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What drives export performance in the BRICS countries? An ARDL investigation

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Abstract

This article aims to investigate the export performance of the BRICS, by making use of Bounds Testing (Nonlinear ARDL) Approach to Cointegration. For the period ranging from Jan/2000 to Mar/2017, the results suggest similarities and asymmetries. The level of exchange rate shows no statistical significance in the determination of long run exports, but its volatility seems to be important, as well as world imports and commodity prices. In the short run, the dynamics of the real exchange rate (either appreciation or depreciation) seems to play a relevant role in export performance, except for Brazil. However, in the case of China, exports rely mainly on the depreciation of the real exchange rate. Finally, all BRICS countries, except Brazil, show a low speed of adjustment to the long run in the face of short-run shocks.

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1. Introduction

There is no doubt that a country's export performance is crucial for a sound current account and, consequently, a sound balance of payments, as it contributes to short and long run economic growth and social development. Export performance matters for every nation of the world and it is no different for the BRICS countries (Brazil, Russia, India, China and South Africa), as these emerging market economies have had a considerable expansion of their export sectors in the past few years, showing similarities, but also differences among them.

Not only does export performance of the BRICS countries have an important impact on each domestic economy, but there is also a tendency of increasing participation of the BRICS in world trade and global economic performance. Despite the recent financial crisis, this group of countries has shown that they are capable of boosting world economic growth, trade flows and financial resources.

The aim of this article is to investigate the export performance for Brazil, Russia, India, China and South Africa (BRICS) by applying the Nonlinear Autoregressive Distributed Lag (NARDL) Bounds Testing Approach to Cointegration. For the period ranging from January/2000 to March/2017, the variables used are exports, real effective exchange rate (level and volatility), world imports (proxy for foreign demand) and commodity prices. We were able to reject the null of no long run relationship for each country, indicating the existence of cointegration among the variables used in the empirical analysis. The empirical estimations also suggest the existence of asymmetries when considering which variables are relevant in the short and long run. The results show that real exchange rate is not statistically significant regarding export dynamics in the long run. However, exchange rate volatility is important, and so are world imports and commodity prices. Despite not showing significance in the long run, real exchange rate dynamics (either appreciation or depreciation) seems to play a relevant role in export performance in the short run, except for Brazil. Nevertheless, in the case of China, exports rely mainly on real exchange rate depreciation. Finally, all BRICS countries, except Brazil, show a low speed of adjustment to the long run in the face of short-run shocks.

Besides this introduction, this paper reviews the literature in Section 2. Section 3 shows the data used in the analysis as well as the econometric methodology and Section 4 reports the results. The last section concludes the article.

2. Literature Review

Naudé and Rossouw (2011) analyze export diversification in Brazil, China, India, and South Africa, from 1962 to 2000. They find evidence of a U-shape relationship between per capita income and export specialization in China and South Africa. On the other hand, their results show partial evidence that export diversification Granger-causes GDP per capita in Brazil, China, and South Africa, but not in India, where the causality is the other way around. The authors also conclude that export diversification has a positive impact on economic development only for South Africa, whereas in the remaining countries export specialization mostly influences economic activity.

Gouvea et al. (2013) investigate the export performance and diversification strategies for the BRICS countries. Their results indicate that China's diversified export portfolio surpasses the ones of Brazil, India, and Russia. Ying et al. (2014) examine the export competitiveness of products based on high technology for the BRICS countries in the U.S. market and come to the conclusion that these countries have comparative advantages.

Bojnec et al. (2014) analyze the relationship between the quality of institutions and BRICS agricultural exports, for the period 1998-2009. Their results show that food exports are positively associated to institutional quality and GDP, and negatively associated with market distance. Kocourek (2015) analyzes whether exports play an important role on structural changes in the BRICS, using data from 1995 to 2012. The main empirical evidence is that there is a shift from primary manufacturing, and from production of merchandise with low value-added, to more sophisticated goods. Besides, in most sectors the driving force of the structural change is associated to domestic customers.

