THRESHOLD OF CURRENCY DEVALUATION AND OIL PRICE MOVEMENTS THAT STIMULATES INDUSTRIAL PRODUCTION

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Abstract

Even though oil prices are not subject to manipulations by individual countries, instability in the same generates shocks that other variables respond to, yet amid these shocks, more units of local currencies in developing countries are needed to acquire foreign inputs for production. Fluctuating oil prices consequently imply that high prices would increase the cost of production and ultimately reduce the purchasing power of industries. This study ascertains threshold effects of exchange rate devaluation and changes in oil prices on the industrial output of thirty developing countries using threshold and nonlinear autoregressive distributed lag (NARDL) regressions. Results revealed percentage rise above the devaluation threshold caused a fall in production by 4.36%. Oil prices within this devaluation region negatively affected output. Below and within the devaluation threshold of 0.692, the relationship patterns switch with oil price variability attracting positive and significant effects, while devaluation impacted industrial output positively with a substantial magnitude of 0.334. A higher devaluation was met with lower output in the industrial sector. In this higher region, increased oil prices weaken devaluation effects by 91.882. When a currency falls more than it is obtainable in the threshold (6.9%), oil prices cut output by a larger magnitude than it stimulated positively when the devaluation rate did not surpass the threshold value.

Keywords: Manufacturing Output, Short-Run Effects, Exchange Rate Devaluation, Oil Price Variation, Africa

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1. INTRODUCTION

The sectors that make up the industrial sector, such as mining and manufacturing, contribute significantly to gross domestic product (GDP), and the output of these sectors is vastly sensitive to exchange rates and oil price movements. Although individual countries do not manipulate oil prices, instability generates shocks that other economic variables respond to (Nguyen et al., 2020; Azad & Serletis, 2020). It makes industrial production a central tool for estimating financial performance. Also, monetary authorities rely on industrial output to measure inflation because inflation could result when output depends beyond demand. Hence, many countries attempt to increase their respective outputs in pursuit of macroeconomic objectives of full employment of resources and economic growth. As a result, monetary and fiscal policies also target improvement in aggregate output and industrial output. A country that promotes growth in its industrial output encourages the investment of local as well as foreign direct investment. Al-Risheq (2016) opines that so much importance is placed on industrial output because this source of output is perceived to be closely associated with real per capita income growth. Industrial output does not exist in a vacuum but reacts with different macroeconomic and microeconomic factors aside from internal manufacturing conditions. Output is generally a function of inputs in a production process. These inputs comprise direct information, such as raw materials, and less-direct inputs referred to as overheads, such as machinery and fuel. The sources and costs of inputs reflect in the prices of output. Furthermore, macroeconomic indicators such as price and exchange rates affect inputs' costs.

Before 1970, multinational oil companies were responsible for fixing oil prices. By 1970, Organization of the Petroleum Exporting Countries (OPEC) started influencing prices through its output decisions. The 1980s date have, however, had global oil prices set by the market forces of demand and supply relative to a reference crude. As in the standard demand curve, high demand causes prices to adjust related to supply levels. Many countries, such as Nigeria, depend highly on raw materials and machine imports. Though expected to create an expansionary effect on the economy, exchange rate devaluation may spell lower outputs in such import-dependent economies.

Crude oil is a leading source of energy around the globe and plays a central role in the economic growth and development of many countries. Crude oil is in demand worldwide for energy generation, and its by-products serve as raw materials. Due to its demand, the oil price is frequently exposed to oil price fluctuations. Fluctuating oil prices, therefore, implies that high prices would increase the cost of production and ultimately reduce the purchasing power of industries (Ojapinwa & Ejumedia, 2012). According to Mankiw and Reis (2007), manufacturers' energy consumption is causing the output to rise despite variations in oil prices. However, the recent impact of oil price variations on industrial production may not be so precise, with arguments that output volume could occur independently of oil price variations (Mankiw & Reis, 2007).

As a result, prices are not exceptionally stable. Instead, variations are common and occur in either large or small proportions in the form of rises or falls. The effects of oil price variations are also not in the same direction for all countries, as rising prices would spell more wealth for oil-exporting countries and more movement of wealth out of oil-importing countries. The reverse occurs in situations of falling prices. This study, however, seeks to determine if the dynamics of wealth transfer as a result of oil price variations cause real effects in the economies of developing countries in terms of annual industrial output. In the same vein, in this developing economy sector, the industrial industry tends to rely more on importing different raw materials and types of machinery and imported labour (expatriates). This dependence makes manufacturing units use foreign currencies more to ensure production processes run. Using foreign currencies implies that they exchange local money for foreign exchange. When exchange rates are closer to the US dollar, fewer units of local currencies can purchase foreign currency for imports and vice versa. Accordingly, it is expected that appreciation of exchange rates will be favourable for industrial output while depreciated rates would be adverse and cause inflation from too many local currency units purchasing too few imported inputs for production.

Several studies have been conducted in African countries individually to determine the impact of oil price fluctuations and exchange rate devaluation on output growth. Currency devaluation has been envisaged as intentionally sinking the official exchange rate of a local currency *vis-à-vis* a foreign currency to financially adjust the domestic economy for a trade surplus (Umoru, 2022). While currency devaluation implies more units of local currencies are needed to acquire foreign goods, including inputs for production, oil prices have been characterised by rises and fall concerning supply, demand, and other market forces (Ibrahim, 2018; Abdelhamid & Heba, 2016). Given that a flexible system of exchange rates allows for variations in relative prices of currencies of countries, such close changes form an essential advantage of flexible exchange rates, as foreign goods can become cheaper when the exchange rate rises against other currencies. Unfortunately, developing African countries seem to have increased relative rates as an illusion with the consistent devaluation of local currencies. Economic literature has also expressed that exchange rate fluctuations (usually on a devaluation scale in African countries) affect industrial output levels. In sum, recent studies have not demonstrated unanimity among investigators regarding the output effects of devaluation in the exchange rate and movements in oil prices at least in recent times.

Therefore, the study's objectives were to ascertain if there are threshold and asymmetric effects of exchange rate devaluation and oil price variations on the output of industrial sectors in developing countries. The essential contribution of the paper is the use of nonlinear autoregressive distributed lag (NARDL) to explore the nonlinear effects of exchange rates and oil price movements simultaneously on the industrial production of 30 African countries in a NARDL estimation setting.

With a provision for bounds co-integration testing configuration which applies to stationary or non-stationary data and mixtures of both, the reliability of NARDL estimates is efficiently guaranteed. Also, the motivation to use the method is their ability to detect threshold values among variables. Therefore, this paper significantly contributes to the existing literature by exploring the threshold effects of exchange rate devaluation and changes in oil prices on the industrial output of thirty developing countries. Most published studies have examined output determinants using traditional labour and capital stock variables.

This paper relates industrial productivity to the devaluation of the exchange rate and changing prices of crude oil in the international market. By implication, the NARDL technique independently measured responses of industrial productivity to positive and negative shocks of devaluation and oil price movement from nonlinear dynamic multipliers. Further, this paper provides refined empirical evidence on the relationship between currency devaluation and industrial output for 30 developing countries. In particular, it articulates the consequence of devaluation empirically above the threshold, which reveals that devaluing currency above the threshold stimulates a reduction in output by 4.36%.

We have assembled this paper into five sections. Section 2 is a review of the literature. Methodology and data issues are covered in Section 3. Section 4 is a discussion of results and policy findings. In Section 5 a conclusion is provided.

2. LITERATURE REVIEW

Oil prices seem to affect industrial output through multiple channels. First, it raises manufacturing overhead, increasing the total cost of production. The higher cost of production is then pushed to consumers in the form of increased commodity prices. On the supply side, increased cost of production would mean reduced purchasing power of firms which would contract total output for local sales and exports, as the case may be. However, Blanchard and Gali (2007) posits that improvements in monetary policy and labour market flexibility have contributed to the decline of the impact of shocks from oil price variations on industrial output and the economy at large.

