BRICS Export Performance:
An ARDL Bounds Testing Empirical Investigation

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Abstract

This article aims to investigate the export performance of the so-called BRICS countries: Brazil, Russia, India, China and South Africa. By making use of ARDL models for the period from January 2000 to December 2014, the results suggest the existence of asymmetries when considering which variables are important influences in the long run. Export performance relies mainly on: i) foreign demand and commodity prices, in the case of Brazil; ii) real effective exchange rate, foreign demand and commodity prices (Russia); iii) real effective exchange rate and commodity prices (India); iv) real effective exchange rate and foreign demand (China); v) foreign demand (South Africa). The estimated coefficients for the error correction mechanism shows higher speed of adjustment for Brazil and China, intermediate speed for India, and lower for Russia and South Africa.

Key Words: Exports, International Trade, Foreign Exchange, ARDL, Cointegration
JEL Classification: C22, F14, F17

Resumo

Este artigo tem como objetivo investigar o desempenho das exportações dos BRICS: Brasil, Rússia, Índia, China e África do Sul. A metodologia aplicada é uma série de Modelos de Defasagens Distribuídas (ARDL) para cointegração, para o período de janeiro de 2000 a dezembro de 2014. Os resultados sugerem a existência de assimetrias ao considerar quais variáveis são influências importantes no longo prazo. O desempenho das exportações baseia-se principalmente em: i) demanda externa e preços das commodities, no caso do Brasil; ii) taxa de câmbio real efetiva, demanda externa e preços de commodities (Rússia); iii) taxa de câmbio real efetiva e preços de commodities (Índia); iv) taxa de câmbio real efetiva e demanda externa (China); v) demanda externa (África do Sul). Os coeficientes estimados referentes aos mecanismos de correção de erro mostram maior velocidade de ajustamento para o Brasil e China, velocidade intermediária para a Índia, e baixa velocidade de ajustamento para Rússia e África do Sul.

Palavras-Chave: Exportações, Comércio Internacional, Taxa de Câmbio, ARDL, Cointegração
Classificação JEL: *C22,* F14, F17

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Introduction

The BRICS countries account for a group of emerging market economies (Brazil, Russia, India, China and South Africa) which have had a considerable expansion of their export sector in the past few years, with similarities, but also differences, in their pattern of export diversification. And there is no doubt that a country's export performance is crucial for a sound current account and, consequently, a sound balance of payments, contributing to short run and long run economic growth and economic development.

The performance of exports of the BRICS countries is an important issue on the basis not only of their impact on each domestic economy, but also because there is a tendency of increasing participation of the BRICS in world trade and global economic performance. Despite the recent crisis, the BRICS can become a group capable of boosting world economic growth, trade flows and financial resources. Along with a high consumption growth potential, due to the emergence of a new middle class and to the size of their populations, such export performance is helping BRICS countries catch up to industrialized nations much faster, although they have not yet reached the level of development of advanced economies.

The aim of this article is to investigate the export performance for Brazil, Russia, India, China and South Africa (BRICS) by applying the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration. For the period ranging from January 2000 to December 2014, 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 our empirical analysis. The empirical results suggest that in the long run, export performance relies mainly on real effective exchange rate (level and volatility) and foreign demand, in the case of China and Russia, foreign demand and commodity prices (Brazil), real effective exchange rate and commodity prices (India) and on foreign demand in the case of South Africa.

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

The literature on exchange rate volatility and trade flows is quite extensive and the purpose of this section is to summarize the general empirical findings and in a second moment to focus on the empirical studies and lessons for the BRICS. As a general rule, one can say that it is difficult to draw an unambiguous conclusion of the effect of exchange rate volatility on trade flows, regardless of the econometric method used, with the coefficient on volatility suggesting a positive, negative or no impact.[1]

Previous studies [Ethier (1973) and Hooper and Kohlhagen (1978)] show that higher exchange rate volatility is associated with higher costs for traders that are risk averse and ultimately to lower foreign trade. The main argument is that if changes in exchange rates become unpredictable it is associated with uncertainty on the profits of international traders and ultimately it reduces the benefits of international trade.

