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Oil price shocks and energy transition in Africa

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Abstract

When commodity prices rise in international markets, Africa's economic performance scarcely improves, and when commodity prices fall, its economic performance suffers substantially. This study examines the effect of oil price shocks on Africa's energy transition (ET). Data is obtained for 53 African countries between 2000 and 2020, with the Driscoll and Kraay and Panel VAR regression procedures used. The results reveal that oil price shocks have an adverse influence on Africa's ET, with the findings being strong in both rural and urban contexts. Furthermore, the results expose that the adverse effect is visible only in net crude oil exporting countries, whereas net oil importing countries have no significant effect. Moreover, oil price shocks cannot explain Africa's urban-rural differences in clean energy access. As policy implications, African policymakers should reduce the rural-urban gap in clean energy by investing more in clean energy and technologies in rural areas, which help enhance the resilience of the energy sector to oil price shocks.

Key words: Crude oil price shocks, energy transition; Panel VAR, Africa

1. Introduction

While Africa is rich in renewable energy resources, the pace of energy transition (ET) towards a low carbon pathway remains slow compared with the continent's development needs. More than in any other part of the world, some 970 million people in the continent lacked access to clean cooking energy sources in 2021 (IRENA and AfDB, 2022). The most popular solution in addressing the energy needs in urban areas is liquefied petroleum gas, but recent price increases have made it unaffordable for 30 million people in Africa, forcing many of them to return to using biomass as they have in the past (International Energy Agency, 2022). Africa must and should greatly increase access to suitable and affordable energy services in order to raise the standard of living of the continent's expanding population. Africa has a chance of becoming a worldwide player in the production and supply of renewable energy if it can identify the opportunities and begin positioning itself, given its enormous renewable energy potential (De Angelis et al., 2021; Achuo et al., 2022). Yet, this will necessitate a combination of strategic planning and investments in infrastructure, skills, and technology (Sokona et al., 2012; Carley and Konisky, 2020; Achuo et al., 2023).

Several studies have identified the causes of low ET in Africa, and some of these studies have gone as far as identifying the practical policies that can foster ET. One of the factors identified is the large renewable energy financing gap that still exists in the continent (Fotio et al., 2022; Schwerhoff and Sy, 2017; Chirambo, 2016; Mungai et al., 2022). The Scaling-Up Renewable Energy Program in Low-Income Countries (SREP) and the Clean Technology Fund (CTF) are examples of climate finance mechanisms that have an impact on enhancing the deployment of renewable energy in Africa (Chirambo, 2016). Also, internal financing mechanisms have been mobilized in literature including the effective use of natural resources and part of the resource rents allocated for investments in renewable energy projects (Nchofoung and Ojong, 2023).

However, the frequent negative oil price shocks at the international markets have put most countries, including African countries into distress in recent years (Baumeister and Kilian, 2016; Kilian, 2014). For instance, the price of oil, fell from a peak of $105 per barrel in 2014 to $37 per barrel in 2016. Achuo (2022) argues that these negative shocks are detrimental to environmental quality in Africa, because a fall in the standard of living following the negative shocks may push individuals and households towards the adoption of relatively cheaper unclean energy. Also, negative shocks raise the cost of capital, increasing the financing cost of firms (Prodromou and Demirer, 2022; Thorbecke, 2019). As the oil market experiences a slump, the incentives for environmentally cognizant investors will fall, which could lead to a decline in the value of environmental assets. In contrast, a rise in oil prices arouses incentives, thereby causing the share prices of eco-friendly companies to rise (Dutta et al., 2020). Conversely, Consumers' reactions would be reduced if they perceived rising oil prices as a temporary tax hike rather than a permanent one. Similar to prior times, businesses today may include energy price volatility in their planning and investments to reduce the impact of significant price swings on operations (Nordhaus, 2007).

Therefore, the purpose of this study is to examine how oil price shocks affect Africa's ET. Several factors motivate the choice of Africa as a case study. (i) African nations actively participate in global climate change debates. The continent has hosted five of the 27 COPs[1] as of 2023 (Morocco in 2001 and 2016, Kenya in 2006, South Africa in 2011, and Egypt in 2022). Via the African Group of Negotiators on Climate Change (AGN), which was established in 1995, African nations coordinate their participation. The AGN has supported a number of programmes related to agriculture, deforestation, financing for climate change, and adaptation (Naidoo and Gulati, 2022). The Nairobi Work Programme for Adaptation and the historic COP17 in Durban, where the

[1] COP is the acronym for "Conference of the Parties", which has since the first COP in 1995 brought together all states that are parties to the United Nations Framework Convention on Climate Change (UNFCCC) every year.

Durban Framework for Enhanced Action kicked off negotiations for the Paris Agreement that was adopted at COP21, were both spearheaded by AGN. The Kigali Amendment to the Montreal Protocol, which calls for phasing out the production of hydrofluorocarbons, a greenhouse gas that contributes to global warming, according to differing timetables for industrialised and developing nations, was also finalised with significant help from the AGN in 2016 (Balcilar et al., 2023). (ii) At the same time, African governments are committed to industrialization and inclusive growth, therefore positions the continent at a point of impasse; fighting for climate change and commitment at industrialisation and inclusive development that necessitate high energy use (Lyes Bouchene et al., 2021). (iii) Most African countries depend on commodity exports for their economic well-being and have little or no role to play in fixing the prices of these commodities at the international markets (Miamo and Achuo, 2022). Commodity prices and macroeconomic performance have an odd relationship in the continent. This may be seen in the fact that when commodity prices rise in international markets, the continent's economic performance scarcely improves, and when commodity prices fall, its economic performance suffers substantially (Nchofoung, 2022). Also, oil commodities constitute a major part of African commodities, with African economies strongly reliant on oil, both for transportation and energy, with many households and businesses outfitted with diesel generators. Any increase in the price of a barrel thus affects purchasing power, mobility, and energy demand. The following question is answered by this research: What effect do oil price shocks have on Africa's ET? The findings revealed that oil price shocks have an adverse influence on Africa's energy transition, with the effect being strong in both rural and urban contexts. Furthermore, the results revealed that the negative association was visible only in net crude oil exporting countries. As policy implications, African policymakers should reduce the rural-urban gap in clean energy by investing more in clean energy and technologies in rural areas, which help enhance the resilience of the energy sector to oil price shocks.