A contraction of output would imply weakened aggregate productivity, which would cause a fall in investment and lead to scarcity that would inflate prices. On a country-to-country basis, shocks from oil variations create dynamics in countries that produce and export oil differently from oil-importing countries. Exports and imports make a platform for wealth transfer. When oil prices rise, oil-importing countries require more resources to get oil. It causes a reduction in aggregate demand for these imports. In oil-exporting countries, however, the reverse occurs as they receive more funds for the same quantity of oil exported when prices are lower. In the case of falling oil prices, oil-exporting countries are usually the losers receiving insufficient funds for oil shipped. Nevertheless, there has been a weakening link between oil prices and the expected effect on output.

Brown and Yücel (2002) explain that oil prices affect the general economy through the natural balance transmission channel. They assert that rising oil prices would cause economic units to demand more money amidst the available money supply. Oil prices have witnessed fluctuations over the years, they presented shocks that have produced macroeconomic effects (De Michelis et al., 2020). They further state that these fluctuations could result from changing aggregate demand, particularly to the market, or disruptions in supply for economic and other reasons. The manufacturing sector uses oil as a source of energy and base for manufacturing different products such as fertilisers, pesticides, body care, paints, and pharmaceuticals (Al-Risheq, 2016).

Al-Risheq (2016) examined the effects of oil price variations and actual exchange rates on industrial production using a panel approach. Data were gathered from fifty-two developing economies for 43 years from 1970 to 2012. The study employed fixed effects regression alongside instrumental variables for data analysis. It was found that higher oil prices cause industrial production to fall, while lower prices increase industrial output. Al-Risheq (2016) attributes this effect to the high dependence of developing economies on oil imports. The study did not consider the possibility of the same plight occurring in developing economies that export oil. Ojapinwa and Ejumedia (2012) sought to give a practical explanation of how oil price shocks impact the industrial output of Nigeria as a lubricant-exporting nation. Using the value at risk (VAR) approach on oil prices, inflation, exchange rate, unemployment, and money supply as time series from 1970 to 2010, they discovered that money supply was weak in determining industrial output and the exchange rate directly impacted Nigeria's industrial work. Oil price and inflation were also significant determinants of industrial production, but the relationship was indirect.

Aye et al. (2014) employed bivariate VAR, maximum likelihood test, and generalized autoregressive conditional heteroskedasticity in mean (GARCH-M) VAR to measure oil price shocks' effect on South African manufacturing output. Monthly manufacturing output and oil prices data from February 1974 till December 2012. The study obtained inverse relation between oil prices and manufacturing work. Scholtens and Yurtsever (2012) also explored the asymmetric effects of increases and decreases in oil prices on industrial production in thirty-eight European industries from the 1983 to 2007 fiscal years. The study used multivariate regression and VAR models. Findings showed that different sectors have varied effects meted by different oil prices. The asymmetries were, however, not found to be statistically significant among the industries. Oyeyemi (2013) found that shocks from unstable oil prices have a long-term impact on the growth of the Nigerian economy after using the ordinary least squares (OLS) regression to analyse the annual time series from 1979 to 2010. While its effect occurred in the long-term, it was positive, implying that oil prices cause output to rise. It negates the theory that higher oil prices cause output to contract. However, regression is not a causality test so the results may be treated with a rather large error level.

With the aid of the panel structural VAR (PSVAR) technique, Rotimi and Ngalawa (2017) found that aggregate output measured by GDP responded positively to an increase in oil prices. They also raise that the effect is more significant in oil-exporting countries. The study also held that the impact of these oil price shocks is transmitted through exchange rate dynamics. Kibunyi et al. (2018) assessed crude oil price variation and its effect on GDP in Kenya. The study used the ARDL model on time series from 1970 to 2016. The findings revealed only the long-run impact of variation in crude oil prices on GDP. The authors believe that the effects stem from Kenya's oil imports and the re-exporting of imported oil to neighbouring countries. Musa and Sanusi (2018) also found that exchange rates determine a country's output through the inflationary effects of the currency values. The findings were inferred from vector error correction results on time series data in Nigeria from 1970 to 2011 fiscal periods.

According to Yu et al. (2022), oil price shocks and the COVID-19 outbreak adversely affected economic activities. Iganiga et al. (2021) state that oil price escalation diminished industrial output. On their part, Uche and Omoke (2020), fluctuations in oil prices had asymmetric effects on production, investment, and unemployment. According to Ugbaka and Nnnak (2020), the instability in global oil prices causes a significant decline in manufacturing output in Nigeria. According to Keji (2018), Okonkwo and Ogbonna (2018), and Manasseh et al. (2019), fluctuations in oil prices cause Interruptions in the movement of commodities across markets around the globe. Omolade et al. (2019) also reported a negative long-run output effect of oil price variability. Cheng et al. (2019) found that global oil price shocks shrink real GDP growth and investment. This research finding was corroborated by Nguyen et al. (2020). According to Miamo and Achuo (2022), there is a two-way causal relationship between global oil prices and real GDP growth rate.

According to Iyke (2019), a rise in global oil prices induces a decline in productivity. For the Azerbaijan economy, Zulfigarov and Neuenkirch's (2020) variations in global oil prices stimulate domestic inflation. Yildirim and Arifli (2021) corroborated the findings of Zulfigarov and Neuenkirch (2020) regarding the Azerbaijan economy, where it was reported that negative oil price shock deteriorates the balance of trade and essential economic activities. Azad and Serletis (2020) said adverse oil production affects uncertainty in oil prices. Li et al. (2021) also reported the asymmetric price effect of uncertainty about oil prices. Volatility in crude oil prices increases the cost of manufacturing output and reduces the firms' production activities, which induces declining output (Choi et al., 2017). Studies by Okafor et al. (2018), Turan and Ozer (2018), and Mo et al. (2019) also reported significant negative results between exchange rate and industrial output.

The subsequent studies found positive effects of oil price variability on output, see the study by Mukhtarov et al. (2021) for Azerbaijan. Ighosewe et al. (2021) found significant short-run and long-run positive impacts of oil price variations on the Nigerian economy. Similarly, Tams-Alasia et al. (2018) found a positive long-run manufacturing output effect in Nigeria following changing oil. It corroborated the results of Gummi et al. (2018) that oil price dynamics positively affected manufacturing output in Nigeria. Aloui et al. (2018) reported a positive impact of oil prices on industrial productivity in Saudi Arabia. This empirical finding was validated by Khan et al. (2020), which found positive industrial production effects of oil prices, and Balashova and Serletis (2020), who reported positive industrial output effect of variability in oil prices in the Russian Federation based on regime-switching regression method.

Still, regarding the role of oil price volatility in influencing the behaviour of key macroeconomic indicators, Ahmad et al. (2022) reported that the impulse response function explicated substantial variance in gross domestic output in response to crude oil price shocks. According to Saddiqui et al. (2018), oil price variations significantly affect the productive implementation of economic policies that positively impact output growth. Studies by Nyangarika et al. (2019), Mehmood et al. (2021), Abdelsalam (2020), and Jiang and Shao (2020) have all established that variation in crude oil prices is indispensable input for industrial goods production.

There has been a continuous devaluation of the local currencies of many African countries against the primary foreign currency benchmark, the US dollar. The results of Uche and Nwamiri (2022) upheld the output retardation effect of the devaluation of the Naira in the short-run. In development, the depreciation of the Naira does not contribute to productivity expansion. Hence, Nigeria has a misalignment between the exchange rate and productivity growth. Nweze and Ejim (2021) also reported that currency devaluation contributed negatively to the manufacturing output of firms in southeast Nigeria. Khan et al. (2022) reported that the devaluation of Pakistan's currency did not affect GDP growth. The results of Khan et al. (2022) upheld the empirical estimations of Ojuolape et al. (2020), where the absence of a significant short-term link was reported between devaluation and output growth, whereas, in the long-term period, the connection between devaluation and development of national output was significantly negative. According to Sugiharti et al. (2020), the devaluation of trading partners' currency reduces a country's exports. In particular, exchange rate instability negatively influenced exports in Indonesia (Sugiharti et al., 2020). Senadza and Diaba (2018) found a negative impact of exchange rate volatility on aggregate exports in Sub-Saharan Africa (SSA).

Christopoulos and Tsionas (2004) found adverse output growth effects of currency devaluation for five countries, while positive output effects of depreciation were found for three countries. These findings contradicted those of Monzur and Mansur (2001), where zero impact of devaluation was reported for output.

