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DYNAMIC ADJUSTMENT BETWEEN ENERGY DEMAND AND PRODUCTIVITY GROWTH WITH EXCHANGE RATE DEVALUATION AS A MODERATING VARIABLE

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ABSTRACT

The research investigates the dynamic adjustment between energy consumption and productivity growth in oil-importing countries, with exchange rate devaluation as a moderating variable. The quantile regression (QR) estimation technique and the Markov-Switching regression were executed in this research paper. Among the striking findings obtained in this research is the fact that the quantile effects of productivity growth on energy consumption are positive and significant. Though their magnitudes vary greatly, productivity growth had the biggest influence on energy demand at the 10th percentile. In particular, a 40% surge in energy consumption was a result of a percentage rise in productivity. Variations in energy consumption are significantly and favourably predicted by productivity growth, even in the presence of the negative moderation effects of currency devaluation. Consequently, increased volatility in the productivity gap would result in increased volatility in energy consumption, with adverse interference from exchange rate devaluation. The smallest moderating effect of devaluation occurred at the 40th quantile of productivity growth, with a coefficient of -0.784. In the productivity growth equation, exchange rate devaluation had robust quantile effects as measured by 0.071, 0.018, 0.161, 0.154, 0.0076, 0.1084, 0.470, 0.102, and 0.135, respectively. We also found productivity growth effects of energy consumption from the 10th through the 90th quantiles. The significance and influence of energy consumption on productivity were highest in the median percentile, with a magnitude of 31.8 percent. The highest moderating effect of devaluation occurred at the 70th quantile of productivity growth. We established that 47% productivity growth was stimulated in view of a percentage rise in currency devaluation in oil-importing countries. In the dynamic adjustment between productivity growth and energy consumption, the moderating effect of exchange rate devaluation was favourable and significant. The Markov-switching estimates upholds the quantile estimates by also revealing significant regime interaction effects between energy consumption and productivity growth even in the presence exchange rate devaluation as a moderating predictor.

Keywords: Energy consumption, productivity growth, currency devaluation, oil importing countries, quantile effects, moderation effect

JEL Classification: C20, F29, C38

Introduction

The research investigates the dynamic adjustment between energy consumption and productivity growth in oil--importing countries, with exchange rate devaluation as a moderating variable. A fundamental component of energy economics is the econometric the econometric modeling modeling of energy demand. Examining the fundamental interactive mechanisms between the rise in productivity and energy consumption is essential because policymakers and central banks may draw significant conclusions from them. Additionally, market participants can benefit from this knowledge because insufficient energy supply in the midst the midst of excess demand is becoming a widely verified source of shock to productivity growth. Any information on how energy shocks affect production might be taken into account by investors when making asset allocation and investing choices. In order to create more suitable laws and regulations, central banks and policymakers who are worried about the instability in energy supply should increase their knowledge of how susceptible exchange rates are to shocks in the price of oil.

The link between energy use and productivity has been the subject of a plethora of empirical studies in the wake of many instances of global oil price shocks. This is due to the fact that fluctuations in energy demand primarily affect the domestic economy through their impact on productivity. The relationship that exists between productivity growth and energy consumption is crucial because it affects how successfully an economy adapts to using energy for productivity. A nation's energy consumption and productivity growth are important measures of its

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economic health. The main instrument needed to drive productivity is trade, which is impacted by exchange rates. Hence, the moderating effect of exchange rate devaluation is considered in this study. A purposeful reduction in the value of a nation's currency in relation to another currency or standard currency (often dollars) is known as currency devaluation (Umoru, 2022; Aiya, 2020). It is one of the instruments used in monetary policy to stabilize economies, particularly in less developed nations with fixed or semi-fixed exchange rates. Devaluation makes domestic sectors more globally competitive, which shifts consumer spending from imported to domestic products. It is used to lower the cost of domestic goods in international markets, promote exports, discourage imports, and repair an unfavourable balance of payments. Imported items are costly in the nation of origin. Following devaluation, more of the nation's currency may be purchased with the same amount of foreign money as it could have previously. This implies that the nation's goods and services will probably be more competitively priced in outside markets. A substantial trade imbalance (where the entire value of imports exceeds the total value of exports) or frequent capital outflows (also known as capital flight) from a nation are typically grounds for devaluation (Kemisola and Jacob, 2022; Kantox, 2021). In view of the possible political implications, currency exchange rates are therefore among the most closely monitored, researched, and influential economic indicators. The research findings further generate tools and methods that investors, policy analysts, and policymakers may use as a reference in their respective endeavors. The research study is made up made up of five parts. Theoretical and empirical literature reviews are covered in part two. The approach as it relates to methodological foundation, estimation techniques, data description, and measurements are discussed in Part 3. 3. The interpretation of results and data analysis is provided in Part 4. The policy implications of the findings are included in Part 5, which serves as a summary conclusion and suggestion.

2. Literature Review

Both theoretically and empirically, there is a pass-through effect of the exchange rate on overseas transactions. As a result, after considering the effects of cross-border shock transmission on domestic markets and economies, numerous conclusions have been drawn. The theoretical postulation of Obstfeld & Rogoff (1995) was predicated on the assumption of steady buying power. This suggests that there is no change in the actual interest rates between the two countries. They forecast that domestic monetary shocks will increase output but have a more unpredictable impact on the world economy. It is widely acknowledged that fluctuations in the price of oil and the exchange rate have a significant impact on economies worldwide, irrespective of a nation's status as an oil producer. Hence, direct and indirect technology shocks to the economy are now being accounted for in the Ramsey model. Examples of these shocks include changes in government expenditure and the production function over time. Unlike monetary disruptions, technological shocks change the quantity produced from a steady input. The Ramsey model, which takes into account changes in the employment and labour markets, is widely accepted to be exogenous, static, or to expand slowly over time.

2.1. Resource Curse Theory (RCT): The resource curse theory, initially proposed by Auty (1993), uses oil as a resource, with the idea that the endowment of a nation with natural resources should result in favourable effects on the wellbeing of its population. The idea first surfaced in the 1950s and 1960s, when natural resource-rich but low- and middle-income nations found themselves unable to make the most of their wealth for economic growth. Stated differently, the theory clarifies a scenario in which the availability of resources has an impact on society's welfare that is either neutral or negative. Wealthy nations with non-renewable resources confront both opportunities and threats. However, when the resources are mismanaged, it leads to social and economic hardship. This is the predicament faced by several African nations that export oil.

2.2. Oil Price Volatility Theory (OPVT): According to this theory, the volatility proposition is based on the observation that natural resource revenue, particularly oil revenue, is erratic and varies in relation to market fundamentals, which has an immediate impact on oil prices. Governments in oil-producing countries set their annual budgets using benchmarked prices that are derived from predictions of oil prices. Sharp changes in oil prices might lead to either a positive or negative fiscal imbalance because of exaggerated budgetary expenditures or shortages of revenue.

2.3. Business Cycle Theory (BCT): With the BCT, Keynes argued that macroeconomic factors like production, inflation, and employment are largely determined by aggregate demand. According to the hypothesis, production rises when overall investment and spending on goods and services rise. Production increases lead to higher output and higher employment levels. On the other hand, low aggregate demand will result in lower production levels, which will lower output, employment, and consumer income. Concerning the world's oil market, the underlying theoretical idea holds that booms and busts in global and regional economies have been brought about by variations in oil prices. Further explanations, namely, the conventional supply shock, the real balance impact, and income transfers, elucidate how varying oil prices explain business cycles in the US (Brown et al. 2019). According to the traditional supply shock hypothesis, an increase in oil prices due to a shortage causes output to decrease. Rationing of oil input is the subsequent effect of rising oil prices on production; this lowers worker productivity and has a negative impact on output.

Conversely, a decline in worker productivity raises the unemployment rate and lowers the real wage rate. Thus, adjustments in oil prices brought about by increases in the commodity's supply result in supply-side shock effects. With the wealth effect channel, rising oil prices lead to a wealth transfer (measured in US dollars) to countries that export oil, which is reflected in higher exports and a positive local currency current account balance (Beckmann, Czudaj, & Arora, 2017). As a result, the value of the local currency decreases in countries that export oil while depreciating the exchange rates of those that import it. Due to commodity hoarding, the initial phase of the oil price shock immediately has inflationary impacts. When an increase in oil prices raises concerns about inflation, this phase persists. Phase two of the cost-push effect is caused by a rise in production costs due to the price of oil. The expansion of money in circulation in connection to production growth is the foundation of the monetarist theory of inflation. Considering this theory, changes in the money supply with constant production translate into changes in the level of prices at home, but inflation is not caused by proportionate changes in the money supply and output. Applications of this idea are widespread in both industrialized and emerging economies. In emerging nations, some have questioned the applicability of the monetarist interpretation.

2.4. Empirical Review

Dong et al. (2023) explored the relationship between oil price volatility, consumption of green energy, and economic performance in the top 25 oil-importing countries between 2005 and 2021, which included a number of African countries. In order to evaluate the interactions between these variables and the mediating function of trade, the study used a panel data approach. The results showed that the volatility of oil prices has a detrimental effect on economic performance. Nonetheless, these negative consequences can be lessened by increasing the use of green energy and boosting trade, which will foster economic expansion and stability. The study emphasizes that in order to increase economic resilience against shocks related to oil prices, investments in renewable energy infrastructure and the promotion of international trade are crucial. To promote sustainable economic growth, policymakers are urged to give priority to trade policies and investments in renewable energy. In a study, Kang et al. (2023) examined the asymmetric effects of disaggregated energy consumption and changes in oil prices on the economic expansion of sub-Saharan African nations that import oil. Data from 1990 to 2019 were examined in the study using the PNARDL model. The results showed that, compared to price declines, rising oil prices have a more notable detrimental effect on economic growth. The study also discovered that using energy from renewable sources improves economic stability by lessening the detrimental consequences of changes in oil prices. The report suggested raising renewable energy investments to lessen reliance on oil imports and promote sustainable economic growth.