As the first study to examine how oil price shocks affect renewable energy in Africa, the study adds to the body of knowledge on the continent's ET. Such a study is important for the continent given that despite their heavy reliance on oil, they are price takers in the international market, thereby making investment decisions in both the energy and non-energy sectors very uncertain. Also, the study examines the effect of such shocks on closing the urban-rural disparity in access to clean energy in the continent, thus, integrating the concept of energy justice in the analyses. Besides, this study controls for possible endogeneity in the modelling framework using the GMM style in the panel VAR regression technique.

To meet this objective, the rest of this article is positioned around a literature review (section 2), data and methodology (section 3), results and discussions (section 4) and finally, concluding remarks and policy implications (section 5).

2. Review of related literature

The theoretical foundation on the economic impact of oil price shocks can be traced back to the renaissance growth theory proposed by Lee et al. (1995) as well as the symmetric/linear relationship theory propounded by Hamilton (1983,1886) and Hooker (1986). Hamilton (1983) argue that high energy prices boost the economic performance of energy-producing countries. He concluded that oil prices contributed to the past economic recessions in the United States prior to the 1972 oil price shock. This was supported by Hamilton (1996) and equally by the work of Kilian and Vigfusson (2017) who argue that oil price volatilities among others account for the reasons why the GDP of the United States drooped in the 70s and 80s. However, Lee et al. (1995) argue that while oil price volatility has an immediate effect on economic growth, the growth effects of oil price variations are only felt after a year. Nevertheless, Darby (1982) argues of no significant relationship between oil price shock and macroeconomic indicators, notably inflation and recession. He further contended that the non-significant effect of oil price shocks on inflation implies that oil price shock has no effect on the purchasing power parity of the households and thus, energy demand.

The debate regarding the empirical relationship between oil price shocks-ET nexus is still unsettled. For instance, Zhang et al. (2020) contend that, at larger oil shock quantiles, the effects of oil shocks on the accumulation of clean energy are asymmetric and vary across quantiles and investment horizons. Also, they establish that at both larger and lower quantiles of clean energy stocks, the consequences of the oil aggregate demand shocks are largely beneficial over the medium run. In the long-term, the effects of oil-specific demand shocks on equities are asymmetric at the higher quantiles of the stock market, Zhang and Shang (2023) supported this claim of asymmetry for Chinese automobile industries. On their part, Maghyereh and Abdoh (2021) posit that aggregate demand shocks is mostly felt in the long and intermediate terms, while oil supply shocks is experienced on the returns of clean energy enterprises in the short term. To research the effects of crude oil price variations on investment and outputs in the renewable energy sector, as well as the macro economic environment in China, Zhao et al. (2021) develop a recursive dynamic computable general equilibrium model. The findings show that a rising global oil price can boost renewable energy investments and outputs while lowering real GDP and exports and enhancing the environment. Murshed and Tanha (2021) for a sample of net oil-importing South Asian economies, simulate the renewable energy-crude oil price nexus. The findings indicate that, while initially higher crude oil prices do not encourage the use of renewable energy, they are likely to increase this consumption after attaining a certain threshold. Haque (2021) for the GCC countries, investigates the factors that influence energy consumption, focusing on the impact of sudden changes in the price of crude oil. Using both static and dynamic panel estimation methods, the study shows an adverse effect of oil price shocks and energy usage. Dutta et al. (2020) find that the influence of crude oil prices on environmental investments appears to be statistically inconsequential, despite being favourable in the majority of cases, using the Markov regime switching regression approach. Their findings also point to a transition between regimes of low and high volatility, suggesting that there are states of high and low volatility for green assets. They also establish that oil market volatility, rather than changes in oil price, is more likely to affect green assets.

On the other hand, the economic performance of the African countries that export oil is significantly impacted by oil price shocks, and the spread of oil prices follows the monetary system. As a result, anytime positive shocks in oil are experienced, severe monetary control measures should be implemented (Rotimi and Ngalawa, 2017). Examining this on the stock market, one would normally steer clear of stocks that are negatively affected by it (Enwereuzoh et al., 2021). The returns on stocks and the price of crude oil typically have nothing in common, African stocks offer opportunities for diversification during times when the price of crude oil shocks other stock markets. African stockpiles provide protection from fluctuations in the price of oil at the global level (Asafo-Adjei et al., 2021).

Despite the growing body of literature with regard to the oil price shock and ET, highlighted extant studies largely fail to empirically investigate the effect of oil price shocks on ET in Africa. Also, no extant literature has investigated the effect of oil price shocks on energy justice. This study fills this knowledge gap by empirically examining the effect of crude oil price shocks on the adoption of renewable energy in Africa. Besides, the study verifies the possibility of oil price shocks in influencing the urban-rural energy gap in Africa.

3. Data and methodology

3.1. Data and description of variables

The data for this study are collected from several sources. The data on Crude oil prices are collected from British petroleum and the rest of the variables are from the World Development Indicators of the World Bank. The data is collected for 53[2] African countries between the years 2000-2020. The choices of countries and periods of study are based on the availability of relevant data on the subject. In essence, the relevant data on renewable energy for African countries are available for this period by the time this study was conducted.

3.1.1. Dependent Variables

The dependent variable is renewable energy transition (ET), which is proxied at first by the percentage of population which has access to clean fuels and technologies for cooking in the economy (ET_total), then further by percentage of population in the rural areas with access to clean fuels and technologies for cooking (ET_rural), also by the corresponding percentage in the urban areas (ET_urban) and finally by the Urban-rural gap in Access to clean fuels and technologies for cooking (%population) (ET_gap). Similar approaches have been used in extant literature to measure ET, including the study of Acheampong et al. (2023). Figure 1 shows the average trend of energy transition in our sample.

Figure 1. Trend of Energy transition in Africa

[2] The only sovereign African country left out is South Sudan due to the non-availability of relevant data on our study period.