Bahmani-Oskooee et al. (2021), Bahmani-Oskooee and Arize (2020), Yunusa (2020), Sugiharti et al. (2020), Upadhyaya et al. (2020) and Handoyo et al. (2022) all found a negative impact of volatility in the exchange rate on output. Bahmani-Oskooee et al. (2021) established the negative asymmetric effect of volatility in exchange rates on commodity trading between the US and the UK. Similarly, Bahmani-Oskooee and Arize (2020) reported negative asymmetric evidence of volatility in exchange rates from trade flows in Africa. The following studies, namely, Handoyo et al. (2022) for the Organization of the Islamic Cooperation (OIC) countries, Ekanayake and Amila (2022) for BRICS (namely Brazil, Russia, India, China, South Africa), Yunusa (2020) for Nigeria, Upadhyaya et al. (2020) for Association of Southeast Asian Nations (ASEAN), Sugiharti et al. (2020), Hussain et al. (2019) for Pakistan, Vo et al. (2019) for Vietnam. All reported negative effects for exchange rate variability. According to Sugiharti et al. (2020), the devaluation of trading partners' currency reduces a country's exports. In particular, exchange rate instability negatively influenced exports in Indonesia (Sugiharti et al., 2020).

The study by Ekanayake and Amila (2022) revealed the negative export effect of accurate exchange rate movements and the long-run negative export effect of exchange rate volatility in all countries of BRICS. The same authors reported mixed short-run results related to export effects of exchange rate volatility notwithstanding the measure of volatility used. Earlier, Sharma and Pal (2020) found a significant negative long-run export effect of volatility in currency exchange rates. According to Bahmani-Oskooee and Karamelikli (2022a), total exports of the UK were stimulated by a reduction in exchange rate volatility, while for selected industries in China, full export was reduced. Whereas, Bahmani-Oskooee and Saha (2021) also reported the absence of asymmetric effects of volatility in currency exchange rates on the trade flows of India, Bahmani-Oskooee and Karamelikli (2022b) established non-linear trade effects of exchange rate volatility for several industries in US and Germany.

Chi (2020) reported considerable asymmetric effects of movements in exchange rates on cross-border trade. Basing the analysis of quintile regression, Liming et al. (2020) found an asymmetric association between the volatility of currency rates and policy uncertainty in China. Bahmani-Oskooee and Kanitpong (2019) found that 50% of industrial output is asymmetrically affected by the volatility of currency exchange rates. Hurley and Papanikolaou (2021) reported that bilateral trade in goods between US and China significantly and negatively responded to the fluctuations in actual exchange rates. According to Adjei (2019), exchange rate volatility wielded significant adverse effects on Ghana's growth rate by exhibiting risk that depresses global trade. Yusuf et al. (2019) found a significant negative impact of exchange rate variability on economic growth in Nigeria. Lin et al. (2018) obtained substantial adverse industrial trade effects of volatility in the exchange rate, which varied considerably across sectors, while Lin and Su (2020) found a non-linear impact of oil price movements on the exchange rates of BRICS.

On the contrary, studies by Shah et al. (2022), devaluation impact output growth at the expense of high energy consumption in Pakistan. Olamide et al. (2022) found that devaluation in the currency exchange rate positively influenced local production to expand the real economic sector in oil-exporting African countries. Yunusa (2020) and Senadza and Diaba (2018) reported positive influences on exchange rate volatility. Yunusa (2020) said the positive impact of volatility in exchange rates on the export of crude oil commodities from Nigeria to the foreign market. According to Senadza and Diaba (2018), exchange rate volatility positively drives the activities of African countries. Smallwood (2019) reported zero effect of exchange rate uncertainty in US trades.

Oseni et al. (2019) reported that actual exchange rate volatility positively influenced industrial productivity in Nigeria. Akinmulegun and Falana (2018) using Granger causality and vector error correction model (VECM) to test causal dynamics within variables revealed that exchange rate variations induce industrial output growth. Accordingly, the study found that industrial output responded to exchange rate shocks positively, with magnitudes higher in the early years. Relatively, Musa and Sanusi (2013) found that exchange rates are a significant determinant of a country's output through inflationary effects of the currency values. The findings were inferred from vector error correction (VEC) results on time series data on Nigeria between the 1970 to 2011 fiscal years.

3. RESEARCH METHODOLOGY

The theory of production explains the relationship between output prices and input prices in production. The theory states that the cost of inputs has an inverse relationship with the output level, *ceteris paribus*. This relationship is inverse because profit maximisation is the firms' main objective and profit depends on production costs and overall output. Oil and related product prices form input prices for production either as raw materials or energy sources. This study is anchored on the theory of production that higher costs of inputs will cause a reduction in output and vice versa. Higher costs would also translate to higher prices of production. For this study, higher oil prices would mean increased cost of inputs for manufacturing and reduced quantity of information to drive output. Exchange rate devaluation effectively measured by calculating the rate of change of local currency with the dollar from the immediate past period to the present-day period would also imply that investment becomes weaker as more units of local currencies would be needed to get a given investment in the real sector.

Numerous alternative econometric techniques could be deployed empirically to find evidence of devaluation and changes in oil prices on industrial output. For example, the system generalized method of moments (GMM) that makes provision for controlling the endogeneity of model variables, the first difference GMM estimation method which uses forward orthogonal deviations transformation to eliminate unobserved effects that do not vary with time, autoregressive integrated moving average (ARIMA), vector error correction modelling and estimation technique, a regime-switching regression method, etc. Nevertheless, we have chosen the threshold regression and NARDL method because of its capacity for simultaneous estimation of short- and long-run nonlinearities by estimating positive and negative partial sum disintegrations of currency exchange rates and oil price movements.

The empirical application of the NARDL methodology took the following steps. Testing for stationary variables and ascertaining order of integration. Accordingly, the NARDL co-integration technique is desirable when variables are integrated of order one and order zero, that is I(0), I(1) or a combination of both. The desirability of NARDL is that it models pooled short- and long-run nonlinearities. In practice, the bounds co-integration test hypothesis is equivalent to testing the following long-term relation: $H_0: \theta_{i2} = \theta_{i3} = \theta_{i4} = 0$ vs $H_1: \theta_{i2} \neq \theta_{i3} \neq \theta_{i4} \neq 0$.

The co-integrating relation is established by calculating Wald statistics that underlie the F-test (Allen & McAleer, 2020; González et al. 2020; Sam et al. 2020). On findings that the calculated Wald F-statistic exceeds the asymptotic critical Wald F-band value, long-run relation is established. The threshold model is as specified.

$$ln\_ind_t = \begin{cases} \beta_0 + \beta_{11} excdev + \beta_{12} lnop + \varepsilon_i; & excdev < \mu \\ \beta_0 + \beta_{21} excdev + \beta_{22} lnop + \varepsilon_i; & excdev \geq \mu \end{cases} \quad (1)$$

$$ln\_ind_t = \begin{cases} \beta_0 + \beta_{11} lnop + \beta_{12} excdev + \varepsilon_i; & lnop < \mu \\ \beta_0 + \beta_{21} lnop + \beta_{22} excdev + \varepsilon_i; & lnop \geq \mu \end{cases} \quad (2)$$

where μ is the unknown threshold value derived from regression estimation; β are coefficients to be estimated via threshold regression.

