange rate stability in the BRICS countries and associated risks.

**Keywords:** FDI, official exchange rate, panel data, co-integration, Pedroni

**JEL Classifications:** C33, F21, F31, O55

## 1 Introduction

The BRICS over the last two decades have become a systemic and influent component in the world economy. At present the BRICS<sup>1</sup> economies constitute

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<sup>1</sup> The acronym “BRICS” stands for Brazil, Russia, India, China and South Africa. The term was initially used by economist Jim O’Neill, of Goldman Sachs, in 2001 while reporting on growth

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over 42 % of the world population and over 20 % of the world GDP (IMF 2015). On top of that the combined foreign reserves of the BRICS countries are estimated to be over US\$ 4 trillion, indicating towards the resilience of these economies and export lead growth in the recent history of global trade.

It is noticeable that the BRICS increasingly recognize themselves as a group, starting from the interaction of Foreign Ministers in 2006, which led to the annual summit of the Heads of State in 2009, the depth and scope of the dialogue among the members was further enhanced. In a fairly short span of time the BRICS has become a new and promising political and economic entity. The effort BRICS have made so far have two dimensions a) towards reforming the structures of global governance, especially in the economic and financial fields b) cooperation among the members of BRICS. On the aspect of financial and economic cooperation, special emphasis has been given and with subscribed capital of US\$ 50 BRICS established the New Development Bank to finance infrastructure and sustainable development projects in the BRICS and other developing countries. On top of that, to forestall the short-term liquidity pressures, with an initial fund of US\$ 100 billion the BRICS have agreed to create the Contingent Reserves Arrangement (CRA). Nevertheless, the CRA also contribute to the stability of international financial architect, along with a reflection on the intention of BRICS members to deepen and consolidate their partnership in the economic-financial area (BRICS 2015).

However, after Global Financial Crisis (2008) and particularly after these last 2 years the synergy between BRICS has begun to breakdown, due to the slow growth in China, political Changes in Brazil and steadily falling commodity prices due to over expansion. The World Bank in her report Global Economic Prospects (2016) has highlighted these downside risks<sup>2</sup> from the emerging markets for the growth in 2016. The BRICS therefore is facing a whole set of new challenges. As such an important investigation of the generalized experience of the BRICS, is both timely and important.

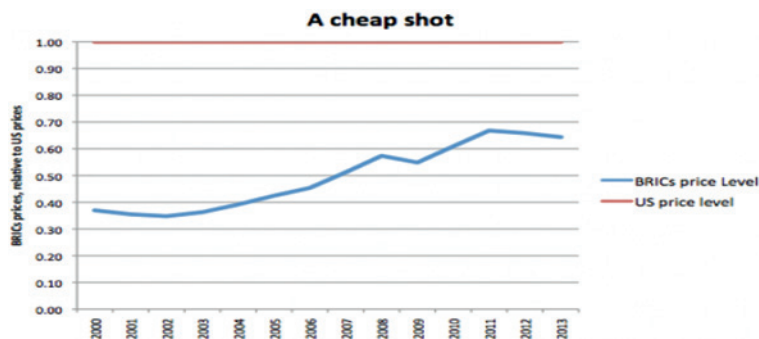
An important aspect we should bring into the limelight here is the exchange rate of the BRICS economics and issues around it. The developing economics

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prospects for the economies of Brazil, Russia, India and China – which together represented a significant share of the world's production and population. Initially called BRICs became BRICS in 2011 with the inclusion of South Africa.

<sup>2</sup> The World Bank (2016) in her reported cautioned that the could be a more protracted slow-down across large emerging markets which could have substantial spillovers to other developing economies, and eventually hold back the recovery in advanced economies. For further details please refer to the report available at < <http://www.worldbank.org/en/publication/global-economic-prospects> >

particularly, China has been accused of competitive devaluation, although we see a long term appreciation in the Reminbi in the last decade and a half. Perhaps, China has been more focused on the provision of liquidity to the real economy than the currency (Briscoe 2015). Nevertheless, an interesting fact is that there is no consensus on how much devaluation or undervaluation is there in a particular currency, for instance study by Gan et al. (2013) suggested that RMB was overvalued in the range of 0.27 % to 11.26 % from the 1st quarter of 1991 to 3rd quarter of 2003 and then it was undervalued in the range of 1.13 % to 8.69 % from the 4th quarter of 2003 to the end of 2007, whereas other studies on the same quest like Wang (2004), Funke and Rahn (2005) and MacDonald and Dias (2007), each suggested different levels of misalignments (undervalue/overvaluations). Hence, the question of overvaluation or undervaluation might be exotic and interesting due to its political dimension, yet the answer varies, depending on the underlying methods used to find it. On the issue of competitive devaluation, Variar (2011) argued that in the post Global Financial Crisis (2008) there has been politicisation of economic issues which included the unfair trade distortions and devaluation of the currencies.<sup>3</sup> Looking at the facts on the grounds and long term trajectories, one could witness that there has been appreciation of currencies, particularly China as the Figure 1 below also suggests.



**Figure 1:** A cheap shot, adopted from the Economist (Source: The Economist 2013).

<sup>3</sup> Variar (2011) argued that in the recent years, especially in the post financial crisis era, there has been a surge in politicisation of economic issues, changing governments in continental Europe, republican-democratic disagreement over debt reduction deals, and political outcry over audit reports. The consequence of politicisation has invariably been the worsening of the economic crisis. Arguably one of the most important issue has been that of the supposed “trade distorting, global imbalance creating, grossly unfair devaluated exchange value of the “People’s currency” – the Renminbi (RMB)”.

As it shows taken together the BRICs have become notably dearer over the past decade. There is an increase in the combined price level from 2001 onward which although plateaued in the last couple of years. Hence, the facts on the ground do not indicate a very large competitive devaluation from the BRICS. The political outcry or debate, whatever one would like to call it may not be the aspect we can cover in this study, or perhaps not in any conclusive arena. Yet, in this paper we are focused on analysing the exchange rate of the BRICS economies. More, specifically speaking this treatise is investigating the association between the exchange rate of the BRICS countries and its association with the Foreign Direct Investment (FDI) and internal demand conditions prevailing in the subject economics. The analysis of the association among these variables of interest will give us an empirical insight into the nexus among them and also verify the notion that whether the exchange rate has been influenced by the flow of FDI and internal demand conditions of these economies. In case we found that it is so, it would imply that there has not been competitive devaluation, at least not in an absolute sense. One might then argue for a partial competitive devaluation for which further lines of inquires could be opened.