As for the literature on trade flows and exchange rate volatility, Ethier (1973) and Hooper and Kohlhagen (1978) show that a higher exchange rate volatility is associated to a lower foreign trade. Assery and Peel (1991) and Vieira and MacDonald (2016) also find a significant impact of real exchange rate volatility on exports, but the latter reports that results are robust only when oil export countries are part of the sample.

Arize et al. (2000) investigate the impact on export flows (1973-1996) for a set of 13 developing economies. Their results suggest that an increase in exchange rate volatility is associated with a negative impact on export demand both in the short and long run. Bahmani-Oskooee and Hegerty (2007) indicate that there is no consensus on the effects of exchange rate volatility on trade flows, especially in the analysis of the floating period (post 1973), when most countries faced an increase in exchange rate volatility. De Grauwe (1988) and Clark (1973) cast doubt on the negative effect of higher exchange rate volatility on trade flows.

As for individual country studies, Huchet-Bourdon and Korinek (2011) analyze the impact of exchange rates (level and volatility) on trade flows for the agricultural and manufacturing/mining sectors in China, the Euro Area and the U.S. They find a significant impact of exchange rate (level) on trade flows, but only a minor effect for exchange rate volatility. There is also evidence that a long-term effect of the real exchange rate is higher on exports than imports. Ekanayake et al. (2012) examine South Africa's trade with the EU, for the period 1980 – 2009. The results indicate that exports are positively affected by foreign income, and negatively by relative prices and exchange rate volatility.

Cavalcanti and Ribeiro (1998) find that relative prices (exchange rates) are relevant in explaining Brazilian exports. Markwald and Puga (2002) also argue in favor of a positive (negative) impact of exchange rate depreciation (appreciation) on exports in Brazil. Aguirre et al. (2007) investigate the Brazilian export performance, from 1985 to 2002, and find the existence of a long-run relationship between the volume of manufactured exports and real effective exchange rate, real exchange rate volatility, output gap and the level of world imports. Bahmani-Oskooee et al. (2013) study the commodity trade between Brazil and the U.S, from 1971 to 2010. Their results indicate that, for most industry sectors, there is no long run impact of exchange rate volatility, and for those that are affected the impact is positive. Another empirical finding is that the impact is not homogenous among sectors and countries.

3. Data and Econometric Approach

As mentioned previously, this work is aimed at analyzing the export performance of Brazil, Russia, India, China and South Africa, known as BRICS countries, for the period ranging from January 2000 to March 2017. The following variables will be analyzed:

i) LEXP: Log of Real Exports of each specific country (Brazil, China. India, Russia, South Africa). US$ Million - Source: DOTS.
ii) LREER: Log of Real Effective Exchange Rate (2005 = 100) of each specific country (Brazil, China. India, Russia, South Africa) broken into two parts: appreciation and depreciation. Source: BIS.
iii) VOLAT: Real Effective Exchange Rate Volatility (estimated via ARCH-GARCH) of each specific country (Brazil, China. India, Russia, South Africa). Source: BIS.
iv) LWIMP: Log of World Imports: US$ Million. Source: DOTS.
v) LPCOM: Log of Commodity Price Index – Emerging Market Economies (2010 = 100). Source: The World Bank.

The empirical analysis developed in this work is based on Autoregressive Distributed Lag (ARDL) models applied to cointegration, as proposed in Pesaran and Shin (1999) and Pesaran et al. (2001). These models were chosen due to their advantage over the cointegration tests in non-stationary variables, such the ones developed by Engle and Granger (1987), Phillips and Hansen (1990) and Johansen (1991), as well as over traditional VAR models. ARDL models applied to cointegration also tend to be more efficient to capture the long-term relationship data in small samples, and they perform well, irrespective of whether variables are stationary I(0), non-stationary I(1), or even mutually cointegrated (Pesaran and Shin, 1999).