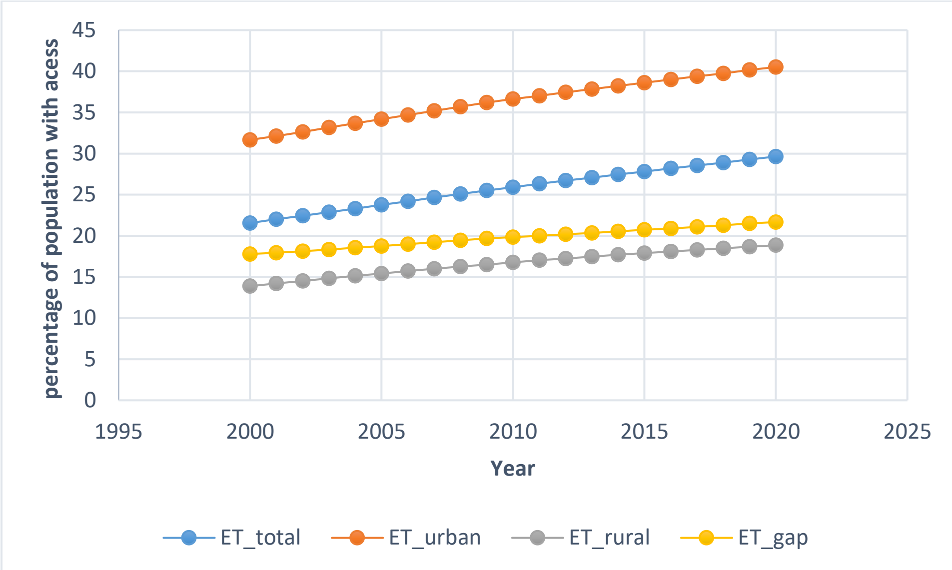

Figure 1 shows that, on average, those living in urban areas have greater access to clean fuels and cooking technologies than those living in rural areas; additionally, the urban-rural gap in access to clean fuels and cooking technology exceeds the actual proportion of the rural population that uses clean energy.

3.1.2. Independent variable of interest

The independent variable of interest is crude oil price shock. This is captured by the cyclical component of the crude oil price, obtained using the Hodrick–Prescott (HP) time-series filter (Hodrick and Prescott, 1997). This filter can be thought of as a Mean Square Error (MSE)-optimal trend signal extractor in a smooth trend model. In this regard, oil price evolution is the sum of the cyclical component (C) and the trend (growth) component (W) as in equation 1.

$$Oil\_Price_t = C_t + W_t \qquad (1)$$

The Mean Square Error (MSE)-optimal trend signal extraction procedure thus involves minimising the variance of the cyclical component subject to a penalty of the variation of the second difference of the growth component, with a given smoothing parameter. The cyclical component of the oil price is therefore a shock and the objective is that in the long run, this component turns to zero, since it represents the gap between the oil price and its growth (or trend) component. Figure 2 shows the evolution of crude oil price and its trend and cyclical components after the application of the HP filter.

Figure 2. Crude oil price and its filtered components

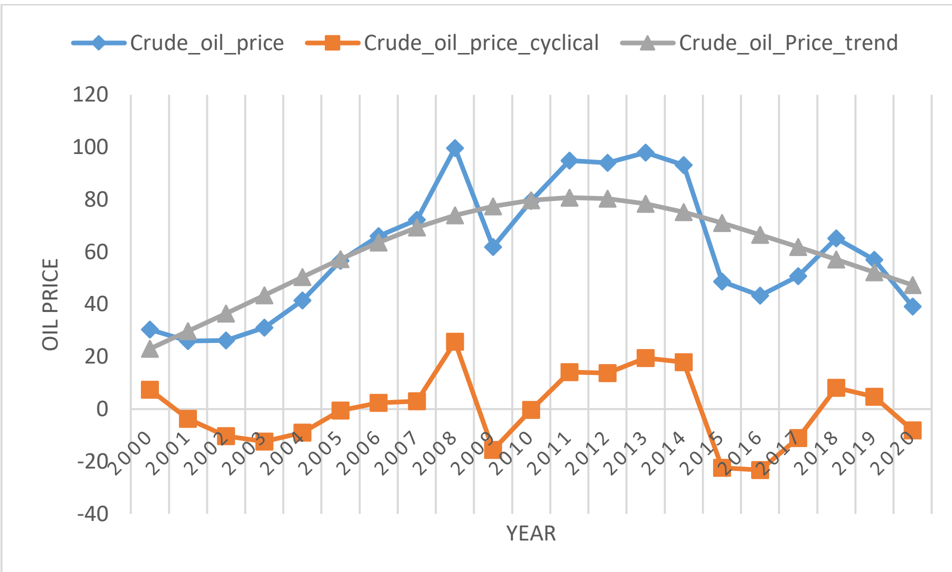

Figure 2 reveals that although oil prices remained low and relatively stable in the early 2000s, they started fluctuating greatly since the mid-2000s, reaching all-time highs in 2008. The observed recurrent variations in oil prices can be blamed on a plethora of factors including demand and supply imbalances (Li et al., 2019; Fueki et al., 2021), monetary and fiscal policy (Gong et al., 2021), the quality of crude oil produced and geographical location of oil wells (Forgha et al., 2015), political instability and manipulation of oil data (Akinsola and Odhiambo, 2020). For instance, the respective oil price increase and decrease in 2008 and 2014 were largely due to demand and supply imbalances (Li et al., 2019). Nevertheless, the recent fall in oil prices since 2020 has equally been blamed on demand and supply imbalances resulting from the outbreak of the COVID-19 pandemic (Gong et al., 2021).

3.1.3. Control variables

Based on related renewable energy literature, several control variables are considered. Following the study of Wang and Zhang (2021), who claim that the influence of trade openness on renewable energy is beneficial in high-income economies and turns to be negative as we head towards low-income countries, trade openness is included in the model as a control variable. In a nutshell, foreign aid and foreign direct investments, if directed towards the energy sector, are equally accessible sources of financing for renewable energy in Africa (Fotio et al., 2022). The next control variable is financial development, which is proxied by the domestic credit to the private sector (%GDP). The variable is expected to produce a positive sign in accordance with the study of Shahbaz et al. (2021), who argue that financial development enhances renewable energy development in developing economies. The control variables are limited to those highlighted because the introduction of other potential control variables like economic growth led to a problem of multicollinearity in the model.

Table 1 summarises the variables of the model, while the corresponding correlation matric is presented in appendix 1.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Access to clean fuels	1092	25.772	33.041	0.1	100
Rural Access to clean fuels	1092	16.616	30.768	0	100
Urban Access to clean fuels	1092	36.373	36.99	0.2	100
Trade openness	990	71.527	39.318	.757	347.997
Foreign direct investment	1090	4.366	7.856	-18.918	103.337
Financial development	987	21.51	23.132	0	142.422
Foreign aid	1082	8.107	8.967	-.251	92.141
oil price	1113	60.737	24.295	25.98	99.67
oil price shock	1113	0	20.082	-27.957	37.64
Urban-rural clean energy access gap	1092	19.757	22.350	-0.2	82

3.2. Model specification and estimation

Based on attendant literature on renewable energy transition in Africa (Fotio et al., 2022; Acheampong et al., 2023), the empirical model is specified as in equation 2.

$$ET_{it} = \beta_0 + \beta_1 Oil\_Price\_shock_{it} + \beta_j X_{it} + \upsilon_i + \varepsilon_{it}, i \neq j \quad (2)$$

Where, the dependent variable, ET is energy transition, β_k are the parameters to be estimated, oil_ price_shock is the oil price shock, in which the cyclical component of the crude oil price obtained from the HP filter, X is the vector of control variables at time t and country, υ_i is the country fixed effect, and ε_{it} is the stochastic error term. All the variables in the model are expressed in their logarithm.