Assery & Peel (1991) investigate the effects of exchange rate volatility on exports using an error correction model and the results supports the significant impact of real exchange rate volatility on exports.

De Grauwe (1988) and Clark (1973) are examples of empirical studies casting doubt on the negative effect of higher exchange rate volatility on trade flows based on the argument that if the income effect dominates the substitution effect the final outcome can be a positive relationship.

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[1] Sousa et al. (2008) develop a literature review based on 52 previous studies from 1998 to 2005 on the determinants of export performance and highlight that they can be characterized by fragmentation and diversity.

In order to evaluate the impact of exchange rate volatility throughout the literature one can rely on the lessons summarized by McKenzie (1999) and Bahmani-Oskooee and Hegerty (2007). The main empirical finding from Bahmani-Oskooee and Hegerty (2007) indicates that there is no consensus on the effects of exchange rate volatility on export and import flows, especially when analyzing the floating period (post 1973) when most countries faced an increase in exchange rate volatility.

Arize et al. (2000) investigate the impact on export flows (1973-1996) for a set of 13 developing economies using cointegration analysis and the results suggests that an increase in exchange rate volatility is associated with a negative impact on export demand both in the short and long run.

Examining studies using the same empirical approach developed by this paper (ARDL cointegration analysis), Huchet-Bourdon and Korinek (2011) analyze the impact of exchange rates (level and volatility) on trade flows for two sectors (agriculture and manufacturing / mining) in China, the Euro area and the United States. The empirical results highlight the existence of a significant impact of exchange rate (level) on trade flows but only minor effect for the exchange rate volatility. There is also evidence of a higher long term effect of the real exchange rate on exports than on imports and the income effect is more relevant than the price effect on trade flows.

Vieira and MacDonald (2016) investigate the relationship between real effective exchange rate volatility and exports for a sample of 106 countries with data from 2000 to 2011 using System GMM panel data analysis. The empirical results corroborates the view on the significant role of the real effective exchange rate volatility for export performance but the results are robust only when oil export countries are part of the sample when an increase (decrease) in exchange rate volatility reduces (increases) export volume and there is evidence that export volume is price and income inelastic.

After this brief review of the empirical literature we can now focus on the studies applied for the BRICS countries. The first part is based on individual country studies and the second one for the BRICS as a set of countries.

Ekanayake et al. (2012) examine the effect of exchange rate volatility on South Africa´s trade (exports and imports) with the EU for the period of 1980 to 2009 using the bounds testing approach to cointegration, and error-correction model. The results for exports indicate that exports positively affected by foreign income and negatively by relative prices and exchange rate volatility.

Srinivasan and Kalayvani (2013) investigate the role of exchange rate volatility on export growth for India from 1970 to 2011 using the ARDL bounds testing approach. The empirical results support the existence of cointegration between exchange rate volatility, real exchange rate, domestic and foreign GDP. Exchange rate volatility has a negative impact on real exports in the short and long run while the real exchange rate (level) has negative impact in the short run and a positive one in the long run. Domestic GDP has a positive long run impact on real exports but no role in the short run. There is also evidence that foreign demand has negative impact on short run but a positive one in the long run.

Todani & Munyama (2005) examines the role of exchange rate volatility on export flows for South Africa using the ARDL bounds testing approach with quarterly data for the period 1984 to 2004. Depending on the measure of volatility used, the results show that either there exist no impact of exchange rate volatility on export flows or when such impact does exist it is a positive one.[2]

Chit (2008) examines the role of exchange rate volatility for bilateral export performance for the ASEAN-China free trade area using a generalized gravity model for a panel data of 20 bilateral observations using quarterly data from 1982:Q1 to 2005:Q1. The panel unit root tests corroborate the existence of a long run relationship between exchange rate volatility and exports. The fixed and random effect estimated models suggest that bilateral real exchange rate volatility has a negative impact on ASEAN-China bilateral exports but the magnitude of the effect is small.

