Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.4, No.20, 2013

Industrial Output Response to Inflation and Exchange Rate in Nigeria: An Empirical Analysis

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Abstract
This study investigates the response of aggregate industrial output to relative change in prices and exchange rate in Nigeria using data from 1970- 2011. A vector error correction (VEC) model was employed and the dynamic correlations of the variables have been captured by the analyses of impulse response and variance decomposition. The response of industrial output to the shock to exchange rate was significantly positive more specifically in the initial years, while shock to prices changes, the industrial output responds negatively although with small magnitude at the beginning. From variance decomposition; the study shows that although the main source of variance in output are own shocks, innovation in the exchange rate account for a higher proportion in the variation of industrial output than that of prices. The study concludes that inflation and exchange rate has the potentials of causing significant changes in industrial output in Nigeria. This study therefore suggests that more policy attention should be given to proper management of the exchange rate and inflation.
Keywords: Industrial output, exchange rate, inflation, VEC model

1.0 Introduction

The path to economic recovery and growth may require increasing production inputs - land, labour, capital and technology and or increasing their productivity. Increasing productivity should be the focus because many other countries that have found themselves in the same predicaments have resolved them through productivity enhancement schemes. For instance, Japan from the end of the World War II and the United States of America from the 1970s have made high productivity the centre point of their economic planning and the results have been resounding. Also, middle income countries like Hong Kong, South Korea, Singapore, the Philippines, India, Mexico and Brazil have embraced boosting productivity schemes as an integral part of their national planning and today they have made significant in-roads into the world industrial markets.
Given the importance of high productivity in boosting economic growth and the standards of living of the people, its measurement cannot but be of importance to both policy makers and researchers. Productivity measurement can be used to evaluate the efficiency of an economy in relation to others. It will also be useful in ascertaining the relative efficiency of firms, sub-sectors and sectors. A knowledge of the relative efficiency of industries and their profitability could aid government in planning its programmes and policies, especially in deciding on which industries should be accorded priority. In addition, it will help the government in deciding the wage level as the input and output of labour will be well quantified. At the micro level, productivity measurement will, among others, aid production planning and sales, especially in checking cost,
Including wages, substitution of factors of production, reduction of wastes, etc. High productivity in the Nigerian manufacturing industry is a necessary condition for the sectors' recovery, achieving competitiveness, boosting the GDP and uplifting the standards of living of the people.
In view of the foregoing, the objective of this paper is to investigate the response of aggregate industrial output to relative change in prices and exchange rate in Nigeria using Vector error correction (VEC) model Approach.

2.0 Literature review

The industrial production, exchange rate and inflation have been studied extensively in many literatures. Zhang (2008) applies Hamilton‟s (2001) approach to investigate the relationship between oil price shock and Japanese industrial production growth using quarterly data from 1957:I to 2006:IV and finds that the oil price changes and macroeconomic activity in Japan appear to be affected by a non-linear relationship.
Adenikinju and Olofin (2000) focus on the role of economic policy in the growth performance of the manufacturing sectors in African countries. They utilize panel data for seventeen African countries over the period 1976 to 1993. Their econometric evidence indicates that government policies aimed at encouraging foreign direct investment, enhancing the external competitiveness of the economy, and maintaining macroeconomic balance have significant effects on manufacturing growth performance in Africa.
Folorunsho and Abiola (2000) examine the long –run determinants of inflation in Nigeria between 1970 and 1998, using the econometric methods of cointegration and error correction mechanism. They find that inflation

in Nigeria could be caused by the level of income, money supply, and public sector balance. The results also indicate that in the long –run, exchange rate, money supply, income and fiscal balance determine the inflation spiral in Nigeria. The study, therefore, concludes that a reduction in fiscal deficits, an increase in domestic production and a stable exchange rate should be pursued as means of controlling inflation in Nigeria.

Morley (1992) analyzed the effect of real exchange rates on output for twenty eight developing countries that have devalued their currencies using a regression framework. After the introduction of controls for factors that could simultaneously induce devaluation and reduce output including terms of trade, import growth, the money supply, and the fiscal balance, he discovered that depreciation of the level of the real exchange rate reduced the output.

Kamin and Klau (1998) using an error correction technique estimated a regression equation linking the output to the real exchange rate for a group of twenty seven countries. They did not find that devaluations were contractionary in the long term. Additionally, through the control of the sources of spurious correlation, reverse causality appeared to alternate the measured contractionary effect of devaluation in the short term although the effect persisted even after the introduction of controls. Apart from the findings from simulation and regression analyses, results from VAR models, though not focused mainly on the effects of the exchange rate on the output per se, are equally informative.

