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HETEROGENEOUS DEPENDENCE OF OIL-FOOD PRICE DYNAMICS IN AFRICA'S NET OIL-EXPORTING COUNTRIES

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Abstract. *The determinants of food prices have attracted sizeable debates among scholars over the last three decades. However, many of these studies ignore the possibility that the impact of oil prices on food prices could vary across the food price distribution. The paper employs a quantile regression technique to ascertain whether food prices respond to the potential heterogeneous impact of crude oil price changes in the six selected African net oil-exporting countries. The coefficient of negative oil price shocks in the panel OLS model is insignificant and positive at the 5% significance level. In contrast, the coefficient of positive oil price shocks significantly affects food prices for the chosen African countries. The quantile regression analysis's empirical findings highlight the diverse dependence effects of various ranges on food prices. All coefficients are non-significant across all quantiles for negative oil price shocks, a conclusion consistent with panel least squares estimate results. Besides, the findings prove that positive changes in oil prices significantly affect the magnitude of food prices in selected African countries. The article concludes that the influence of crude oil price variations on food prices is diverse and positive across quantiles for a subset of Africa's net oil-exporting countries. The findings of this study could have a crucial policy and economic implications for economic agents and stakeholders in diverse fiscal environments. As a result, economic agents must make timely decisions to respond to the effects of oil price uncertainty on Africa's food market.*

Key words: *Oil prices, Food prices, Heterogeneity effects, Quantile regression, Africa*

JEL Classification: Q17, Q41, O55, C33

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1. INTRODUCTION

Global household food prices have generated headlines and raised public anxiety in the aftermath of the COVID-19 pandemic. Africa is particularly vulnerable to the COVID-19 pandemic consequences on four fronts: rising food costs, increasing gasoline prices, decreased tourism earnings, and possibly increased barriers to accessing foreign capital inflows. Recent data indicates that COVID-19 pandemic has resulted in skyrocketing domestic gasoline prices and a significant increase in consumer food prices, albeit perceptions differ across Africa. Indeed, rising food and oil prices have begun to trickle down to domestic consumer prices, as retailers, unable to absorb the additional costs, have passed them on to customers. Energy costs are increasing, putting a strain on the entire food chain. Food prices may rise as demand for oil increases, as it is required to operate agricultural equipment, transport agricultural inputs and produce, and meet end-user demand. Similarly, expenditures associated with food imports would result in outflows during periods of rising oil prices, exerting upward pressure on domestic food prices. Several oil-producing countries have adversely affected agriculture, notably Nigeria, due to increased food costs, severe weather, and reduced farming operations. As a result, crude oil prices are a substantial source of volatility in food prices, and there are serious worries about the domestic policy space available to sustainably solve these problems. As a result, it is necessary to assess the impact of the diverse reliance on oil and food price dynamics in selected African nations.

Nevertheless, a slew of research has concluded that the price of crude oil has a considerable effect on food prices (see Alghalith, 2010; Ciaian & Kances, 2011; Kyung & Jeong, 2011; Peri & Baldi, 2012; Nazlioglu & Soytas, 2012; Baumeister & Kilian, 2013; Pal & Mitra, 2018; Koirala et al., 2015; Nicola et al., 2016; Jadidzadeh & Serletis, 2018; Taghizadeh-Hesary, Rasoulinezhad & Yoshino, 2018). Baumeister and Kilian (2013) argue that oil price changes drive food prices. In contrast, studies such as Reboredo (2012), Gardebroek and Hernandez (2013), Zhang and Chen ((2014), and Fowowe (2016), amongst others, confirm neutrality between oil prices and food prices. Another viewpoint focuses on the transmission mechanism between crude oil and food prices, which operates continuously in diverse phases. Also, recent studies like Ibrahim (2015), George and Ogede (2020), and Adeosun, Olayeni, and Ayodele (2021) employ NARDL methodology to gauge the asymmetries effect of changes in oil prices on explanatory variables. These studies provide conflicting outcomes. Thus, an unexpected surge in the actual cost of oil was mirrored by deliberate increases in agricultural output prices in the United States (Baumeister & Kilian, 2013). Also, Adeosun et al. (2021) establish a significant oil-food relationship that changes across frequencies. The authors also contend that oil price behaviour may have exhibited structural breaks, suggesting reasons for gauging the distributional effect of oil price shocks. The inconsistent outcomes regarding the oil price and food price debates raise questions about how much intensifying oil prices can explain the increase in food prices.