The NARDL regression model is thus given by:

$$ln\_ind_{it} = \sum_{j=1}^{p} \phi_j ln\_ind_{it-j} + \sum_{j=1}^{q} (\theta_j^{+\prime} excdev_{it-ij}^{+} + \theta_j^{-\prime} excdev_{it-ij}^{-}) + lnop_{it} + \varepsilon_{it} \quad (3)$$

$$\Delta ln\_ind_{it} = pln_{ind_{t-1}} + \theta_j^{+'} excdev_{t-1}^{+} + \theta_j^{-'} excdev_{t-1}^{-} + \sum_{j=1}^{p=1} \gamma_j \Delta ln\_ind_{t-j} + \sum_{j=0}^{q=1} (\varphi_j^{+'} \Delta excdev_{it-1}^{+} + \varphi_j^{-'} \Delta excdev_{it-j}^{-}) + lnop_{it} \quad (4)$$

$$\Delta ln\_ind_t = p\xi_{it-1} + \sum_{j=1}^{p=1} \gamma_j \Delta ln\_ind_{it-j} + \sum_{j=0}^{q=1} (\varphi_j^{+'} \Delta excdev_{it-1}^{+} + \varphi_j^{-'} \Delta \mathrm{excdev}_{it-j}^{-}) + lnop_{it} \quad (5)$$

$$ln\_ind_{it} = \sum_{j=1}^{p} \phi_j ln\_ind_{it-j} + \sum_{j=1}^{q} (\theta_j^{+\prime} lnop_{it-ij}^{+} + \theta_j^{-\prime} lnop_{it-ij}^{-}) + excdev_{it}^{-} + \varepsilon_{it} \quad (6)$$

$$\Delta ln\_ind_{it} = pln\_ind_{t-1} + \theta_j^{+\prime} lnop_{t-1}^{+} + \theta_j^{-\prime} lnop_{t-1}^{-} + \sum_{j=1}^{p=1} \gamma_j \Delta ln\_ind_{t-j} + \sum_{j=0}^{q=1} (\varphi_j^{+'} \Delta lnop_{it-1}^{+} + \varphi_j^{-'} \Delta lnop_{it-j}^{-}) + excdev_{it} \quad (7)$$

$$\Delta ln\_ind_t = p\xi_{it-1} + \sum_{j=1}^{p=1} \gamma_j \Delta ln\_ind_{it-j} + \sum_{j=0}^{q=1} (\varphi_j^{+'} \Delta lnop_{it-1}^{+} + \varphi_j^{-'} \Delta lnop_{it-j}^{-}) + excdev_{it} \quad (8)$$

where the non-linear error correction term (*ecterm*) is given by $pln\_ind_{t-1} + \theta_j^{+\prime} excdev_{t-1}^{+} + \theta_j^{-\prime} excdev_{t-1}^{-}$, $pln\_ind_{t-1} + \theta_j^{+\prime} lnop_{t-1}^{+} + \theta_j^{-\prime} lnop_{t-1}^{-}$, θ_i^{+} and θ_j^{+} lag parameters, and ε_{it} is an independent and identically distributed process with zero mean and constant variance.

This study used secondary data from thirty countries that span 26 years from 1995 to 2020, and a cross-section of thirty countries, making a total of 780 observations. In our sample, the West African CFA franc is used in five countries, namely, Côte d'Ivoire, Benin, Mali, Burkina Faso, and Togo that practice fixed exchange rates while others operate the floating exchange rate system. Our analysis is not affected considering the NARDL method of estimation we have implemented in the study. This is because with NARDL, residual correlations are prevented and hence, our estimations are devoid of endogeneity. Besides, according to Jareño, et al. (2019, 2020), González et al. (2020), the NARDL methodology is robust for small samples regardless of the stationarity of the variables.

Table 1. Variable definition

Variable	*Definition*	*Proxy*	*Source*
excdev	Exchange rates (LCU/$)	% Δ of local currency in relation to USD from the immediate past to present period	International Monetary Fund
op	Oil price variation	Oil price ($/barrel)	International Energy Agency
ind	Industrial production	Manufacturing output	World Bank

Source: Researchers' elaboration.

4. RESULTS AND DISCUSSION

According to Table 2, within the sampled periods, oil prices have reached an up-high rate of $109.45 per barrel. The lowest value is $12.28 in a period of an oil glut. The dataset's range and standard deviation reveal significant variations in oil prices for the observed period.

Table 2. Oil prices

Variable	*Mean*	*Min.*	*Max.*	*Std. dev.*	*Kurtosis*
Oil prices	52.88654	12.28	109.45	30.93374	-0.91014

Source: Researchers' estimations.

Some countries are oil-rich while others are not. This does not in any way affect our analysis because oil prices are exogenously determined by OPEC cartel. Moreover, the oil quota is not fixed by the governments of oil-producing countries rather, the OPEC does. And the effects of oil price increase (decrease) as driven by global economic activities affect all economies. Table 3 presents descriptive measures of exchange rate devaluation in all countries studied.

Table 3. Exchange rate devaluation (LCU/$) during 1995–2020

Country	*Mean*	*Minimum*	*Maximum*	*Std. dev.*	*Kurtosis*
Angola	4.089	-0.078	45.552	12.220	9.879
Benin	0.005	-0.164	0.197	0.082	0.496
Burkina Faso	0.005	-0.164	0.197	0.082	0.496
Cabo Verde	0.009	-0.166	0.197	0.080	0.247
Cameroon	0.005	-0.164	0.197	0.082	0.496
Chad	0.005	-0.164	0.197	0.082	0.496
Côte d'Ivoire	0.005	-0.164	0.197	0.082	0.496
Egypt	0.071	-0.067	0.774	0.171	11.361
Ethiopia	0.076	0.004	0.227	0.068	0.146
Gabon	0.005	-0.164	0.197	0.082	0.496
Ghana	0.184	0.006	1.044	0.214	10.147
Guinea	0.101	-0.185	0.624	0.154	5.037
Kenya	0.027	-0.082	0.165	0.063	-0.289
Malawi	0.208	0.002	0.890	0.247	1.383
Mauritania	0.045	-0.079	0.241	0.064	2.464
Mauritius	0.033	-0.091	0.173	0.071	-0.673
Morocco	0.003	-0.131	0.162	0.062	0.884
Mozambique	0.110	-0.144	0.577	0.171	1.514
Namibia	0.069	-0.282	0.241	0.128	0.952
Niger	0.005	-0.164	0.197	0.082	0.496
Nigeria	0.181	-0.058	3.219	0.627	24.636
Rwanda	0.085	-0.034	0.863	0.167	20.537
Sierra Leone	0.121	-0.051	0.593	0.126	7.110
South Africa	0.069	-0.282	0.241	0.127	0.937
Tanzania	0.061	-0.039	0.205	0.054	0.416
The Gambia	0.072	-0.114	0.432	0.115	2.871
Togo	0.005	-0.164	0.197	0.082	0.496
Tunisia	0.042	-0.094	0.156	0.070	-0.866
Uganda	0.055	-0.078	0.247	0.078	0.122
Zambia	0.149	-0.193	0.423	0.174	-0.912

Source: Researchers' estimations.

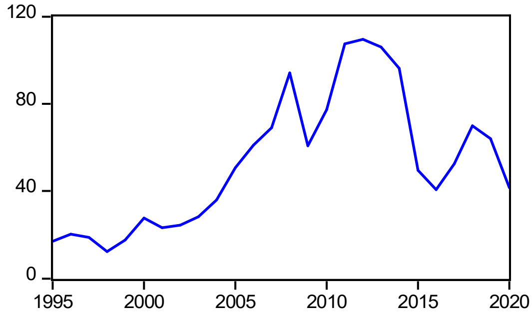
Table 4. Industrial output

Country	*Mean*	*Minimum*	*Maximum*	*Std. dev.*	*Kurtosis*
Angola	3065	198	8036	2640	-1.299
Benin	940	175	1516	425	-0.805
Burkina Faso	1015	336	1672	467	-1.514
Cabo Verde	83	41	133	28	-1.127
Cameroon	3504	1558	5470	1431	-1.634
Chad	200	15	375	103	-1.028
Côte d'Ivoire	3468	1655	6939	1761	-0.52
Egypt	29408	9829	59820	16537	-1.335
Ethiopia	1741	374	5709	1767	0.319
Gabon	1621	128	3488	1263	-1.774
Ghana	2846	449	7280	2583	-1.209
Guinea	591	107	1354	422	-1.574
Kenya	4119	757	7921	2619	-1.738
Malawi	534	180	1272	287	0.905
Mauritania	321	145	489	119	-1.576
Mauritius	1256	822	1740	308	-1.629
Morocco	12464	6645	18512	4239	-1.657
Mozambique	1065	305	1479	334	-0.54
Namibia	957	311	1685	494	-1.523
Niger	523	207	1006	277	-1.353
Nigeria	25544	8810	54760	15272	-0.934
Rwanda	419	132	930	235	-0.719
Sierra Leone	57	20	86	20	-1.149
South Africa	42535	24620	58933	10006	-0.991
Tanzania	2552	349	5307	1529	-1.192
The Gambia	66	29	88	15	0.363
Togo	342	101	1089	317	0.823
Tunisia	5539	3419	8137	1572	-1.447
Uganda	2573	359	5939	2243	-1.98
Zambia	1115	340	2103	614	-1.687

Source: Researchers' estimations.