Foreign direct investment (FDI) is an international flow of capital that gives a parent company or multinational enterprises (MNEs) control over foreign affiliates. Since the early 1980s, FDI has been recognized as an important instrument of resource to flow across national borders to stimulate exports by improving industrial competitiveness and economic growth.<sup>4</sup> In a perfectly competitive economy, FDI itself may be of little significance, hence we use an imperfect and asymmetric information of the market characteristics to explain FDI flows. A bulk of the literature focuses on the causes and impacts of FDI inflows in macroeconomic framework irrespective of the market conditions prevailing in the host country. The official exchange rate appears to be one such factor that has been subjected to intense debate due to inconclusive evidence on the subject. A critical question that confronts analysts is to

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<sup>4</sup> Several researchers have identified the benefits of FDI which may accrue to host countries (Meyer 2003). For developing countries, it is not only a major source of finance but also an important means for narrowing technology gap with high income countries. Other notable benefits may include enhancement of managerial skills, development of the export markets as well as spill-over effect leading to the improvement in productive efficiency in the host economy. Several other factors such as the development of infrastructure, removal of trade and investment barriers, development of multinational banking and other financial institutions network have contributed greatly in the growth of FDI especially during the last decade.

explain how the relationship between exchange rate movements and FDI inflows. The evidence on this relationship is mixed; some considers it positive or negative while others could not find any relationship at all. Studies on causal relationships between exchange rate and FDI also reveal a lack consensus.

In general, FDI impacts positively on the host country's balance of payments (BOP) and appreciates exchange rate (somewhat similar to the Dutch disease problem). For developing economies, among them we can list BRICS, such an impact can be detrimental to trade and income account balance with serious implications for the overall balance of payments and foreign exchange reserves (Sarno and Tayler 1999). The combined effects of FDI on current account balance in the short and long run varies in time and may differ from country to country depending largely on how FDI impacts domestic savings and economic growth. If it flows in the form of acquisitions of the current assets in newly manufacturing sectors (NMS), the evidence suggests that it did little to improve the current account balance as a large share of the financial receipts from the sale of the existing capital stock eventually stimulates expenditure on consumption and imports rather than capital formation (Mencinger 2003).

During the last few decades, quite a large number of studies have been conducted in analyzing the determinants as well as the impacts of inward FDI in host countries. Since country-specific characteristics differ, analysts are not expected to come up with conclusive sets of explanatory variables. Besides this, factors such as methodologies, sample-selection, analytical tools influence in explaining diverse empirical evidences. Despite the growing volume of studies examining the relationships among FDI and macroeconomic factors, the ambiguity and inconclusiveness still persist as ever before. Of these, FDI and exchange rate is one such relationship which depends, among others, on the destination of goods produced. Whereas FDI led import substitution increases domestic purchasing power of the consumers, the depreciation of the host country's currency may stimulate FDI by lowering the cost of capital goods/investment. In case FDI complements exports, it may have the opposite effect. Therefore, currency appreciation is less likely to encourage FDI inflows because of its adverse effects on international competitiveness. Concomitantly, this nexus provides rationale to the subject treatise by raising the question that whether the flux of FDI into the BRICS economies and dynamics of economic growth had some implications for the exchange rate in the recent past. This study contributes to the existing literature by analyzing the relationship among FDI, internal demand and exchange rate movement in the BRICS countries. In order to do so, we employed panel unit root, panel co-integration and panel causality for the data spanning over the period 1992–2013. In order to

substantiate our empirical findings, panel co-integration, Pedroni and Johansen-Fisher panel co-integration tests are conducted to compare co-integration results among individual panel countries.<sup>5</sup> The results derived from Dumitrescu-Hurlin panel causality test and Granger Causality tests for the causal patterns for individual countries, will enhance our understanding of the nexus among under analysis variables and their economic implications for policy measures in achieving long-term economic stability and growth.

Structure wise this paper is divided into four sections, the next section provides a brief overview of the relevant literature. The proposed methodology and the structure of the model is discussed in Section 3. The empirical analysis and the major findings of the study are presented and discussed in Section 4 which will lead us to draw conclusions and shed light on policy implications in the last section.

## 2 FDI, Aggregate Demand Conditions & Exchange Rate Nexus

Foreign direct investment and capital flows targeted mainly in export sector is a relatively new phenomena in the global economy. Such inflows of foreign capital change the sectorial composition of the economy and it has its influence on the exchange rate of the destination country. There is fair amount of literature on the debate about the relationship between FDI and exchange rate, perhaps since the start of the FDI. Before, we come to nexus of the exchange rate with FDI and macroeconomic (aggregate demand) condition, it might be worth posing this question that why FDI happens at first place. There is large amount of literature covers the determinants of FDI.<sup>6</sup> Nevertheless,

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<sup>5</sup> In particular, the study uses panel causality test introduced by Dumitrescu and Hurlin (2012) which is a version of Granger (1969) non-causality test for heterogeneous panel data models with fixed coefficients. It takes account of the two dimensions of heterogeneity, viz. the heterogeneity of the regression model used to test the Granger causality and the heterogeneity of causal relationships.