Considering the variables mentioned above, and defining μ as the intercept and t as a time trend, the ARDL model can be defined as:

$$\begin{aligned}\Delta LEXP_t = \mu + \alpha_1 t + \beta_1 LEXP_{t-1} + \beta_2 LREER_{t-1} + \beta_3 VOLAT_{t-1} + \beta_4 LWIMP_{t-1} + \\ +\beta_5 LPCOM_{t-1} + \sum_{i=1}^{p} \beta_6 \Delta LEXP_{t-i} + \sum_{i=0}^{q} \beta_7 \Delta LREER_{t-i} \\ + \sum_{i=0}^{r} \beta_8 \Delta VOLAT_{t-i} + \sum_{i=0}^{s} \beta_9 \Delta LWIMP_{t-i} + \sum_{i=0}^{m} \beta_{10} \Delta LPCOM_{t-i} + u_t\end{aligned} \quad (1)$$

We account for asymmetries in the real exchange rate by making use of NARDL (Nonlinear Autoregressive Distributed Lag) models, which was introduced by Shin et al. (2014). The asymmetric impact of the real exchange rate is accounted for by introducing its positive (appreciation) $REER_t^{+}$ and negative (depreciation) $REER_t^{-}$ changes.

$$\begin{aligned}REER_t^{\mp} = \sum_{i=1}^{t} \Delta REER_t^{+} = \sum_{i=1}^{t} \max(REER_i, 0) \\ REER_t^{-} = \sum_{i=1}^{t} \Delta REER_t^{-} = \sum_{i=1}^{t} \min(REER_i, 0)\end{aligned} \quad (2)$$

Equation (1) can be rewritten in a typical Error Correction Model (ARDL-ECM), but considering the above-mentioned asymmetries in the real exchange rate.

$$\begin{aligned}\Delta LEXP_t = \mu + \alpha_1 t + \beta_1 LEXP_{t-1} + \beta_2 LREER_{t-1}^{+} + \beta_3 LREER_{t-1}^{-} + \beta_4 VOLAT_{t-1} + \\ +\beta_5 LWIMP_{t-1} + \beta_6 LPCOM_{t-1} + \sum_{i=1}^{p} \beta_7 \Delta LEXP_{t-i} + \sum_{i=0}^{q} \beta_8 \Delta LREER_{t-i}^{+} \\ + \sum_{i=0}^{k} \beta_9 \Delta LREER_{t-i}^{-} + \sum_{i=0}^{r} \beta_{10} \Delta VOLAT_{t-i} + \sum_{i=0}^{s} \beta_{11} \Delta LWIMP_{t-i} + \sum_{i=0}^{m} \beta_{12} \Delta LPCOM_{t-i} + u_t\end{aligned} \quad (3)$$

Prior to the estimation of an ARDL model applied to cointegration, it is important to make sure that no variable in the empirical model is I(2). In fact, we performed unit root tests and found no I(2) variable. Also, before going any further with estimations related to short and long run dynamics, it is important to check the performance of the ARDL estimates through some diagnostic tests. These include an autocorrelation LM test and a stability test of the estimated regressions. As usual, the LM test statistics for residual serial correlation (H_0 = no serial correlation) up to the specified order is performed by the estimation of an auxiliary estimation of the residuals on the original RHS variables and the lagged residual (in our case, 12 lags were used). As for stability tests, the cumulative sum (CUSUM) and the cumulative sum of squared (CUSUMSQ) recursive residuals tests (Brown, Durbin and Evans, 1975) allow us to look at coefficient stability. Parameter instability is found if the cumulative sum falls outside the area between two 5% critical lines.

Once the researcher has made sure that the estimated model has no serial correlation problem and that it is dynamically stable, the ARDL Bounds testing methodology can be applied to confirm that the variables in the model cointegrate, i.e., they have a long run relationship. Pesaran's Bounds testing is a Wald test (F-test) to check the joint significance of the model's long-term parameters. Under the null hypothesis of no cointegration (H_0: $\delta_1 = \delta_2 = 0$), Pesaran et al. (2001) provide bounds on critical values for the F statistics. The lower bound is calculated on the assumption that all variables of the model are ARDL stationary (there is no cointegration), whereas the upper bound is calculated on the assumption that all variables are I(1), that is, there is cointegration. Finally, an F-statistic falling between the bounds means that the test is inconclusive.