While empirical evidence suggests that asymmetric reactions exist in oil prices and inflation (George & Ogede, 2020), the empirical evidence for the link between oil prices and food prices appears to be mixed. Methodologically, the literature reveals numerous explanations for various outcomes, ranging from estimation techniques, sample scope, campaigns for substitute energy sources, and monetary policies. Besides, the current study contends that these empirical outcomes may be biased, assuming that the distributional heterogeneity of food price returns is ignored. In theory, oil-food price shocks significantly impact society since food accounts for a more significant proportion of poorer customers' demand; a global increase in food prices substantially influences inflation in poorer countries. The same can be said for energy prices, which have skyrocketed. Rising food and oil prices on trade terms vary by nation. However, it has been positive in nearly half of the oil-producing countries, particularly those exporting commodities. The impact varies by the economic group; for example, farmers who grow and export commodities may benefit, but urban consumers who use imported food and oil may suffer. Hence, given the significance of oil-food debates and the current happenings amid COVID-19, it is expedient to examine whether crude oil price changes drive food price changes in Africa and whether the effects vary across time and the distribution of food prices in Africa.

Given the preceding, the policy thrust of this study is to gauge the heterogeneous dependence of oil-food price dynamics in the net oil-exporting countries. These countries include Algeria, Angola, Gabon, South Africa, Egypt, Morocco, and Nigeria. These countries also import refined products made from crude oil (Ogede, George andAdekunle, 2020), and their primary source of revenue is crude oil exports. In combination with the COVID-19 pandemic, the fluctuating oil prices are a danger to these countries' consumer pricing (Ogede, 2020a). Besides, the current events have crippled economies and shattered livelihoods, rendering food and health services exorbitant or inaccessible. Thus, to our knowledge, the quantile regression model has been validated in studies such as Mehnatfar, Khanian, and Azari (2018), Lahiani (2018), Nusair and Olson (2019), Ogede (2020a), and Ogede and Adegboyega (2021) that examine inflation and exchange rate behaviour in response to changes in oil prices. For example, Ogede (2020a) established a significant disparity in the magnitude and sign of the inflation returns. Nevertheless, there is a dearth of empirical literature demonstrating a link between oil price changes and food prices in Africa using a quantile regression model approach.

This study contributes to the body of knowledge in two ways. To begin with, it studies the influence of oil price variations on food prices in a grouping of Africa's net oil exporters: Morocco, Angola, South Africa, Egypt, Algeria, and Gabon, as well as Nigeria. Second, the study uses the quantile regression (QR) model to examine the effects of oil price fluctuations on the median and conditional dispersion of food prices using the quantile regression (QR) model. The essay examines how food prices fluctuate in response to variations in oil prices. The justification for using quantile regression on the equation of oil price changes is that QR can uncover the entire conditional dispersion of consumer price returns. As a result, the study assesses how oil price fluctuations affect food prices based on their location on the dispersion of food price returns. Finally, the study contributes to a deeper understanding of the discussion and serves as a policy document discussing well-being assessment and appropriate policy proposals for overcoming emerging oil-food price crises in the selected nations. The outcomes emphasize the varied dependence impacts of multiple quantiles of food prices. All coefficients are insignificant across all quantiles for negative oil price shocks, confirming the panel OLS results. Furthermore, it is established that increases in oil prices have a considerable impact on the scale of food prices in some African countries. The remainder of the study is structured as a review of pertinent literature. Section 3 presents a discussion of methodology and an examination of data sources. The findings are discussed in Section 4. Section 5 concludes the study and highlights the report's policy recommendations.