Table 4 contains descriptive measures of industrial output in the thirty countries studied. South Africa, Egypt, and Nigeria had the most significant values, while Sierra Leone, the Gambia, and Cabo Verde had the lowest values. Oil prices rose gradually from 1998 before steeply rising from 2004 to 2008. In subsequent periods, there have been falls and peaks, with the lowest price in 2016. It is shown in Figure 1 below.

Figure 1. Graphical representation of oil prices



Source: Researchers' estimations.

The graphical representation provided in Figure A.1 (see Appendix) and shows the directional movement of the outcome variables for all developing African countries. All variables plotted generally move in the same direction, affirming the positive significance of large values of exchange rate devaluation, and oil price variation on the output of industrial sectors of African countries.

Table 5. Optimal lag selection

Lag	*Log likelihood (LogL)*	*Linear regression (LR)*	*Final prediction error (FPE)*	*Akaike information criteria (AIC)*	*Schwarz information criterion (SIC)*	*Hannan-Quinn information criterion (HQ)*
0	-874.3505	NA	0.002866	2.658638	2.679057	2.666552
1	1066.919	3859.008	8.21e-06	-3.196724	-3.115047	-3.165066
2	1091.974	49.57787	7.82e-06	-3.245375	-3.102440	-3.189972
3	1454.027	713.1356	2.68e-06	-4.315234	-4.111041*	-4.236088
4	1479.958	50.83954*	2.55e-06*	-4.36654*	-4.101088	-4.263648*

*Note: * indicates the chosen lag length by the selection criterion*
Source: Researchers' estimations.

The test for the optimum lag to be used revealed lag 3 as optimum for the SIC and lag 4 as optimum for other criteria except for log-likelihood. As with time series data, macroeconomic panel variables are expected to be stationary for robust results. The study tested the stationarity of the three variables using different panel unit root tests. All variables were static at first, differencing at most implying the suitability of the data to produce good results given the period of study.

Table 6. Panel unit root results

Variables	*Levin, Lin and Chu t-values (LLC)*		*Breitung t-stat*		*Im, Pesaran and Shin W-stat (IPS)*		*Augmented Dickey–Fuller (ADF) Fisher test*		*Fisher chi-square (PP-Fish)*	
	I(0)	*I(1)*	*I(0)*	*I(1)*	*I(0)*	*I(1)*	*I(0)*	*I(1)*	*I(0)*	*I(1)*
ind	-0.51	-10.4*	-0.05	-8.5*	-0.16	-9.4*	71.9	190.29*	39.5	360.9*
op	4.5	-15.4*	1.341	-6.1*	4.497	-9.2*	11.9	199.50*	10.1	229.2*
excdev	-31.9*		-7.3*		-14.1*		422.6*		296.9*	

*Note: * significance at 1%.*
Source: Researchers' estimations.

P-values of the respective statistics of Table 7 are higher than the 5% significance level and thus reveal an absence of co-integration among the study variables.

Table 7. Co-integration results

Measures	*Statistic*	*Probability value*	*W-statistic*	*Probability value*
v-statistic	-2.545361	0.9945	-2.820290	0.9976
rho-statistic	3.635575	0.9999	3.733016	0.9999
PP-statistic	5.082999	1.0000	5.290866	1.0000
ADF-statistic	5.178269	1.0000	5.524504	1.0000

Source: Researchers' estimations.

Threshold regression estimates are presented in Panel A of Table 8 below. For oil prices, the threshold value stood at 101.4488 and was significant, as depicted by a p-value less than 0.05. It implies that oil prices have a threshold relationship with industrial output. In the lower region of the threshold ($lnop \leq 101.4488$), oil prices impacted positively and significantly on industrial output. Still, within the area, exchange rate devaluation had a significant favourable influence on industrial work as well, excelling by a lower effect of a magnitude of 0.115 than oil prices impacted creation. Once oil prices extend above the threshold, the results reverse. Oil prices above 101.4488 negatively influenced industrial work. Accordingly, increased oil prices would reduce production and vice versa, but this relationship significantly affects the output. The devaluation effect followed the same pattern with 0.692 (with a p-value < 0.05), implying a significant and positive impact on industrial output.

The threshold analysis for *excdev* reveals that 0.0692 is the threshold value and is significant at the 0.05 level. Thus, as a predictor variable, when *excdev* is at the threshold point or within the lower region of the threshold value, a positive and significant effect of a magnitude of 0.334 on output is obtained. In other words, a 10% devaluation causes output to rise by 30%. Oil prices within this *excdev* region will positively affect production. Above the *excdev* threshold of 0.692, the relationship patterns switch with oil price variability attracting a significant negative effect with a magnitude of 91.882 while devaluation negatively influences industrial output by 4.361. A higher devaluation will be met with lower industrial output. It could be attributed to the non-existence of the Marshall-Lerner condition. The magnitude of influence of *excdev* in both regimes is pretty different, revealing *excdev* as a necessary predictor of output. In this higher region, increased oil prices will weaken results by 91.882. Thus, oil prices when the currency falls more than it is obtainable in the threshold affect output inversely and by an enormous magnitude than it affected output positively (10.508) when the devaluation rate did not surpass the threshold value.

Table 8. Threshold regression results for countries

Threshold variable — ln_ind	*lnop*	*excdev*
Panel A. Floating exchange rates		
lnop_g	90.142 (333.87) 0.00	-91.882 (-27.56) 0.00
excdev_g	0.115 (1.43) 0.152	-4.361 (-18.10) 0.00
cons_t	0.345 (1.65) 0.099	1.146 (16.16) 0.00
lnop_h	-117.591 (-2.12) 0.034	10.508 (14.32) 0.00
excdev_h	-0.066 (-4.00) 0.00	0.334 (27.82) 0.00
μ	101.448 (12.16) 0.00	0.692 (11.36) 0.00
Panel B. Floating fixed rates		
lnop_g	20.4798 (12.136) 0.000	-41.276 (-130.2) 0.000
excdev_g	0.165 (0.139) 1.305	-1.038 (-20.56) 0.000
cons_t	1.147 (5.86) 0.000	1.956 (18.24) 0.00
lnop_h	-128.003 (-5.378) 0.000	11.459 (10.459) 0.000
excdev_h	-0.278 (-5.935) 0.000	1.042 (23.587) 0.000
μ	156.59 (14.651) 0.000	0.132 (187.41) 0.000

Source: Researchers' estimations.

NARDL estimates for currency devaluation are presented in Table 8, Panel A below. Examining asymmetric effects of stochastic resonance (SR), the error correction term (*ecterm*) is 0.404 and insignificant at the 5% significance level. It implies that short-run coefficients do not adjust to equilibrium in the long-run. Devaluation had asymmetric effects on industrial production. Rising devaluation rates lead to falling industrial output while falling rates are accompanied by increasing output. Oil prices within this model have a significant and positive effect on production. Higher oil prices will increase production and lower costs and so cause declining output. The chi-square statistic is 0.12 at 0.728 p-values signifying there is no significant asymmetry in the short-run between periods where *excdev* increase is negative and when *excdev* decrease is positive.

Examining LR estimates, exchange rate effects are similar to short-run estimates in terms of the nature of the impact (negative in increased rate and positive in decreased rate). P-values of all variables are somewhat below the 5% significance level, revealing the meaningful asymmetric effect of exchange rate devaluation on industrial production in LR. However, the impact of both is more significant in the long-run. In the long-run, oil prices uphold significance in predicting industrial output and become negative in their effect, as shown by the 0.4399 coefficient. The diagnostic test also confirms that asymmetry is meaningfully evident in the model in both the short- and long-run (chi-square statistic = 10.28; $p < 0.05$).