Ndung‘u (1993) estimated a six-variable VAR money supply, domestic price level, exchange rate index, foreign price index, real output, and the rate of interest in an attempt to explain the inflation movement in Kenya. He observed that the rate of inflation and exchange rate explained each other. A similar conclusion was also reached in the extended version of this study (Ndung‘u 1997).

Folawemo and Osinubi (2006) examined the efficacy of monetary policy in controlling inflation rate and exchange rate instability. The analysis performed was based on a rational expectation framework that incorporates the fiscal role of exchange rate. Using quarterly data spanning over 1980:1 to 2000:4 and applying times series test on the data used, the study showed that the effects of monetary policy at influencing the finance of government fiscal deficit through the determination of the inflation-tax rate affects both the rate of inflation and exchange rate, thereby causing volatility in their rates. The study revealed that inflation affects volatility in its own rate, as well as the rate of real exchange.

Rogers and Wang (1995) obtained similar results for Mexico. In a five-variable VAR model output, government spending, inflation, the real exchange rate, and money growth most variations in the Mexican output resulted from own shocks. They however noted that exchange rate depreciations led to a decline in output. Adopting the same methodology, though with slightly different variables. Copelman and Wermer (1996) reported that positive shocks to the rate of exchange rate depreciation, significantly reduced credit availability, with a negative impact on the output. Surprisingly, they found that shocks to the level of the real exchange rate had no effects on the output, indicating that the contractionary effects of devaluation are more associated with the rate of change of the nominal exchange rate than with the level of the change of the real exchange rate. They equally found that own shocks to real credit did not affect the output, implying that depreciation depressed the output through mechanisms other than the reduction of credit availability.

It is important to mention the work of Odusola and Akinlo (2001) who examined the linkage among exchange rate, inflation and output in Nigeria. A structural VAR model was employed which captured the interactions between exchange rate and output. Evidence from the contemporaneous models showed a contractionary impact of the parallel exchange rate on output only in the short term. Prices, parallel exchange rate and lending rate were found to be important sources of perturbations in the official exchange rate. In addition, output and parallel exchange rate were significant determinants of inflation dynamics in Nigeria. The authors concluded by suggesting more concerted efforts by the Central Bank towards taming the parallel exchange rate behavior and formulating monetary policies that enhance income growth. Largely the findings were informative.

3.0 Data and Methodology

3.1 Data Source

The data set for this paper consists of annual time series from 1970 - 2011. The variables under consideration are industrial output (GDP), Inflation measured as consumer price index (INF) and exchange rate (EXG). The data are obtained from central bank of Nigeria Statistical bulletin 2010 and 2011.

3.2 Model Specification

Sims’s (1980) seminal work introduces unrestricted vector autoregressions (VARs) that allows feedback and dynamic interrelationship across all the variables in the system and appears to be highly competitive with the large-scale macro-econometric models in forecasting and policy analysis.

To provide an empirical insight into the response of aggregate industrial output to relative change in prices and exchange rate in Nigeria, we estimates three-variable VAR model by using GDP, INF, and EXG. The following model was formulated:

$$GDP_t = a_0 + a_1 INF_t + a_2 EXG_t + u_t \tag{1}$$

Where a_0 is the constant and a_1, a_2 are coefficient to be estimated and u_t is an error term. GDP is the Industrial output, INF is the consumer price index(yearly change in prices), and EXG is the Real official exchange rate.

The General basic model of VAR (*p*) has the following form

$$y_t = \mu + \psi D_t + A_1 y_{t-1} + \ldots + A_p y_{t-p} + u_t \tag{2}$$

where y_t is the set of *K* time series variables $y_t = (y_{1t}, \ldots, y_{Kt})'$, $A_i\,'s$ are (*K* × *K*) coefficient matrices, μ is vector of deterministic terms , D_t is a vector of nonstochastic variables such as economic intervention and seasonal dummies and $u_t = (u_{1t}, \ldots, u_{Kt})'$ is an unobservable error term. Although the model (2) is general enough to accommodate variables with stochastic trends, it is not the most suitable type of model if interest centers on the cointegration relations. The VECM form

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} \Delta y_{t-p+1} + \mu + \psi D_t + u_t \tag{3}$$

Where $\Pi = \alpha\beta'$

In the VECM model, attention focuses on the (*n*× *r*) matrix of cointegrating vectors β, which quantify the "long-run" relationships between variables in the system, and the (*n*× *r*) matrix of error-correction adjustment coefficients α , which load deviations from the equilibrium (*i.e.* Πy_{t-1}) to Δy_t for correction. The Γ_i coefficients in (3) estimate the short-run effects of shocks on Δy_t ,and therefore allow the short-run and long-run responses to differ.

