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DYNAMICS OF INDUSTRIAL PRODUCTION IN BRICS COUNTRIES

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-Abstract -

This paper investigates the long run and short run dynamics between industrial production and factors affecting production in the Emerging Market Economies of Brazil, Russia, India, China and South Africa (BRICS). Using the Chudik and Pesaran (2013) P-ARDL model and monthly data from 1994:01 – 2013:12, the study finds evidence of a cointegrating relationship between industrial production and selected variables. It is further observed that capital, labour, per capita income and exports have a positive long run impact on industrial production in the BRICS. A currency appreciation (an increase in the exchange rate), however, has a negative impact on industrial production. In the short run, it is found that imports, exports, exchange rates, labour, capital and per capita income significantly affect industrial production.

Keywords: *Dynamics of Industrial Production, BRICS countries, P-ARDL*

JEL Code: *E6, E63, L6*

1. INTRODUCTION

Despite the alarming levels of unemployment and sluggish output growth in the developing world, most developing countries are facing a challenge to diversify their economies and achieve their potential through industrialization. In many cases, government policies are tailored towards fulfilling a political agenda rather than stimulating industrial output production (see Nkurayija, 2011; Akinmulegun, S2014; Olotu *et al*., 2015). The political economy of public policy hypothesises is such that monetary policy is limited to restraining inflation (to low single digits) as an election campaign strategy while fiscal policy is centred on government subsidies and price controls, which has led to product shortages and inefficiencies. In a bid to circumvent these ills, Brazil, Russia, India, China and South Africa (BRICS) have come together to build a giant Emerging Market Economy (EME). As stated by Chun (2014), their sole aim is to partner for development, integration and industrialization. They aim at achieving output growth through industrialization; creating room for development via trade liberalization; and developing both domestic and international markets. To achieve this, policies and development institutions were established and strengthened in order to mobilize funds (e.g., the establishment of BRICS New Development Bank, the BRICS Think Tank group, Annual BRICS Summit, BRICS Competition Conference and BRICS Business Forum, among others) for infrastructural development and economic growth via industrialization (see also Di Maio, 2015).

With all the effort being exerted to achieve industrialization and sustainable output growth, it is interesting to note that the BRICS' total industrial share of global GDP is still declining (see Dietzenbacher *et al.*, 2013). Naude et al. (2013), Aradhna (2014) and Naudé et al. (2015) confirm the declining trend of manufacturing/industrial contribution to GDP and the fall in the industrial share of employment in BRICS countries. This development has been blamed on differentiated growth dynamics and changes in the final demand patterns of the world.

The focus of this study, therefore, is on industrialization (as proxied by manufacturing sector contribution to GDP) in the BRICS, which is rooted in growth theory, evolutionary economics and institutional economics that maintain that manufacturing is important for economic development. Improvement in technology is in turn, needed for successful industrialization (Fu *et al*., 2011). This study, accordingly, aims at investigating the determinants of industrial output production in BRICS countries; the long run and short run relationship between industrial output production and factors affecting production in these countries; whether the impact of long run factors of production can foster industrial output production; and the steady-state relationship between industrial output production and factors affecting production in BRICS countries.

There are a few studies that have empirically analysed the nature of industrialization in the BRICS (see Naudé et al., 2013; Aradhna, 2014; Aldrighi and Colistete, 2015). This paper complements these studies by providing a more detailed analysis of the determinants of industrial production in the BRICS using a panel ARDL. To the best of our knowledge, no study has been carried out to analyse industrial production in BRICS countries using a Panel ARDL technique.

According to Aradhna (2014), BRICS countries focus on structural changes in shifting production away from low productivity labour-intensive sectors towards high productivity skill- and capital-intensive activities that can foster output growth through increases in productivity and technological development. Industrial production perfectly fits this profile. The industrial sector is defined as a branch of economic activities concerned with the processing of raw materials and manufacturing of goods and services, and may also involve commercial activities that stimulate the economy. At micro level, the sector is proxied by manufacturing sector contribution to GDP (see Naudé et al., 2013; Aradhna, 2014; Aldrighi and Colistete, 2015).

An economy's stock of capital, labour, knowledge and the way they are structured and allocated across industries for production activities determine the overall industrial production. For instance, an optimal allocation during diversification will maximize welfare and boost output production in the long run while other misallocations result in lower levels of output production and therefore show up in a lower level of total output productivity which affects the economy (see Jones, 2011).