2. REVIEW OF THE RELATED LITERATURE

A plethora of literature has been documented regarding the oil price and food price debates. The review of the related empirical studies shows that the outcomes are diverse and renews the discourse on how much intensifying oil prices can explain changes in food prices. The first standpoint argues for the existence of linkages between oil prices and food prices (see Alghalith, 2010; Ciaian & Kances, 2011; Kyung & Jeong, 2011; Peri & Baldi, 2012; Nazlioglu & Soytas, 2012; Pal & Mitra, 2018; Jadidzadeh & Serletis, 2018; Taghizadeh-Hesary, Rasoulinezhad & Yoshino, 2018). For example, Taghizadeh-Hesary et al. (2018) employ a Panel-VAR model to investigate the interaction between food and energy prices in eight Asian economies. According to the authors, oil prices significantly impact food costs. Jadidzadeh and Serletis (2018) explore whether the market-driven shocks of global oil prices have affected global and US corn prices and whether the underlying market-driven volatilities in the global oil market account for changes in the overall US corn prices. In divergence to the empirical literature that confirms the existence of linkage, studies such as Reboredo (2012), Gardebroek and Hernandez (2013), Baumeister and Kilian (2013), Zhang and Chen (2014), Fowowe (2016), amongst others, confirm the neutrality concerning food-energy price dynamics. For instance, Zhang and Chen (2014) show that the grains index exhibits a substantial response to anticipated volatility in oil prices. Additionally, Fowowe (2016) reported a comparable outcome for the South Africa study. Additionally, numerous studies have found possible asymmetries involving oil and food prices by exploring NARDL, Markov switching, and VAR methodologies. Ibrahim (2015), Meyer, Sanusi, and Hassan (2018), and Adeosun et al. (2021) all indicate mixed results regarding food prices' relation to oil prices.

Meanwhile, there is no long-term relationship between decreased oil costs and lower food prices. Additionally, the model demonstrates no short-term asymmetry in food price behaviour, as the association between the waxing and waning in fuel-food prices is minimal. Using a panel vector autoregressive (PVAR) model, Taghizadeh-Hesary et al. (2018) examine the relationship between fuel and food prices rigorously and conclude that oil prices have a considerable impact on food rates in designated Asian economies. Recently, Adeosun et al. (2021) employed wavelet and Markov-switching techniques to investigate the oil-food price dynamics in Nigeria. Thus, to eliminate contradicting behaviour and adjust for disturbances near the edge of the wavelet impulses, the author used monthly data from 1995: M1 to 2019: M5. The data demonstrate that the direct response of oil price shocks to food prices shifted across frequencies, indicating that the immediate impact of oil price shocks on food prices predominated, with evidence of a slight spillover effect in the short term.

While there is substantial literature on the linear and non-linear effects of oil price variations on food prices, limited studies have been conducted to assess the nexus using the quantile regression technique. As a result of this lacuna, it is conceivable to estimate the heterogeneous dependency of oil price changes on food prices based on the location of food prices within the respective distribution following Lahiani (2018). The quantile regression model's advantages over many other techniques include highlighting discoveries that look minor throughout the whole sample year but are highly noteworthy when assessed partially with some sample space. It provides a temporary difference in the elasticity of the food price. Additionally, it is reasonable to anticipate that the food price index will be distorted (Lahiani, 2018).

3. METHODOLOGY AND SOURCES OF DATA

This study employs a quantile regression (QR) model to investigate the heterogeneous dependence on oil-food price dynamics in Africa's net oil-exporting countries following the work of Lahiani (2018), Nusair and Olson (2019), and Ogede (2020a). The net oil-exporting countries include Algeria, Angola, Egypt, Gabon, Morocco, and Nigeria. The study spans 19 years, from 2001 to 2019. The oil price is obtained from the OPEC Bulletin, while the food price index is calculated and sourced by the Food and Agriculture Organization (FAO). The food price index is also used to evaluate the monthly change in worldwide food costs for a basket of goods. These studies contend that the impacts of changes in oil prices differ across the distribution of inflation. Consequently, the paper structured the QR model as:

$$Z_r(Z_t|K_t) = K_t\beta_q \quad (1)$$

Equation (1) is modified to reflect oil-food prices interaction as:

$$z_r(FP_t|\Delta OP_t) = \alpha.(k) + \beta(k)\Delta OP_t + \varepsilon_t(k) \quad (2)$$

FP_t and ΔOP_t are the food price and oil price changes, respectively, at the time represented by *t*, and ε_t is the error term.