The non-linear impacts of fluctuating oil prices and disintegrated energy use on the economic expansion of the Middle Eastern and North African (MENA) oil-importing countries were investigated by Vosooghzadeh et al. (2023). The study looked at data from 1990 to 2019 using a PNARDL model. The results demonstrated that rising oil prices are more harmful to economic expansion than falling prices. The study also demonstrated how using renewable energy supports economic stability by mitigating adverse shocks to the price of oil. To lessen reliance on oil imports and strengthen the region's economy, the report suggested boosting investments in renewable energy infrastructure and enhancing energy efficiency.

Shocks to the oil price and their impact on the energy transition in 53 African countries between 2000 and 2020 were investigated by Charfeddine and Barkat (2020). The study evaluated how changes in oil prices affect the move towards renewable energy sources using a panel data technique. The findings showed that rising oil prices encourage energy security by hastening the adoption of renewable energy technologies and lowering reliance on oil imports. According to the study's findings, African nations should develop policies that promote the energy transition and economic stability, as well as invest in infrastructure for renewable energy sources.

2.4.1. Review of previous studies on energy consumption and exchange rates

Taking into account the research conducted by Iyoboyi & Muftau (2023), who used yearly time series data from 1971 to 2022 to examine the impacts of currency rate depreciation on energy demand in Nigeria. Their multivariate vector error correction research showed that Nigeria's energy consumption had not increased as a result of the Naira's exchange rate devaluation. Iganiga et al. (2023) used data from 1995 to 2021 to examine how shocks to oil prices affected industrial output in sub-Saharan African nations. A Structural VAR (SVAR) model was utilized in the study to describe the dynamic interactions between industrial production and oil prices. The findings demonstrated how sensitive the industrial sector is to changes in external oil prices by showing that positive shocks to the price of oil result in a notable drop in industrial output. Additionally, the study discovered that nations with more industrial diversity were more resilient to shocks related to oil prices. The study came to the conclusion that increasing energy efficiency and diversifying the industrial base are crucial for promoting economic expansion and lowering reliance on foreign oil imports. It is recommended that policymakers back measures that promote industrial investment in renewable energy sources. Korkmaz (2021) examined how the exchange rate and energy consumption affected the GDP of nine randomly chosen European nations. The research employed yearly data from 2002 to 2020. The panel data approach utilized for data analysis. The investigation found a he study discovered a causal relationship between the nine European nations' economic development and their energy use and exchange rate. Shehu & Youtang (2021) examined the link of causation between Nigeria's growth, trade flows, exchange rate volatility (ERV), and energy consumption. The time series data used for the research study spanned the years 1980 through 2019. The findings demonstrated that trade flows and Nigeria's economic development was significantly impacted by exchange rate volatility while the performance of economic growth was not much impacted by energy demand or exchange rates. Akpan & Atan (2021) studied how changes in currency rates and energy consumption affected Nigeria's actual production growth. They acquired data for the years 1986 through 2020 on a quarterly basis. The data was analyzed using a GMM approach. The analysis established absence of a meaningful correlation between exchange rate fluctuations and increase in production. The effects of energy demand and real exchange rate fluctuations on the industrial production of Nigeria's manufacturing sector were examined by Jongbo (2021). The findings demonstrated that industrial production was significantly impacted by the actual exchange rate.

Charfeddine and Barkat (2020) examined the effects of shocks to oil prices on Africa's energy transition, focusing on 53 African nations between 2000 and 2020. The research employed a panel data methodology to examine the impact of oil price changes on the uptake of renewable energy technologies. The results demonstrated that when nations work to lessen their reliance on oil imports, rising oil costs hasten the switch to renewable energy. This change fosters sustained economic growth in addition to improving energy security. According to the study's findings, in order to promote a more seamless energy transition, African countries should give infrastructure for renewable energy sources top priority along with supportive laws. Akinlo & Lawal (2020) studied the short- and long-term effects of currency rate swings on Nigeria's energy consumption and amount of agricultural exports. The period of coverage was 1981-2018. Along with other diagnostic tests, the GARCH was employed to evaluate the volatility of exchange rates. The analytical method used was the ARDL. The results demonstrated that the official exchange rate considerably affected the amount of agricultural exports. Kogid et al. (2020) examined the effects of currency rates and energy consumption on Malaysia's economic expansion. The data from 1981 to 2019 were analyzed using the ARDL bounds test. They discovered that there is a long-term co-integration between GDP growth, nominal and real exchange rates, and energy consumption. As a result, the exchange rate significantly impacted economic growth. The data was analyzed using the OLS regression approach. The findings demonstrated that industrial production was significantly impacted by the actual exchange rate. The exchange rate appeared to be unstable based on the ARCH and GARCH results. Furthermore, according to the SUR model, there was no discernible effect of exchange rate fluctuation on the non-oil and oil sectors, respectively.

The research carried out by Sa'ad & Adom (2020) determined the frequency of asymmetry in energy demand and its causes in Nigeria and suggests a multifaceted strategy for upcoming regulations. In a similar study, Liddle & Huntington (2020) reiterate the importance of economic growth in energy demand specifications based on data from their panel research of OECD nations. De Schryder et al. (2020) investigate how 61 oil-importing nations' energy demands are impacted by the US currency. According to their panel data estimation, there is a corresponding decrease in energy consumption when the US dollar exchange rate appreciates (local currency depreciates). Amano and Van Norden's (2020) looked at US ties with Germany, Japan, and the United States. The authors pointed out how energy costs affect exchange rate fluctuation. The volatile character of oil prices was attributed to a number of variables, like Covid-19 and shifts in the geopolitical landscape. It is crucial to look into the connection between oil prices and exchange rates because of this. Oyovwi (2019) investigated how Nigeria's energy consumption was impacted by fluctuations in currency rates. Yearly data from 1980 to 2018 were used in the study. The exchange rate volatility was produced using the GARCH approach. The study discovered that while there was a long-term negative correlation between the two variables, energy demand and exchange rate volatility had a short-term positive and substantial link.

In their assessment of the relationship between energy demand and exchange rates in Iran, Ghoddusi et al. (2019) find that when the exchange rate declines, there is a corresponding fall in the demand for energy. Lawal (2020) investigated the connection between the success of Nigeria's industrial sector and exchange rate movements. The ARDL approach was used to evaluate annual time-series data from 1986 to 2022. The findings show that the manufacturing sector's production is positively impacted by exchange rates. The impact of inflation and the currency rate on Nigeria's industrial was also investigated by Okafor et al. (2021). They discovered that an exchange rate positive shock had a negative impact on Nigeria's production growth by using an SVAR model. As a result, the thorough analysis of the body of existing research presented above reveals a significant vacuum in the knowledge on the unequal pass-through of exchange rates to output growth in Nigeria. The few studies that used data from Nigeria were predicated on symmetric relationships rather than taking into account the problem of non-linearity and asymmetries. The few previous investigations that looked on the potential for asymmetric effect, also did not take into account current statistics.

According to Coudert's (2020) assessment, there is evidence to suggest that the Balassa effect was the cause of the real exchange rate appreciation trend that was seen in the nations of Central and Eastern Europe in the early part of 2010. Although there were other contributing elements, the estimated Balassa effect helps to explain the true appreciation, according to the author. Using data from 2000M01–2007M12 and 2009M01–2018M02, respectively, to estimate the linear ARDL model, Adekoya & Adebiyi (2020) reported a significant relationship between the pre-crisis oil price and CPI, but the post-crisis period had no relationship at all despite an increased trend in the CPI. Accordingly, the authors also reported that the relationship between oil prices and inflation for developing nations was notably favourable over the long term during the pre-crisis era. This relationship is considerable and robust in the post-crisis era. According to Chaudhuri & Daniel (2019), the relative prices of the commodities that make up the output bundle should rise in line with the relative price of oil in a country that imports oil. Thus, this would lead to an increase in the real exchange rate and the oil producer's income differentials. The authors provided evidence that the US dollar real exchange rate's non-stationary behaviour during the post-Brexit era was caused by the oil prices' non-stationary behaviour.

In the post-Bretton Woods era, Amano & van Norden (2020) highlighted the significance of real domestic oil prices for the real exchange rate and income disparity for the United States, Japan, and Germany. According to Habib & Kalamova (2019), there is no correlation between salary disparities in Saudi Arabia and Russia and a long-term positive association between real oil prices and salaries in Russia. Gatawa & Mahmud (2019) examined the effects of currency rate swings on Nigeria's energy consumption and agricultural exports. The period of coverage was 1981–2018. Along with other diagnostic tests, the GARCH was employed to evaluate the volatility of exchange rates. The analytical method used was the ARDL. The findings showed that the official exchange rate significantly affected agricultural exports. Similarly, Suseeva (2019) showed that income disparities in Russia versus the euro and the actual oil price had a long-term beneficial association. Using a panel of sixteen developing nations, Choudhri and Khan (2019) presented compelling evidence for the Balassa Samuelson effects' mechanisms.

2.5. Gaps in reviewed literature: The majority of the research regarding the relationship between energy demand and exchange rate depreciation has concentrated on oil-producing markets. There is not much research on importing economies, despite their rising significance for trade and financial flow in the global economy (Aziz, 2021). Moreover, contradictory findings have come from the few studies conducted on these marketplaces (Blanchard and Giah, 2019; Choi et al., 2019; Ragayan, 2019; Bala and Chin, 2019). The lack of unifying studies on the link between energy demand and productivity growth with a moderate effect of exchange rate devaluation may mislead local investors, international investors, and multinational firms that are vulnerable to energy demand risk. The current study uses many statistical techniques, such as quantile regression analysis and Markov-switching regression, to fill a vacuum in the literature. It seeks to offer reliable empirical data to policymakers, investors, and multinational corporations.