In order to test for cross-sectional dependence before choosing a regression method, Pesaran's (2015) test for weak cross-sectional dependence is employed. This is preferred because the weak dependence null hypothesis is more acceptable than the independence null hypothesis, which could be rather constrictive for big panels (Pesaran, 2015). Typically, cross-sectional dependence is attributed to the impact of certain unobserved common characteristics that are shared by all the countries, such as globalisation, and have an impact on each of them, possibly in different ways. To correct for this cross-sectional dependence, the second generation unit root test is further applied, with the null hypothesis that assumes that all series are non-stationary (Pesaran, 2007). The second generation of panel unit root tests eliminates the first generation's strict requirement that cross-section units be cross-sectionally independent and permit cross-sectional dependence. In order to estimate equation 1, the fixed effect Driscoll and Kraay (1998) standard error correction is employed in the first place to address any potential cross-sectional dependence that might arise between the panels as a result of the economic co-movements of shocks across different economies. The study further adopts the panel VAR using the GMM style, set up by Abrigo and

Love (2016), correcting for possible sources of endogeneity in the model. The impulse-response functions (IRF) and the forecast error variance decomposition (FEVD) analyses are the two structural components of the panel VAR. The IRF holds all other shocks to zero and describes how one variable responds to a shock in another variable within a system (Love and Zicchino, 2006), with confidence intervals produced by Monte Carlo simulations provided to IRF. For the African economy, Nchofoung (2022) recently used the method to verify the response of SSA economies to commodity terms of trade shocks, while Miamo and Achuo (2022) used it to verify the effect of oil price shock on economic growth in the same sub-region.

4. Results and discussions

4.1. Preliminary results

The results begin with the test of cross-section dependence (Table 2) and that of unit roots (Table 3).

Table 2. Pesaran (2015) test of weak cross-sectional dependence

Variable	CD-test	p-value	Mean ρ	mean abs(ρ)
Access to clean fuels	53.172	0	0.31	0.76
Rural access to clean fuels	8.026	0	0.05	0.66
Urban access to clean fuels	27.324	0	0.16	0.73
Trade openness	17.298	0	0.1	0.36
Foreign direct investment	7.846	0	0.04	0.26
Financial development	57.434	0	0.34	0.53
Foreign aid	17.346	0	0.11	0.32

Table 3. Pesaran (2007) Test of unit roots

Variables	P-value at level		Decision
	With trend	Without trend	
Access to clean fuels	0.020	0.001	I(0)
Rural access to clean fuels	0.000	0.0000	I(0)
Urban access to clean fuels	0.004	0.001	I(0)
Trade openness	0.013	0.019	I(0)
Foreign direct investment	0.009	0.000	I(0)
Financial development	0.000	0.000	I(0)
Foreign aid	0.000	0.000	I(0)
Oil price cyclical	0.0143	0.011	I(0)

NB: I(0) shows that the variables are integrated at level; P-value at level is the probability value of the test statistics at level.

Table 2 shows that all the variables of the model presents characteristic of cross-sectional dependence, while all the variables are equally stationary at level as apparent on Table 3.

4.2. Baseline results: Driscoll and Kraay (1998)

This section presents and discusses the results at first place through the Driscoll and Kraay (1998). Table 4 presents the results of the regression through the Driscoll and Kraay (1998) regression methodology.

Table 4. Driscoll and Kraay (1998) method

	(1)	(2)	(3)
	Total	Rural areas	Urban areas
VARIABLES	Dependent Variable: Access to clean cooking fuels and technologies		
Oil price shock	-0.0394*	-0.0317**	-0.0466*
	(0.0193)	(0.0146)	(0.0241)
Trade openness	-0.117***	-0.0832***	-0.130***
	(0.0165)	(0.0132)	(0.0178)
Foreign direct investment	0.0651**	0.0379***	0.0694**
	(0.0261)	(0.0131)	(0.0310)
Foreign aid	-0.00274	-0.00119	-0.000726
	(0.00318)	(0.00235)	(0.00316)
Financial development	0.192***	0.0764***	0.249***
	(0.0348)	(0.0184)	(0.0510)
Constant	29.24***	20.64***	38.62***
	(1.317)	(1.151)	(1.102)
Observations	869	869	869
Fisher	13.39***	8.700***	18.41***
R-Squared	0.5901	0.5796	0.5980

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 shows that a shock on crude oil prices has a negative effect on access to clean sources of energy and technologies for cooking, with the results robust in urban and rural areas, corroborating the results of Haque (2021). Also, trade openness and foreign aid present negative effects, with that of foreign aid non-significant. Financial development and foreign direct investment inflows on their part present positive significant effects. To further verify the robustness of the results, Table 5 presents the results in net oil exporting countries different from those of net oil importing countries. This is particularly important given that an increase in oil prices at the international market would benefit more economies that rely on oil exports and may render economies that import oil helpless.