4. Results

As already mentioned, if the cointegration test statistics falls between the critical values calculated by Pesaran et al. (2001), it is necessary to know the order of integration of variables to reject the null hypothesis. Thus, we ran the following unit root tests: Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and the Modified Dickey-Fuller Test (DF-GLS).

As Table 1 makes clear, the results vary according to the variable analyzed. The unit root results are robust for commodity price index and world imports since these are the same variables for all countries. For the remaining variables, the unit root results are quite robust for the real effective exchange rate (REER), except for the Indian KPSS test. As for exports, there is some divergence for the unit root estimations of Brazil, China, and South Africa, but non stationarity prevails. Finally, results related to exchange rate volatility vary for the case of Russia, India, and China.

Table 1: Unit Root Tests

	Country	ADF	PP	KPSS	DF-GLS
Commodity Price Index Emerging Countries	-	1.017	-1.437	0.345**	-0.813
World Imports	-	-1.760	-2.227	0.312**	-1.888
Real Effective Exchange Rate (REER)	Brazil	-0.032	-0.003	0.255**	-1.903
	Russia	-2.358	-2.654	0.368**	-0.205
	India	-2.594	-2.811	0.086	-2.415
	China	-1.733	1.302	0.354**	-1.197
	S. Africa	-1.918	-0.698	0.187*	-2.122
Exports	Brazil	-1.656	-3.492*	0.335**	-1.711
	Russia	-1.713	-1.659	0.324**	-1.820
	India	-1.569	-2.255	0.318**	-1.389
	China	-1.970	-3.767*	0.407**	-0.744
	S. Africa	-4.371**	-3.829*	0.268**	-2.207
REER Volatility	Brazil	-4.372**	-4.415**	0.060	-4.352**
	Russia	-2.484	-3.173*	0.601**	-2.836
	India	-2.010	-2.099	0.319**	-2.065
	China	-3.797**	-3.789**	0.148**	-3.513**
	S. Africa	-4.707**	-4.614**	0.073	-4.243**

Notes: * and ** mean rejection of the null hypothesis at 5% and 1% respectively
ADF, PP and DF-GLS: H_0 - unit root; KPSS: H_0 – stationarity
All variables in log, except REER Volatility

In fact, some degree of discrepancy is expected since these variables have behaved quite differently in the BRICS countries throughout the entire period of investigation. But in general, the unit root results are somewhat robust regarding the final interpretation for the stationarity of each variable. Therefore, this makes ARDL modelling and bounds testing applicable.

In order to run the ARDL models, we allow each estimation to go up to the 6 lags and the best model for each country is selected according to the Akaike Bayesian Criteria (AIC). The order of the variables for each NARDL model is as follows: Log of Exports, Log of Real Effective Exchange Rate (Depreciation and Appreciation), Real Effective Exchange Rate Volatility, Log of World Imports and Log of Commodity Price Index. Table 2 reports the NARDL models, along with lags of each model selected, a column with only the significant variables to facilitate our analysis, as well as the results of the autocorrelation LM test for each country.

Table 2: NARDL Estimations
Dependent Variable: Exports (of each country)

Country	Lags Selected Model	Autocorrelation LM Test [Prob]
Brazil	$(6, 0, 1, 5, 1, 2)^2$	0.708 [0.701]
Russia	$(2, 4, 3, 6, 0, 0)^2$	3.378 [0.184]
India	$(6, 2, 3, 5, 6, 3)^3$	0.798 [0.670]
China	$(5, 3, 0, 6, 0, 2)^2$	0.489 [0.782]
South Africa	$(3, 1, 1, 2, 0, 1)^3$	0.558 [0.756]

Notes: An * means significance only at 10%. All variables are in natural log, except REER Volatility.
1 = with constant and trend; 2 = with constant and no trend; 3 = no constant. no trend.