Table 9. NARDL results for countries — exchange rate devaluation

Variables	Long-run estimates			Short-run estimates		
	Coef.	z	P > z	Coef.	z	P > z
Panel A. Floating exchange rates						
ecterm				0.40436	0.040436	0.094
excdevdecrease	1.159	2.915	0.034			
excdevincrease	-0.162	-2.114	0.029			
lnop	-0.439	-7.439	0.000			
Δexcdevdecrease				0.018	0.280	0.781
Δexcdevincrease				-0.074	-2.860	0.004
Δlnop				0.253	2.251	0.013
cons_t				0.128	5.098	0.000
	$\chi^2(1)$ = 10.28, Prob. < χ^2 = 0.000			$\chi^2(1)$ = 10.12, Prob. < χ^2 = 0.000		
Panel B. Fixed exchange rates						
ecterm				0.573	0.646	0.094
excdevdecrease	2.048	5.759	0.001			
excdevincrease	-0.120	-6.568	0.000			
Lnop	-1.170	-4.135	0.002			
Δexcdevdecrease				0.229	0.154	0.001
Δexcdevincrease				-0.019	-5.750	0.001
Δlnop				0.253	6.824	0.000
cons_t				0.110	7.001	0.000
	$\chi^2(1)$ = 10.28, Prob < χ^2 = 0.000			$\chi^2(1)$ = 15.32, Prob < χ^2 = 0.000		

Source: Researchers' estimations.

The NARDL estimates for oil price movements are presented in Table 10. *Ecterm* was 0.276, and it is significant at 0.05 level of significance. Therefore, the industrial output can adjust to long-run equilibrium aftershocks emanating from *excdev* and *op* in SR. significance was found for regressors in the long- and short-run. Relatively, asymmetry is significantly validated for oil price movements on industrial production. Rising oil prices cause industrial output to fall at both periods of analysis while falling oil prices stimulate some production levels. Interestingly, exchange rate devaluation harmed output in both periods. As devaluation rises (local currencies continue to fall in value against the dollar), industrial output falls.

LR estimates were also significant ($p < 0.05$), with the nature of the effect of declining and rising oil prices, reversed from a positive to negative impact. As oil prices rise over time, industrial output falls, as revealed in the -0.62 coefficient. In periods of declining oil prices, industrial output also rises more strongly than when oil price increases are recorded. Exchange rate devaluation shows a steady relationship with output in the long-run as long-run coefficients remain negative. However, in the long-run, the devaluation rates have more impact on the industrial output level with -1.39 than in the short-run. The diagnostic test shows a chi-square statistic of 9.88, significant at 0.0017 in the short-run. It reveals considerable asymmetry in industrial output's reaction to rising and falling oil prices. Rising oil prices lead to falling output while rising costs accompany rising output.

According to NARDL results, an oil price decrease confirms the relationship between oil prices and output when prices are below the threshold. They both showed that lowered prices had positive and significant relationships. For the above threshold values of oil price movements, oil prices had a negative and significant impact on output. Short-run estimates validate the threshold results with a negative and significant impact. Exchange rate devaluation also harmed output. As devaluation rises (local currencies continue to fall in value against the dollar), industrial output falls. It is similar to threshold results in which, at higher prices than the threshold, the exchange rate negatively impacts production, and such impact is significant in threshold regression results. In periods of decrease in devaluation, the effect reverses to a positive one and is also substantial in NARDL. It confirms threshold results of the positive impact of *excdev* on output in lower oil price regions.

Table 10. NARDL results for countries — oil prices

Variables	Long-run estimates			Short-run estimates		
	Coef.	z	P > z	Coef.	z	P > z
Panel A. Floating exchange rates						
ecterm				0.276	2.840	0.004
lnopdecrease	0.375	10.66	0.000			
no increase	-0.621	11.950	0.000			
excdev	-1.3958	-5.171	0.000			
Δlnopdecrease				0.003	-6.060	0.000
Δlnopincrease				-0.018	-4.340	0.000
Δexcdev				-0.024	-21.411	0.000
cons_t				-0.495	-2.362	0.019
	$\chi^2(1)$ = 7.26, Prob > χ^2 = 0.001			$\chi^2(1)$ = 9.88, Prob > χ^2 = 0.0017		

Panel B. Fixed exchange rates						
ecterm				2.136	6.531	0.004
lnopdecrease	0.356	19.237	0.000			
no increase	-1.790	19.468	0.000			
excdev	-1.052	-4.523	0.000			
Δlnopdecrease				1.158	-7.428	0.000
Δlnopincrease				-0.129	-5.601	0.000
Δexcdev				-0.017	-32.408	0.000
cons_t				-3.115	-0.436	0.013
$\chi^2(1) = 4.57$, Prob > $\chi^2 = 0.000$				$\chi^2(1) = 5.329$, Prob > $\chi^2 = 0.0025$		

Source: Researchers' estimations.

Comparison of estimates. The signs of the NARDL and threshold coefficient estimates obtained for both countries with fixed and floating exchange rates are the same. The estimates of threshold regression with oil price variation and exchange rate devaluation as predictors of industrial output growth clearly express the existence or non-existence of the threshold relationship between oil price variation, exchange rate devaluation, and output of industrial sectors in countries covered by the study. For oil price variation, the threshold value stood as a value of 101.448 was significant, as shown by a p-value of 0.00, lower than 0.05. The output of industrial sectors in developing countries is 0.345 when oil price variation and devaluation are null, as depicted by the constant term. Investigating the variables with the g-coefficient where oil price variation was above a threshold value, oil price variation negatively impacted industrial output. Given the significance of this effect with p-value < 0.05, we so reject the null hypothesis and accept the alternative that oil price variation deleteriously impacted industrial output in developing countries. Also, investigating with higher value of oil price variation, oil price variability became associated with lower production in the industrial sector, as shown by a coefficient of -117.591. This result is corroborated by NARDL, where the *lnop* increase had a significant negative coefficient of -0.621. It is also significant as the value of 0.00 is lower than 0.05, i.e., p < 0.05, with p-the conclusion that oil price variation significantly affected the output of industrial sectors in developing countries.

The threshold analysis for exchange rate devaluation stood at (0.692) and was highly significant with a t-value of 11.36 and a zero p-value, i.e., p < 0.05. This value shows that exchange rate devaluation above the threshold harmed industrial output in developing countries within the analysis period. Similarly, this threshold estimate is supported by NARDL results where *excdev* increase reported a significant negative coefficient of -0.162. The alternative hypothesis of a significant adverse output effect of currency devaluation in developing countries is upheld by this study only when the devaluation threshold of 6.9% is exceeded. In what follows, the g-coefficient, where exchange rate devaluation reported a coefficient of 0.334, reflects the positive output effect arising from exchange rate devaluation within threshold value in developing countries. Given a t-ratio of 27.82 and p-value of 0.00 devaluation effect is significant. This threshold estimate is supported by NARDL results where *excdev* decrease reported a significant favourable influence of a magnitude of 1.159.

Oil price variation within this exchange rate region will positively stimulate 10.508% of industrial output following a percentage rise in oil price variations. The value of exchange rate devaluation on a further investigation using the g-coefficient shows that exchange rate devaluation harmed the industrial sector's output in developing countries as indicated by -4.361. In other words, a 1% exchange rate depreciation of developing countries covered this study induced a 4.36% fall in output. The calculated p-value is less than 0.05, i.e., p-value < 0.05, implying that the negative effect of exchange rate devaluation is significant. Oil prices within this excel region negatively affected output. Above the *excdev* threshold of 0.692, the relationship patterns switch with oil price variability attracting significant adverse effects. Increased devaluation would have industrial output reduced for that year. Most developing economies are import-dependent, causing many manufacturing inputs to be imported using foreign currency. When devaluation occurs, more local currency units are used to purchase several inputs, reducing manufacturing firms' purchasing power, lesser teams of information, and, automatically, more inferior outputs. On the other hand, when devaluation lessens, lower units of the country's local currency can purchase more inputs, increasing factors of production employed and outputs.