The composition of manufacturing value added, its contribution to GDP and employment by major sectors in BRICS countries during the periods 2000 to 2014 and 1980 to 2008 are shown in Tables 1 and 2. The table also shows the structural changes during these periods. India, as indicated in the Table, is the only country where the share of manufacturing value added in GDP increases considerably. In the other countries in the bloc, there are marginal declines, and evidence of declining trend of manufacturing sector contribution to GDP (dis-industrialization). In Table 2, there is a decline in the share of primary sectors' employment in all the BRICS countries. India and China are the only countries that recorded an increase in manufacturing sector employment while in the other countries, it declined.

Table 1: Share of manufacturing Value Added as % of GDP (2000 - 2014)

Sectors	Brazil		Russia		India		China		South Africa	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Agriculture	5.5	5.5	6.4	3.9	23.0	16.9	14.7	9.2	3.2	2.5
Mining	26.0	23.0	38.0	36.0	26.0	30.0	45.0	43.0	32.0	29.0
Manufacturing	**15.1**	**11.0**	**17.0**	**14.0**	**15.0**	**17.0**	**32.0**	**30.0**	**19.0**	**13.0**
Utilities	3.0	13.0	4.4	2.6	1.9	3.0	2.7	2.9	1.9	2.8
Construction	7.2	3.7	6.6	4.0	6.3	7.1	5.6	8.9	2.5	2.0
Services	67.9	71.0	55.6	60.0	50.9	53.0	39.8	48.2	64.8	68.0

Source: *World DataBank (World Development Indicators); Author's calculations*

Table 2: % Shares of Sectorial Employment (1980 - 2008)

Sectors	Brazil		Russia		India		China		South Africa	
	1980	2008	1995	2008	1980	2008	1987	2008	1980	2008
Agriculture	38.4	17.8	27.7	21.5	69.9	54.0	59.2	40.2	12.6	5.7
Mining	0.5	0.3	1.4	1.2	0.5	0.6	1.8	1.3	11.1	2.4
Manufacturing	**12.8**	**12.0**	**17.3**	**13.7**	**10.3**	**12.3**	**16.0**	**18.5**	**15.0**	**14.3**
Utilities	0.8	0.4	1.9	2.3	0.3	0.3	0.3	0.5	1.6	0.7
Construction	8.9	7.2	7.7%	7.3	1.9	6.7	4.5	6.7	7.8	8.3
Services	38.6	61.3	44.0	54.0	17.1	26.0	18.3	32.8	51.8	68.6

Source: Naude et al (2013) & *Author's calculations*

2. INDUSTRIAL PRODUCTION AND FACTORS AFFECTING PRODUCTION IN BRICS COUNTRIES

In order to effectively model industrial production and factors affecting production in the BRICS, we employ the Aggregate Production Function (APF) in the Neo-Classical framework of the Cobb-Douglas production function. One of the main reasons why this study is interested in the APF is because of the empirical puzzle (as predicted by the neoclassical model) that countries with low per-capita incomes grow faster than countries with high per-capita incomes, so that over time, per-capita incomes converge. According to Calderón and Yeyati (2009), all BRICS member countries are EMEs with a per-capita income lower than the average per-capita income in the G7 countries. This satisfies the puzzle that the BRICS countries are expected to grow faster than the G7 countries. However, there is no evidence that the low income countries are catching up with the developed countries (see Acemoglu and Robinson, 2012; Arias and Wen, 2015). Secondly, the APF explains long run growth as emanating from economic activities that create new technological knowledge and relationships between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs. This is in line with the aim of this study, which is to investigate the long run and short run relationships between industrial output production and factors affecting production in BRICS countries. In addition, the APF is interesting because it often leaves a role for policymakers. The model holds that the long run growth rate of an output in the economy is explained by policy measures (see Felipe, 2001 and Frimpong and Oteng-Abayie, 2006).

Therefore, the point of departure for the Cobb-Douglas production function is an economy in which there are two types of factors of production (see Rebelo, 1990). These are the reproductive economy, which can be accumulated over time (e.g. physical and human capital) and the non-reproductive economy, which is available in the same quantity in every period of time (e.g. land). In this economy (reproductive and non-reproductive), it is assumed that industrial production is given by a production function of the following form:

$$Y_t = A_t L_t^{\beta} K_t^{\alpha},\ 0 < a < 1,\ 0 < b < 1, \quad (2.1)$$

where Y_t is the total output (real value of all goods produced in a year) at time t; A_t is total factor productivity over time; L_t is labour input (total number of man-hours over a given period); K_t is capital input (real value of all machinery, equipment, and buildings at a given time); and β and α are the output elasticity of capital and labour, respectively. These values are constantly determined by the available technology.