Thus, following Ogede (2020a), oil prices are segmented into negative and positive variations to analyze the asymmetric effect of oil-food prices on Africa's net oil-exporting countries. Besides, the monthly crude oil price sourced from OPEC statistical bulletins was transformed by modelling realized volatility. The realized volatility model is piloted by Andersen & Bollerslev (1998) and modified by Ogede (2020b) in gauging the monthly oil price volatility as specified in equation (3). These are in divergence to studies such as Baumeister & Kilian (2013); Avalos (2014); Fowowe (2016); Reboredo (2012); Ibrahim (2015); Taghizadeh-Hesary, Rasoulinezhad & Yoshino (2018), amongst others, that investigate the impact of oil price shocks on food prices. The monthly realized volatility (MRV) model uses squared intra-month returns to generate more true volatility measures, and it is structured as:

$$OP_t = MRV_t = \sum_{t=1}^{D} r_t^2 \quad (3)$$

where OP_t represents the oil prices at time *t*, MRV_t and r_t^2depicts the monthly realized volatility and intra-month returns at time *t*, respectively.

The equation is then integrated into to become equation (4),

$$q_r(FP_t|\Delta OP_t) = \alpha.(k) + \beta(k)\Delta MRV_t + \beta(\tau)\Delta Pos_t^+ + \beta(\tau)\Delta Pos_t^- + \varepsilon_t(k) \quad (4)$$

4. RESULTS AND DISCUSSION

This section explores and explains the empirical evidence about the diverse dependence of oil-food price dynamics in Africa's net oil-exporting countries. The analyses included a variety of econometric approaches, including panel unit root, ordinary least squares (OLS), and quantile regression (QR). Table 1 summarizes the results of descriptive statistics on changes in oil prices and the returns on food price indexes. As the standard deviations suggest, food and oil prices have been highly variable during the study period. According to skewness data, food prices and positive oil price changes are positively skewed, whereas negative crude oil price changes are negatively skewed. At the 5% significance level, all variables have Jarque-Beta (J-B) probability values less than the 0.05 critical value. Table 2 summarizes the results of the stationary tests and demonstrates the confirmation of stationary for the series.

Table 1 Descriptive Statistics

	lnFP_Ind	Neg_Shock	MRV	Pos_Shock
Mean	4.3411	-0.0319	0.6395	0.0362
Median	4.3355	0.0000	0.5744	0.0191
Maximum	4.7629	0.0000	2.9170	0.1959
Minimum	3.9466	-0.3109	0.0112	0.0000
Std. Dev.	0.2649	0.0605	0.5368	0.0441
Skewness	0.0337	-2.4547	1.5999	1.2112
Kurtosis	1.4952	9.1505	6.2476	3.9477
J-B (Prob.)	21.463 (0.000)	585.77 (0.000)	196.61 (0.000)	63.991 (0.000)

Source: Authors' Computation, 2021

Table 2 Panel Unit Root Test

Method	Statistic	Prob.**	Cross-sections	Obs.
Levin, Lin & Chu test	-2.31121	0.0104	4	901
Im, Pesaran and Shin W-stat +	-16.8519	0.0000	4	901
ADF - Fisher Chi-square+	260.422	0.0000	4	901
PP - Fisher Chi-square+	260.635	0.0000	4	905