<sup>6</sup> On this aspect, while analyzing the determinants of US FDI into Western Europe Reuber et al. (1973) found that the main factors that attracted the US investment were lucrative markets, liberal host government, technological infrastructure and cultural proximity. Whereas, Agarwal (1980) found labor costs, country size, the nature of the exchange rate regime and political factors including political stability as main factors explaining FDI inflows. Similarly, Buckley et al. (2002) found that the variation of FDI inflow into developing countries can be explained by various factors such as GDP and its growth, R & D intensity, economies of scale, per capita exports and imports,

considering the scope of subject study and in effort to be a bit more specific, we take the FDI for granted and come to the main theme under analysis which is the nexus of it with the exchange rate. On this issue, we have a number of studies to acknowledge which have investigated the significance of relationship between exchange rate and FDI inflows. For instance, Caves (1989) reported a significant negative correlation between the level of exchange rates (both nominal and real) and FDI inflows in the US. On the direction of causality first if we consider the angle from exchange rate to FDI there are studies like Froot and Stein (1991) which found that a real depreciation of the US dollar increased FDI inflows in the US during 1973–1988. The relationship seemed to be more prominent in industries with a higher level of potential information asymmetry such as chemical and machinery industries. Similarly, Kogut and Chang (1996) and Blonigen (1997) also concluded that the real appreciation of the Japanese Yen led to more entries of Japanese firms in the US.<sup>7</sup> A number of later studies including, Dees (1998), Beak and Okawa (2001), Pan (2003), Farrel, Gaston, and Sturm (2004), Osinubi and Amaghionyeodiwe (2009), Liu (2010), Wafure and Nurudeen (2010), Renani and Mirfatah (2012) and Takagi and Shi (2011) came up with a similar conclusion in relation to the relative wealth hypothesis that the real depreciation of currency promotes FDI inflows in host country. Likewise, Vijay Kumar et al. (2010) used yearly data of BRICS economies for the period 1975–2007 and found significant negative relationship between FDI and real exchange rate. Hence, in the light of the evidence reported by these studies it bring home to us that exchange rate depreciation has been mostly attracting the FDI. However, contrarily, the survey results reported by Ali and Guo (2005) concluded that the exchange rate was not the key factor for MNE in exploiting economic opportunities in China. Their findings make the depreciation of exchange rate as a controversial locomotive for FDI. Moreover, it also poses

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exchange rate differentials, the level of development of country's infrastructure, tariff barriers, and dependence on the host country's raw material, the level of political stability and political risk, proximity between host and home countries and availability of skilled manpower. Schneider and Frey (1985) used data on 80 developing countries and found that country's level of development attracted FDI while political instability led to a sharp decline in FDI. Yet some studies have specifically emphasized the critical role of developed infrastructure in attracting FDI inflows, (Wheeler and Moody 1992; World Investment Report 1998).

<sup>7</sup> The empirical evidence by Blonigen (1997) lends further support to the earlier findings by Kogut and Chang (1996) by reporting that the real appreciation of Japanese yen against the US dollar had positive impact on the number of Japanese acquisitions in the US, especially in those manufacturing industries with more firm specific assets.



the question about the repercussions which could be the reverse causation in either direction, putting it in a more sober way, it raises a query that if depreciation has led to FDI influx, what will be the impact of that FDI on the exchange rate?

The financial liberalization of the past two decades highlighted the significance of foreign exchange rates in impacting FDI inflows in emerging economies. The depreciation of exchange which may or may not strongly influence and cause the flux of the FDI into the country, the ever depreciating or volatile exchange may not be desirable. On this aspect, Kiyota and Urata (2004) examined the relationship between FDI and real exchange rate for Japan. Similarly, Abbott et al. (2012) found that developing countries with fixed or intermediate exchange rate regimes have attracted more FDI compared to the ones with flexible exchange rate regime. Similarly, among other studies, Alaba (2003), Ogunleye (2008) and Dhakal et al. (2010) conclude that weak currency discourages the volume of FDI inflows in the host country. Their results indicate that real exchange rate level did stimulate FDI whereas exchange rate volatility discourages FDI. Perhaps, it's not only the exchange rate volatility of BRICS themselves, the volatility in the exchange rate of other countries, for instance as investigated by Maradiaga, Zapata, and Pujula (2012), volatility of G-3 currencies (US\$, Yen & Euro) could also have adverse implications for the BRICS exports particularly for China and Brazil. Hence, the accusation of competitive devaluation which could cause volatility in the exchange rate market could also discourage the influx of FDI. Concomitantly, it implies that the devaluation might be an irrational strategy. Hence, we see this phenomena in the light of BRICS economies and how the level of FDI has influenced their exchange rates.

The second dimension of this study is the association between the internal demands on the exchange rate. The proxies we are using to present internal demands are the household consumption, capital formulation and income or GDP per capita. In the light of the theory of aggregate demand and Keynesians argument, these elements constitutes the internal demand of an economy. Logically, the increase in the internal demand based economic and productivity growth (Balassa-Samuelson effects<sup>8</sup>) should affect the exchange rate through the

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**8** In 1964, Bela Balassa and Paul Samuelson, independently observed that countries with higher levels of productivity growth experienced rapidly rising real wages and so appreciating real exchange rates. Academic studies since have suggested the picture is not as simple as Balassa and Samuelson first thought and that many other factors can also influence the model. However, many long term investors in emerging market currencies, for example, have been able to benefit from the appreciation of those currencies which is arguably due to the Balassa-Samuelson effect, (FT, 2016) available at [http://lexicon.ft.com/Term?term=Balassa\\_Samuelson-effect](http://lexicon.ft.com/Term?term=Balassa_Samuelson-effect)

real wage increase, but also through another channel which is not focused in the existing literature, i.e. the demand for the consumable. However, despite exhausting efforts we have not found much to report on the relationship among these constituents of internal demand and the exchange rate. Among the limited amount of evidence we reflect on, study by Gan et al. (2013) and Tang (2015) found that the real GDP growth lead to the depreciation of Chinese currency whereas FDI leads to appreciation. However they could not find a relationship between growth and exchange in long term. Although they used the economic growth on aggregate rate rather than the per capital measure which may give us better representation of the demand channel on which this study is focused. Moreover, the economic growth in China has been export lead with investment as its biggest constituent, therefore to look for the proxies to better represent the outlook of internal demand we will have to bring the factors this study is suggesting into consideration.