On the condition that $(\beta + \alpha) = 1$, the Cobb-Douglas model shows constant returns to scale. This means that doubling the usage of capital K_t and labour L_t will also double output Y_t. Conversely, if $(\beta + \alpha) > 1$, it shows increasing returns to scale, and if $(\beta + \alpha) < 1$, it shows diminishing returns to scale. An equivalent of equation (1) is a linear function of the logarithms of the three variables given as:

$$log(Y_t) = c_o + log(A_t) + \beta \, log(L_t) + \alpha \, log(K_t)$$
(2.2)

where Y_t, L_t and K_t denote output, labour and capital, respectively, c_o is a constant parameter and A_t is Total Factor Productivity (TFP) or other factors not captured by labour and capital (also considered as unconventional inputs). For purposes of this study, these factors or inputs include: per-capita income, exchange rates, imports and exports. We assume TFP is a function of per-capita income (KY), imports (IMP), exports (NXP) and exchange rates (EX) over a particular period of time t which is given by:

$$A_t = f(KY_t, IMP_t, NXP_t, EX_t)$$
(2.3)

Therefore, substituting A_t in equation (2.3) into equation (2.1), we get a new extended Cobb-Douglass production function given by:

$$Y_t = KY_t^{\beta 1} IMP_t^{\beta 2} NXP_t^{\beta 3} EX_t^{\beta 4} L_t^b K_t^a,$$
(2.4)

Equation (2.4) represents our industrial production model for the BRICS countries where Y_t is viewed as industrial production that captures the industrial sector contribution to GDP. Following Omar and Hussin (2015:102), we take logs of the equation (2.4) and simplify it to capture our industrial output production (IP) in a panel form as:

$$logIP_{i,t} = c_i + \beta_1 logKY_{i,t} + \beta_2 logIMP_{i,t} + \beta_3 logNXP_{i,t} + \beta_4 logEX_{i,t} + blogL_{i,t} + alogK_{i,t} + \varepsilon_{i,t} \quad (2.5)$$

where $IP_{i,t}$ (industrial output production) is a proxy of $Y_{i,t}$; c_i is a constant term; $\beta_1 logIMP_{i,t} + \beta_2 logNXP_{i,t} + \beta_3 logEX_{i,t} + \beta_4 logKY_{i,t}$ capture TFP or $logA_t$; $blogL_{i,t}$ and $alogK_{i,t}$ are labour and capital respectively; i is a country specific term; and $\varepsilon_{i,t}$ is an error term.

3. METHODOLOGY

This study aims at investigating how fast BRICS countries have diversified the structure of their economies over the years. Other specific objectives include: investigating the determinants of industrial production in BRICS countries; analysing the long run and short run relationship between industrial output production and factors affecting production in BRICS countries; investigating whether the impact of long run factors of production can foster industrial production; and examining the steady-state relationship between industrial production and factors affecting the production in BRICS countries.

To model the data appropriately and extract both the long run and short run relationships in achieving the above objectives, this study takes into account the existence of unit roots and/or cointegration associated with the data to determine the appropriate methodology. To achieve this, Giles (2013) enumerates four situations that normally confront data and subsequently determine the choice of method used:

- when all of the series are I(0), and hence stationary: In this case, the appropriate methodology is Ordinary Least Square (OLS) estimation of the data in levels.
- when all the series are integrated of the same order (*e.g.* I(1)), but they are not cointegrated: In this case, the correct model is a VAR in first differences involving no long run elements.
- when all of the series are integrated of the same order, and are also cointegrated: In this case, there are two types of regression models that can be estimated: (i) An OLS regression model using the levels of the data. This will provide the long run equilibrium relationships between the variables. (ii) An Error Correction Model (ECM), estimated by OLS. This

model will represent the short-run dynamics of the relationship between the variables.

- Finally, is a more complicated situation where some of the variables in question are stationary in levels i.e. I(0), and some are I(1) or even fractionally integrated leading to no clear cut order such as in the three situations noted above: This situation is particular to the series employed in this study and forms the basis for the adoption of the advanced methodology of Chudik and Pesaran (2013) P-ARDL model.