3. Materials and Methods

The research focuses on how energy demand in economies that produce and import oil dynamically adjusts to exchange rate devaluations and income disparities. The quantile ARDL regressions (QARDL) estimation technique and the Markov-Switching regression are all used in this work. The QARDL regression methodology is a new technique that has been recently executed by Zhu, Lin, Zhu, & Liu (2023), Shu, Li, Ma, & Qureshi, (2022), Godil et al. (2021), and Ali et al. (2021). The QARDL estimation was found appropriate for the following reasons: It facilitates both short-term and long-term dynamic interactions between variables across the different quantiles. Besides, given that OLS estimator requires the slope coefficient to be the same for all quantiles; it is a reflection of the absence of knowledge regarding the impact of the predictor variables on response variable for different quantiles even when it has been resolved in the literature that at various quantiles, regressors are likely to have distinct effects on the outcome variable. Only with the quantile technique can the effects of different explanatory factors at various dependent variable quantiles be estimated. In addition, the QR eliminates outlier-related discrepancies in the results we have estimated in this study. Following the work of Zhu et al. (2023), our quantile ARDL regression specifications are as follows:

$$QEND = \omega(\tau) + \sum_{i}^{p} \phi_{END}(\tau) END_{t-i} + \sum_{i}^{q_1} \phi_{PROG}(\tau) PROG_{t-i} + \sum_{i}^{q_2} \phi_{EXD}(\tau) EXD_{t-i} + e_{1t}(\tau) \quad (1)$$

$$QPROG = \omega(\tau) + \sum_{i}^{p} \phi_{PROG}(\tau) PROG_{t-i} + \sum_{i}^{q_1} \phi_{END}(\tau) END_{t-i} + \sum_{i}^{q_2} \phi_{EXD}(\tau) EXD_{t-i} + e_{2t}(\tau) \quad (2)$$

Given that our quantile ranges from Q0.1 to Q0.9, we further specify the equations (1) and (2) in such a manner that the potential sequential association amongst the variables is captured by the error terms $e_{3t}(\tau), e_{4t}(\tau)$. Equations (3) and (4) represent such specification:

$$Q\Delta END_t = \omega(\tau) + \rho END_{t-i} + \delta_{PROG} PROG_{t-i} + \delta_{EXD} EXD_{t-i} + \sum_i^{p} \phi_{END}(\tau) END_{t-i} + \sum_i^{q_1} \phi_{PROG}(\tau) PROG_{t-i} + \sum_i^{q_2} \phi_{EXD}(\tau) EXD_{t-i} + e_{3t}(\tau) \quad (3)$$

$$Q\Delta PROG_t = \omega(\tau) + \rho PROG_{t-i} + \delta_{END} END_{t-i} + \delta_{EXD} EXD_{t-i} + \sum_i^{p} \phi_{PROG}(\tau) PROG_{t-i} + \sum_i^{q_1} \phi_{END}(\tau) END_{t-i} + \sum_i^{q_2} \phi_{EXD}(\tau) EXD_{t-i} + e_{4t}(\tau) \quad (4)$$

A re-specification of equations (3) and (4) with error correction term yields the QARDL models given in (5) and (6):

$$Q\Delta END_t = \omega(\tau) + \rho(\tau) END_{t-i} - \delta_{PROG}(\tau) PROG_{t-i} - \delta_{EXD}(\tau) EXD_{t-i} + \sum_i^{p-1} \phi_{END}(\tau) \Delta END_{t-i} + \sum_i^{q_1-1} \phi_{PROG}(\tau) \Delta PROG_{t-i} + \sum_i^{q_2-1} \phi_{EXD}(\tau) \Delta EXD_{t-i} + e_{5t}(\tau) \quad (5)$$

$$Q\Delta PROG_t = \omega(\tau) + \rho(\tau) PROG_{t-i} - \delta_{END}(\tau) END_{t-i} - \delta_{EXD}(\tau) EXD_{t-i} + \sum_i^{p-1} \phi_{PROG}(\tau) \Delta PROG_{t-i} + \sum_i^{q_1-1} \phi_{END}(\tau) \Delta END_{t-i} + \sum_i^{q_2-1} \phi_{EXD}(\tau) \Delta EXD_{t-i} + e_{6t}(\tau) \quad (6)$$

where: *END* is energy demand, *PROG* is productivity growth, *EXD* is exchange rate devaluation;

$$\delta_{PROG}(\tau), \delta_{END}(\tau), \delta_{EXD}(\tau), \phi_{END}(\tau), \phi_{PROG}(\tau), \phi_{EXD}(\tau)$$

are the estimated parameters for different quantiles, e is error term. In this study, we conducted the Wald test to ascertain the significance or otherwise of non-linearity in the quantile effects of the dynamic adjustment between the variables in our study as well as the constancy of estimated coefficients at the various quantiles. Also we piloted the granger causality test to determine the trend of dynamic interaction between the research variables. Secondary data, which spanned the years 1986 through 2023, were used in the study. Data on energy demand, exchange rate devaluation, and productivity growth were sourced from World Development Indicator (WDI) for the period of thirty seven years January 1, 1986 to June 30, 2024.

4. Results

The United Arab Emirates, Saudi Arabia, and Kuwait experienced no fluctuations in exchange rates at all, while the sampled oil-exporting countries in Table 4.2 exhibit an average annual change in currency rates of 0.1 percent over the period under study. Overall, these countries' exchange rate fluctuations were relatively consistent. Nigeria, at 30.5 percent, saw the largest percentage change despite its low volatility. The globe has been declining in recent years, with the United Arab Emirates being the only nation to witness an increase. There are violations of normality standards in the panel data.

Table 2 shows the summary statistics on productivity growth. This report refers to Kenya as an oil importer. Uganda has the most prevalent depreciating income differentials, as indicated by a negative mean value of 0.10 percent. Turkey had the highest average value, at 0.4%. Tanzania had the largest

Table 1: Summary Statistics on energy consumption

Country	Mean	Max	Min.	Quant.*	Std. Dev.	Kurt.
Botswana	0.001	0.067	-0.060	0.001	0.011	2.641
Hong Kong	0.001	0.030	-0.018	0.000	0.010	2.434
Kenya	0.001	0.032	-0.042	0.001	0.001	3.787
Morocco	0.000	0.010	-0.001	0.000	0.001	7.407
Rwanda	0.001	0.031	-0.051	0.001	0.008	8.687
Sweden	0.001	0.042	-0.031	0.000	0.008	8.487
Switzerland	0.001	0.305	-0.076	0.000	0.013	168.251
Tanzania	0.000	0.001	-0.001	0.000	0.000	10.470
Turkey	0.001	0.080	-0.020	0.001	0.010	14.461
Uganda	0.000	0.000	0.000	0.000	0.020	10.206
All	0.001	0.305	-0.076	0.000	0.012	148.621

Source: Authors' results using Eviews 13

Table 2: Summary statistics on productivity growth

Country	Mean	Max	Min.	Quant.*	Std. Dev.	Kurt.
Botswana	-0.0002	0.0204	-0.0256	0.0018	0.0045	10.41
Hong Kong	0.0001	0.1182	-0.0718	0.0140	0.0142	3.60
Kenya	-0.0010	0.0868	-0.1138	0.0066	0.0175	7.06
Morocco	0.0003	0.0687	-0.0758	0.0076	0.0145	7.60
Rwanda	0.0001	0.1144	-0.0286	0.0002	0.0067	114.32
Sweden	0.0013	0.0571	-0.1504	0.0152	0.0140	6.05
Switzerland	0.0007	0.0604	-0.1276	0.0120	0.0108	11.77
Tanzania	0.0003	0.2128	-0.1427	0.0115	0.0167	44.04
Turkey	0.0040	0.1080	-0.1313	0.0140	0.0208	3.74
Uganda	-0.0001	0.1153	-0.1070	0.0124	0.0142	5.52
All	0.0006	0.3239	-0.2538	0.0102	0.0220	21.09

Source: Authors' results using Eviews 13

annual income disparity at 21.28 percent, while Botswana had the lowest at 2.04 percent. Considering the neighbouring highest value of 21.27 percent, none of the distributions at the national level demonstrated normality.

Table 3 shows the summary statistics on exchange rate devaluation. The average income differences on yearly currency values for the studied oil-importing nations varied from 0.0001 (0.02%) for Switzerland to 0.0042 (0.42%) for Turkey. Turkey also saw the largest annual increase in currency rates during that time, at 14.38%. Following in order on maximum values were Rwanda, Tanzania, and Sweden, with respective percentages of 7.43%, 5.20%, and 4.71%. Turkey likewise got the lowest value in the pool, 24.02%, indicating that the Turkish Dinar is the most volatile currency.

Every variable underwent a stationarity test to prevent erroneous findings. None of the data sets in Table 4 included a unit root at first difference. With statistical significance (p<.01), all data stationarity tests rejected the null hypothesis and accepted all alternative hypotheses. Consequently, during the course of the study, there was a decent level of consistency between the data and energy consumption of the two groups. Co-integration criteria are generally ignored if an economic series is level-stationary. The study used a panel co-integration test to verify the long-term connection status of the variables for the separate groups.