Study by Zhang, Chau, and Zhang (2013) examined the Renminbi exchange rate determination against US dollar, looking at the forex market microstructure (order flow)<sup>9</sup> they found that the order flow as a measure of excess demand for the currency (RMB – Dollar in this case) to a large extent explains the fluctuation in the currency. However, what determines the demand and magnitude of the order flows for a particular currency is the underlying macroeconomic factors. Putting it more specifically, it is the consumption of the household and house hold real income which this study intended to investigate. On the competitive devaluation and implication for growth, seminal study by Rodrik (2008) argued that an undervaluation of currency could lead to high economic growth. On similar lines and using the empirical framework for derivation of undervalue real exchange rate, a very comprehensive study by Razmi, Rapetti, and Skott (2012) considering over 153 countries found that the currency undervaluation affects the capital formation in the developed countries negatively whereas the results were positive for developing countries. It suggests that the undervaluation could affect the investment and capital formulation positively, however what happens as the country grows, specifically how this capital formulation and economic growth affects the exchange rate, more specifically in the BRICs economies? That is the question! Concomitantly, there are two reasons for undertaking this study. Firstly, the empirical evidence is not conclusive which may be of very limited use in

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<sup>9</sup> The daily order flow is the imbalance of the buyer-initiated orders and seller-initiated orders during the opening time of the working day (see Evans and Lyons 2002 for details).

guiding policy makers. Hence, the controversy motivates this research on the comparative relationship between the real exchange rate and FDI inflows. Secondly, this study specifically focuses on BRICS economies for the earlier discussed importance of this political-economic entity and the controversies surrounding the exchange rates in these economies.

### 3 Methodology and Data

In this paper, we employed the panel data to study the relationships between the official exchange rate (OCR) and explanatory variables which include Foreign Direct Investment, Household Consumption, Gross Domestic Product *per capita* and Gross Capital Formation.

#### 3.1 Data

The data from 1992 to 2013 is obtained from the World Bank Development Indicators. Depicting the relationship among the under analysis we get the following equation:-

$$OER = f(HC, FDI, GCF, GDP \text{ per capita}) \quad [1]$$

where FDI is foreign direct investment, level of household consumption [HC hereafter], annual growth rate of gross domestic product per capita [GDPPC hereafter] and Gross Capital Formation [GCF hereafter]. Among these four explanatory variables employed in this analysis, *FDI* is considered as the explanatory variable of the prime interest. The choice of these variables relies on the appropriateness and suitability of the proxy used to represent either the FDI inflows, exchange rate dynamics or macroeconomic conditions of the internal aggregate demand. Household consumption expenditure is the market value of all goods and services, including durable goods purchased by households in BRICS countries. FDI represents the total *FDI* inflows into BRICS countries. *OER* is the exchange rate of BRICS countries that is determined by the national authorities relative to US dollars; *GDP per capita* is the gross domestic product per capita of BRICS countries; and *GCF* is the total gross domestic investment in BRICS countries. The empirical model form for this specification is given by:

$$OER_{it} = \beta_0 + \beta_1 HC_{it} + \beta_2 FDI_{it} + \beta_3 GCF_{it} + \beta_4 GDPPC_{it} + \varepsilon_{it} \quad [2]$$

Where *FDI*, *HC*, *OER*, *GCF*, and *GDP per capita* are as defined earlier in eq. [1]. The  $\beta_0$  is the constant,  $\beta_1$  to  $\beta_4$  are estimated parameters in the model and  $i$  is observation subscript for panel data for BRICS countries and  $\varepsilon_{it}$  is an error term.

In this study, we employed Pedroni and Johansen-Fisher panel co-integration tests. An important advantage of the panel group estimators is that the form in which the data is pooled allows for greater flexibility in the presence of heterogeneity of the co-integrating vectors. The results of panel group estimators are designed to test the null hypothesis  $H_0: \beta_i = \beta_0$  for all  $i$  against the alternative hypothesis  $H_A: \beta_i \neq \beta_0$ , so that the values for  $\beta_i$  are not constrained to be the same under the alternative hypothesis. Clearly, this is an important advantage for applications such as the present one, because there is no reason to believe that, if the co-integrating slopes are not equal to one, which they necessarily take on some other arbitrary common value. Another advantage of the panel group estimators is that the point estimates have a more useful interpretation in the event that the true co-integrating vectors are heterogeneous. Specifically, point estimates for the panel group estimator can be interpreted as the mean value for the co-integrating vectors (Pedroni 2001).

## 4 Empirical Evidence

In order to investigate the possibility of panel co-integration, first of all, it is necessary to determine the existence of unit roots in the data series. For this purpose we have chosen the Im, Pesaran and Shin (IPS, hereafter) method, which is based on the well-known Dickey-Fuller procedure. Im, Pesaran, and Shin (2003) denoted as IPS proposed a test for the presence of unit roots in panels that combines information from the time series dimension with that from the cross section dimension, such that fewer time observations are required for the test to have power. Since the IPS test has been found to have superior test power by researchers in economics to analyze long-run relationships in panel data, we will also employ this procedure. IPS begins by specifying a separate ADF regression for each cross-section with individual effects and no time trend:

$$\Delta y_{it} = \alpha_i + \rho_i y_{i, t-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i, t-j} + \varepsilon_{it} \quad [3]$$

Where  $i = 1, \dots, N$  and  $t = 1, \dots, T$

IPS uses separate unit root tests for the  $N$  cross-section units. Their test is based on the Augmented Dickey-fuller (ADF) statistics averaged across groups.

After estimating the separate ADF regressions, the average of the  $t$ -statistics for  $p_1$  from the individual ADF regressions,  $t_{iT}(p_i)$ :

$$\bar{t}_{NT} = \frac{1}{N} \sum_{i=1}^N t_{iT}(p_i\beta_i) \tag{4}$$

The  $\bar{t}$  is then standardized and it is shown that the standardized  $\bar{t}$  statistic converges to the standard normal distribution as  $N$  and  $T \rightarrow \infty$ . IPS (1997) showed that  $\bar{t}$  test has better performance when  $N$  and  $T$  are small. They proposed a cross-sectionally demeaned version of both test to be used in the case where the errors in different regressions contain a common time-specific component.