The term Πy_{t-1} is the only one that includes I(1) variables. Hence, Πy_{t-1} must also be I(0). Thus, it contains the cointegrating relations. The Γ_{jS} (*j* = 1, . . . , *p* − 1) are often referred to as the *short-run* or *short-term parameters*, and Πy_{t-1} is sometimes called the *long-run* or *long-term* part.

3.3 Unit Root Test

Since we are using times series data sets for the analysis, it is important that we first test the data sets for stationarity properties. Hence, to examine the stationarity properties of the data sets, we use a variety of units root tests. The motivation behind the assortment of tests is to obtain reliable and consistent results.

First, the Augmented Dickey Fuller (ADF) tests and Phillips-Perron (PP) tests are used to check whether each data series is integrated and has a unit root. The ADF test is based on the following regressions.

$$\Delta y_t = a_0 + a_1 y_{t-1} + \sum_{i=1}^{n} a_1 \Delta y_i + e_t \lambda_i \tag{5}$$

$$\Delta y_t = a_0 + a_1 y_{t-1} + \sum_{i=1}^{n} a_1 \Delta y_i + \delta_t + e_t \tag{6}$$

Where

y_t is a time series, t is a linear time trend, Δ is the first difference operator, a_0 is a constant, n is the optimum number of lags on the dependent variable and e_t is the random error term. The difference between equation (5) and (6) is that the first equation includes just drift. However, the second equation includes both drift and linear time trend. This study also employs the Philip-Perron test (1988). The regression equation for the PP test is given by

$$\Delta Y_t = \alpha + bY_{t-1} + \varepsilon_t \tag{7}$$

3.4 VAR Cointegration Test

The results of the integration tests are then pursued by Co-integration tests. The Existence of long-run equilibrium (stationary) relationships among economic variables is referred to in the literature as cointegration. The Johansen procedure will be employed to examine the question of cointegration and provide not only an estimation methodology but also explicit procedures for testing for the number of cointegrating vectors as well as for restrictions suggested by economic theory in a multivariate setting. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary variables may be stationary. If such a stationary combination exists, then the non-stationary time series are said to be co-integrated. The VAR based co-integration test using the methodology developed in Johansen (1991, 1995). Johansen's methodology takes its starting point in the vector auto regression (VAR) of order p given by

$$y_t = \mu + \Delta_1 y_{t-1} + \ldots + \Delta_p y_{t-p} + \varepsilon_t \tag{8}$$

Where

y_t is an nx1 vector of variables that are integrated of order commonly denoted (I(1)) and ε_t is an nx1 vector of innovations. This VAR can be rewritten as

$$\Delta y_t = \mu + \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} \Delta y_{t-p+1} + \varepsilon_t \tag{9}$$

Where

$$\Pi = -(I_n - A_1 - \ldots - A_p) \text{ and } \Gamma_i = -(A_{i+1} + \ldots + A_p)$$

To determine the number of co-integration vectors, Johansen (1988) and Johansen and Juselius (1990) suggested two statistic test, the first one is the trace test (λ trace). It tests the null hypothesis that the number of distinct cointegrating vector is less than or equal to n against a general unrestricted alternatives n = r. the test calculated as follows:

$$\lambda_{trace}(r) = -T \sum_{r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{10}$$

Where T is the number of usable observations, and the $\hat{\lambda}_i$ are the estimated eigenvalue from the matrix. The Second statistical test is the maximum eigenvalue test (λ max) that is calculated according to the following formula

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{11}$$

The test concerns a test of the null hypothesis that there is r of co-integrating vectors against the alternative that r + 1 co-integrating vector.

4.0 Empirical Analysis

Software for the analysis: Eviews 7

4.1 Unit Root Tests

Before using the data in the estimation of VAR/VECM, we need to know time series properties of all the variables. Accordingly, a series of unit root test, such as Augmented Dickey-Fuller (ADF, 1981) and Phillips-Perron (PP, 1988) tests are used to determine the order of integration for each series. The ADF unit root tests used Akaike information criterion for lag order selection and PP unit root tests lag length are decided based on Akaike's information criterion and AR spectral – GLS detrended spectra. The null hypothesis of non-stationary is rejected if the t-statistic is less than the critical t-value.