As for diagnostic tests, Table 2 also reports the Autocorrelation LM Test for each of the NARDL model chosen. All estimated models are free from serial correlation problems. Regarding CUSUM and the CUSUMSQ stability tests, they show considerable parameter instability in the case of South Africa. China also shows some instability, but very little and closely related to the 2008 financial crisis.[1]

We now turn to the examination of the existence of cointegration vectors between the variables, by applying the ARDL Bounds Testing Approach. Table 3 reports these results, considering Pesaran's et al. (2001) critical values. The null hypothesis of "no cointegration vectors" can be rejected (at 5%) for Brazil, Russia, and South Africa, once the F-statistics are greater than the critical values. As for China and India, the long run relationship can only be detected at 10% and it is inconclusive at 5%, but when one compares F-Statistics of both countries with their respective critical values, the F-statistics is much closer to the 5% I(1) bound.

[1] Due to space limitation, the results for the CUSUM and CUSUM Squared are not reported and can be requested to the authors.

Table 3: NARDL Cointegration Test - Bounds Testing Approach

	F-Statistics	Critical Values				Long Run
		I(0) Bound		I(1) Bound		Cointegration NARDL Model
		10%	5%	10%	5%	
Brazil	8.95	2.08	2.39	3.00	3.38	Yes
Russia	3.54	2.08	2.39	3.00	3.38	Yes
India	3.24	1.81	2.14	2.93	3.34	Yes 10% Inconclusive at 5%
China	3.28	2.08	2.39	3.00	3.38	Yes 10% Inconclusive at 5%
S. Africa	3.47	1.81	2.14	2.93	3.34	Yes

Notes: H_0 (no long-run relationship).

Overall, it means that there is a long run relationship between the variables analyzed. However, Table 4 reports the existence of important differences amongst countries, when considering which variables are playing a significant role in the long run. The first result which calls our attention is the complete lack of statistical significance of the real exchange rate of all BRICS countries in determining the dynamics of their respective exports in the long run. On the other hand, exchange rate volatility seems to be important. This is a remarkably interesting result: it seems that what really matters is not whether the real exchange rate appreciates or depreciates, but its volatility, meaning that exporters are more concerned with exchange rate risks than with either exchange rate appreciation or depreciation. Another important result is that world imports seem to be a crucial to all BRICS countries, except for India.

In the case of Brazil, export performance relies mainly on foreign demand and commodity prices. These two factors point to one major importer of Brazilian goods, which is China. Brazil has taken great advantage of the considerable Chinese economic growth in the past few years and exported high quantities of agriculture and metal commodities, such as soybeans and related soy products, and iron ore. As for Russia, export performance relies on REER volatility and foreign demand. Russia is a major exporter of commodities such as crude oil, petroleum goods and natural gas, which account for about half of the country's exports. This explains why our estimations selected the above-mentioned variables. India's export performance depends on REER volatility (negatively) and commodity prices (positively). Gems and precious metals, petroleum products, service goods, automobiles and machinery are the main products exported by India. In the case of China, long run export performance relies on foreign demand. There is no doubt China is one of the fastest growing economy for the past decades, relying mainly on its exports to many parts of the world. In order to have such performance, a strong foreign demand is of utmost importance. Finally, South Africa´s export performance relies on foreign demand, REER volatility (negatively) and commodity prices (positively). South Africa's export products are mainly mineral products, precious metals, iron and steel products and vehicles.

The next question is to address the short run adjustment, via an Error Correction Representation (ECM) of the NARDL models. In fact, as long as there is long-run equilibrium, any short run disequilibrium can be seen as a process of adjustment to the long run. However, the speed of adjustment can be faster or slower, depending on the country´s characteristics.

Table 5 reports the ECM results for the estimated NARDL models, as well as the statistically significant variables for short run dynamics. As expected, the Error Correction Term (ECM_{t-1}) is negative for all estimations performed. Russia (29%), India (10%), China (20%), South Africa (19%) all show low speeds of adjustment, meaning that the long-run equilibrium relationship among the variables returns to the steady state very slowly. On the other hand, the highest speed of adjustment is associated to the case of Brazil (80%), showing that that the adjustment process, towards the long-run equilibrium, is quite fast as 80 percent of the shock is corrected within the first month.