Table 3: Summary Statistics on exchange rate devaluation

Country	Mean	Max	Min.	Quant.*	Std. Dev.	Kurt.
Botswana	0.0008	0.0388	-0.0201	0.0073	0.0112	2.60
Hong Kong	0.0000	0.0026	-0.0036	0.0002	0.0007	10.10
Kenya	0.0007	0.0201	-0.0132	0.0012	0.0034	10.42
Morocco	0.0004	0.0277	-0.0126	0.0038	0.0067	4.20
Rwanda	0.0011	0.0743	-0.0611	0.0010	0.0130	17.00
Sweden	0.0011	0.0471	-0.0373	0.0101	0.0131	3.41
Switzerland	0.0001	0.0236	-0.1434	0.0066	0.0125	26.61
Tanzania	0.0007	0.0631	-0.0536	0.0008	0.0068	24.75
Turkey	0.0042	0.1438	-0.2402	0.0121	0.0218	36.51
Uganda	0.0008	0.0301	-0.0442	0.0033	0.0077	10.52
All	0.0011	0.1538	-0.2402	0.0032	0.0133	126.25

Source: Authors' results using Eviews 13

The panel co-integration test tests for the presence of significant relationships among panel variables in the long run. The Fisher-Johansen panel co-integration tool was utilized and produced the following results, outlined in Table 5. The long-term association between energy consumption, exchange rate depreciation, and income disparities is confirmed by all statistically significant (p<.01) results. The long-term correlation is anticipated given that these events occur in both the oil-producing and oil-importing economies.

Table 5: Unrestricted Co-integration Rank Test

Hypothesized No. of CE(s)	Fisher Stat.* (trace test)	Fisher Stat.* (max-eigen test)
None	173.2***	189.6***
At most 1	1523***	153.4***
At most 2	1303***	1303***

*** Significant at 1%

Source: Authors' results using Eviews 13

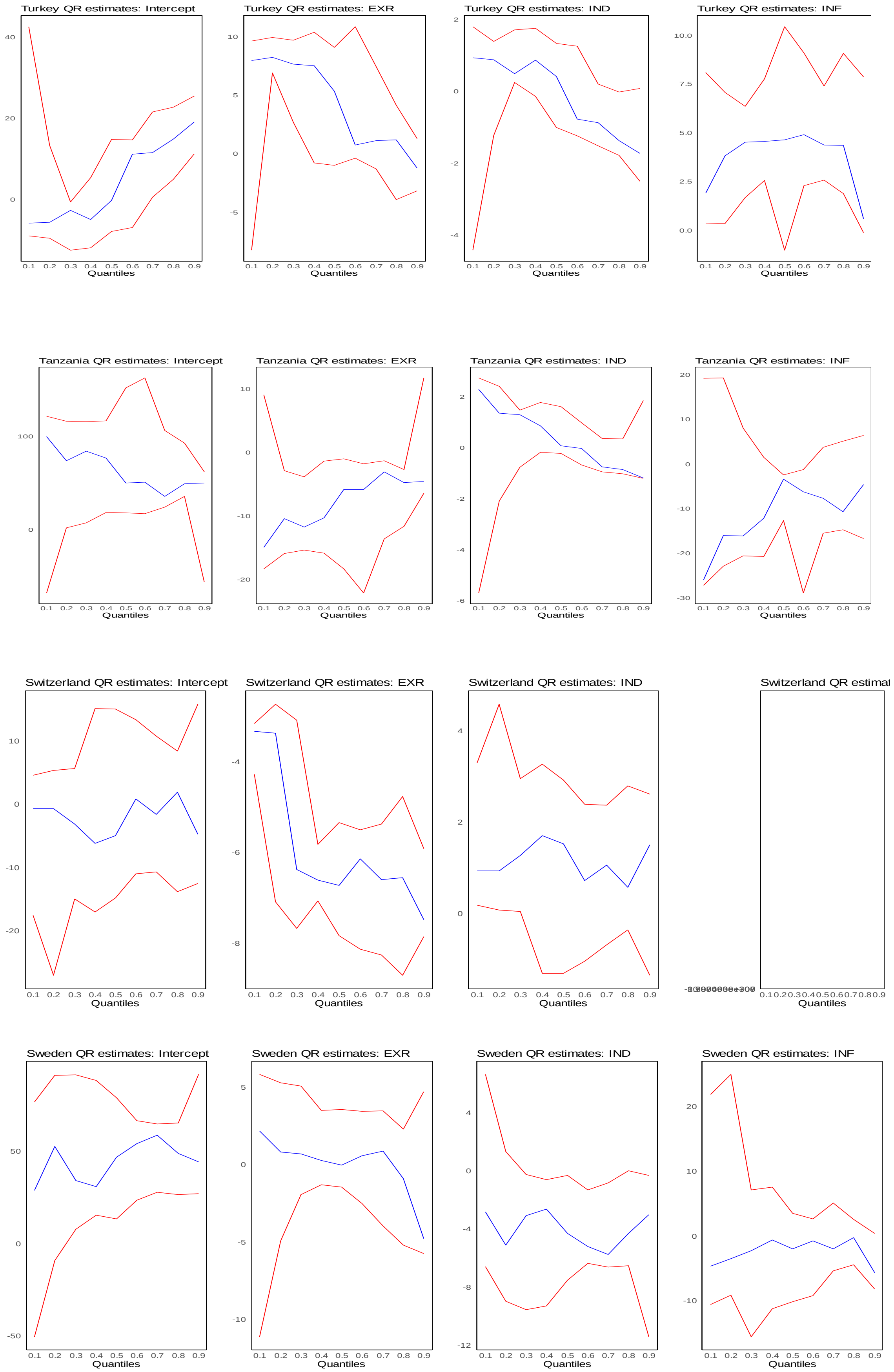
Figure 1 below is the Quantile Regression Charts- for all oil importing countries covered by the study. According to an analysis of the quantile process curves for Oil Importing Countries, the effect of all variables in this analysis either decreases and peaks at the later quantile and vice versa for all the countries. Only Hong Kong and Switzerland has a fairly constant value through time.

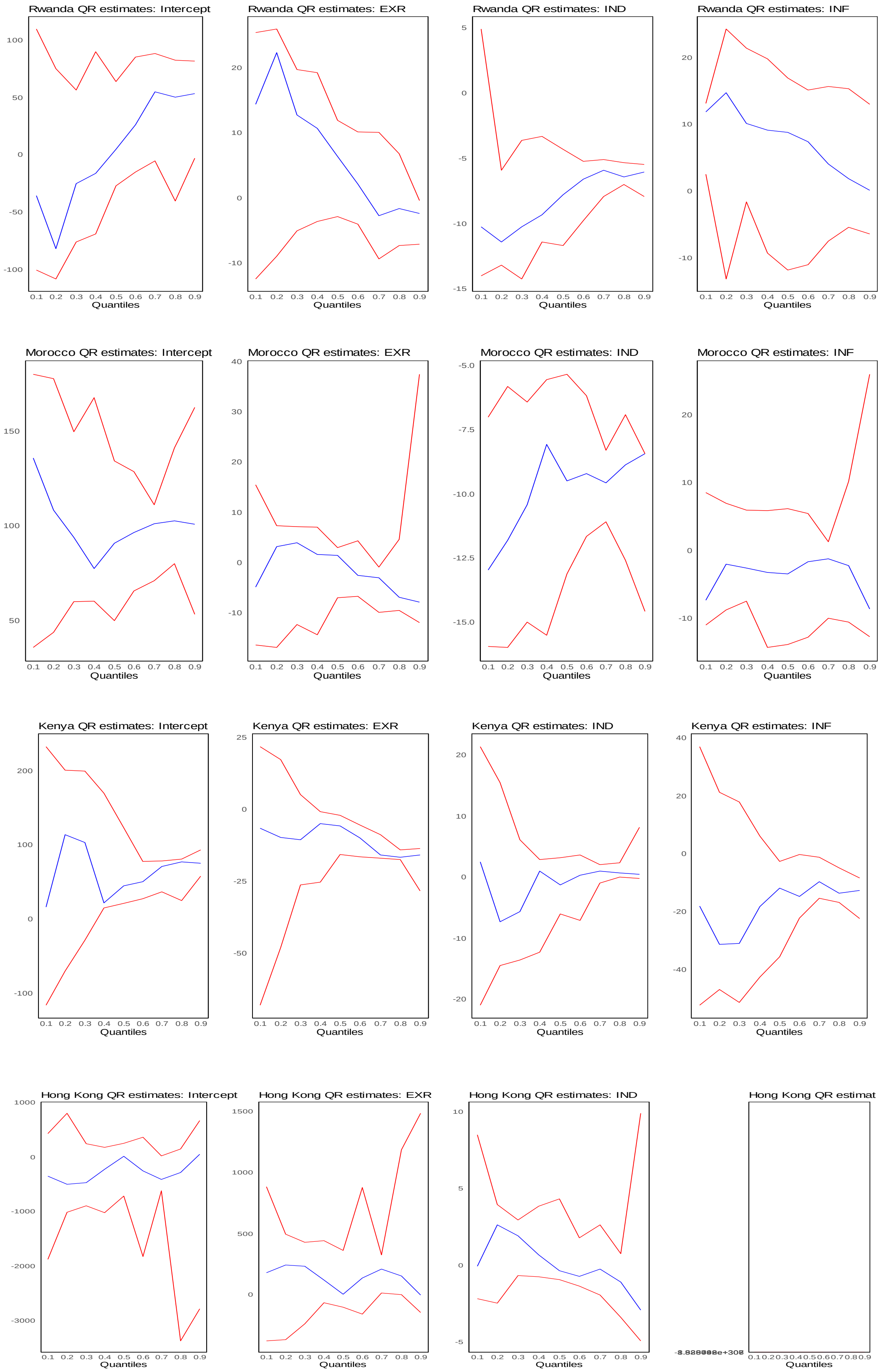
Table 4: Unit root test results

I(0)- Level	Levin, Lin & Chu t*	Breitung t-stat	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square
EXD	-106.425***	-26.060***	-60.144***	1728.60***	1001.74***
PROG	-100.615***	-33.231***	-61.116***	1646.81***	1011.85***
END	-118.630***	-20.3072***	-70.3036***	1061.23***	1064.66***