Aguirre et al. (2007) investigate the impact of exchange rate volatility on the export of manufactured goods in Brazil for 1985 to 2002 using the ARDL cointegration analysis. The authors found the existence of a long-run relation (cointegration) between the volume of Brazilian

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[2] Similar results for South Africa were found by Nyahokwe & Ncwadi (2013).

manufactured exports and the real effective exchange rate, the real exchange rate volatility, the output gap (manufacture sector) and the level of world imports (proxy for foreign income).

Cavalcanti & Ribeiro (1998) found that relative prices (exchange rates) are relevant in explaining Brazilian exports. Neves et al. (2007) estimates exports price and income elasticities for seven Brazilian states and the results indicate that state exports are price and income inelastic. Markwald & Puga (2002) argues in favor of a positive (negative) impact of exchange rate depreciation (appreciation) on exports but the effect is higher when there is exchange rate depreciation, supporting the hysteresis hypothesis. The authors suggested that periods of exchange rate depreciation are associated with an increase in the size (number of companies) of the export base.

Vieira et al. (2014) investigate the role of the trade-weighted real exchange rate and foreign income on the export performance of Brazilian states using data from 1996 to 2009 for a panel data estimation based on System GMM. The empirical results suggest that state exports are price (exchange rate) and income (foreign) inelastic. There is also evidence that the real exchange rate effect for non-Mercosur partners plays a significant role on state export performance. The estimation for the Mercosur export partners reveals that lagged exports and commodity prices are significant, but there is no robust evidence on the role of trade-weighted GDP and lagged trade-weighted real exchange rate. The results do not reveal statistical significance for current trade-weighted real exchange rate and state GDP.

The second part of the empirical literature review focus on the BRICS as a group of countries instead of individual country studies.

Gouvea et al. (2013) investigate the export performance and diversification strategies for the BRIC countries using two portfolio approaches (Markowitz and single index model). The results indicate that China's export portfolio dominates the portfolios of Brazil, India, and Russia and China has a more diversified export profile.

Naudé & Rossouw (2011) analyzes economic performance and export diversification in the BCIS(Brazil, China, India and South Africa) for the period of 1962 to 2000 using Granger causality tests and applied general equilibrium (AGE) models. There is evidence of a U-shape relationship between per capita income and export specialization (China and South Africa) and partial evidence that export diversification Granger causes GDP per capita in Brazil, China and South Africa, but not in India, where the causation is the other way round. The results for the AGE models indicate that only for South Africa export diversification has a positive impact on economic development (GDP, employment and household consumption) while for the remaining countries it is the export specialization that was found to have a positive impact on the economic activity.

Cheng et al. (2007) investigate the increasing role of the BRICS as the largest global economic group pointing out for the problems faced by these countries in terms of obstacles for doing business and a lack of long-term conditions to promote and improve economic growth. Chen & Lombaerde (2014) in examining the relationship between globalization and regionalization of the BRICS emphasizes how integration in the global economy, associated to a higher degree of trade openness, is related to integration in the regional economy. The empirical results suggest that the relative globalization of the BRICs is related to more global sourcing by the BRICs, improvement in regional competitiveness of the BRICs, and more asymmetry and trade dependence when considering regional trade partners.

Ying et al. (2015) investigate export competitiveness of products based on high technology for the BRIC countries in the U.S. market and found that these countries have comparative advantages. Investments in R&D and patents have a positive relation to U.S. export of high tech products. The authors argue that foreign direct investment (FDI) does not directly promote export competitiveness.

A recent paper from Kocourek (2015) analyzes the issue of exports as a relevant factor of structural changes for the BRICS using data from 1995 to 2012 and calculates the individual shares of nine major industries on the value added and on exports for each country. The main empirical evidence is that there was a shift from primary manufacturing and from production of merchandise with low added value, to more sophisticated goods and in the majority of sectors the driving force of the structural change is associated to the domestic customers. Foreign demand plays a crucial role on

industry output of other sectors such as mining, quarrying and manufacturing. There is no significant impact of exports for construction, financial intermediation, real estate, renting, and other business activities.