Using The ADF tests and PP tests (Table 1), all other variables possess unit roots at their levels since each reported t-statistics is not smaller than their respective 5% critical values. Hence , the variables are stationary after first differencing (Table 2).

Table 1: **ADF and PP Test at Levels**

Variables	Constant				Constant & Trend			
	ADF Test		PP Test		ADF Test		PP Test	
	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.
GDP	-1.046678	0.7274	-0.901457	0.7778	-2.696954	0.2431	-2.696954	0.2431
INF	6.021315	1.0000	15.71890	1.0000	2.054107	1.0000	7.837850	1.0000
EXG	0.531562	0.9858	0.5070920	0.9850	-1.562079	0.7906	-1.576756	0.7849
	5% critical value -2.935001		5% critical value -2.935001		5% critical value -3.523623		5% critical value -3.523623	

Table 2: **ADF and PP Test at first difference**

Variables	Constant				Constant & Trend			
	ADF Test		PP Test		ADF Test		PP Test	
	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.
GDP	-6.959603	0.0000	-7.827281	0.0000	-6.892491	0.0000	-8.174967	0.0000
INF	-5.044910	0.0000	-4.044919	0.0031	-4.731202	0.0000	-6.631902	0.0000
EXG	-3.614431	0.0045	-5.866572	0.0000	-6.124688	0.0000	-6.124662	0.0000
	5% critical value -2.936942		5% critical value -2.936942		5% critical value -3.526609		5% critical value -3.526609	

4.2 Cointegration test

The unit root tests confirmed that the series are integrated thus satisfying the initial assumption for co-integration analysis.

Table 3: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-828.1635	NA	6.51e+14	42.62377	42.75174	42.66968
1	-679.0239	267.6865*	4.94e+11*	35.43712*	35.94899*	35.62078*
2	-676.5989	3.979559	6.99e+11	35.77430	36.67007	36.09569
3	-674.2211	3.536175	1.00e+12	36.11390	37.39357	36.57303

* indicates lag order selected by the criterion , LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error , AIC: Akaike information criterion SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Lag length were selected to be one (see Table 3) using information criteria and satisfied the mathematical stability condition.

Table 4: Cointegration test (Linear deterministic trend)
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.473359	29.96345	29.79707	0.0478
At most 1	0.097641	4.313966	15.49471	0.8766
At most 2	0.005093	0.204258	3.841466	0.6513

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 5: Cointegration test (Linear deterministic trend)
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.473359	25.64948	21.13162	0.0108
At most 1	0.097641	4.109708	14.26460	0.8476
At most 2	0.005093	0.204258	3.841466	0.6513

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The results of the maximal eigenvalue and trace test statistics for the two models were presented in Tables 4 and 5. The p-value at 5% level of significant indicates that the hypothesis of no cointegration among the variables can be rejected for Nigeria. Both Trace test and Maximum Eigenvalue test found one cointegrating relationships at 5% significant level between the Industrial output, change in prices and exchange rate variables in Nigeria. Since the variables are cointegrated, thus, it is concluded that there exists a long-run equilibrium relationship among the variables under study.

4.3 Impulse Response Functions for VEC Model

Impulse Response Functions (IRFs) are one of the useful tools of the VAR/VECM approach for examining the interaction between the variables in this study. They reflect how individual variables respond to shocks from other variables in the system. When graphically presented, the IRFs give a visual representation of the behaviour of variables in response to shocks. The responses are for a particular variable to a one-time shock in each of the variables in the system. As noted by Odusola and Akinlo (2001), the interpretation of the impulse response functions takes into consideration the first differencing of the variables as well as the vector error correction estimates. The response forecast period is ten years to enable us capture both the long term and short term responses.