Table 5. Comparing openness in the oil market

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Access to clean fuels and technology for cooking					
VARIABLES	Total	Rural areas	Urban areas	Total	Rural areas	Urban areas
	Net oil exporting countries			Net oil importing countries		
Oil price shock	-0.0821***	-0.0595**	-0.0944***	0.0192	0.0173	0.0237
	(0.0274)	(0.0209)	(0.0325)	(0.0126)	(0.0109)	(0.0159)
Trade openness	-0.225***	-0.149***	-0.254***	-0.0682***	-0.0594***	-0.0720***
	(0.0465)	(0.0439)	(0.0497)	(0.0124)	(0.0161)	(0.0136)
Foreign direct investment	0.169***	0.109***	0.126**	0.0236*	0.0138*	0.0174**
	(0.0495)	(0.0275)	(0.0535)	(0.0307)	(0.0195)	(0.0240)
Foreign aid	-0.00696	0.00275	-0.000786	0.000772	-0.00156	0.00345
	(0.0108)	(0.00699)	(0.0148)	(0.00267)	(0.00264)	(0.00347)
Financial development	0.136***	0.106*	0.383***	0.202***	0.131***	0.201***
	(0.0330)	(0.0521)	(0.0268)	(0.0282)	(0.0195)	(0.0383)
Constant	45.64***	35.50***	51.28***	20.99***	13.84***	31.62***
	(4.324)	(3.701)	(4.941)	(0.805)	(0.502)	(0.746)
Observations	299	299	299	570	570	570
Fisher	22.51***	9.508***	58.07***	39.71***	15.77***	40.43***
R-Squared	0.5300	0.5671	0.5428	0.6190	0.6211	0.5908

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results in Table 5 show that the negative effect of oil price shocks on energy transition is only feasible in net oil exporting countries, whereas, the effect in oil importing countries presents positive signs though insignificant. For the control variables, the signs are similar to those on Table 4. Also, it is worth noting that the magnitude of the negative effect coefficients is greater in the oil-exporting countries group than in the general results, further indicating the sources of this negative relationship. For the oil-exporting countries, the positive coefficients though non-significant are small compared to the rest of the results.

4.3. Robustness analyses through Panel VAR and Common Correlated Effects Mean Group (CCEMG)

Table 6. Common Correlated Effects Mean Group (CCEMG) regression

	(1)	(2)	(3)
		Dependent variable:	
VARIABLES	Access to Clean fuels	Rural access to clean fuels	Urban access to clean fuels
Oil price shock	-0.0144**	-0.0233***	-0.0311***
	(0.00711)	(0.00168)	(0.0103)
Trade openness	-0.0424**	-0.00998*	-0.0791***
	(0.0205)	(0.00587)	(0.0296)
Foreign direct investment	0.0150***	0.0117***	0.102***
	(0.0475)	(0.0010)	(0.0060)
Foreign aid	-0.00174	-0.00527	-0.0199
	(0.00861)	(0.00588)	(0.0171)
Financial development	0.253***	0.00173	0.261**
	(0.0885)	(0.0143)	(0.104)
Constant	25.80***	14.32***	37.02***
	(4.823)	(4.410)	(7.813)
Observations	857	857	857
chi2	13.99**	15.743**	18.88**

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 3. Impulse responsive function for Africa