*** significant at 1%

Source: Authors' results using Eviews 13


Turkey QR estimates: Intercept
Turkey QR estimates: EXR
Turkey QR estimates: IND
Turkey QR estimates: INF
Tanzania QR estimates: Intercept
Tanzania QR estimates: EXR
Tanzania QR estimates: IND
Tanzania QR estimates: INF
Switzerland QR estimates: Intercept
Switzerland QR estimates: EXR
Switzerland QR estimates: IND
Switzerland QR estimat
Sweden QR estimates: Intercept
Sweden QR estimates: EXR
Sweden QR estimates: IND
Sweden QR estimates: INF
Quantiles


Rwanda QR estimates: Intercept
100
50
0
-50
-100
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Rwanda QR estimates: EXR
20
10
0
-10
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Rwanda QR estimates: IND
5
0
-5
-10
-15
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Rwanda QR estimates: INF
20
10
0
-10
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Morocco QR estimates: Intercept
150
100
50
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Morocco QR estimates: EXR
40
30
20
10
0
-10
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Morocco QR estimates: IND
-5.0
-7.5
-10.0
-12.5
-15.0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Morocco QR estimates: INF
20
10
0
-10
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Kenya QR estimates: Intercept
200
100
0
-100
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Kenya QR estimates: EXR
25
0
-25
-50
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Kenya QR estimates: IND
20
10
0
-10
-20
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Kenya QR estimates: INF
40
20
0
-20
-40
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Hong Kong QR estimates: Intercept
1000
0
-1000
-2000
-3000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Hong Kong QR estimates: EXR
1500
1000
500
0
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Hong Kong QR estimates: IND
10
5
0
-5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Quantiles
Hong Kong QR estimat
-8.828008e+308
0.10.20.30.40.50.60.70.80.9
Quantiles

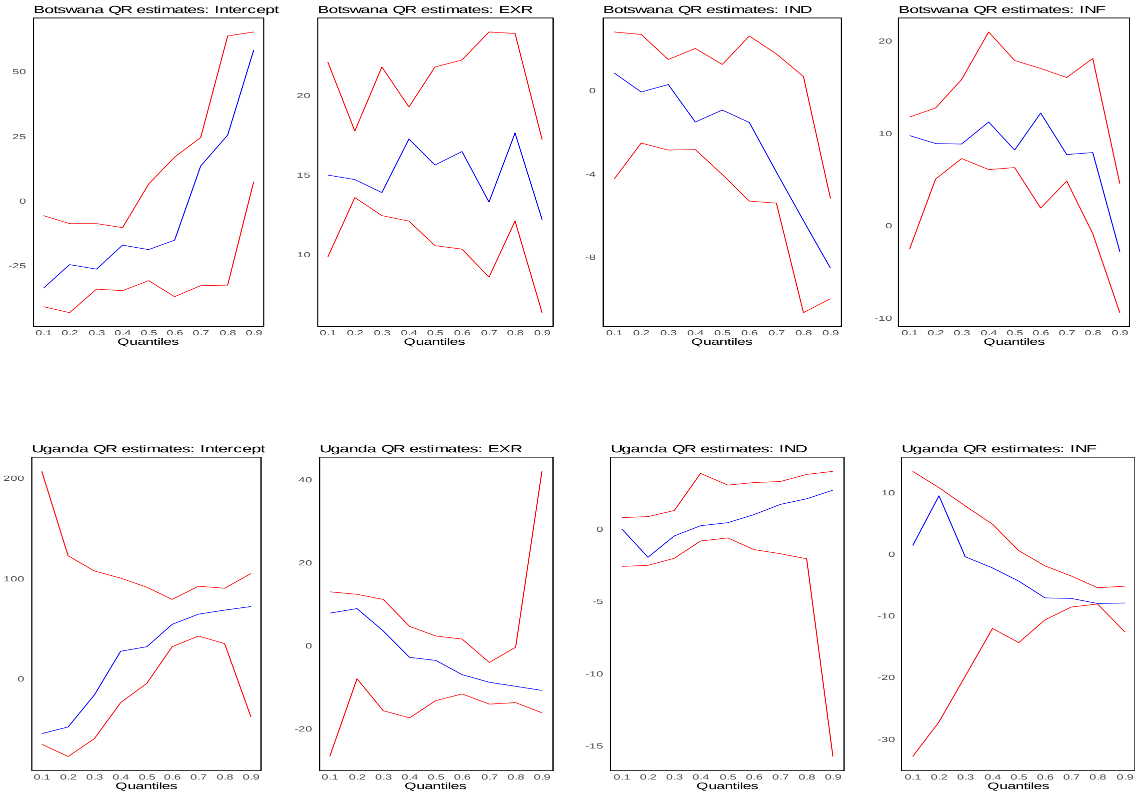


Figure 1: Quantile Regression Charts- (oil importing countries)

Source: Authors' results using Eviews 13

Table 8 reports quantile results for the energy demand of oil-importing countries. A closer inspection of the results shows that the long-run estimates are approximately identical in sign and size to the short-run estimates. The quantile adjustment coefficients are significant and negative for all quantiles, with the implication that a short-run perturbation in energy consumption of oil-importing countries would always revert to the long-term equilibrium value of energy demand at a speed of 23 percent in the 10th quantile, 46 percent in the 20th quantile, 25.5 percent in the 30th quantile, 14.6 percent in the 40th quantile, 26.7 percent in the median quantile, 13 percent in the 60th quantile, 21 percent in the 70th quantile, 32.4 percent in the 80th quantile, and 15.5 percent in the 90th quantile, respectively. Focussing analysis on the short-run quantile regression estimates, it can be seen that productivity growth is a direct predictor of energy demand; a one percent rise in exchange rate devaluation results in a decrease in all the percentiles of energy consumption for all the oil-importing nations researched by the study. Energy demand was shown to be negatively impacted by exchange rate devaluation. Another striking result obtained was that all the quantile effects of productivity growth on energy consumption (0.4042, 0.2430, 0.1770, 0.1837, 0.1375, 0.1185, 0.1028, 0.1246, and 0.1628) are positive and significant. Though their magnitudes vary greatly, the projected impacts of the various quantiles of the regression line typically have the same shape. The coefficient of productivity growth in the 10th quantile is 0.4042. This is statistically significant (p = 0.00).

Accordingly, more than any other percentile, productivity growth had the biggest influence on energy demand at the 10th percentile. A 40% surge in energy consumption was a result of a percentage rise in productivity. Likewise, for the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, and 90th percentiles of energy consumption, respectively, negative and significant coefficients of -0.2400, -0.2225, -0.2482, -0.1784, -0.1217, -0.1731, -0.2881, -0.3521, and -0.6584 were associated with exchange rate devaluation. By implications, variations in energy consumption are significantly and favourably predicted by productivity growth even in the presence of negative moderation effects of currency devaluation. Consequently, increased volatility in the productivity gap would result in increased volatility in energy consumption, with adverse interference from exchange rate devaluation. In the dynamic adjustment between energy demand and productivity growth, the moderating effect of exchange rate devaluation was considerably unfavorable. The smallest moderating effect of devaluation occurred at the 40th quantile of productivity growth, with a coefficient of -0.784. Overall, energy consumption falls by 78.4 percent in oil-importing countries due to a percentage shock in currency devaluation.

Table 8: Quantile results for energy consumption of oil-importing countries

Variables	OLS	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6	Q0.7	Q0.8	Q0.9
$\Delta PROG(\tau)$	0.2370	0.4042	0.2430	0.1770	0.1837	0.1375	0.1185	0.1028	0.1246	0.1628
P-val	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.01	0.05	0.00
$\Delta EXD(\tau)$	-0.173	-0.240	-0.225	-0.248	-0.784	-0.1217	-0.193	-0.288	-0.352	-0.654
P-val	0.00	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00
$\omega(\tau)$	1.130	-0.157	-0.386	1.168	2.137	1.052	0.013	0.021	1.070	1.116
P-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\rho_{ecm}(\tau)$	-0.233	-0.460	-0.395	-0.255	-0.146	-0.267	-0.130	-0.210	-0.324	-0.155
P-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$PROG(\tau)$	0.2270	0.4012	0.2330	0.1750	0.1830	0.1355	0.1175	0.1020	0.1241	0.1622
P-val	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
$EXD(\tau)$	-0.163	-0.245	-0.220	-0.244	-0.678	-0.1213	-0.162	-0.289	-0.344	-0.666
P-val	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quantile Slope Equality Tests		*Wald test: 63.45 (.00)*				*Ramsey Reset Test: QLR Lambda stat: 0.0068(.93)*				

Source: Authors' results using Eviews 13

Table 9 reports the Wald test results for the energy consumption equation of oil-importing countries. According to the test results, all coefficients (adjustment coefficients, short-run, and long-term parameters) are relatively constant and different from zero. In sum, there are non-linear quantile interactions or dynamic adjustment effects between energy consumption and productivity growth. Hence, the short-run and long-term dynamic adjustments differ significantly across the different quantiles.