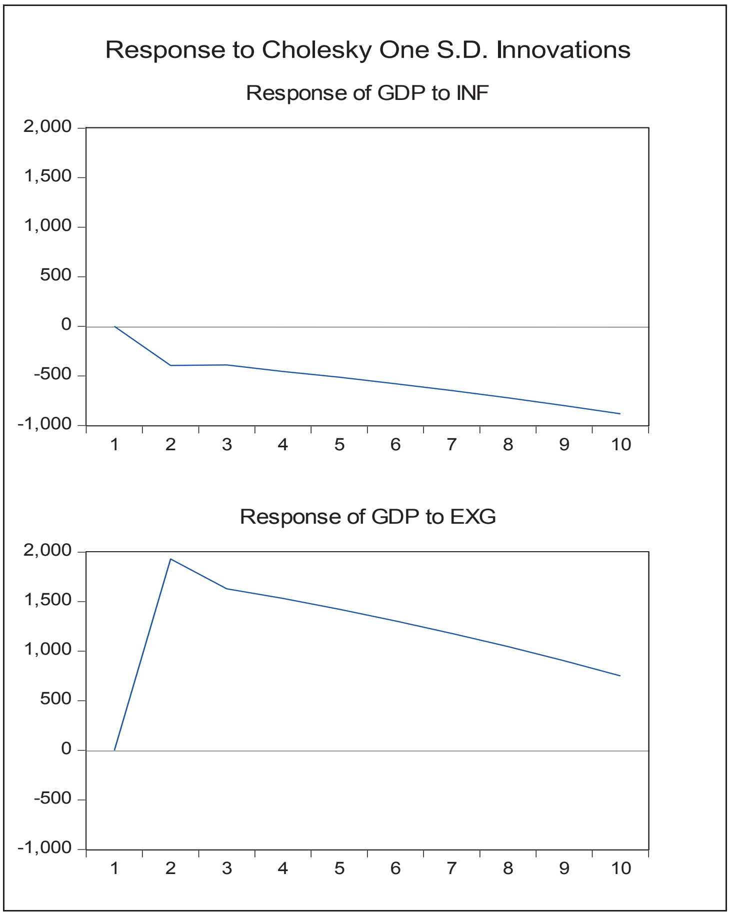

Figure 1: Shocks to Inflation and Exchange rate

Figure 1, shows the impulse response function of Inflation and exchange rate shocks. The response of industrial output to a standard deviation shock from change in prices is negative but quite minimal more specifically at initial periods but its deepens in the second year before it's stabilize to a new negative level which continuous even after the tenth year's period.

The response of Industrial output (GDP) to exchange rate innovations is positive more specifically at second year but reduces subsequent to another positive level which continuous even after the tenth year's period.

4.4 VEC Model Forecast Error Variance Decomposition

The results of variance decomposition at VEC Model reveal the forecast error in each variable that can be attributed to innovations in other variables over ten year periods. In VEC Model, the forecast error variances of all the variables in the system are largely due to their own innovations, although over time the innovations of other variables show a tendency to increase gradually. Forecast error Variance decompositions are presented in the Table 6, which help identify the main channels of influence for individual variables. The numbers under each variable represent the percentage of variance of the variable analyzed that was attributable to the particular variable over a 10 year period.

Variance of industrial output (GDP)
Table 6: Variance Decomposition of GDP

Variance Decomposition of GDP: Period	S.E.	GDP	INF	EXG
1	14401.28	100.0000	0.000000	0.000000
2	19209.72	98.94686	0.042158	1.010985
3	23030.55	98.73774	0.057936	1.204323
4	26278.71	98.65997	0.074662	1.265367
5	29141.62	98.64059	0.091826	1.267587
6	31723.44	98.65010	0.110823	1.239077
7	34087.18	98.67486	0.132086	1.193054
8	36274.76	98.70719	0.156146	1.136663
9	38315.71	98.74219	0.183466	1.074346
10	40231.77	98.77621	0.214548	1.009243

According to Table 6, industrial output accounted for its contemporary variance from its own innovations with about 100 per cent in the first year, although it shows gradual decline from about 100% in the first year to about 98 % in the long term. There was some variation caused by inflation and exchange rate. However, in later periods, exchange rate increasingly contributed to variations of industrial output with more than 1%. Although, inflation variable make very little contribution to the variance of industrial output but the impact of exchange rate is more.

5.0 Conclusion

This study investigates the response of aggregate industrial output to relative change in prices and exchange rate in Nigeria using Cointegrated VAR methodology. We used Johansen cointegration test to see if there is present of long-run relation between the variables under study. The results of which provide evidence of long-run equilibrium relationship among the variables. Since, there is evidence of long-run relationship among the variables, a vector error correction (VEC) model was employed and the dynamic correlations of the variables have been captured by the analyses of impulse response and variance decomposition. For Impulse response function: the response of industrial output to a standard deviation shock from change in prices is negative but quite minimal more specifically at initial periods while the response of Industrial output (GDP) to exchange rate innovations is positive more specifically at second year but reduces subsequent to another positive level which continuous even after the tenth year's period. From variance decomposition; the study shows that although the main source of variance in output are own shocks, innovation in the exchange rate account for a higher proportion in the variation of industrial output than that of prices. The study concludes that inflation and exchange rate has the potentials of causing significant changes in industrial output in Nigeria. This study therefore suggests that more policy attention should be given to proper management of the exchange rate and inflation in Nigeria.

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