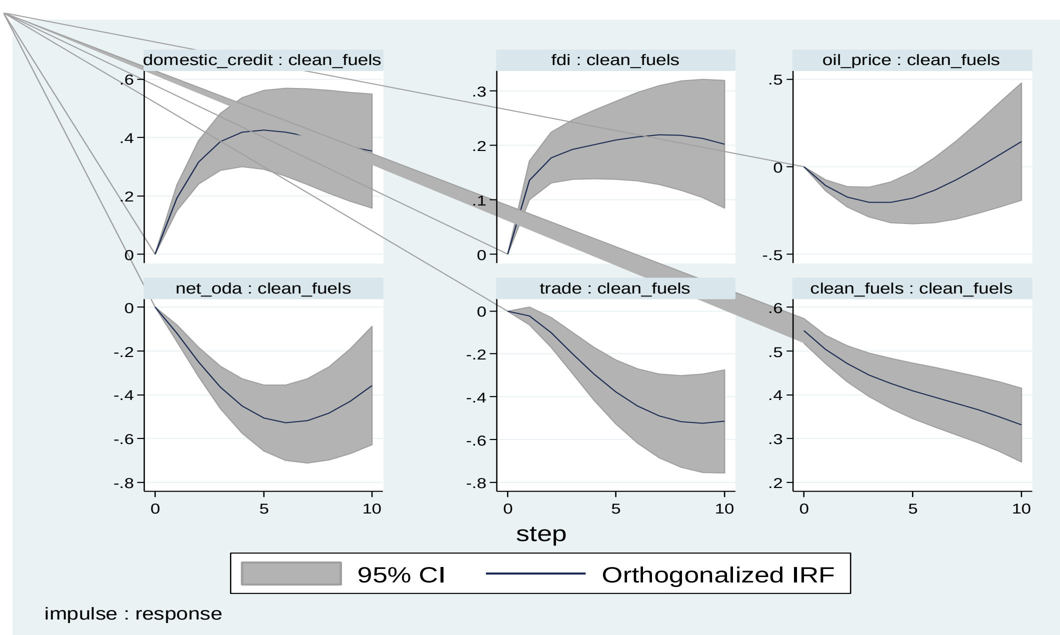

Figure 4. Impulse response function for rural clean energy access

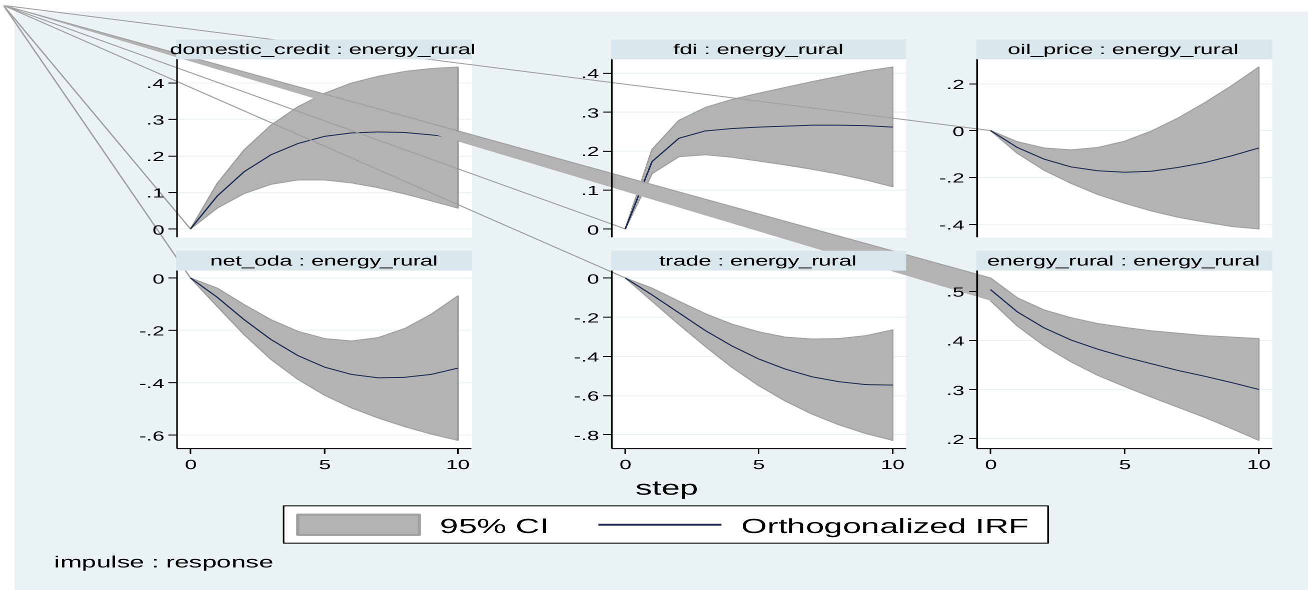

Figure 5. Impulse response function for urban clean energy access

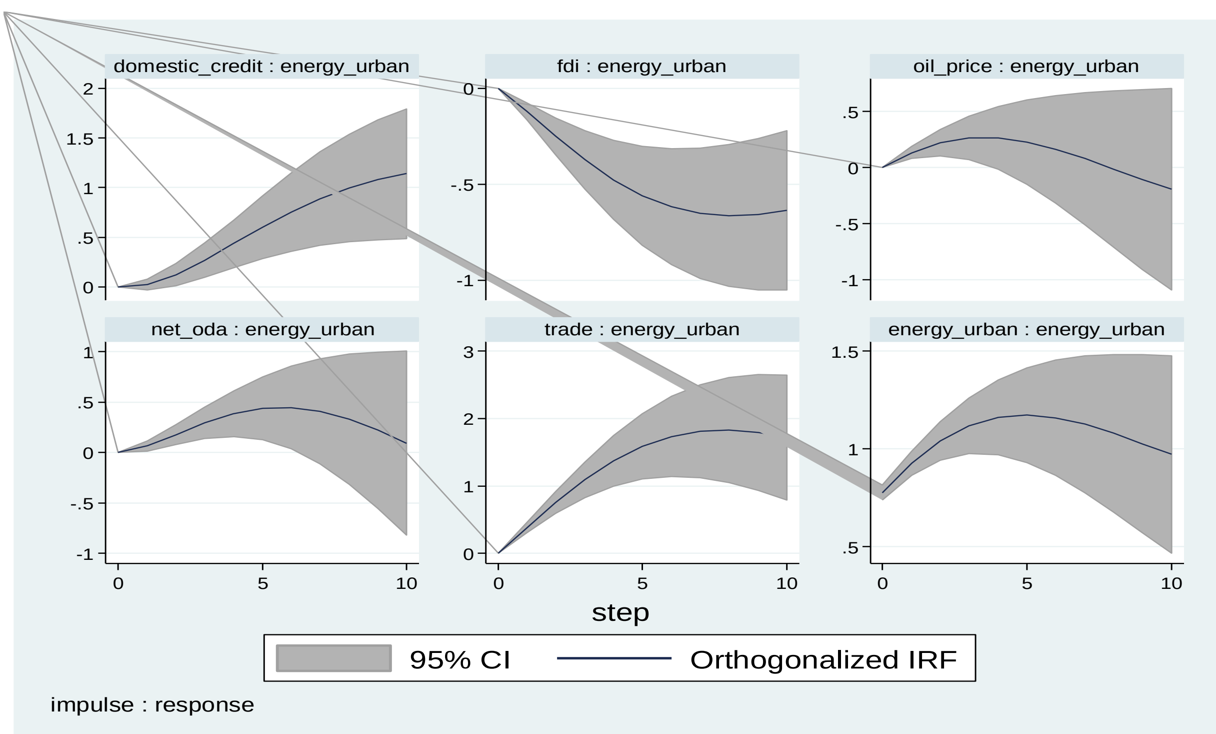

Table 6 and Figures 3, 4 and 5 show that the negative effect of oil price shocks on energy transition is robust even when CCEMG and the panel VAR methods are applied. This result is equally robust with these methods in both the urban and rural settings. The results of the PVAR are stable as apparent in appendix A2, with all the Eigen values within the unit circle. Furthermore, when the effect of the oil price shock is differed by a period as presented in appendix A 5, the negative effect of the oil price shock on energy transition is still present. However, the magnitude of the negative effect is smaller in the differed effect, demonstrating that, policies are always put in place to counteract negative shocks such that the effects are attenuated in the long-run.

4.4. Do oil price shocks reduce injustice in renewable energy access?

To check whether oil price shocks affect the disparities in access to clean energy and technologies in Africa, the model is specified as in equation 3:

$$disparity_{it} = \beta_0 + \beta_1 oil\_price\_shock_{it} + \beta_j X_{it} + \upsilon_i + \varepsilon_{it}, i \neq j \qquad (3)$$

Wherein, disparity is defined as the gap between urban and rural residents' accessibility to clean fuels and cooking methods and the other symbols and variables are as defined in equation 2. Moreover, oil price shock mitigates disparity if $\beta_1 < 0$. Otherwise, it increases it. Table 7 presents the results of this disparity.

Table 7. Urban Rural Disparities in Access to clean energy

	(1)	(2)	(3)
	Dependent variable: Urban-Rural Clean energy access gap		
VARIABLES	Africa	Net oil exporting countries	Net oil importing countries
Oil price shock	0.0149	0.00524	0.00648
	(0.00977)	(0.0492)	(0.00455)
Trade openness	-0.0468***	0.102***	-0.0126**
	(0.00568)	(0.0103)	(0.00564)
Foreign direct investment	0.0315	-0.350*	0.0312
	(0.0387)	(0.191)	(0.0202)
Foreign aid	0.000467	0.0281	0.00501*
	(0.00300)	(0.0330)	(0.00272)
Financial development	-0.173***	-0.274***	-0.0699***
	(0.0388)	(0.0327)	(0.0211)
Constant	17.98***	18.13***	17.78***
	(0.485)	(4.464)	(0.398)
Observations	869	299	570
Fisher	27.01***	67.71***	12.36***
R-Squared	57.050	52.103	68.420

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 shows that the effect of oil price shock on rural-urban disparity in renewable energy access is non-significant though positive. In reality, oil price shocks affect the national economies as a whole and not only the urban or rural areas. For instance, an increase in inflation as a result of oil price shocks affects the purchasing power in both the rural and urban areas. The oil price literature argues that the mechanisms through which oil price shocks affect the macroeconomic environment is mostly through exchange rates and inflation (Nordhaus, 2007). Following this author, there won't actually be a multifactor productivity response to price changes in a world where technological development is exogenous; the only reaction is substitution along a certain technological frontier. This is typical of the African economy, given that their green technologies are exogenous to these economies.