4.1 Panel Unit Root test

Tables 1 and 2, presents the results of the IPS and LLC panel unit root test at level indicating that all variables are  $I(0)$  in the constant of the panel unit root regression. These results clearly show that the null hypothesis of a panel unit root in the level of the series cannot be rejected at various lag lengths. We assume that there is no time trend. Therefore, we test for stationary allowing for a constant plus time trend. In the absence of a constant plus time trend, again we found that the null hypothesis of having panel unit root is generally rejected in all series at level form and various lag lengths. We can conclude that most of the variables are non-stationary in with and without time trend specifications at level by applying the IPS and LLC test which is also applied for heterogeneous panel to test the series for the presence of a unit root. The results of the panel unit root tests confirm that the variables are non-stationary at level.  
Automatic lag selection using Schwarz Info Criterion.

Table 1: Panel unit root test – Im, Pesaran and Shin (IPS).

Variable	Level		First order difference	
	Constant	Constant + Trend	Constant	Constant + Trend
FDI	5.0565 (1.000)	2.4890 (0.9936)	−2.3485*** (0.0094)	−6.2658*** (0.0000)
HC	−0.9443 (0.9133)	−1.5742 (0.0577)	−6.4557*** (0.0000)	−3.5812*** (0.0002)
OER	0.9771 (0.8358)	−1.0455 (0.1479)	−6.1216*** (0.0000)	−5.2345*** (0.0000)
GCF	−1.2056 (0.1140)	−0.4981 (0.3092)	−6.7458*** (0.0000)	−5.5279*** (0.0000)
GDP per capita	−4.5995 (0.0000)***	−2.9227 (0.0017)***	−10.0343*** (0.0000)	−8.7186*** (0.0000)

Notes: \*, \*\* and \*\*\* indicates rejection of the null hypothesis of no-co-integration at 10 %, 5 % and 1 %, levels of significance. Automatic lag selection is done using Schwarz Info Criterion.

**Table 2:** Panel unit root test – Levin, Lin and Chu (LLC).

Variable	Level		First order difference	
	Constant	Constant + Trend	Constant	Constant + Trend
FDI	2.10902 (0.9825)	−0.62540 (0.2659)	−4.78636*** (0.0000)	−4.67108*** (0.0000)
HC	3.86179 (0.9999)	0.52875 (0.7015)	−3.37876*** (0.0004)	−4.17002*** (0.0000)
OER	−1.56718 (0.0585)*	−3.52404 (0.0002)***	−12.7168*** (0.0000)	−10.5501*** (0.0000)
GCF	3.30264 (0.9995)	1.37376 (0.9152)	−1.35012*** (0.0000)	−3.14875*** (0.0000)
GDP <i>per capita</i>	3.80764 (1.0000)***	0.74693 (0.7724)***	−2.51877*** (0.0059)	−3.52934*** (0.0000)

Notes: \*, \*\* and \*\*\* indicates rejection of the null hypothesis of no-co-integration at 10 %, 5 % and 1 %, levels of significance.

Tables 1 and 2 also present the results of the tests at first difference for IPS and LLC tests in constant and constant plus time trend. We can see that for all series the null hypothesis of unit root test is rejected at 95 percent critical value (1 percent level). Hence, based on IPS and LLC tests, there is strong evidence that all the series are in fact integrated of orders one.

We can conclude that the results of panel unit root tests (IPS and LLC tests) reported in Tables 1 and 2 support the hypothesis of a unit root in all variables across countries, as well as the hypothesis of zero order integration in first differences. At most of the 1 % significance level, we found that all tests statistics in both with and without trends significantly confirm that all series strongly reject the unit root null. Given the results of IPS and LLC tests, it is possible to apply panel co-integration method in order to test for the existence of the stable long-run relation among these variables.

### 4.2 Panel Co-integration Tests

The next step would be to test for the existence of a long-run co-integration among exchange rate and the independent variables using panel co-integration tests suggested by Pedroni (1999, 2004). We will make use of seven panel co-integrations by Pedroni (1999), since he determines the appropriateness of the tests to be applied to estimated residuals from a co-integration regression after normalizing the panel statistics with correction terms. The procedures proposed by Pedroni make use of estimated residual from the hypothesized long-run regression of the following form:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \dots + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad [5]$$

for  $t = 1, \dots, T$ ;  $i = 1, \dots, N$ ;  $m = 1, \dots, M$ ,

Where  $T$  is the number of observations over time,  $N$  number of cross-sectional units in the panel, and  $M$  number of regressors. In this set up,  $\alpha_i$  is the member specific intercept or fixed effects parameter which varies across individual cross-sectional units. The same is true of the slope coefficients and member specific time effects  $\delta_i t$ . Pedroni (1999, 2004) proposes the heterogeneous panel and heterogeneous group mean panel test statistics to test for panel co-integration. He defines two sets of statistics. The first set of three statistics  $Z_{\hat{v}, N, T}$ ,  $Z_{\hat{\rho}N, T}$  and  $Z_{tN, T}$  is based on pooling the residuals along the within dimension of the panel. The statistics are as follows

$$Z_{\hat{v}, N, T} = T^2 N^{3/2} \sum_{i=1}^N \sum_{t=1}^T \hat{L}_{11i}^2 \hat{e}_{i,t}^2 \quad [6]$$

$$Z_{\hat{\rho}N, T} = T \sqrt{N} \sum_{i=1}^N \sum_{t=1}^T \hat{L}_{11i}^2 \hat{e}_{i,t}^2 \quad \frac{1}{\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{11i}^2} \left( \hat{e}_{i,t1} \Delta \hat{e}_{i,t} \hat{\lambda}_i \right) \quad [7]$$

$$Z_{tN, T} = \tilde{\sigma}_{N,T}^2 \sum_{i=1}^N \sum_{t=1}^T \hat{L}_{11i}^2 \hat{e}_{i,t}^2 \quad \frac{1/2}{\sum_{i=1}^N \sum_{t=1}^T \hat{L}_{11i}^2 \hat{e}_{i,t}^2} \left( \hat{e}_{i,t1} \Delta \hat{e}_{i,t} \hat{\lambda}_i \right) \quad [8]$$