Table 9: Wald test results for energy consumption equation of oil-importing countries

Variable	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6	Q0.7	Q0.8	Q0.9
Wald test	Short-run coefficient test results								
H_0	$\phi_{PROG}=0$	$\phi_{PROG}=0$	$\phi_{PROG}=0$	$\phi_{PROG}=0$	$\phi_{PROG}=0$	$\phi_{PROG}=0$	$\phi_{PROG}=0$	$\phi_{PROG}=0$	$\phi_{PROG}=0$
Wald statistic	6.123**	14.127***	13.200***	11.136***	12.356***	7.358***	18.228***	13.332***	9.145***
P-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H_0	$\phi_{EXD}=0$	$\phi_{EXD}=0$	$\phi_{EXD}=0$	$\phi_{EXD}=0$	$\phi_{EXD}=0$	$\phi_{EXD}=0$	$\phi_{EXD}=0$	$\phi_{EXD}=0$	$\phi_{EXD}=0$
Wald statistic	11.348***	25.448**	22.101***	26.335***	7.225***	8.663**	12.1345***	18.231***	14.247***
P-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H_0	$\phi_{PROG}(Q0.1)=\phi_{PROG}(Q0.2)=\phi_{PROG}(Q0.3)=\phi_{PROG}(Q0.4)=\phi_{PROG}(Q0.5)=\phi_{PROG}(Q0.6)=\phi_{PROG}(Q0.7)=\phi_{PROG}(Q0.8)=\phi_{PROG}(Q0.9)$								
Statistic	79.014***								
P-val	(0.0000)								
Wald test	$\phi_{EXD}(Q0.1)=\phi_{EXD}(Q0.2)=\phi_{EXD}(Q0.3)=\phi_{EXD}(Q0.4)=\phi_{EXD}(Q0.5)=\phi_{EXD}(Q0.6)=\phi_{EXD}(Q0.7)=\phi_{EXD}(Q0.8)=\phi_{EXD}(Q0.9)$								
Statistic	56.129***								
P-val	(0.0000)								
Wald test	Long-run coefficient test results								
H_0	$\delta_{PROG}=0$	$\delta_{PROG}=0$	$\delta_{PROG}=0$	$\delta_{PROG}=0$	$\delta_{PROG}=0$	$\delta_{PROG}=0$	$\delta_{PROG}=0$	$\delta_{PROG}=0$	$\delta_{PROG}=0$
Wald statistic	17.29***	5.13**	23.21***	13.15***	3.35**	5.24***	14.13***	19.98***	16.09***
P-val	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
H_0	$\delta_{EXD}=0$	$\delta_{EXD}=0$	$\delta_{EXD}=0$	$\delta_{EXD}=0$	$\delta_{EXD}=0$	$\delta_{EXD}=0$	$\delta_{EXD}=0$	$\delta_{EXD}=0$	$\delta_{EXD}=0$
Wald statistic	10.37***	8.32***	4.39***	12.71***	11.30***	16.38***	10.35***	14.01***	19.38***
P-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H_0	$\delta_{PROG}(Q0.1)=\delta_{PROG}(Q0.2)=\delta_{PROG}(Q0.3)=\delta_{PROG}(Q0.4)=\delta_{PROG}(Q0.5)=\delta_{PROG}(Q0.6)=\delta_{PROG}(Q0.7)=\delta_{PROG}(Q0.8)=\delta_{PROG}(Q0.9)$								
Statistic	124.005***								
P-val	(0.0000)								
H_0	$\delta_{EXD}(Q0.1)=\delta_{EXD}(Q0.2)=\delta_{EXD}(Q0.3)=\delta_{EXD}(Q0.4)=\delta_{EXD}(Q0.5)=\delta_{EXD}(Q0.6)=\delta_{EXD}(Q0.7)=\delta_{EXD}(Q0.8)=\delta_{EXD}(Q0.9)$								
Statistic	59.7085								
P-val	(0.0000)								
Wald test	Speed of adjustment test results								
H_0	$\rho(Q0.1)=0$	$\rho(Q0.2)=0$	$\rho(Q0.3)=0$	$\rho(Q0.4)=0$	$\rho(Q0.5)=0$	$\rho(Q0.6)=0$	$\rho(Q0.7)=0$	$\rho(Q0.8)=0$	$\rho(Q0.9)=0$
Wald statistic	10.12***	6.28***	9.28***	2.23**	5.24***	5.00***	25.12***	22.18***	34.19***
P-val	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000
H_0	$\rho(Q0.1)=\rho(Q0.2)=...=\rho(Q0.9)$								
Statistic	27.893***								
P-val	(0.0000)								

Note: *** and ** indicates significance at 1% and 5% levels respectively

Table 10 reports the quantile Granger causality test results for energy consumption in oil-importing countries. Following the statistical significance of the causality test statistic as reported by the zero probability values, it implies the presence of a two-way dynamic adjustment or interactive effects between energy use and productivity growth across all the quantiles, Q0.1 to Q0.9. By implication, both current and past realizations of energy consumption and productivity growth are dynamically interactive.

induced productivity growth for all the quantiles. It was discovered that the exchange rate devaluation was a positive and significant predictor of productivity growth throughout the quantile. What this implies is that exchange rate devaluation is positively associated with productivity growth in all the quantiles. In particular, for all percentiles of productivity growth, exchange rate devaluation had robust quantile effects as measured by 0.071, 0.018, 0.161, 0.154, 0.196, 0.108, 0.470, 0.102, and 0.135, respectively. Additionally, the research outcomes show that a one percent increase in energy demand was matched by 0.016, 0.166, 0.113, 0.152, 0.128, 0.118, 0.107, 0.118, 0.124, and 0.132 percent increases in productivity growth for the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, and 90th, respectively, and p-values are all less than five percent. These productivity growth effects of energy consumption at the various quantiles are significant at the 5 percent level.

Table 10: Quantile Granger causality test results for energy consumption of oil-importing countries

Variable	[Q0.1-Q0.9]	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6	Q0.7	Q0.8	Q0.9
$\Delta PROG(\tau) \rightarrow \Delta END(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta END(\tau) \rightarrow \Delta PROG(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta EXD(\tau) \rightarrow \Delta END(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta END(\tau) \rightarrow \Delta EXD(\tau)$	0.187	0.723	0.334	0.451	0.173	0.241	0.198	0.125	0.177	0.325
$\Delta EXD(\tau) \rightarrow \Delta PROG(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta PROG(\tau) \rightarrow \Delta EXD(\tau)$	0.291	0.345	0.677	0.490	0.568	0.249	0.365	0.332	0.897	0.334

Source: Authors' results using Eviews 13

Table 11 reports the quantile results for productivity growth in oil-importing countries. As found with the results for energy demand, long-run estimates of productivity growth are roughly similar, both in sign and size, to the short-run quantile estimates. The quantile adjustment speeds are 0.359, 0.126, 19.1, 22.1, 14.5, 26.6, 13.6, 24.5, 26.9, and 13.4 percent for the respective quantiles (10th–90th). From the p-values, it can be observed that all adjustment coefficients are well behaved, that is, significant and negative. By statistical inference, long-term equilibrium productivity growth could be established at the given speed following a short-run disturbance in the values of energy consumption and currency devaluation in all oil-importing countries. According to the short-run quantile regression estimation results, a one percent rise in currency devaluation

The significance and influence of energy consumption on productivity were highest in the median percentile, with a magnitude of 31.8 percent. The median coefficient of 0.0076 was the least productive effect of exchange rate devaluation. This indicates that the median productivity growth was least affected by devaluation, though the effect is

Table 11: Quantile results for productivity growth of oil-importing countries

Variable	OLS	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6	Q0.7	Q0.8	Q0.9
$\Delta END(\tau)$	0.016	0.166	0.113	0.152	0.128	0.318	0.107	0.118	0.124	0.132
P-val	0.01	0.00	0.00	0.02	0.01	0.08	0.00	0.00	0.02	0.01
$\Delta EXD(\tau)$	0.076	0.071	0.018	0.161	0.154	0.196	0.108	0.470	0.102	0.135
P-value	0.51	0.20	0.13	0.17	0.26	0.51	0.60	0.00	0.38	0.01
$\omega(\tau)$	1.349	-0.117	1.106	1.040	-0.312	0.201	0.415	0.162	0.903	0.154
P-val	0.11	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
$\rho_{ecm}(\tau)$	-0.359	-0.126	-0.191	-0.221	-0.145	-0.266	-0.136	-0.245	-0.269	-0.134
P-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$END(\tau)$	0.015	0.169	0.115	0.159	0.139	0.325	0.106	0.112	0.123	0.133
P-val	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
$EXD(\tau)$	0.006	0.070	0.028	0.150	0.152	0.199	0.118	0.570	0.111	0.125
P-value	0.50	0.10	0.03	0.20	0.22	0.55	0.60	0.00	0.08	0.00
Quantile Slope Equality Tests		*Wald test: 70.02 (.00)*			*Ramsey Reset Test: QLR Lambda stat: 3.9855 (.20)*					

Source: Authors' results using Eviews 13

positive. The highest moderating effect of devaluation occurred at the 70th quantile of productivity growth, with a coefficient of 0.470. By implication, 47% productivity growth is stimulated given a 1% increase in currency devaluation in oil-importing countries. Away from the 50th quantile effect, productivity growth and exchange rate devaluation are significantly interrelated. In the dynamic adjustment between productivity growth and energy consumption, the moderating effect of exchange rate devaluation was favourable and significant.

Table 12 reports the Wald test results for the productivity growth equation of oil-importing countries. The test results are the same as those obtained for the energy consumption function in Table 9 above. All adjustment coefficients, short-run, and long-term coefficients differ relatively across all the quantiles. This conveys the non-linear quantile interactions or dynamic adjustment effects between productivity growth and energy consumption.