Bojnec et al. (2014) examine the relation between the BRIC agricultural exports and the quality of institutions (legal structure and security of property rights and freedom to international trade) using a gravity trade model and panel data analysis for 1998 to 2009. The empirical results indicate an increase in agriculture food exports from Brazil and China while Russia faced a pattern of stagnation and high volatility. Brazil and India increased their market shares in the importing markets and there was a deterioration of these shares for Russia. Exports of agriculture food are positively associated to institutional quality and GDP and there is a negative association with market distance.

As one can see based on the previous review of empirical studies, there is quite a lot of differences when evaluating the role of exchange rate volatility, price (exchange rate level) and foreign income for export performance, which can be considered expected to some extent, since each of the BRICS countries has its own historical, economic, political and social specificities. The role of each one of these variables can also vary when considering different time periods for each country but in general it is fair to say that these emerging economies growth strategies, in part explained by export performance, will be affected by price (exchange rate level and volatility) and income effects. There is also an additional concern to incorporate international movements in commodity prices into the investigation since exports from the BRICS are still heavily concentrated on commodities, and this is part of our empirical task.

3.   Data and Econometric Approach

In order to investigate the export performance of the BRICS countries the following equation is estimated for the period ranging from January 2000 to December 2014:

$$LEXP_t = \beta_0 + \beta_1 VOLAT_t + \beta_2 LREER_t + \beta_3 LWIMP_t + \beta_4 LPCOM_t + \varepsilon_t \qquad (1)$$

where:
- LEXP: Log of Exports (US$ Millions) - (Source: DOTS).
- LREER: Log of Real Effective Exchange Rate (2005 = 100) - (Source: BIS).
- VOLAT: Real Effective Exchange Rate Volatility - (Source: BIS).
- LWIMP: Log of World Imports (US$ Millions) - (Source: DOTS).
- LPCOM: Log of Commodity Price Index – Emerging Market Economies (2010 = 100)
       (Source: The World Bank).

It is worth mentioning the following: i) 'L' indicates that the variables are in natural log form; ii) the volatility of the real effective exchange rates of each country was calculated via ARCH-GARCH models; iii) world imports are used as proxy for international demand for exports; iv) exports and real effective exchange rate (level and volatility) refer to each country analyzed; v) the commodity price index refers to the index related to developing and emerging economies.

The empirical analysis developed in this work is based on Autoregressive Distributed Lag (ARDL) models applied to cointegration, as proposed in Pesaran & 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 & 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 & Shin, 1999).

A traditional ARDL model with two variables can be defined as:

$$y_t = \alpha_0 + \delta_1 y_{t-1} + \dots + \delta_s y_{t-s} + \beta_1 x_{t-1} + \dots + \beta_s x_{t-s} + \varepsilon_t \qquad (2)$$

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Before 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)[3]. Having had this confirmation, a typical Error Correction Model (ARDL-ECM) can estimated by the following specification:

$$\Delta y_t = \alpha_0 + \delta_1 y_{t-1} + \delta_2 x_{t-1} + \sum_{i=0}^{n} \phi_1 \Delta y_{t-i} + \sum_{i=0}^{n} \phi_2 \Delta x_{t-i} + \varepsilon_t \qquad (3)$$

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 over time. 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 are used). As for stability tests, the cumulative sum (CUSUM) and the cumulative sum of squared (CUSUMSQ) recursive residuals tests (Brown, Durbin & Evans, 1975) allow us to look at the constancy of the coefficients in a model. Parameter instability is found if the cumulative sum falls outside the area between the two 5% critical lines. This is crucial in ARDL estimations once the CUSUM and CUSUMSQ are also able to diagnose the influence of structural breaks in the estimations.

Once the researcher has made sure that the model estimated has no serial correlation problem and that it is dynamically stable, the ARDL-Bounds testing methodology can be applied in order to confirm that the variables in the model cointegrate, that is, 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. However, under the null hypothesis of no cointegration (H_0: $\delta_1 = \delta_2 = 0$), the critical values of the Wald test have no standard asymptotic distribution for any order of integration of the regressors. As a result, Pesaran et al. (2001) provide bounds on the critical values for the F statistics, where the lower level is calculated on the assumption that all variables of the model are stationary and, therefore, 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.