Where  $\hat{e}_{i,t1}$  is the residual vector of the OLS estimation of eq. [5] and where the other terms are properly defined in Pedroni (2004). The second set of statistics is based on pooling the residuals along the between dimension of the panel. It allows for a heterogeneous autocorrelation parameter across members. The statistics are as follows:

$$\tilde{Z}_{\hat{\rho}N, T} = \sum_{i=1}^N \sum_{t=1}^T \hat{e}_{i,t}^2 \quad \frac{1}{\sum_{t=1}^T} \left( \hat{e}_{i,t1} \Delta \hat{e}_{i,t} \hat{\lambda}_i \right) \quad [9]$$

$$\tilde{Z}_{tN, T} = \sum_{i=1}^N \sum_{t=1}^T \hat{e}_{i,t}^2 \quad \frac{1/2}{\sum_{t=1}^T} \left( \hat{e}_{i,t1} \Delta \hat{e}_{i,t} \hat{\lambda}_i \right) \quad [10]$$

These statistics compute the group mean of the individual conventional time series statistics. The asymptotic distribution of each of those five statistics can be expressed in the following form:

$$\frac{X_{N,T} \mu \sqrt{N}}{\sqrt{v}} \Rightarrow N(0, 1) \quad [11]$$

Where  $X_{N,T}$  the corresponding form of the test statistics is, while  $\mu$  and  $v$  are the mean and variance of each test respectively. They are given in Table 2 in Pedroni

(1999). Under the alternative hypothesis, Panel  $v$  statistics diverges to positive infinity. Therefore, it is a one sided test were large positive values reject the null of no co-integration. The remaining statistics diverge to negative infinity, which means that large negative values reject the null.

Coming to the next step which is to test whether the variables are co-integrated using Pedroni's (1999, 2001, 2004) and Johansen-Fisher panel co-integration tests. This is to investigate whether long-run steady state or co-integration exist among the variables and to confirm what Coiteux and Olivier (2000) state that the panel co-integration tests have much higher testing power than conventional co-integration test. Since the variables are found to be integrated in the same order  $I(1)$ , we continue with the panel co-integration tests proposed by Pedroni (1999, 2001, 2004). Co-integrations are carried out for constant and constant plus time trend and the summary of the results of co-integrations analyses are presented in Table 3.

**Table 3:** The Pedroni panel co-integration test.

Test	Constant trend	Constant + Trend
Panel $v$ -statistic	0.0321	-0.0529
Panel $\rho$ -statistic	1.7175	0.8400
Panel $t$ -statistic: (non-parametric)	-1.8990***	2.3118***
Panel $t$ -statistic ( $adf$ ): (parametric)	-3.5827	-2.2485***
Group $\rho$ -statistic	2.1056	2.0034**
Group $t$ -statistic: (non-parametric)	-4.2975***	-7.8393***
Group $t$ -statistic ( $adf$ ): (parametric)	-5.5962***	-4.4160***

Notes: All statistics are from Pedroni's procedure (1999) where the adjusted values can be compared to the  $N(0,1)$  distribution. The Pedroni (2004) statistics are one-sided tests with a critical value of -1.64 ( $k < -1.64$  implies rejection of the null), except the  $v$ -statistic that has a critical value of 1.64 ( $k > 1.64$  suggests rejection of the null). \*, \*\* and \*\*\* indicates rejection of the null hypothesis of no-co-integration at 10 %, 5 %, and 1% levels of significance.

In constant level, we found that 3 out of 7 statistics reject null by hypothesis of no co-integration at the 1% level of significance for the Panel  $t$ -statistic (non-parametric), while the group- $adf$  and group  $t$ -Statistic is significant at 1% level of significance. The results of the panel co-integration tests in the model with constant level show that independent variables do hold co-integration in the long run for a group of BRICS-5 countries with respect to OER. In the panel co-integration test for our model with constant plus trend level, the results indicate that 4 out of 7 statistics reject the null hypothesis



of no co-integration at both 1% and 5% level of significance. It is shown that independent variables do hold co-integration in the long run for a group of BRICS countries with respect to RER. However, since all the statistics conclude in favor of co-integration, and this, combined with the fact that the according to Pedroni (1999) the panel non-parametric (*t*-statistic) and parametric (*adf*-statistic) statistics are more reliable in constant plus time trend, we conclude that there is a long run co-integration among our variables in the BRICS countries. Supporting finding are shown in the Table 4 presenting results of Johansen-Fisher panel co-integration including individual cross section results. The results indicate that there is a long run relationship

**Table 4:** Johansen fisher panel co-integration test.

Unrestricted Co-integration (Trace and Maximum Eigen-value)				
Hypothesize CE(s)	Fischer Statistics* (Trace Test)	Probability	Fischer Statistics* (Max. Eigen Test)	Probability
None	137.3	0.0000	78.23	0.0000
At most 1	103.7	0.0000	86.01	0.0000
At most 2	31.69	0.0005	22.96	0.0109
At most 3	17.95	0.0558	14.59	0.1478
At most 4	18.28	0.0505	18.28	0.0505
<b>Individual cross section results</b>				
Cross section	Trace test statistics	Prob.**	Max-Eigen test	Prob.**
<b>Hypothesis of no co-integration</b>				
Brazil	107.9770	0.0000	46.9478	0.0008
Russia	129.4150	0.0000	54.0317	0.0001
India	126.2852	0.0000	47.9167	0.0006
China	255.8956	0.0000	143.8064	0.0000
SA	73.6675	0.0238	29.1098	0.1669
<b>Hypothesis of at most 1 co-integration relationship</b>				
Brazil	61.0293	0.0018	32.1119	0.0122
Russia	75.3832	0.0000	42.8779	0.0003
India	78.3685	0.0000	42.6887	0.0003
China	112.0892	0.0000	79.2712	0.0000
SA	44.5577	0.0988	24.6667	0.1131
<b>Hypothesis of at most 2 co-integration relationship</b>				
Brazil	28.9174	0.0629	17.2712	0.1596
Russia	32.5053	0.0238	17.2268	0.1616

(continued)

Table 4: (continued)