According to the quantile causality test results in Table 12, it can be seen that a two-way dynamic

Table 12: Wald test results for productivity growth equation of oil-importing countries

Variable	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6	Q0.7	Q0.8	Q0.9
Wald test	Short-run coefficient test results								
H_0	$\gamma_{END}=0$	$\gamma_{END}=0$	$\gamma_{END}=0$	$\gamma_{END}=0$	$\gamma_{END}=0$	$\gamma_{END}=0$	$\gamma_{END}=0$	$\gamma_{END}=0$	$\gamma_{END}=0$
Wald statistic	24.81***	23.90***	6.200***	14.32***	16.76***	10.51***	15.33***	2.52**	27.45***
P-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000
H_0	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$	$\gamma_{EXD}=0$
Wald statistic	9.14***	12.12***	17.13***	29.16***	22.10***	4.18***	12.15***	28.05***	15.45***
P-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H_0	$\gamma_{END}(Q0.1)=\gamma_{END}(Q0.2)=\gamma_{END}(Q0.3)=\gamma_{END}(Q0.4)=\gamma_{END}(Q0.5)=\gamma_{END}(Q0.6)=\gamma_{END}(Q0.7)=\gamma_{END}(Q0.8)=\gamma_{END}(Q0.9)$								
Statistic	139.57***								
P-val	(0.0000)								
H_0	$\gamma_{EXD}(Q0.1)=\gamma_{EXD}(Q0.2)=\gamma_{EXD}(Q0.3)=\gamma_{EXD}(Q0.4)=\gamma_{EXD}(Q0.5)=\gamma_{EXD}(Q0.6)=\gamma_{EXD}(Q0.7)=\gamma_{EXD}(Q0.8)=\gamma_{EXD}(Q0.9)$								
Statistic	114.01***								
P-val	(0.0000)								
Wald test	Long-run coefficient test results								
H_0	$\mu_{END}=0$	$\mu_{END}=0$	$\mu_{END}=0$	$\mu_{END}=0$	$\mu_{END}=0$	$\mu_{END}=0$	$\mu_{END}=0$	$\mu_{END}=0$	$\mu_{END}=0$
Wald statistic	10.13***	13.168**	12.24***	18.15***	29.45***	9.48**	12.38***	11.18***	10.29***
P-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H_0	$\mu_{EXD}=0$	$\mu_{EXD}=0$	$\mu_{EXD}=0$	$\mu_{EXD}=0$	$\mu_{EXD}=0$	$\mu_{EXD}=0$	$\mu_{EXD}=0$	$\mu_{EXD}=0$	$\mu_{EXD}=0$
Wald statistic	10.24***	33.12***	8.47***	5.66***	30.24***	18.77**	14.45***	34.21***	13.69***
P-val	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H_0	$\mu_{END}(Q0.1)=\mu_{END}(Q0.2)=\mu_{END}(Q0.3)=\mu_{END}(Q0.4)=\mu_{END}(Q0.5)=\mu_{END}(Q0.6)=\mu_{END}(Q0.7)=\mu_{END}(Q0.8)=\mu_{END}(Q0.9)$								
Statistic	176.15***								
P-val	(0.0000)								
H_0	$\mu_{EXD}(Q0.1)=\mu_{EXD}(Q0.2)=\mu_{EXD}(Q0.3)=\mu_{EXD}(Q0.4)=\mu_{EXD}(Q0.5)=\mu_{EXD}(Q0.6)=\mu_{EXD}(Q0.7)=\mu_{EXD}(Q0.8)=\mu_{EXD}(Q0.9)$								
Statistic	113.09***								
P-val	(0.0000)								
Wald test	Speed of adjustment test results								
H_0	$\rho(Q0.1)=0$	$\rho(Q0.2)=0$	$\rho(Q0.3)=0$	$\rho(Q0.4)=0$	$\rho(Q0.5)=0$	$\rho(Q0.6)=0$	$\rho(Q0.7)=0$	$\rho(Q0.8)=0$	$\rho(Q0.9)=0$
Wald statistic	3.45**	7.12***	2.59**	9.23***	11.35***	9.34***	3.99**	6.23***	8.25***
P-val	0.002	0.000	0.013	0.000	0.000	0.000	0.002	0.000	0.000
H_0	$\rho(Q0.1)=\rho(Q0.2)=\rho(Q0.3)=\rho(Q0.4)=\rho(Q0.5)=\rho(Q0.6)=\rho(Q0.7)=\rho(Q0.8)=\rho(Q0.9)$								
Statistic	46.120***								
P-val	(0.0000)								

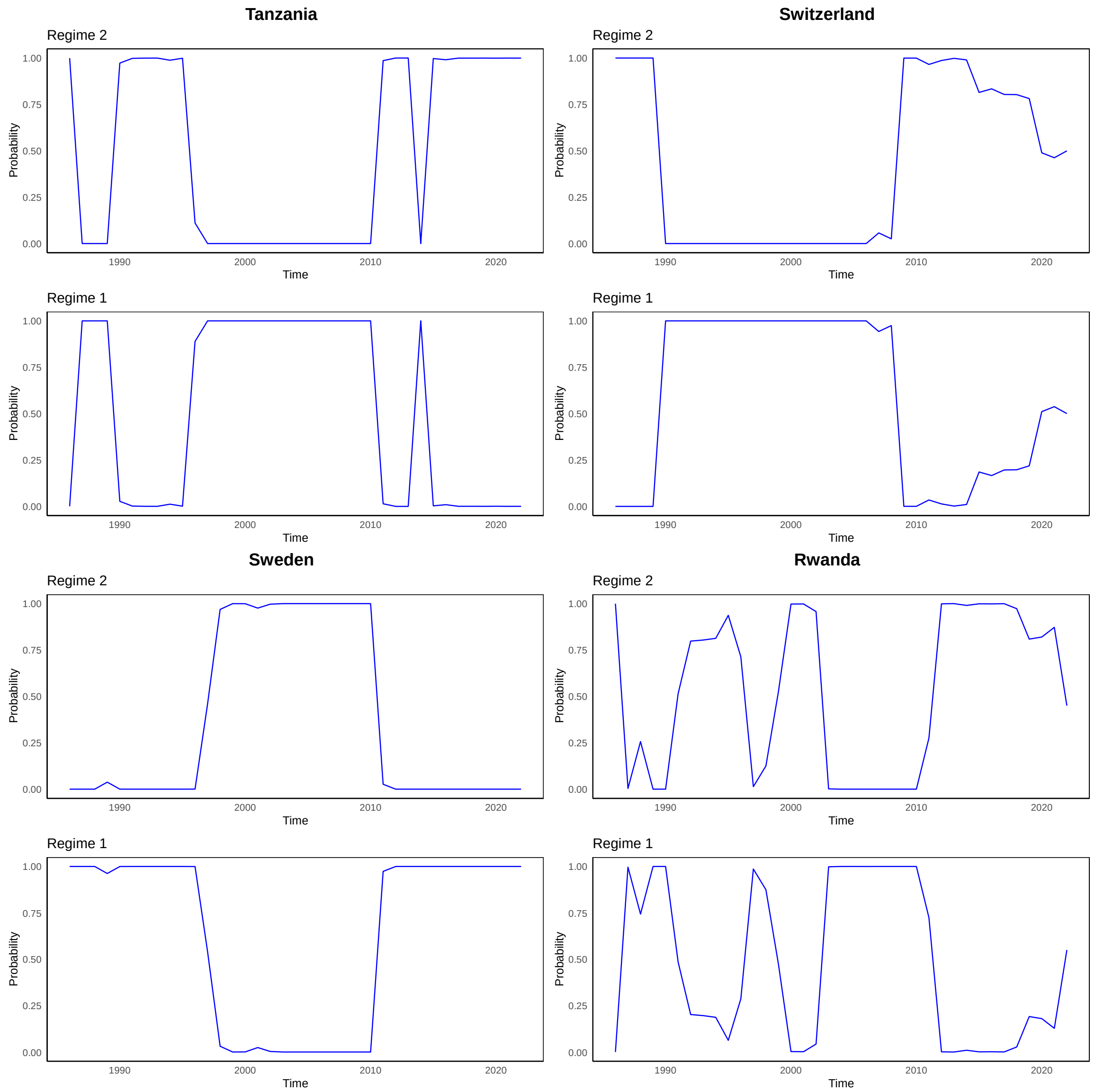
Note: *** and ** indicates significance at 1% and 5% levels respectively interaction exists between energy consumption and productivity growth across all the quantiles. Only in the case of currency devaluation did we have a one-way dynamic adjustment.

Figure 2 below shows the Markov switching regression charts for oil-importing countries. The majority of the countries showed volatility clustering, according to the time series plot of each country's cross section. Hong Kong has some of the least annual fluctuations in all the variables considered in this study when compared to other oil-importing nations.