Once such relationship is confirmed, the long-run equilibrium coefficients can be estimated, as well as the ECM itself, which provides the long-term balance adjustment speed. In fact, the ARDL model is able to keep information on both short and long run properties of the estimated model, and disequilibrium is seen as a process of adjustment to the long run.

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 related to some variables are inconclusive, especially those related to exports and real effective exchange rate volatility. 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 ARDL model is as follows: Log of Exports, Log of Real Effective Exchange Rate, Real Effective Exchange Rate Volatility, Log of World Imports and Log of Commodity Price Index. Table 2 reports the ARDL models, along with the autocorrelation LM test for each country analyzed. It is clear that the lags chosen for each variable vary amongst BRICS countries. In the case of Brazil and China , lagged 'exports' seem to play an important role, as 6 lags were chosen. As for Russia, 'world

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[3] We performed unit root tests and found no I(2) variable. We decided not to report the results in order to save page space.

imports' is the variable with more lags chosen, whilst in India the 'volatility of the real effective exchange rate' is the variable with more lags chosen.

In order to go on with the analysis regarding long-run and short-run dynamics of the BRICS export performance, we must decide whether the models estimated are suitable for further analysis. Therefore, some diagnostic tests are needed. Table 2 also reports the Autocorrelation LM Test for each of the ARDL model chosen. It is clear that able vary among BRICS countries, and all estimated models are free from serial correlation problems.[4] As for the CUSUM and the CUSUMSQ stability tests, which are reported in the appendix, show that there is some parameter instability in the case of China and South Africa. Russia also shows some instability, but very little.

Table 1
Unit Root Tests (Jan/2000 – Dec/2014)

	Variables / Tests	ADF	PP	KPSS	DF-GLS
Log of Commodity Price Index - Emerging	LPCOM	1.22	1.16	0.30**	-1.15
Log of World Imports	LWIMP	-2.35	-2.73	0.23**	-2.40
Log of Real Effective Exchange Rate	Brazil	-2.50	0.29	0.17*	-2.09
	China	1.11	1.40	0.35**	-1.22
	India	-2.39	-2.63	0.15*	-1.86
	Russia	-2.16	-2.69	0.35**	0.10
	South Africa	-2.35	-2.26	0.10	-2.33
Log of Exports	Brazil	-3.30	-4.54**	0.27**	-2.76
	China	-1.59	-4.54**	0.35**	-1.35
	India	-1.76	-3.56*	0.22**	-2.00
	Russia	-2.23	-2.21	0.25**	-2.28
	South Africa	-5.20**	-5.09**	0.23**	-2.68
Real Effective Exchange Rate Volatility	Brazil	-4.95**	-4.894**	0.053	-5.110**
	China	-3.76**	-3.80**	0.14	-3.09*
	India	-1.78	-1.86	0.34**	-1.57
	Russia	-4.40**	-4.34**	0.08	-4.30**
	South Africa	-4.55**	-4.54**	0.07	-4.09**

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

Table 2
ARDL Models - Dependent Variable: Exports (of each country)

Country	ARDL Model	Autocorrelation LM Test (Prob) (H_0 - no autocorrelation)
Brazil	(6, 0, 0, 1, 2)[1]	0.737 (0.390)
Russia	(2, 0, 1, 6, 2)[1]	2.355 (0.124)
India	(2, 5, 6, 3, 0)[1]	0.774 (0.378)
China	(6, 1, 0, 6, 2)[1]	0.203 (0.652)
South Africa	(3, 1, 0, 2, 2)[3]	2.094 (0.147)

Notes: ARDL model with maximum of six lags for all countries. Choice of model based on Akaike Information Criteria. Order of Independent Variables (Exports, Real Effective Exchange Rate - REER, REER Volatility, World Imports, Commodity Price Index). 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.

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[4] All estimations are available upon request.