3.1. Brief Definition of Variables

In line with Sari et al. (2008), we employ monthly data of the BRICS countries over the period 1994:1 to 2013:12. The variables used are drawn from the literature and rooted in the Cobb-Douglass growth theory (the APF). The Dependent variable is industrial production (IP) as proxied by the contribution of the manufacturing sector to GDP while other variables are the production variables, trade variables and control variables as explained below:

- Production variables are capital (K) and labour (L) (see Jajri and Ismail, 2010; Ayres and Voudouris, 2014). Capital is measured by gross capital formation. It consists of added outlays to the fixed assets of the economy plus net changes in the level of inventories while labour (L) is the labour force participation rate (% of total population aged between 15 and 65) as compiled by the International Labour Organization (ILO).
- In line with Sebri and Ben-Salha (2014), trade variables are total volume of imports (IMP) and exports (NXP). These variables capture the open economy status of the BRICS countries.
- Control Variables are per-capita income (KY) and real exchange rate (EX) as posited in Omolade and Ngalawa (2014). Per-capita income is captured by GDP per capita based on purchasing power parity while the real exchange rate is the local currency per US dollar.

3.2. Data Sources

The data for this study are obtained from the individual countries' central bank's statistical bulletins, World Bank's World Development Indicators (WDI), Organization for Economic Co-operation and Development (OECD), International Monetary Fund's (IMF), International Financial Statistics (IFS), Quantec Database and the statistics offices of each country. In addition, all data are in 2005 base year and are expressed in natural logarithms except labour that is already in percentage.

3.3. Estimation Technique

Following Rafindadi and Yosuf (2013), Gerni et al. (2013), Mohaddes and Raissi (2014) and Al Mamun et al. (2013), we adopt the Panel Autoregressive Distributed Lag (P-ARDL) model of Chudik and Pesaran (2013) to test for the existence of long run and short run relationships between industrial production and factors affecting production in BRICS countries. The choice of the ARDL methodology for this study is based on a number of features that give it some advantages over conventional short run and long run estimates. For example, the ARDL model:

- is a contemporary technique for the investigation of long run and short run dynamics (Giles, 2013);
- can be used with a mixture of I(0) and I(1) variables. This means that this approach can be applied to data, whether they are purely I(0), I(1), a mixture of I(0) and I(1), mutually co-integrated, or irrespective of their order of integration but not I(2) (See Sari et al., 2008; Katircioglu, 2009);
- allows different variables to be assigned different lags in the model (Giles, 2013);
- can accommodate more than two lags and up to six variables (Giles, 2013);
- simultaneously estimates the short run and long run parameters of the model (Dritsakis, 2011; Shin *et al*., 2014);
- is good for both small and large sample sizes (see Narayan, 2005 and Rafindadi and Yosuf, 2013); and
- involves just a single-equation set-up, making it simple to implement and interpret (Giles, 2013).

On the whole, the Chudik and Pesaran (2013) model is suitable for panel analysis as it accounts for cross-sectional dependence and can allow for one or two structural breaks when carryout the unit root testing.

Suppose the P-ARDL regression model for the BRICS countries is given by:

$$\Delta Y_{it} = \beta_{i0} + \beta_1 \Delta X_{it-1} + \beta_2 \Delta X_{it-2} + \beta_3 \Delta X_{it-3} \dots \dots .. + \beta_P \Delta X_{it-p} + \alpha_1 y_{it-1} + \alpha_2 y_{it-2} + \alpha_3 y_{it-3} + \cdots \dots + \alpha_Q y_{it-q} + \varepsilon_{it}$$
(3.1)

where Y_{it} is a $(k \times 1)$ vector of endogenous variables capturing industrial production; β_{io} is a $(k \times 1)$ vector of intercept/drift components of the constant term; i represents the BRICS' countries' specific terms; Δ denotes the first difference operator; X_i and y_i are lagged explanatory variables $(for\ every\ i = 1 \dots \dots ... p\ and\ q)$; $\beta_1 - \beta_p$ represent short run dynamics of the model; $\alpha_1 - \alpha_q$ correspond to the long run relationship; and ε_{it} is a vector of disturbance terms.

3.4. Why Panel Data Analysis

Following Mahembe (2014:95), Hasio (2014), Gujarati (2004) and Baltagi (2008), we consider pooling cross-sectional time series data because panel data:

- offers more explanatory data, more variability, fewer collinearity among the variables, additional degrees of freedom and it is more efficient when compared to time-series or cross-sectional data (Baltagi, 2008:7);
- can control for heterogeneity in individual data (Baltagi, 2008:6);
- is suitable for the study of dynamic adjustments (Baltagi, 2008:7);
- is able to ascertain and measure effects that are not detectable in pure cross-section or time series data (Baltagi, 2008:8);
- allows for the creation and analysis of more complex behavioral models (Baltagi, 2008:8), such as economies of scale and technological change (Gujarati, 2004:639); and
- removes the problem of non-standard distributions that is emblematic of unit root tests in time series analysis (Baltagi, 2008).