Table 13: Quantile Granger causality test results for productivity growth of oil-importing countries

Variable	[Q0.1-Q0.9]	Q0.1	Q0.2	Q0.3	Q0.4	Q0.5	Q0.6	Q0.7	Q0.8	Q0.9
$\Delta END(\tau) \rightarrow \Delta PROG(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta PROG(\tau) \rightarrow \Delta END(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta EXD(\tau) \rightarrow \Delta END(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta END(\tau) \rightarrow \Delta EXD(\tau)$	0.652	0.114	0.932	0.237	0.456	0.556	0.236	0.458	0.248	0.251
$\Delta EXD(\tau) \rightarrow \Delta PROG(\tau)$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\Delta PROG(\tau) \rightarrow \Delta EXD(\tau)$	0.291	0.345	0.677	0.490	0.568	0.249	0.365	0.332	0.897	0.334

Source: Authors' results using Eviews 13



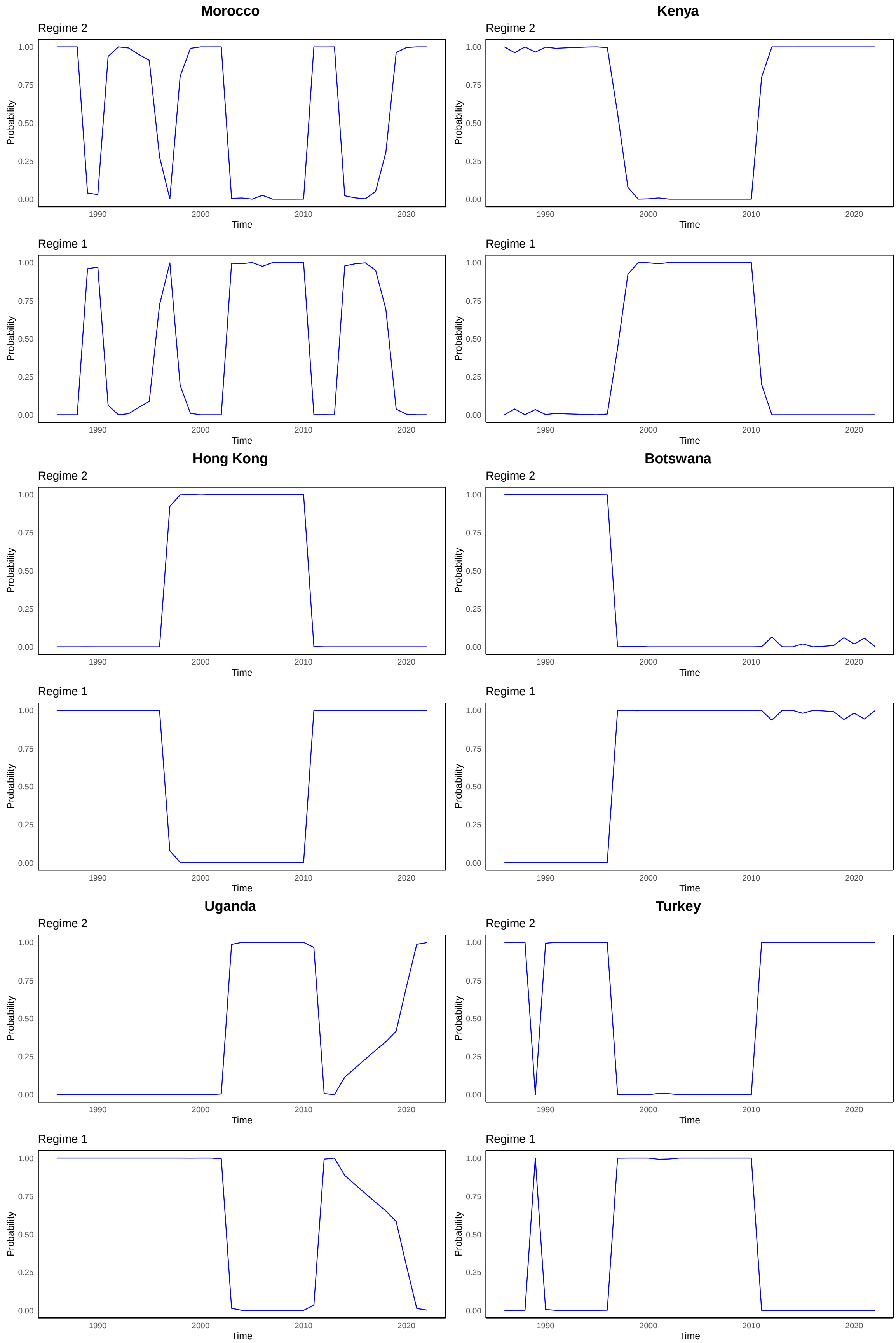


Figure 2: Markov Switching regression for oil-importing countries

Source: Authors' results using Eviews 13

4.1. Discussion

Although currency depreciation suggests that purchasing foreign products, such as industrial inputs, needs more units of the local currency (Ibrahim, 2021; Abdelhamid & Heba, 2019), Such depreciating variations constitute a crucial benefit of flexible exchange rates, as they enable variations in the relative values of different national currencies. As a result, foreign items become less affordable when the value of their respective currencies appreciates. Regretfully, the persistent depreciation of local currencies appears to have created the illusion of higher relative rates in developing African countries. Accordingly, changes in currency rates have an impact on productivity, especially industrial production levels. In African nations, these variations typically take the form of devaluation. The productivity growth rate of oil-importing countries can only be predicted by the significant positive values of energy consumption at the first and second regimes over the previous one, two, three, and four years. This finding does not align with the findings reported by De Schryder et al. (2020), where energy consumption in oil-importing countries was reported to have fallen as a result of local currency depreciation. Given that energy has a limited supply, the demand for it may have an impact on the value of exchange rate depreciation. The need for energy, which may be used to generate electricity during production and provide a favourable environment for industrialization in both oil-producing and oil-importing countries, is a significant variable that is influenced by differences in income and currency rates. Energy demand's value may vary depending on how well-liked and accepted it is. Positive advances in legislation, effective technological advancements, or more adoption by merchants or financial institutions can all cause the price of energy consumption to increase. On the other hand, trade may drop due to security flaws or regulatory restrictions that make it unlawful. Similar to other investments, market adjustments may affect the demand for energy. In a home economy, the price of different energy sources can be purposefully adjusted. In the near term, these influences and adjustments have the potential to cause significant, rapid swings in price and can occur independently of currency movements.

Changes in exchange rates have an adverse effect on the demand for energy since prices in this market are set by the actions of buyers and sellers. Since the majority of energy consumers and suppliers are located in other nations, the relative strength of the local currency will have an immediate impact on energy demand and prices. Investors are looking for safer areas to keep their money. Energy demand may increase as a result of poorer profits on currency markets brought on by exchange rate depreciation. It was discovered that there was a positive correlation between energy changes and income differences in performance. The need for energy is a component of the highly specialized manufacturing that makes all economic sectors viable. It was shown that exchange rates might fluctuate without reference to the price of energy. Energy demand is not correlated with any national currency since it is decentralized and operates independently of the financial system. Consumption and supply dynamics undoubtedly affect energy consumption. Compared to the enormous forex market, energy usage and trade volume are negligible. Governments, banks, and corporations trade large sums of money in the foreign currency market. There was no evidence of a substantial correlation between income differences and the adjustment of energy consumption. Although in a distinct economic setting, short-term correlations between energy consumption, exchange rate depreciation, income disparities, and the inflation rate have been noted. It has been shown that disparities in income respond to changes in energy consumption. During times of extreme volatility, institutional investors and hedge funds may employ arbitrage opportunities or trading strategies that take into account both energy demand and income differentials. Changes in energy consumption might have an impact on income disparities as a result of these transactions. The lack of a correlation between income disparities and exchange rate depreciation in oil-exporting nations implies that the main factors influencing these nations' currencies are OPEC-set oil prices, external shocks from imports, and global economic trends importing oil as the main source of energy. Variations in the price of commodities, changes in the world economy, and differences in interest rates, financial crises, and investor risk aversion can all have an impact on currency prices. Volatility in energy demand can also be caused by changes in political dynamics or uncertainty, as investors may reposition themselves in reaction to perceived threats.

5. CONCLUSION

The dynamic adjustments between energy demand and productivity growth were investigated using exchange rate depreciation as a moderating factor in this research. Among other things, the estimated quantile models offer a helpful framework for analyzing the impacts of altering the rate of global energy expansion in relation to production capacity as well as the impact of altering production with respect to energy consumption in 10 oil-importing countries. The model demonstrates significant positive dynamic interactions between energy demand and productivity growth despite fluctuations in exchange rates (devaluation) in oil-importing countries. The significance and influence of energy consumption on productivity were highest in the median percentile, with a magnitude of 31.8 percent. Productivity growth had the biggest influence on energy demand at the 10th percentile. The study established that a 40 percent rise in energy consumption was a result of a percentage rise in productivity.

Based on the features of the short-term effects of the energy demand shock on the exchange rate market, investors and policymakers may decide what to invest in and how to modify policies. It is advised that policymakers in all nations with exchange rates take precautions to guard against the detrimental consequences of sudden shocks, given the short-term behaviour of exchange rates after oil shocks. To lessen the negative effects of shocks on energy demand, a stable economic environment is crucial. Monetary policymakers and central banks should focus more on curtailing the immediate effects of shocks to the energy supply, which cause incessant disruptions in consumption of the same. In addition, exchange rate devaluation should be curtailed by appropriate intervention measures. As a course of action, encouraging investments in renewable energy is advised for the set of countries covered by the study. These economies are still in the early stages of development and are somewhat removed from the industrialised world's technical cutting edge. It is important to create sustainable resources to meet energy demands and mitigate the effect of rising oil prices on food inflation. A sustainable energy transition can boost a nation's economic output. Every nation should create measures to guarantee a secure and reasonably priced transition to sustainable energy (Khan et al., 2022). Governments could create an inclusive environmental and economic energy strategy and offer incentives for green and renewable energy by waiving a percentage of the prices (Khan et al., 2021). By guaranteeing the substitution of comparatively clean and alternative energy resources for conventionally utilised energy resources, governments should diversify their energy demands (Dagar et al., 2021b; Murshed et al., 2021). Also, governments of oil-importing nations should improve their oversight and control functions over the import of foreign hot money in order to stop external shocks from the energy market that could disrupt the productivity of developing countries. Due to its impact on the real sector and all other economic sectors, research on energy demand is market research that requires all empirical attention. Hence, there is a crucial need to do comparable research on issues related to energy demand and sectoral productivity growth in emerging countries.

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