Source: Authors' Computation, 2021

The nexus between food prices and changes in oil prices, negative oil shocks, and positive oil shocks in selected African net oil-exporting countries is presented in Table 3. The findings of the OLS are presented to illustrate the average influence of changes in oil price shocks on food prices and to compare them to the quantile regression (QR) of the selected nations, namely Algeria, Angola, Gabon, South Africa, Egypt, Morocco, and Nigeria. The coefficient of negative oil price shocks in the panel OLS model (0.198) is insignificant and positive at the 5% significance level. Additionally, the table illustrates that the coefficient of positive oil price shocks (-0.859) has a considerable negative effect on food prices in selected African countries. For the selected African countries, a negative oil price shock often forces these countries to offer incentives to purchasers to take the product off their hands due to concerns about storage capacity running out. The negative oil price shock may also necessitate a drop in crude oil export profits, further undermining the government's commitment to diversification through agricultural production growth and provision of agricultural subsidies. Additionally, the empirical data indicate that the overall direction of the coefficients change with quantile and are only minimally different from the OLS coefficients. The results of the regressive quantile model are depicted visually in Fig. 1a-c.

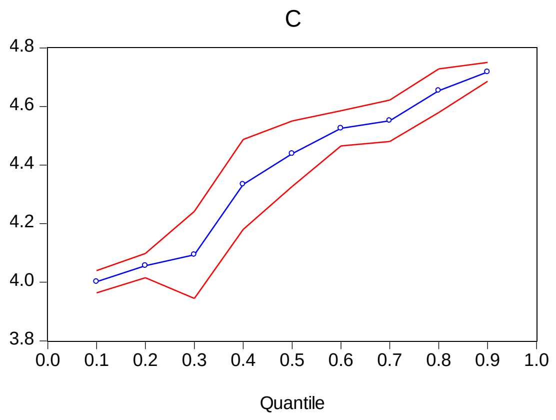

Fig. 1a Quantile Process Estimate of C

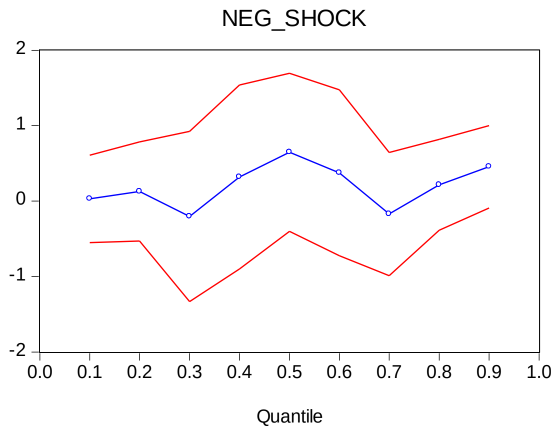

Fig. 1b Quantile Process Estimate of Negative Shock

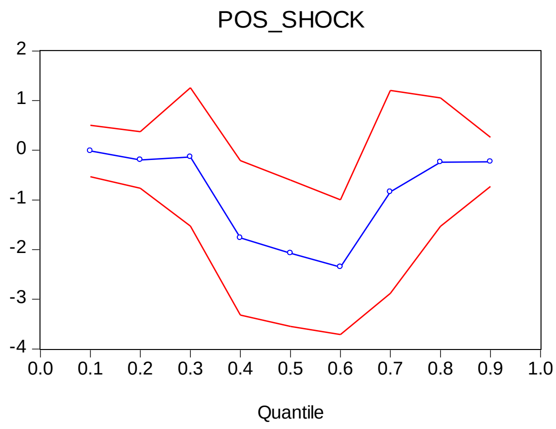

Fig. 1c Quantile Process Estimates of Positive Shocks

The indicator of positive oil prices (-2.0734) produces a negative and significant effect on food prices at the 10 per cent significance level. The coefficient of adverse oil prices (0.646) exhibits a positive and insignificant impact on food prices, revealing the asymmetric nexus in the selected African countries. The results further explain that a 1 per cent improvement in the median value of negative oil prices will translate into a 0.64 per cent increase in food price median value. A 1 per cent increase in the median value of a positive oil price shock will translate into a 2.07 per cent decrease in the median value of food prices.