Unrestricted Co-integration (Trace and Maximum Eigen-value)				
Hypothesize CE(s)	Fischer Statistics* (Trace Test)	Probability	Fischer Statistics* (Max. Eigen Test)	Probability
India	35.6798	0.0094	27.3007	0.0060
China	32.8180	0.0218	17.4946	0.1499
SA	19.8910	0.4302	13.0340	0.4491
Hypothesis of at most 3 co-integration relationship				
Brazil	11.6462	0.1747	11.3412	0.1379
Russia	15.2785	0.0539	11.4834	0.1316
India	8.3791	0.4258	7.0286	0.4858
China	15.3234	0.0531	12.0349	0.1093
SA	6.8570	0.5943	5.2891	0.7050
Hypothesis of at most 4 co-integration relationship				
Brazil	0.3050	0.5808	0.3050	0.5808
Russia	3.7951	0.0514	3.7951	0.0514
India	1.3504	0.2452	1.3504	0.2452
China	3.2885	0.0698	3.2885	0.0698
SA	1.5679	0.2105	1.5679	0.2105

Note: \*\*MacKinnon-Haug-Michelis (1999) *p*-values.

between FDI, GDPPC, GCF, HC and OEX. Also, the individual cross section results also indicate a strong co-integration among the variables at the country level.

We now estimate the model specified in eq. [2] using Panel Least Squares. The OEX is the response variable and results are presented in the Table 5:

Table 5: Panel least squared.

Variables	Coefficients	Sig. value
Constant	14.987	0.000*
Household Consumption	3.320	0.000*
FDI	−3.270	0.000*
Gross Capital Formulation	3.980	0.000*
GDP per Capita	−0.050	0.000*
R-squared	0.7836	
Adjusted R-squared	0.7669	
Durbin-Watson Stat.	2.3712	
Prob. (F-statistics)		0.000*

Notes: \* and \*\* indicates significance at 1% and 5 % level of significance.

The models estimated above clearly demonstrate with sufficient statistical evidence that FDI and GDPPC have a negative relationship with OEX in our panel of countries. However, HC and GCF have a positive impact on the OEX. All the results were statistically significant at 1% level. The model in terms of its goodness of fit showed an  $R^2$  value of 0.7836 explaining more than 78% variation in the exchange rate in BRICs attributed to under analysis explanatory variables.

### 4.3 Panel Causality Test

Rooted in the Granger causality test, Hurlin (2007) and Dumitrescu & Hurlin (2012) propose an approach for evaluating causal relationships in heterogeneous panels that is increasingly used in a number of studies (Erdil and Yetkiner 2009; Hood, Kidd, and Morris 2008, Hurlin and Venet 2008). This approach suggests that, in the context of heterogeneous panel data, four different hypotheses could be established as regards causality. The first, homogenous non-causality (HNC) implies that no individual causality exists from  $x$  to  $y$ . Conversely, homogeneous causality (HC) occurs when there is the same causal relationship from  $x$  to  $y$  for all the individuals. The other two cases correspond to heterogeneous processes. Firstly, there is heterogeneous causality (HEC), which implies that for all the individuals in the sample one could find a causal relationship from  $x$  to  $y$ , but that this relationship is unique for any individual. Finally, the heterogeneous non-causality hypothesis (HENC) posits that there is a subgroup of individuals for which there is a causal relationship from  $x$  to  $y$ , while at the same time there is another subgroup of individuals for which  $x$  does not cause  $y$  (Dumitrescu and Hurlin 2012; Hurlin 2007). The proposed test starts from a linear model such as the following:

$$Y_{i,t} = \alpha_i + \sum_{k=1}^K \gamma^{(k)} y_{i,t-k} + \sum_{k=1}^K \beta^{(k)} x_{i,t-k} + \epsilon_{i,t} \quad [12]$$

Where  $y$  and  $x$  are two stationary variables observed on  $T$  periods and on  $N$  individuals. For simplicity, individual effects  $\alpha_i$  are assumed to be fixed. In addition, lag orders  $K$  are assumed to be identical for all cross-sections units of the panel, and the panel is balanced. Finally, parameters  $\gamma_i^{(K)}$  and  $\beta_i^{(K)}$  are different across individuals but constant, i. e. it is a fixed coefficient model with fixed individual effects.

The Hurlin test compares the null hypothesis of HNC against the alternative HENC. If the null hypothesis (HNC) is accepted, the variable  $x$  does not Granger-

cause the variable  $y$  for all the cross-sectional units. Under the alternative hypothesis (HENC), we allow for some  $N_1 < N$  individual processes with no causality from  $x$  to  $y$ .

$$H_1 \begin{cases} \beta_i = 0 & \forall i = 1, \dots, N_1 \\ \beta_i \neq 0 & \forall i = N_1 + 1, N_1 + 2, \dots, N \end{cases}$$

Where  $N_1$  is unknown but satisfies  $0 \leq N_1/N < 1$ .

In other words, if HNC is rejected and if  $N_1 = 0$ , we can confirm that the variable  $x$  Granger-causes  $y$  for all the individuals in the panel. In these cases, we also get a homogeneous result in terms of the causal relationship. Finally, if HNC is rejected and  $N_1 > 0$ , the causal relationship may be heterogeneous and differs according to the cross-sectional units in question <sup>1</sup>.

This test is based on a new statistic which results from averaging individual Wald statistics, like the unit root test for heterogeneous panels widely used by the literature (Im, Pesaran, and Schin 2003). In non-technical terms, this test computes  $N$  individual regressions, one for each cross-sectional unit, estimating the individual Wald statistic for the explanatory variable of interest. Then it averages the  $N$  individual Wald tests to obtain the standardized average Wald statistic – the  $Z$ -tild value – and finally compares this value with the corresponding critical value for a given level of confidence. Hurlin (2007) demonstrates that the standardized average Wald statistic –  $Z$ -tild – converges to a normal distribution as long as  $T > 5 + 2K$  where  $K$  is the number of lags. In addition, for the moment conditions to hold series are assumed to be independent cross-sections and panels must be strongly balanced. A full detailed discussion of the asymptotic properties of the average Wald statistic for fixed  $T$  samples can be seen in Hurlin (2007) and Dumitrescu and Hurlin (2012).