4.5.Further discussion of results

The negative effect of oil price shocks on energy transition concords with the results of Haque (2021) for GCC countries. This negative effect can be explained through some indirect macroeconomic mechanisms. In times of negative oil price shocks, the trade deficit grows, the currency loses value, inflation rises, and economic activity falls. An increase in inflation would lead to an increase in energy prices, leading to a fall in the demand for energy. In the African case, most households and individuals have sources of non-renewable energy available around them, including wood and coal which is abundant in the continent. In essence, Over 60% of the energy in sub-Saharan Africa comes from biomass and waste, followed by 16% each of oil and coal, 4% each of gas and nuclear, and 1% each of hydro and renewables (Enerdata, 2019). Coal accounts for 51% of the energy mix used to generate power. Natural gas accounts for 11% of electrical generation, followed by oil at 7%, hydro at 24%, and solar, wind, and geothermal at 3%. An increase in modern energy prices would therefore lead to an increase in the demand for these non-clean energy sources which are almost free in some parts of Africa. As the oil market undergoes a downturn, the incentives for environmentally conscious investors will fall, which could lead to a decline in the value of environmental assets. In contrast, when oil prices rise, incentives increase, causing the share prices of eco-friendly companies to rise (Dutta et al., 2020).

Most African nations' economies are solely reliant on commodity exports, yet they play almost little part in setting global commodity prices. There is a peculiar connection between commodity prices and macroeconomic growth on the continent. The fact that the continent's economy does not benefit much from an increase in global commodity prices and suffers greatly when those prices drop provides evidence of this (Nchofoung, 2022). Many homes and companies in Africa utilise diesel generators for backup power, and transportation relies heavily on oil, therefore oil commodities also play a significant role in African commodities. The cost of living, accessibility, and energy demand are all influenced by the price of a barrel of oil. For example, oil prices plunged from a high of $105 a barrel in 2014 to a low of $37 in 2016, leading to a fall in economic activities in several African countries. In this regard, Omolade et al. (2019) demonstrate how in Nigeria, for example, production growth slowed from 1.1% in December 2015 to 1.2% in the first quarter of 2016, and this trend persisted through the end of the third quarter of 2016. Also, Central African Economic and Monetary Community oil-producing countries noticed a similar pattern. The average annual rate of economic growth in this union's member Gabon slowed from 2.1% in 2014 to 1.3% in 2015.

According to the International Monetary Fund (2017) research, several African countries are particularly vulnerable to the drop in oil prices because of their reliance on oil exports. Gabon, Angola, and the Republic of the Congo all rely heavily on oil exports (between 40 and 50 percent of GDP), while in Equatorial Guinea, oil exports make up 80 percent of GDP. In the same way, Angola, the Republic of Congo, and Equatorial Guinea all rely heavily on oil exports to fund their economies. As a way out way for economic survival, some of these countries opted to devalue their currencies, or witnessed these currencies depreciate as a way out of this shock. For example, the Algerian dinar fell from around 90 to 111 dinar to $1, the Angolan kwanza from around 115 to 335 kwanza to $1, and the Egyptian pound fell from around 9 to 12 pounds to $1 (International Monetary Fund, 2017). Depreciation in exchange rate implies the currency of the countries are weaker, and literature has it that foreign investors do not seek to invest in economies with weak exchange rates because foreign products turn out to be more expensive in such countries (Buffie, 1986). Also, falling exchange rates lead to an upsurge in the general price levels in the economy, as foreign products become more expensive within the national economy. This is especially true for Africa, as the majority of the countries depend on foreign goods than domestic manufactured goods, including investment in the energy sector. In fact, Shahbaz et al. (2018) argue that exchange rate devaluation reduces energy consumption.

Looking at the control variables, the negative effect of trade openness on energy transition is in line with the study of Wang and Zhang (2021), who claim that the influence of trade openness on renewable energy is beneficial in high-income economies and turns out to be negative as we head towards low-income countries. An increase in trade openness increases economic competitiveness, and each economy looks to minimise the production cost of its output. In this case, less competitive low-income countries including African countries turn to opt for non-renewable sources of energy for production, which is relatively cheaper. Also, the positive effect of financial development corroborates the results of Shahbaz et al. (2021), who argue that financial development enhances renewable energy development in developing economies. A developed financial system makes credit available for both domestic and local investors, including those ready to invest in renewable energy projects. The positive effect of FDI is in accordance with the study of Fotio et al. (2022) for Africa, who argue that financial globalisation through foreign direct investment inflows act as available capital for investments in renewable energy sectors in the continent.

5. Conclusion and policy implications

Despite having a wealth of renewable energy resources, Africa's development needs are not being met by the current rate of the energy transition towards a low-carbon pathway. The majority of African countries are in trouble as a result of the ongoing negative shocks in oil prices on the global markets. Examining how oil price shocks affect Africa's energy transition was the goal of this study. Data was collected for 53 African countries between the 2000-2020 periods and analysed through the Driscoll and Kraay (1998) and the Panel VAR regression methodologies. The findings revealed that oil price shocks have an adverse influence on Africa's energy transition, with the findings being strong in both rural and urban contexts. Furthermore, when net oil importing and exporting countries were studied separately, the results revealed that the negative association was visible only in net crude oil exporting countries, whereas net importing countries had no effect. Furthermore, oil price shocks could not explain Africa's urban-rural differences in clean energy access. Conclusively, oil price shocks have an adverse effect on energy transition in Africa, with this effect substantial only in net oil exporting countries. Besides, oil price shocks cannot explain the clean energy injustice in Africa.

As policy implications, African policymakers should reduce the rural-urban gap in clean energy by investing more in clean energy and technologies in rural areas, which help enhance the resilience of the energy sector to oil price shocks. Also, changes in international prices of crude oil would have no effect on the demand of clean fuels in the national economies. However, for this to be effective, the States should use periods of oil windfalls to increase investments in renewable energy technologies and apportion oil rents stored as funds to subsidies clean energy prices during negative oil price shocks. Also, crude oil importing countries should import and store more crude oil during low prices, with the surplus used to boost internal demand during high energy prices. For oil exporting countries, their oil should be stored as reserves during low prices and more oil should be rather imported and subsequently exported during high energy prices. In such a case, the extra funds obtained during high prices should be used to finance economic activities in order to maintain stable clean energy prices within the national economies.