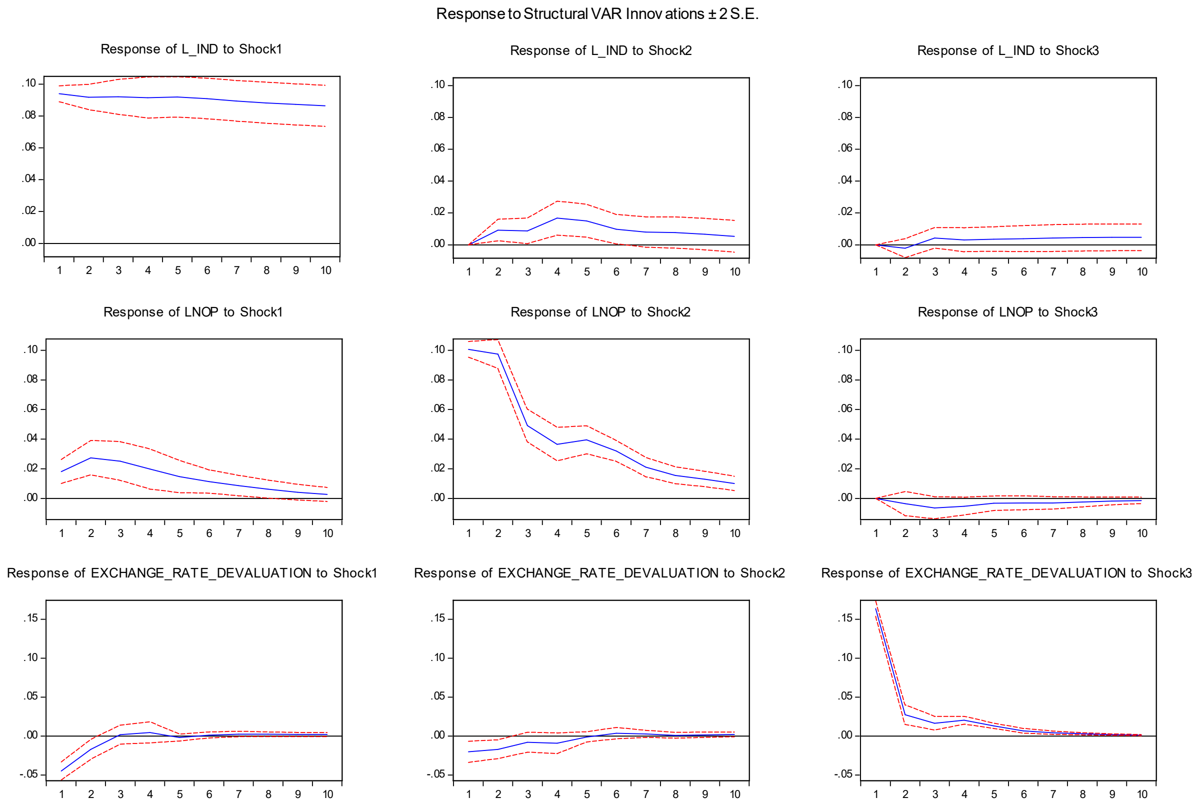
SVAR results in Figure 2 below show a positive relationship between oil price variation and industrial output in developing nations. In other words, higher movements in oil prices will cause industrial output to rise, while weak actions will cause output to move in the same direction and by a lower magnitude than when variation is large. The study's findings contradict the result of Olubusoye and Musa (2020), who found that oil price shocks do not significantly impact real sectors using the SVAR model. The findings of our research, where the g-coefficient shows that oil price variation had a negative impact on industrial sector output, compare favourably with those obtained by Al-Risheq (2016), who, after using a panel approach, concluded that oil price variations and real exchange rate variations caused significant changes in industrial production of a negative degree.

In a more profound analysis using thresholds, the study finds similar results with SVAR results when it is above -0.692 in developing economies. Then, devaluation above 6% had a positive-expansionary effect on output. When the difference between exchange rates in the past and present periods is lower than the threshold value, the manufacturing sector flourishes as production output is significantly enhanced. This can be attributed to the rates motivating local production of inputs and reducing capital needed for entry into the real sector. Above threshold rates for devaluation mean worsening devaluation or more units of local currencies used to purchase foreign currency. It occurs from higher costs of capital imports when currencies of countries imported from are converted to local currencies. In turn, hyperinflation occurs from increased output cost from manufacturing and the falling value of money held. Devaluation above the threshold level is weak as a monetary policy expansionary tool because rather than rising activities from the real sector, it cripples the industrial sector. This deleterious effect of devaluation above threshold values is identical to the contractionary results of devaluation obtained by Luciano (2022) and those of Ojuolape et al. (2015), that reported currency devaluation and output had no relation in SR, while in LR, output effects of devaluation are adverse. Our findings validated those of Sajid et al. (2018) that found insignificant exchange rate depreciation threshold effects on the inflation rate in Pakistan.

Threshold analysis supports the results, but only when oil price variation is below or within the region of 101.448. It supports the expectation that rising oil prices will cause a rise in the cost of production and lower outputs and hence validates findings by Iganiga et al. (2021) that rise in oil price diminishes industrial output, and a decrease in oil price fuels industrial production. We found no support for the study of Abdelhamid and Heba (2016), which reported that oil price shocks had zero effect on manufacturing output in Saudi Arabia during the SR era. Our results are in tune with results obtained by Ibrahim (2018) and with the LR findings of Abdelhamid and Heba (2016) that the oil price shock effect on manufacturing output exists after 10 quarters based on impulse response functions (IRF) analysis. The findings of Ojapinwa and Ejumedia (2012) based on the VAR approach with time series from 1976 to 2010, that exchange rate was a direct predictor of industrial production also lends credence to the result of our coefficient of exchange rate devaluation (0.334), which is a positive value and also significant in determining the output of the industrial sector.

Our study reveals empirical support for Eksi et al. (2011), who found LR causation from oil price to industrial production in the US, concluding that oil prices affect industrial production in Organization for Economic Co-operation and Development (OECD) countries. The direct relationship can be attributed to occurring gains (losses) from oil exports from oil-producing nations cushioning the negative effect the high (low) cost of oil would have had on manufacturing in terms of low (high) output. Furthermore, high commodity prices and productivity within the period would have intensified inflation and growth, offsetting oil prices' negative influence on industrial output to produce a positive pattern. The pull towards sustainability and reduced use of fossil fuels may have a downward toll on the demand for oil for manufacturing, causing the industrial output to rise despite rising oil prices.

Figure 2. Impulse responses



Source: Researchers' estimations.

5. CONCLUSION

The paper explores the relationship among oil price variations, exchange rate devaluation, and industrial output in developing economies drawing from data from thirty African countries by utilising NARDL, structural VAR, and threshold regressions. The study reveals that oil price variation had a significant threshold relationship with industrial output, while increased oil prices significantly reduced output. Threshold analysis for exchange rate devaluation reported a coefficient of the exchange rate (-4.361) as a predictor variable that had a negative and significant effect on the output of the industries in developing countries. By implication, when local currencies weaken against the dollar, imports increase production costs and cause output to reduce. Industrial outputs rise when oil prices rise and fall when oil prices fall. Industrial output falls when local currencies fall above 6.9% against foreign currencies. In particular, devaluation above 6.9% had a negative effect on output. Below threshold rates of exchange rate devaluation mean improving industrial production in developing countries. When the difference between exchange rates in the past and present periods is lower than the threshold value, the manufacturing sector flourishes as production output is significantly improved.

The paper also reveals that positive output levels are induced when a change in oil prices is above the threshold level of 101.448%. Within this price level still, oil prices will cause increased output. In other words, oil price movements above 101.448 support the firm's supply curve in which a lower cost of inputs will cause production to rise. When oil prices decline within the threshold, manufacturing firms have existing resources able to purchase a larger volume of information and thus increase output. Oil prices on their own are not subject to manipulation by individual countries. However, with this impact found in African countries in our sample, policies that would be influential would be the introduction of oil subsidies for players in the manufacturing or industrial sector when oil prices rise within the threshold. When oil prices fall below 101.448, it will be better to take out the subsidies as the subsidies would weaken the real sector, negatively impacting the economy.

Our results are robust to NARDL specification as we found that devaluation had asymmetric effects on industrial production. Rising devaluation rates lead to falling industrial output; while lowering rates are accompanied by increasing output. Relatively, asymmetry is significantly validated for oil price movements on industrial production. Rising oil prices cause industrial output to fall at both periods of analysis while falling oil prices stimulate some production levels. Previous values of industrial workers were also found to predict current values. The findings relative to oil prices negate the theory of production that increased input prices will cause lower output and vice versa. Annual industrial outputs should be monitored closely to ensure mechanisms are in place to maintain and drive industrial output for economic growth instead of the conventional reduction in output of subsequent periods, as shown in the results of this study. Industrial outputs are usually the end products of machines and other resources used in the manufacturing process. Industrial associations and the government should invest in biofuel and other non-oil sources of energy to maintain increased output amid adverse oil price variations. In times of chronic exchange rate devaluation, the government could offer tax rebates and other grants to the manufacturing sector to cushion the devaluation's negative effect on production costs. This study uniquely takes a panel approach using 30 countries to provide empirical evidence of the nature and significance of the impact oil price variations and exchange rate devaluation have on the industrial output of economies of developing nations. The analysis could be an extended comparison between developing and developed countries where data is available. It has the capability of increasing the sample size of the study for more revealing empirical evidence as regards the subject matter accordingly.