Table 3 Ordinary Least Square and Quantile Regression Results

Variable	OLS		QR (Median)	
	Coefficient	Prob.	Coefficient	Prob.
Neg_Shock	0.198404	0.5392	0.646549	0.2255
Pos_Shock	-0.859670*	0.0533	-2.073452	0.0060*
C	4.378592***	0.0000	4.438553	0.0000***

Note: *Significant at 10%, **Significant at 5%, ***Significant at 1%.
Source: Authors' Computation, 2021

Table 4 establishes an essential distinction through the conditional distribution of food prices. It provides the results for the 10th to 90th conditional quantiles. The empirical findings of the quantile regression analysis point out the heterogeneous dependence impacts of various distributions on food prices. As shown in Table 4, all variables are insignificant throughout all distributions for negative oil prices, similar to the panel OLS results. The findings indicate a positive association between food prices and negative oil prices in the lower to higher quantiles of 0.10 to 0.90. Furthermore, the result shows that positive changes in oil prices positively impact the food price distributions in the selected African countries. The coefficients are insignificant across the quantiles except in the 0.40, 0.50, and 0.60 quantiles at the 1% and 5% significance levels, respectively. The outcome is in tandem with the empirical investigations of Adeosun et al. (2021), Lahiani (2018), Taghizadeh-Hesary et al. (2018), and Ogede and Adegboyega (2021). For instance, Adeosun et al. (2021) demonstrate that the immediate response of oil price changes to food prices shifted across frequencies. However, a fascinating question arising from our findings is whether the results are robust or varied. The paper compared OLS results, which gauge the overall impact, with conclusions from QR at each quantile. It is noted that the results diverge. The paper contends that the impact of crude oil price changes on food prices is heterogeneous and positive across quantiles for the selected net oil-exporting countries in Africa. Thus, the findings support the erstwhile extant studies that expose that oil price changes as crucial potential causes of soaring food prices (Baumeister & Kilian, 2013; Ciaian & Kances, 2011; Nazlioglu & Soytas, 2012; Jadidzadeh & Serletis, 2018; Taghizadeh-Hesary, Rasoulinezhad & Yoshino, 2018). Moreover, the quantile process estimates of positive and negative oil price shocks provide lower (0.10) and upper (0.90) quantiles, substantially different from zero. The results indicate that a considerable increase in food prices in response to oil price changes could help investors and policymakers plan ahead of shocks. The findings may require a domestic policy framework to strengthen the economic agents in different economic and financial circumstances. Specifically, the conclusion that positive and negative oil price changes positively affect food prices requires particular attention.

Table 4 Quantile Process Estimates

Quantile/ Variable	C			Neg_Shock			Pos_Shock		
	Coef.	t-Stat	Prob.	Coef.	t-Stat	Prob.	Coef.	t-Stat	Prob.
0.10	4.001	206.9	0.000***	0.295	0.101	0.919	0.265	-0.056	0.955
0.20	4.056	191.9	0.000***	0.335	0.383	0.703	0.291	-0.671	0.503
0.30	4.093	54.1	0.000***	0.575	-0.35	0.724	0.711	-0.190	0.849
0.40	4.333	55.4	0.000***	0.622	0.514	0.608	0.793	-2.224	0.027**
0.50	4.438	77.7	0.000***	0.535	1.209	0.228	0.752	-2.759	0.006*
0.60	4.525	148.4	0.000***	0.561	0.668	0.505	0.692	-3.398	0.001***
0.70	4.551	126.6	0.000***	0.416	-0.409	0.682	1.042	-0.805	0.422
0.80	4.653	122.5	0.000***	0.307	0.699	0.485	0.659	-0.365	0.716
0.90	4.717	287.5	0.000***	0.279	1.633	0.104	0.253	-0.923	0.357

Note: *Significant at 10%, **Significant at 5%, ***Significant at 1%.
Source: Authors' Computation, 2021