We analyze both Dumitrescu and Hurlin (2012) at panel level and Granger Causality at individual country level among FDI, OEX, HC, GCF and GDPPC. First, we estimate panel causality using Pairwise Dumitrescu-Hurlin Panel Causality test. The results are reported in Table 6 below.

We observe that OEX has uni-directional causality with FDI, HC, GCF and GDPPC. The results were significant at 1% level, suggesting strong and significant influence of these variables on OEX. Also, there exists a bi-directional causality between FDI and GDPPC, GDPPC and HC, FDI and HC, FDI and GCF and GCF and HC at panel level. There after we analyze causal patterns among these variables in individual countries. The results are reported in the Table 7.

It showed that the HC and FDI have a strong bi-directional amongst them in all countries except Russia. Similarly FDI and GDPPC have a strong bi-

**Table 6:** Dumitrescu – Hurlin panel causality.

Causality hypothesis	W-Stat.	Zbar-Stat.	Probability
HC → OEX	26.7022	20.2418	0.0000*
OEX → HC	2.75491	0.37109	0.7106
GDPPC → OEX	41.6539	32.6483	0.0000*
OEX → GDPPC	2.70829	0.33241	0.7395
GCF → OEX	34.6066	26.8006	0.0000*
OEX → GCF	2.41921	0.09253	0.9263
FDI → OEX	35.5531	27.5860	0.0000*
OEX → FDI	2.43102	0.10233	0.9185
GDPPC → HC	7.86544	4.61165	0.0000*
HC → GDPPC	6.49926	3.47804	0.0005*
GCF → HC	6.21510	3.24225	0.0012*
HC → GCF	6.10188	3.14831	0.0016*
FDI → HC	12.1567	8.17244	0.0000*
HC → FDI	10.5107	6.80658	0.0000*
GFC → GDPPC	5.13622	2.34703	0.0189*
GDPPC → GFC	5.91150	2.99033	0.0028*
FDI → GDPPC	9.96177	6.35113	0.0000*
GDPPC → FDI	9.43379	5.91302	0.0000*
FDI → GCF	4.54436	1.85592	0.0635**
GCF → FDI	7.17033	4.03487	0.0000*

Notes: \*1% level of significance, \*\*5% level of significance \*\*\*10% level of significance.

directional causality among them in India, China and South Africa. FDI, GDPPC, GCF and HC have strong uni-directional causality with OEX in India and China whereas in South Africa only HC, FDI and GCF have strong uni-directional causality with OEX. GCF and FDI have a strong uni-directional causality between them i. e. GCF Granger causes FDI in Brazil, India and China and a strong bi-directional causality in South Africa. We also observe a strong bi-directional causality among GDPPC and HC, HC and FDI, GFC and GDPPC, FDI and GCF and GDPPC and FDI only in South Africa. The results for individual countries are consistent with the causality patterns observed for with the panel data. Table 8 presents results of long-run causality analysis.

The results for individual countries are consistent with the causality patterns observed for with the panel data. Table 7 presents results of long-run causality analysis. It is apparent that DGCF, DGDPPC and DHC have a strong long-run causality within the model as well as short-run causality. It lead use to conclude in the next section.

**Table 7:** Pairwise Granger causality for individual countries.

Causality Hypothesis	Brazil	Russia	India	China	SA
HC → OEX			**	***	
OEX → HC					*
GDPPC → OEX			***	***	
OEX → GDPPC					
GCF → OEX			***	***	
OEX → GCF					*
FDI → OEX				***	**
OEX → FDI			**		
GDPPC → HC			**	**	***
HC → GDPPC		**	*		***
GCF → HC		***	*		
HC → GCF		***			
FDI → HC	*		**	**	***
HC → FDI	***		*	***	**
GFC → GDPPC		***			**
GDPPC → GFC		***			**
FDI → GDPPC			*	*	***
GDPPC → FDI	***		**	***	*
FDI → GCF					**
GCF → FDI	**		**	***	**

**Notes:** \*, \*\* and \*\*\* denotes significance at 10 %, 5 % and 1 % level of significance respectively. The blank cell indicates no evidence of any causality. The lag selection is chosen using Schwarz Information Criterion. The significance is assessed using the probability values calculated in Granger Causality.

## 5 Conclusion

In the light of our empirical analysis and findings we can hereby conclude that exchange rate volatility is directly affected by the flows of FDI, GDP per capita, Capital formulation and Household consumption in the BRICS countries. There is robust evidence of an inverse relationship of exchange rates with foreign direct investment and gross domestic product per capita for BRICS countries. It also implied that the exchange rate in BRICS has been subject to the FDI inflows and conditions of internal demand, hence the accusations may not hold, at least not in the absolute form. On panel level, all the these variables impact significantly on official exchange rates as evident from Panel Least Squares results. Exchange rate volatility exposes economies to bigger risks e. g. exchange rate volatility directly impacts foreign direct inflows. On the bases of empirical

**Table 8:** Results of long run panel causality analysis.

DFDI	$f(DGCF, DGDPPC, DHC, DOEX)$ ECT -0.181151 <i>t-statistic</i> -1.301340
DGCF	$f(DFDI, DOEX, DHC, DGDPPC)$ ECT 2.846727** <i>t-statistic</i> 4.564185
DGDPPC	$f(DOEX, DHC, DGCF, DFDI)$ ECT $2.02 \times 10^{-8}$ *** <i>t-statistic</i> 2.332448
DHC	$f(DGDPPC, DOEX, DFDI, DGCF)$ ECT 1.744902** <i>t-statistic</i> 2.192012
DOEX	$f(DGCF, DGDPPC, DHC, DFDI)$ ECT $-3.30 \times 10^{-11}$ <i>t-statistic</i> -1.376253

Notes: \*, \*\* and \*\*\* represents significance at 10 %, 5 % and 1 % level of significance. The lag selection is chosen using the Schwarz Information Criterion.

findings, the policy implications is that BRICS countries should try to minimize the exchange rate volatility in order to enhance economic growth in the long-run. The causal pattern for each individual country is indicative of how these variables impact on exchange rate volatility and steps that regulating authorities should take in order to minimize exchange rate risks.

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