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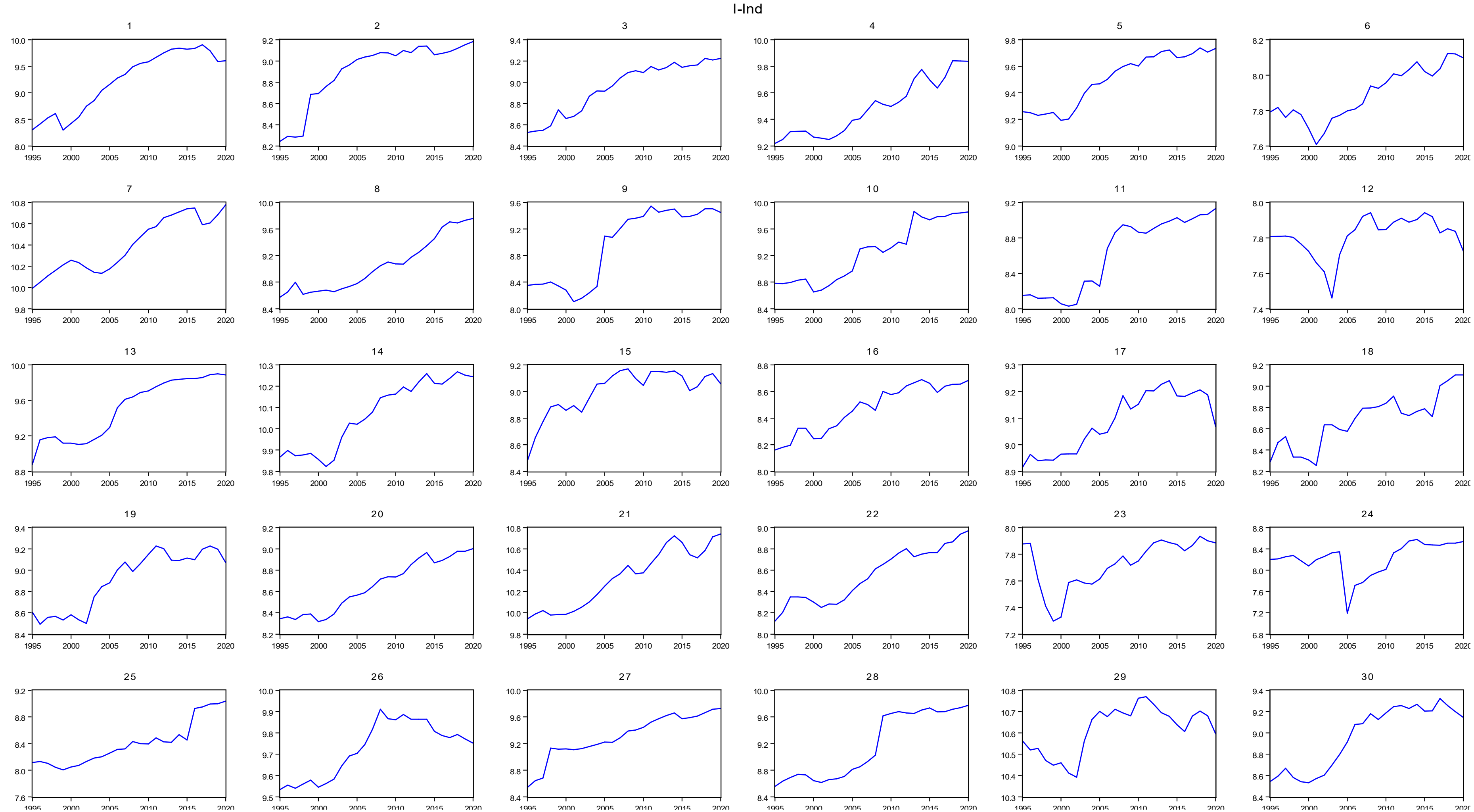
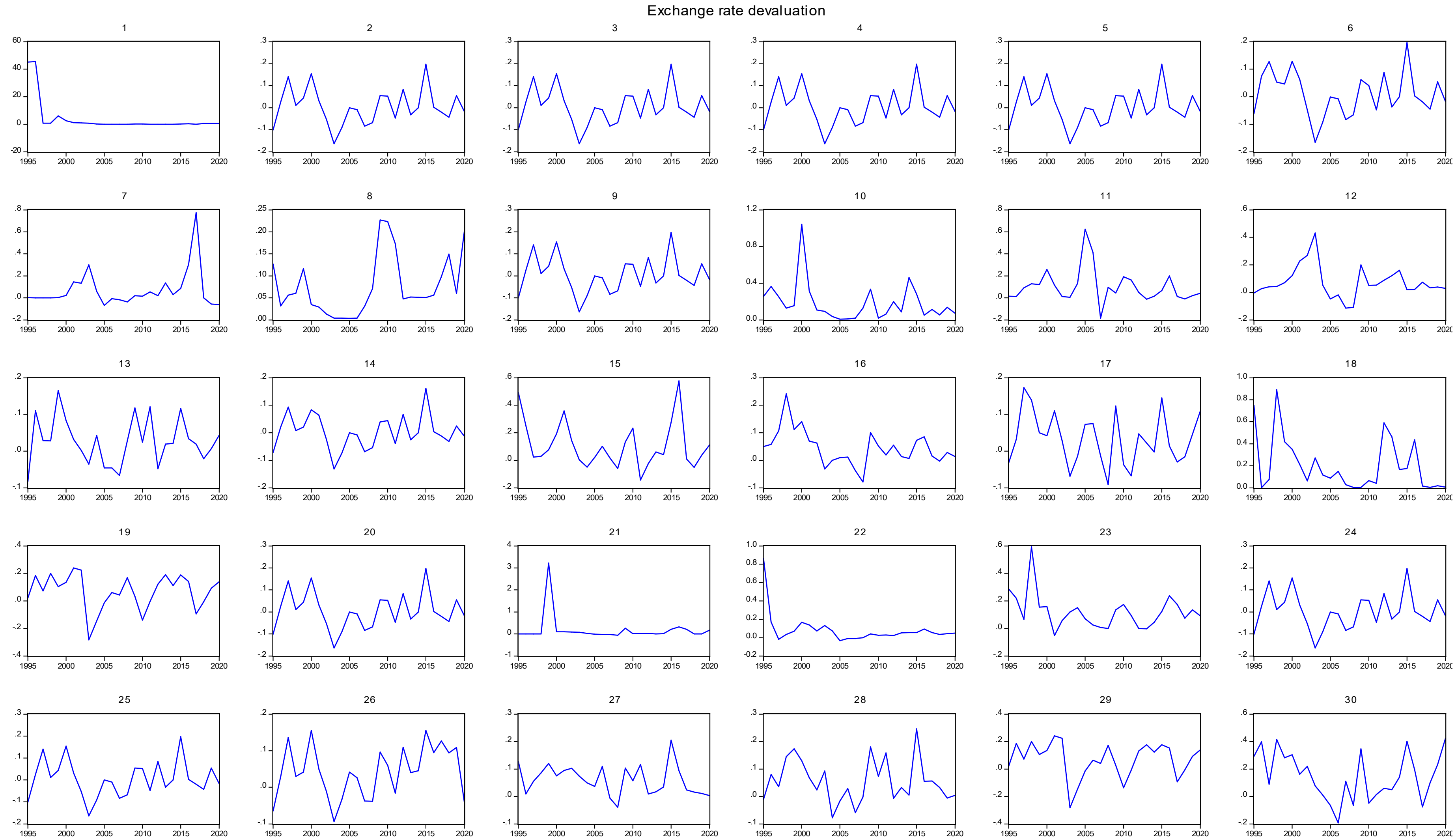
APPENDIX

Figure A.1. Graphical representation of industrial outputs for sampled countries



Source: Researchers' estimations.

Figure A.2. Graphical representation of exchange rate devaluation for sampled countries



Source: Researchers' estimations.