Future research on the topic could conduct empirical studies to determine the mechanisms through which oil price shocks affect Africa's energy transition. Furthermore, country-specific research can be done to help shape policy more effectively.

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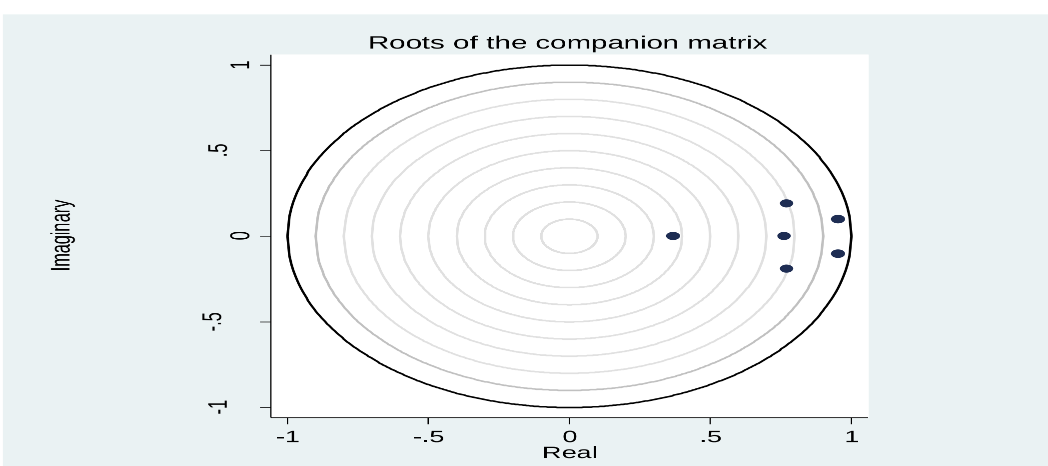
Appendix

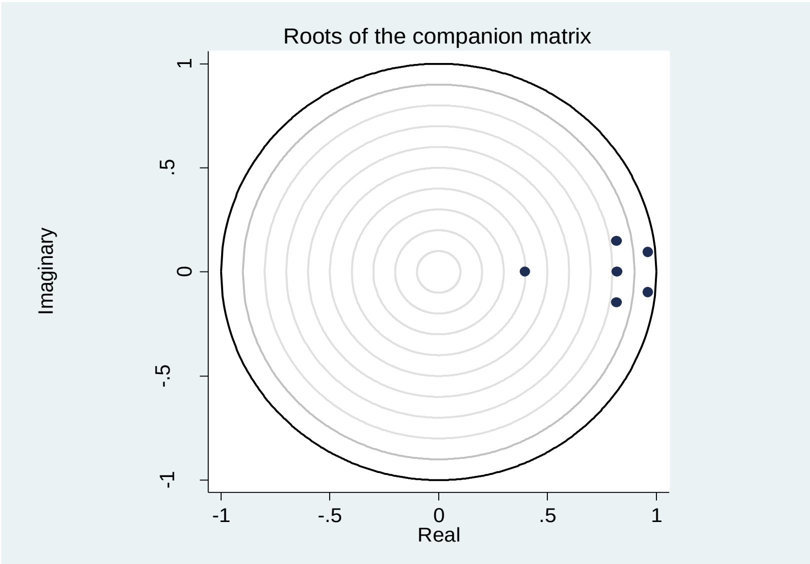
A1. Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Access to clean fuels	1.000							
(2) rural Access to clean fuels	0.937	1.000						
(3) urban Access to clean fuels	0.949	0.815	1.000					
(4) trade openness	0.333	0.283	0.344	1.000				
(5) foreign direct investment	0.025	0.028	-0.005	0.365	1.000			
(6) financial development	0.621	0.592	0.584	0.142	-0.046	1.000		
(7) foreign aid	-0.475	-0.397	-0.504	-0.192	0.038	-0.261	1.000	
(8) oil price shock	0.008	0.016	0.004	0.083	0.126	-0.006	-0.043	1.000

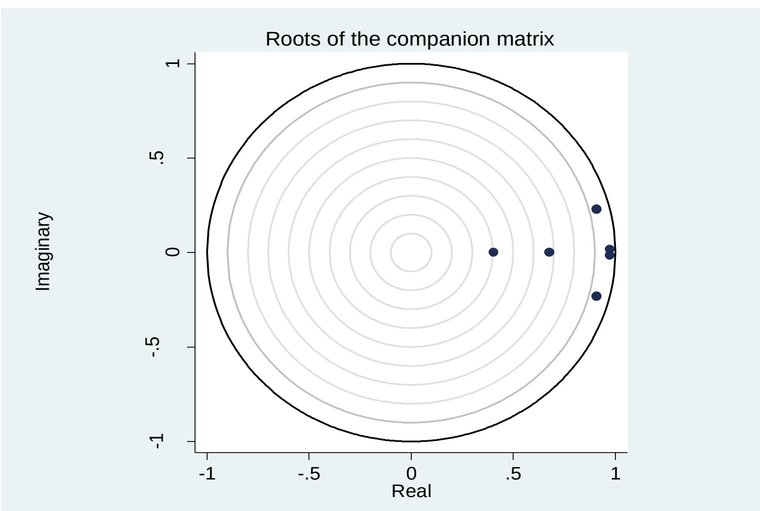
A2. Stability of PVAR model for Africa



A3. Stability of PVAR model in the rural setting



A4. Stability of the PVAR in the urban setting



A5. Effect of the oil price shock differed by a period

VARIABLES	(1) eq1 Access to clean fuels	(2) eq2 Rural Access to clean fuels	(3) eq3 Urban Access to clean fuels
Oil price shock (-1)	-0.0364*	-0.0290**	-0.0429*
	(0.0201)	(0.0131)	(0.0247)
Trade openness	-0.103***	-0.0726***	-0.114***
	(0.0162)	(0.0123)	(0.0182)
Foreign direct investment	0.0475*	0.0346**	0.0554
	(0.0268)	(0.0164)	(0.0322)
Foreign direct investment	-0.00545	-0.00306	-0.00280
	(0.00316)	(0.00282)	(0.00249)
Financial development	0.152***	0.0490*	0.200***
	(0.0378)	(0.0234)	(0.0543)
Constant	30.01***	21.04***	39.55***
	(1.547)	(1.299)	(1.274)
Observations	793	793	793
Fisher	22.88***	12.38***	33.57***

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1