4. ESTIMATION RESULTS

We begin by testing for stationarity. In addition, the tests for cross-sectional dependence and determination of lag selection criteria are done. A test is also conducted to determine the strength of the model selection before embarking on the P-ARDL regression. The study also carries out a cointegration test that finally leads to the incorporation of a P-ARDL Error Correction Model.

4.1. The Panel ARDL Unit Root Results

We test the data for the presence of unit roots (stationarity) using a robust version of Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS) and the Augmented Dickey-Fuller Test (ADF). Different approaches are used in order to compare and validate the results and to further ensure consistency (See Moon and Perron, 2004; Demetriades and Fielding, 2012; Ishibashi, 2012 and Frimpong, 2012). The results show that only exchange rates are stationary in levels i.e. I(0), while all other variables are integrated of order one i.e. I(1). None of the variables is I(2). As shown in Table 3, the dependent variable is I(1), which satisfies the Pesaran *et al.* (2001) condition for testing and running an ARDL model.

Table 3: Levin et al., IPS and Augmented ADF unit root tests

Variable	Levin, Lin, Chu (individual intercept)			Levin, Lin, Chu (individual intercept and trend)		
	Order of integration	t* Statistics	P-Value	Order of integration	t* Statistics	P- Value
Industrial production	I(1)	-7.06046	0.0000***	I(1)	-7.78681	0.0000***
Imports	I(1)	-70.9336	0.0000***	I(1)	-86.2116	0.0000***
Exports	I(1)	-41.9356	0.0007***	I(1)	-54.6091	0.0010***
Exchange rates	I(0)	-27.3567	0.0000***	I(0)	-33.4942	0.0000***
Labour	I(1)	-4.44365	0.0034***	I(1)	-4.65629	0.0000***
Capital	I(1)	-1.63839	0.0507**	I(1)	-1.83571	0.0332**
Per capita income	I(1)	-1.75217	0.0339**	I(1)	-1.82306	0.0341**

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10% respectively.

Variables	IPS Unit-root test (individual intercept)	IPS Unit-root test (individual intercept and trend)

	Order of integration	t* Statistics	P Value	Order of integration	t* Statistics	P- Value
Industrial production	I(1)	-11.3642	0.0000***	I(1)	-10.7897	0.0000***
Imports	I(1)	-62.8885	0.0000***	I(1)	-67.7558	0.0000***
Exports	I(1)	-6.00020	0.0000***	I(1)	-4.88129	0.0000***
Exchange rates	I(0)	-21.7836	0.0000***	I(0)	-22.4592	0.0000***
Labour	I(1)	-10.0301	0.0000***	I(1)	-9.57040	0.0000***
Capital	I(1)	-6.55210	0.0000***	I(1)	-6.47163	0.0000***
Per capita income	I(1)	-6.92596	0.0000***	I(1)	-6.36449	0.0000***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10% respectively.

Variables	ADF-Fisher Chi Square Unit root-test (individual intercept)			ADF-Fisher Chi Square Unit root-test (individual intercept and trend)		
	Order of integration	t* Statistics	P- Value	Order of integration	t* Statistics	P- Value
Industrial production	I(1)	151.640	0.0000 ***	I(1)	127.601	0.0000***
Imports	I(1)	453.826	0.0000 ***	I(1)	528.863	0.0000***
Exports	I(1)	59.7182	0.0000 ***	I(1)	42.2605	0.0000***
Exchange rates	I(0)	361.007	0.0000 ***	I(0)	346.251	0.0000***

Labour	I(1)	125.952	0.0000 ***	I(1)	106.980	0.0000***
Per capita \income	I(1)	67.5535	0.0000 ***	I(1)	61.2786	0.0000***
KY	*I(1)*	73.1296	0.0000 ***	I(1)	59.8966	0.0000***

"***", "**" and "*" represent statistical significance at 1%, 5%, and 10% respectively.

4.2. Cross-Sectional Dependency

Despite that Chudik and Pesaran (2013) account for cross-sectional dependence and with the standard Augmented Dickey-Fuller (ADF) test suggested by Pesaran (2007) to remove the influence of cross-sectional dependence employed, a chow test is first conducted to determine whether data for the BRICS can be pooled together. The results support pooled regression for the BRICS countries. Subsequently, the Pesaran CD (cross-sectional dependence) test is employ to test whether the residuals are correlated across entities. The benchmark null hypotheses that are tested for the cross-sectional dependence are:

- $H0: \alpha = 1$, there is no correlation of the residuals (error term).
- $H1: \alpha \neq 1$, there is correlation of the residuals (error term).