We now turn to the examination of the existence of cointegration vectors between the variables, by applying the ARDL Bounds Testing Approach, as in Pesaran et al. (2001). Table 3 reports these results, taking into account Pesaran's et al. (2001) critical values. The null hypothesis of "no cointegration vectors" can be rejected (at 5%) for all Brazil, Russia, India and China, once the F-statistics are greater than Pesaran's critical values. As for South Africa, the long run relationship can only be detected at 10%. But we have to remember that there is considerable parameter instability in the South African case. Overall, it means that there is a long run relationship between the variables analyzed for each country-member of the BRICS group, with an exception of South Africa.

Table 3
Cointegration Test (ARDL Bounds Testing Approach)

| Country | F-Statistics | Critical Values | | | | Long Run Cointegration |
| | | I(0) Bound | | I(1) Bound | | |
		10%	5%	10%	5%	
Brazil	12.783	2.68	3.05	3.53	3.97	Yes
Russia	4.336	2.68	3.05	3.53	3.97	Yes
India	10.193	2.68	3.05	3.53	3.97	Yes
China	8.512	2.68	3.05	3.53	3.97	Yes
South Africa	3.396	1.90	2.26	3.01	3.48	Yes at 10%; Inconclusive at 5%

Notes: H_0 (no long-run relationship)

After applying the ARDL Bounds Testing Approach to all models, we estimate the long-run equilibrium coefficients, which are reported in Table 4. The empirical results suggest the existence of asymmetries among countries, when considering which variables are playing a significant role in the long run. Let's focus on each country separately:

- **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 took 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.

- **Russia:** export performance relies on real effective exchange rate (level and volatility), foreign demand and commodity prices. 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 ARDL model selected the above mentioned variables.

- **India:** export performance relies on real effective exchange rate (level and volatility) and commodity prices. Gems and precious metals, petroleum products, service goods, automobiles and machinery are the main products exported by India.

- **China:** export performance relies on real effective exchange rate and foreign demand. There is no doubt China is one of the fastest growing economy for the past decades, relying mainly on its exports around the world. In order to have such performance, the control of exchange rate (kept constantly at a competitive level for exports) is of utmost importance, as well as a strong foreign demand. But one must remember that there is considerable parameter instability in China´s ARDL model.

- **South Africa:** export performance relies on foreign demand. South Africa´s export products are mainly mineral products, precious metals, iron and steel products and vehicles. As in the case of China, South Africa also shows considerable parameter instability in the estimated ARDL model.

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

Country (ARDL Model)	Brazil (6, 0, 0, 1, 2)	Russia (2, 0, 1, 6, 2)	India (2, 5, 6, 3, 0)	China (6, 1, 0, 6, 2)	S. Africa (3, 1, 0, 2, 2)
Variables	Coeffic. (Prob.)	Coeffic. (Prob.)	Coeffic. (Prob.)	Coeffic. (Prob.)	Coefficient (Prob.)
Real Effective Exchange Rate	0.059 (0.521)	1.228* (0.006)	0.508** (0.093)	-1.168* (0.000)	0.224 (0.256)
REER Volatility	7.761 (0.631)	195.530* (0.018)	-683.751* (0.048)	491.079 (0.190)	-27.844 (0.519)
World Imports	0.649* (0.000)	2.158* (0.000)	0.175 (0.236)	0.881* (0.000)	1.089* (0.000)
Commodity Price Index	0.370* (0.000)	-0.569* (0.030)	0.665* (0.000)	0.034 (0.698)	-0.011 (0.959)
Trend	0.002 (0.009)	-0.004* (0.008)	0.007* (0.000)	0.009* (0.000)	-

Notes: All variables are in natural log except for REER Volatility. Commodity Price Index
is related to developing countries.

The next question to be asked is related to the short run adjustment, via an Error Correction Representation (ECM) of the ARDL 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. It means that we have to know whether this speed of adjustment is fast or slow. Table 5 reports the ECM results for the estimated ARDL models. As expected, the error-correction term (ECM_{t-1}) is negative for all estimations performed (on average ECM_{t-1} = -0.56). It means that, on average, 56% of the shock is corrected after the first month. The lowest speed of adjustment is found in South Africa (23%), meaning that, for the South African case, the long-run equilibrium relationship between its variables returns to the steady state very slowly. But, again, one must remember that South Africa shows a substantial parameter instability and its long run equilibrium is not as significant as in the other countries analyzed. On the other hand, the highest speed of adjustment is associated to the case of China (87%), followed by Brazil (81%), that is, in these two countries the adjustment process, towards the long-run equilibrium, is quite fast.