5. Conclusion and Policy Recommendations

This paper investigates the potential heterogeneous impact of oil price changes on food prices in six (6) net oil-exporting African countries, namely: Algeria, Angola, Egypt, Gabon, Morocco, and Nigeria spanning from 2001 to 2019. The study employs the food price index as a proxy for food and monthly oil prices to gauge the negative and positive oil price changes. The paper uses a quantile regression approach to address the potential heterogeneous impact of the oil price changes on food prices in six (6) African countries. The investigation yielded the following findings and conclusions. Firstly, the ordinary least squares and quantile regression (median) results on the connection between food prices and variations in oil prices shocks in selected African net oil-exporting countries. The coefficient of negative oil price shocks in the panel OLS model is insignificant and positive at the 5% significance level. In contrast, the coefficient of positive oil price shocks has a significant negative effect on food prices in several African countries. Additionally, the quantile regression analysis's empirical findings highlight the diverse dependence effects of various ranges on food prices. All coefficients are non-significant across all quantiles for negative oil price shocks, a conclusion consistent with panel least squares estimate results. Additionally, the result of the quantile regression establishes that positive changes in oil prices have a significant effect on the extent of food prices in selected African countries. The article argues that the influence of crude oil price variations on food prices is diverse and positive across quantiles for a subset of Africa's net oil-exporting countries.

The findings may have significant policy and economic consequences for economic actors and stakeholders operating in various socio-economic situations. For example, the reflection of the quantile process's lower (0.10) and upper (0.90) quantile estimates of positive and negative oil price shocks is significantly different from zero. The above provides helpful information to investors and policymakers about the possibility of a significant increase in food prices in response to oil price changes. The policy makers should also motivate the development of a domestic policy framework to strengthen economic agents in various socio-economic settings. Specifically, the findings that positive and negative oil price changes positively affect food prices require attention. Also, given the anti-inflationary characteristics of food, a portion of food or agricultural input subsidies should be provided to increase food production. Furthermore, fiscal and monetary authorities in these countries should change public policy measures to accommodate oil price reductions and reduce food prices. In addition, these nations have to develop a long-standing agricultural framework to protect the individual domestic economies against food crises induced by increased oil prices.

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HETEROGENA ZAVISNOST DINAMIKE CENA NAFTE I HRANE U AFRIČKIM ZEMLJAMA IZVOZNICAMA NAFTE

Determinante cena hrane su predmet rasprave među naučnicima u poslednje tri decenije. Međutim, mnoge studije zanemaruju mogućnost da uticaj cena nafte na cene hrane može da varira u zavisnosti od distribucije cena hrane. Ovaj rad koristi kvantil regresivnu tehniku da odredi da li cene hrane odgovaraju potencijalnom heterogenom uticaju promena cene sirove nafte u šest odabranih afričkih zemalja izvoznica nafte. Koeficijent negativnih šokova cene nafte u panel OSL modelu nije značajan i pozitivan je na nivou od 5%. Nasuprot tome, koeficijent pozitivnih šokova cena nafte značajno utiče na cenu hrane u odabranim afričkim zemljama. Empirijski rezultati kvantil regresivne analize naglašavaju efekte zavisnosti različitih rangova na cene hrane. Svi koeficijenti su ne-značajni preko svih kvantila za negativne šokove cena nafte, što je u skladu sa rezultatima panel procene najmanjih kvadrata. Osim toga, rezultati dokazuju da pozitivne promene u ceni nafte značajno utiču na veličinu cena hrane u odabranim afričkim zemljama. Rad zaključuje da je uticaj varijacija cene sirove nafte na cene hrane raznovrstan i pozitivan za odabrane afričke zemlje izvoznice nafte. Rezultati ove studije mogli bi imati važne političke i ekonomske implikacije za ekonomske činioce i donosioce odluka u različitim fiskalnim okruženjima. Kao rezultat, ekonomski činioci moraju da donose pravovremene odluke kako bi odgovorili na efekte neizvesnosti cene nafte na afričko tržište hrane.

Ključne reči: *cene nafte, cene hrane, efekti heterogenosti, kvantil regresija, Afrika*