The Pesaran's test of cross-sectional dependence conducted on the regression does not indicate the presence of common factors affecting the cross-sectional units (no cross-sectional dependence). Since the $\mathrm{P-Value\ of}\ O.0333 < 5\%$, the study accepts the null hypothesis of no correlation of the residual and fails to accept the alternative hypothesis that there exists a correlation of the residuals in the model.

4.3. The Panel ARDL Lag Determination

For the P-ARDL model, we estimate the regressions separately to obtain the optimal lag length for each variable. The orders of lags are selected using the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) which are used mostly in panel estimation (see Ali and Ali, 2008; Raza et al., 2015). The results are presented in Table 4.

Table 4: Panel ARDL Lag Selection Criteria

Serial No	Variables Name	Lags Selection
1	Industrial production (IP)	3
2	Imports (IMP)	2
3	Exports (NXP)	2
4	Exchange rates (EX)	2
5	Labour (L)	4
6	Capital (K)	3
7	Per-Capita Income (KY)	3

Since different variables can be assigned different lags as they enter the model, we tested for the optimal lag length of each variable. The results show 3 lags for Industrial Production (IP), 2 lags for Imports (IMP), 2 lags for Exports (NXP), 2 lags for Exchange Rates (EX), 4 lags for Labour (L), 3 lags for Capital (K), and 3 lags for Per-Capita Income (KY). The lag length is obtained on each first difference variable in line with Dritsakis (2011). We further employed the unrestricted likelihood ratio test for the optimum lag lengths and found the most appropriate lag length for the entire model to be 3 as shown in Table 5. Lag 3 gives the minimum criteria for the value of AIC and SIC hence making it the optimal lag length for the variables in the system. The 3-lags for the P-ARDL model is consistent with Nowak-Lehmann *et al.* (2011).

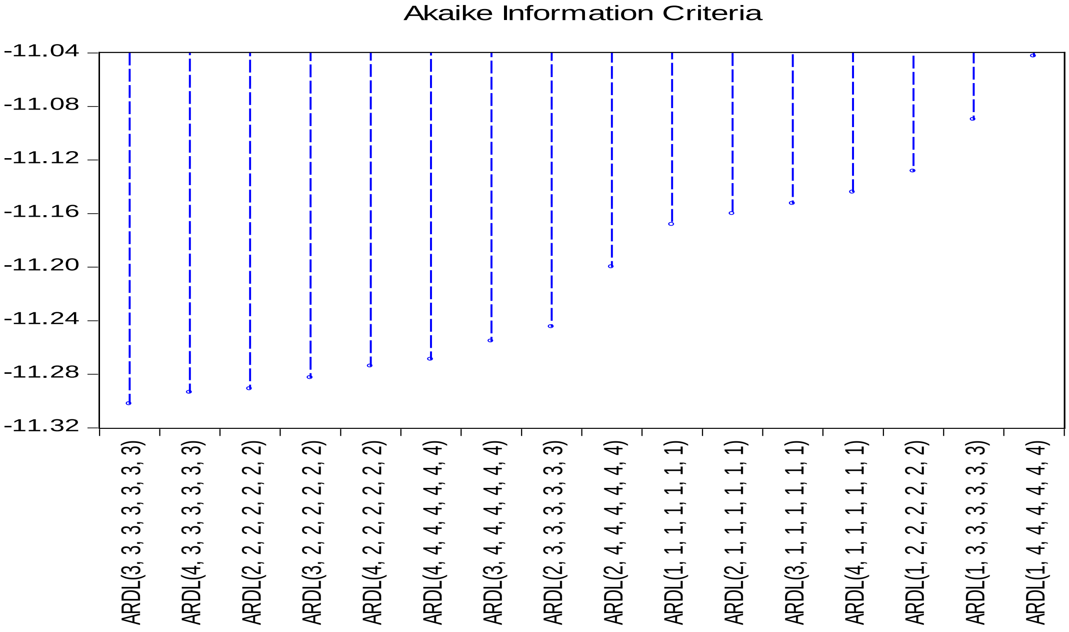
Table 5: The Panel ARDL Optimum Lag Selection Criteria