Table 4: Long Run Coefficients (Dependent Variable: Log of Exports)

Country	Brazil	Russia	India	China	S. Africa
(Lags)	(6,1,0,5,1,2)	(2,4,3,6,0,0)	(6,2,3,5,6,3)	(5,3,0,6,0,2)	(3,1,1,2,0,1)
	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]	Coeffic. [Prob.]
REER (Appreciation)	0.107 [0.174]	0.438 [0.226]	-0.701 [0.475]	0.034 [0.932]	-0.115 [0.592]
REER (Depreciation)	0.107 [0.175]	0.433 [0.231]	-0.659 [0.504]	0.104 [0.788]	-0.097 [0.655]
REER Volatility	17.590 [0.142]	-40.09 [0.055]	-1922.22 [0.030]	1886.34 [0.163]	-109.67 [0.001]
World Imports	0.962 [0.000]	1.355 [0.000]	0.498 [0.279]	2.472 [0.000]	0.530 [0.000]
Commodity Price Index	0.254 [0.002]	0.017 [0.915]	1.454 [0.005]	-0.529 [0.109]	0.430 [0.004]

Note: All variables in log, except REER Volatility

One possible explanation for the highest speed of adjustment of Brazil can be associated to the argument that the dynamics of the real exchange rate (either appreciation or depreciation) seems to play an important role in export performance, except for Brazil. A second possible explanation is because both short run statistically significant variables for Brazil (World Imports and Commodity Price Index) are not under control of Brazilian domestic policies, since they are external variables. The time patterns of these two variables might be responsible for a faster short run adjustment in Brazil, compared to the other BRICS countries that rely on other variables (REER and Exports).

If we analyze the behavior of REER volatility for all five countries, it is clear that Brazil has the highest REER volatility and since this variable is capturing the degree of price uncertainty for exports, one can assume that it is likely that the short run adjustment for Brazil should be faster.

Table 5: Short Run Dynamics:
Error Correction and Significant Variables

Country	ECM(-1) [Prob.]	Significant Variables (Short Run)
Brazil	-0,802 [0,00]	World Imports (-1, -4); Commodity Price Index (-1)
Russia	-0,296 [0,00]	REER – Depreciation (-2, -3); REER - Appreciation (0, -2); World Imports (-1, -2, -4, -5)
India	-0,108 [0,00]	REER – Depreciation (-1); REER - Appreciation (-1); World Imports (-1, -4); REER Volatility (-4, -5); Commodity Price Index (-1, -2)
China	-0,205 [0,00]	REER – Depreciation (-1, -2); Commodity Price Index (-1); World Imports (-1, -2, -3, -4, -5)
South Africa	-0,190 [0,00]	Exports (-1, -2); REER – Depreciation; REER - Appreciation; World Imports (0, -1)

Note: All variables in log, except REER Volatility

5. Conclusion

The main goal of this work was to investigate the export performance of Brazil, Russia, India, China and South Africa (BRICS) from January 2000 to March 2017 using Nonlinear Autoregressive Distributed Lag (NARDL) models and, more specifically, the bounds testing approach to cointegration.

The first important result reached by our estimations is that there is a long run relationship between the variables, which were exports, level and volatility of real exchange rate, commodity prices and world imports, as proxy for foreign demand. However, even though they cointegrate in the long run, the analysis of each variable shows that the level of real exchange rate itself has no statistical significance in determining the dynamics of exports in the long run, but exchange rate volatility does, and so do world imports and commodity prices.

The cointegration found amongst the variables in the long run does not mean that shocks don´t occur in the short run, with adjustments along the way via error correction mechanism. In this case, our estimations showed a low speed of adjustment for all BRICS countries, except Brazil. But Brazil is also the only country in which real exchange rate dynamics, either appreciation or depreciation, does not seem to be relevant for export performance in the short run. In the case of China, exports rely mainly on the depreciation of the REER, meaning that this is the only case where nonlinearity of the exchange rate is found.

After all, one can say that the inclusion of variables, such as REER volatility and commodity prices, other than the traditional ones, such as price effect captured by REER and income effect captured by world imports, seems to be justified on empirical grounds.

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