Table 5
Error Correction - Short Run Dynamics

Country / ARDL Model	ECM(-1)	Prob.
Brazil (6, 0, 0, 1, 2)	-0.818	0.000
Russia (2, 0, 1, 6, 2)	-0.295	0.000
India (2, 5, 6, 3, 0)	-0.582	0.000
China (6,1,0,6,2)	-0.871	0.000
South Africa (3, 1, 0, 2, 2)	-0.236	0.000

Conclusion

The main goal of this work is to investigate the export performance for Brazil, Russia, India, China and South Africa (BRICS) from January 2000 to December 2014 using autoregressive distributed lag (ARDL) models in order to test for the existence of cointegration. 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 our empirical analysis. The empirical results suggest that in the long run, export performance relies mainly on real effective exchange rate (level and volatility) and foreign demand (China and Russia), foreign demand and commodity prices (Brazil), real effective exchange rate and commodity prices (India) and on foreign demand (South Africa).

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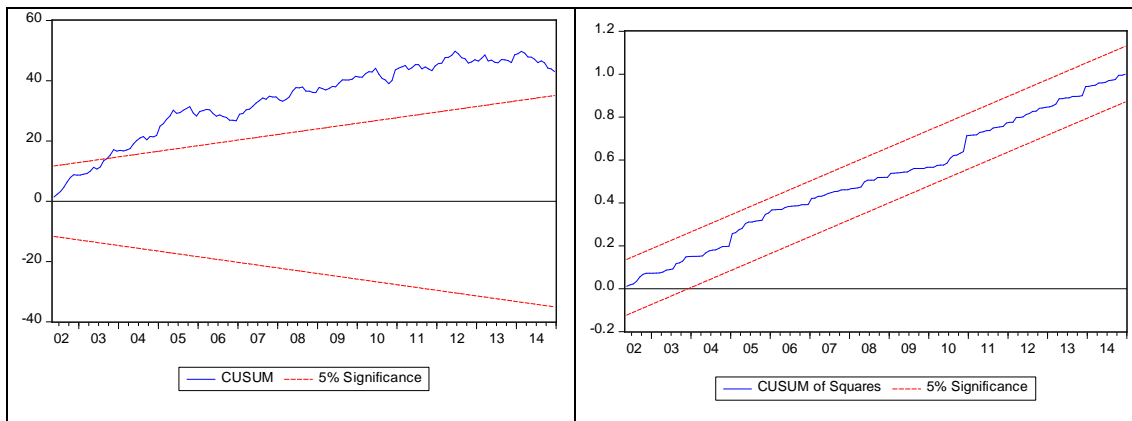
Appendix