Lag Lengths	AIC	SIC
2	-7.569456	-7.475190
3	-7.685606*	-7.550924*
4	-7.671150	-7.525843
5	-7.675214	-7.489073
6	-7.676548	-7.459361

4.4. Measuring the Strength of the Model Selection Criteria

In order to determine the strength of the Akaike Information Criterion (AIC) over other criteria (the Schwarz criterion and Hannan-Quinn criterion) for model selection in the regression as well as to determine the long run and short run relationships in this study, we employ the criteria graph to determine the top sixteen (16) different P-ARDL models based on the bench mark analysis, "the lower the value of the AIC, the better the model". As shown in Figure 1, the first ARDL (3, 3, 3, 3, 3, 3,3) model appears to be strongly preferred over the others as it gives the lowest (most negative) value of the Akaike Information Criterion. In addition, the ARDL (4, 3, 3, 3, 3, 3, 3) model appears to be the top second.

Figure 1: The Strength of the Model Selection Summary



5. INTERPRETATION OF RESULTS

5.1. The Panel ARDL Regression Model

Estimation results of the P-ARDL are presented in Table 6. The estimates show that in the long run, all variables in the model (except for imports) are statistically significant in explaining industrial output production. It is observed that capital (K), labour (L), per capita income (KY) and exports (NXP) have a positive long run impact on industrial production in the BRICS. This relationship is consistent with economic theory and empirical evidence (Jajri and Ismail, 2010; Ayres and Voudouris, 2014; Sebri and Ben-Salha, 2014; Omolade and Ngalawa, 2014) that an increase in these variables will lead to an increase in industrial production. A currency appreciation (an increase in the exchange rate), however, has a negative impact on industrial production. This relationship is also in line with expectations, economic theory and empirical evidence (see Omolade and Ngalawa, 2014) that currency appreciation affects industrial production due to lower export (i.e. causes a trade deficit, which can exert a contractionary effect on the economy).

In the short run, it is found that coefficients of all explanatory variables are statistically significant. The results throw more light on which are the major drivers of industrial production in BRICS countries. The estimates show that all variables in the model are statistically significant, hence affecting industrial production in the BRICS. The overall results for the panel analysis allow for heterogeneous short run dynamics and a common long run cointegrating vector in stimulating industrial output production. Further confirming the existence of the appropriate model and cointegration, is the default parameter estimate of the short run coefficient (COINTEQO1), which is found to be both negative and statistically significant as expected (otherwise, there will be no proper cointegration).

As shown in Table 6, a large number of variables with a negative impact on industrial output production appear in the short run equation. All the short run coefficients show the dynamic adjustment of all the variables (see Dritsakis, 2011). According to Engle and Granger (1987), an Error Correction Mechanism

(ECM) exists for a cointegrated relationship. Therefore, a negative and significant coefficient of the error correction term is an indication of cointegration.

Table 6: Panel ARDL Dynamic Regression for Short run and Long run Estimates

Dependent Variable: D(LOGIP)				
Method: ARDL				
Sample: 1994M01-2013M12				
Model selection method: Akaike info criterion (AIC)				
Selected Model: ARDL(3, 3, 3, 3, 3, 3, 3)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
LOGIMP	-0.010522	0.009773	-1.076571	0.2819
LOGNXP	0.024340	0.008252	2.949505	0.0033
LOGEX	-0.079702	0.012747	-6.252870	0.0000
L	0.008635	0.004219	2.046799	0.0409
LOGK	0.004534	0.001935	2.343612	0.0193
LOGKY	0.000102	4.26E-05	2.399555	0.0166
Short Run Equation				

COINTEQ01	-0.584465	1.33E-16	-4.39E+15	0.0000
D(LOGIP(-1))	-0.196344	9.37E-17	-2.10E+15	0.0000
D(LOGIP(-2))	-0.099535	4.66E-17	-2.14E+15	0.0000
D(LOGIMP)	-0.002395	2.18E-18	-1.10E+15	0.0000
D(LOGIMP(-1))	-0.003731	5.76E-18	-6.48E+14	0.0000
D(LOGIMP(-2))	-0.001430	2.72E-18	-5.26E+14	0.0000
D(LOGNXP)	-0.007125	4.25E-19	-1.68E+16	0.0000
D(LOGNXP(-1))	-0.002690	4.14E-18	-6.50E+14	0.0000
D(LOGNXP(-2))	-0.003627	8.82E-19	-4.11E+15	0.0000
LOGEX	0.046119	1.07E-17	4.29E+15	0.0000
LOGEX(-1)	0.022678	5.42E-18	4.18E+15	0.0000
LOGEX(-2)	0.048387	6.80E-18	7.12E+15	0.0000
D(L)	0.042119	7.16E-17	5.88E+14	0.0000
D(L(-1))	-0.016019	1.59E-16	-1.01E+14	0.0000
D(L(-2))	0.007014	5.02E-17	1.40E+14	0.0000
D(LOGK)	-0.033031	2.77E-17	-1.19E+15	0.0000
D(LOGK(-1))	0.010320	1.46E-16	7.06E+13	0.0000
D(LOGK(-2))	-0.001812	2.51E-17	-7.21E+13	0.0000
D(LOGKY)	-3.73E-08	3.59E-20	-1.04E+12	0.0000
D(LOGKY(-1))	-0.000280	8.47E-20	-3.30E+15	0.0000
D(LOGKY(-2))	0.000115	3.22E-20	3.58E+15	0.0000
C	0.051971	8.33E-18	6.24E+15	0.0000