Figure 1A: Brazil – Cusum and Cusum of Squares
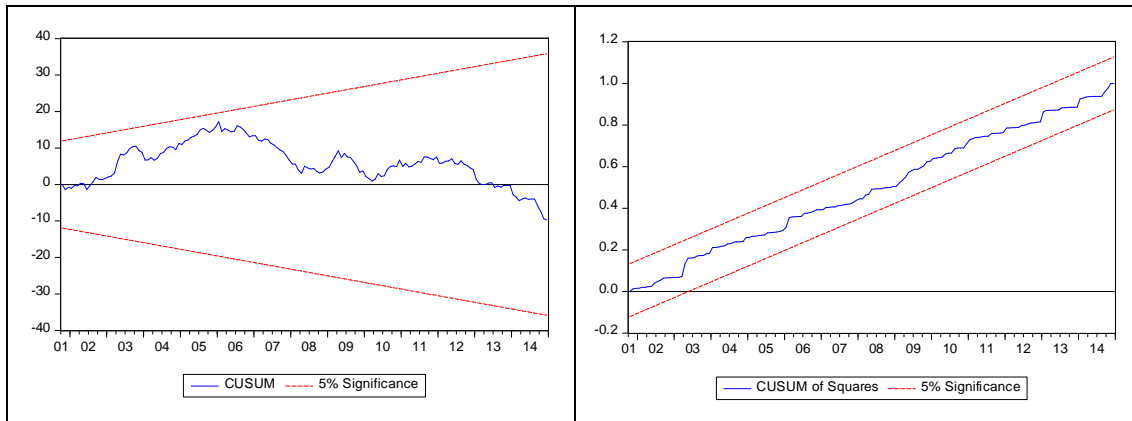
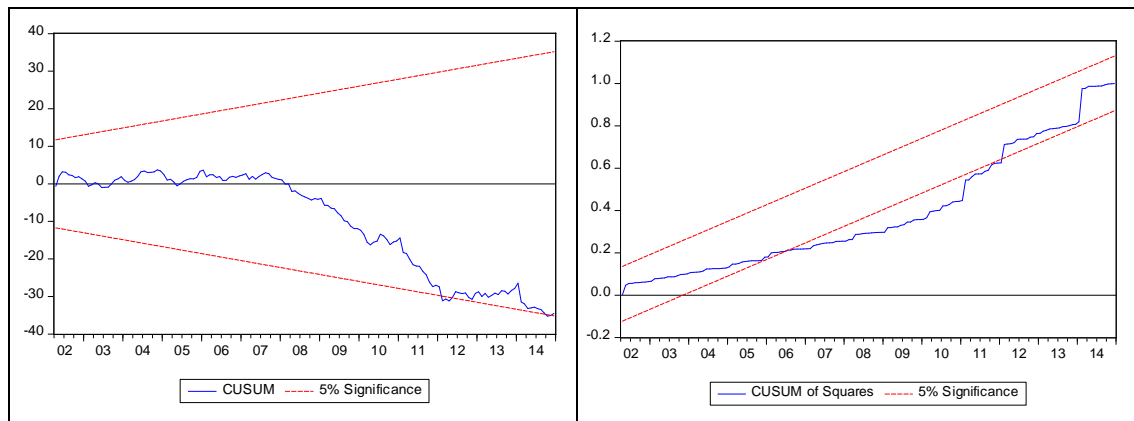## Figure 1B: Russia – Cusum and Cusum of Squares
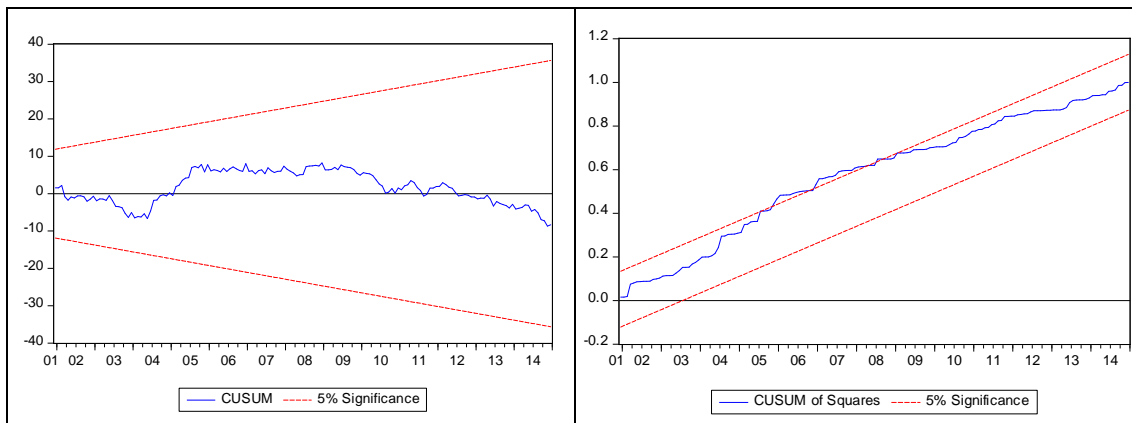
Figure 1C: India – Cusum and Cusum of Squares

Figure 1D: China – Cusum and Cusum of Squares

Figure 1E South Africa – Cusum and Cusum of Squares