5.3. The Panel ARDL Cointegration Results

Table 7 shows a P-Value of less than 0.05. Accordingly, the study rejects the null hypothesis of no cointegration and fails to reject the alternative hypothesis that there exists a long run cointegration relationship among the variables in the model. The F-statistic value of 11.998 is larger than the upper band of the Pesaran critical value of 4.09 at 5% level (See Pesaran and Pesaran, 1997:478). This again shows evidence of cointegration. There is a significant and positive value of the F-statistical value, indicating a long run cointegration relationship between industrial output production and other variables in the model.

Table 7: The Panel ARDL Cointegration Testing

Wald Test			
Equation: ARDL			
Test Statistic	Value	Df	Probability
F-statistic	11.99780	(7, 1151)	0.0000
Chi-square	83.98461	7	0.0000

5.4. The P-ARDL Error Correction Model (ECM)

Using the ECM, the study investigates the short run and long run dynamics of the present model. The ECM coefficient shows how quickly or slowly (speed of adjustment) the variables return to equilibrium. As shown in Table 8, the negative sign of the ECM coefficient shows the existence of disequilibrium in the short run and convergence in the long run. The ECM value of -0.240003 suggests a relatively low speed of adjustment from the short run deviation to the long run equilibrium of industrial production. More precisely, it indicates that about 24% deviation from the long run industrial production in the EMEs is corrected in each period. In addition, the error correction term is statistically significant at 5% level, indicating that long run equilibrium is attainable. These results are consistent with Waliullah and Rabbi (2011) and Bannerjee *et al*. (2008) who argued that a highly significant error correction term is further proof of the existence of a stable long run relationship.

Table 8: Error Correction Coefficient

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECT(-1)	-0.240003	0.088888	-2.700062	0.0070

6. CONCLUSIONS

This study examined the dynamics of industrial production in the BRICS using a panel data analysis method and monthly data covering the period between 1994 and 2013. The estimation results reveal the existence of a long run relationship between industrial production and a number of selected variables in the BRICS during the period under review. This relationship is consistent with economic theory and empirical evidence in other countries (see, for example, Gerni *et al*., 2013). It is observed that capital (K), labour (L), per capita income (KY) and exports (NXP) have a positive long run impact on industrial production in the BRICS. However, a currency appreciation (an increase in the exchange rate), has a negative impact on industrial production. This relationship is also in line with theoretical expectations and empirical evidence, similar to Omolade and Ngalawa (2014), that there exist a direct relationship between exchange rates and manufacturing sector growth. A similar result was obtained by Égert and Leonard (2008) in their study of the Republic of Kazakhstan.

The study results also show that there exists a stable and balanced relationship in the establishment of steady-state of the economy as revealed by the negative sign and significant value of the ECM. The ECM integrates the short run dynamics with the long run equilibrium without losing either the short run or long run information. Thus, the result shows that there is a relationship between industrial production and the selected variables in the BRICS countries and that long run equilibrium can be attained (see Waliullah and Rabbi, 2011).

Finally, all the variables employed in the model, except imports, significantly determine industrial production and a stable relationship between industrial production and factors that explain output production in BRICS countries was established. This confirms the possibility of a steady-state relationship between industrial output production and factors affecting production in BRICS countries. The policy implication stemming from the analysis is that a sound economic policy is important for output production and industrialization in BRICS countries while poor policy will result in a nexus of constraints from which escape may be difficult (or impossible). The industrial sector, therefore, should also be listed as a sector that can actualize the diversification process and boost economic performance in the EMEs. There should also be policy consistence in curtailing the declining trend of industrial production.

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