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Murshed, M., Ali, S. & Papyrakis, E.

DOI 10.1007/s13563-022-00310-w
ISSN 2191-2203
ESSN 2191-2211

Publisher: Springer

Mineral Economics
https://doi.org/10.1007/s13563-022-00310-w

ORIGINAL PAPER

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Oil, export diversification and economic growth in Sudan: evidence from a VAR model

Sabna Ali[1] · Syed Mansoob Murshed[1,2] · Elissaios Papyrakis[1]

Received: 20 July 2021 / Accepted: 22 February 2022

Abstract

There is an extensive literature demonstrating a positive link between export diversification and economic growth. In parallel, the resource curse thesis posits export concentration as an important mechanism curtailing growth in mineral-rich countries. Our analysis contributes to this literature by empirically investigating the interaction between oil dependence captured by the share of oil rents in GDP and export diversification and economic growth for Sudan. We do this with the help of a VAR model using annual data between 1960 and 2018. In comparison to earlier studies, our dataset covers also Sudan's post-oil boom period, which coincided with a substantial drop in oil dependence after the 2011 secession of South Sudan. We find that oil rents appear to have a statistically significant and negative effect on export diversification, although contemporaneously rather than in the long-term. However, we find no evidence of a statistically significant impact of either oil dependence or export diversification on economic growth, as suggested by the resource curse hypothesis.

Keywords Sudan · Vector Autoregressive Model · Resource Curse · Oil · Export Diversification

Introduction

There is an extensive theoretical and empirical literature linking economic diversification to enhanced economic growth prospects. Several scholars claim that export diversification, for instance, can be conducive to sustained growth by reducing the macroeconomic impact of market volatility and reduce exposure to price/production shocks associated with specific commodities (see Bleaney and Greenaway 2001; Ghosh and Ostry 1994; Koren and Tenreyro 2007). Others also argue that diversification enhances long-term growth, since it allows the utilization of multiple production factors, facilitates the introduction of new economic activities and prevents revenue volatility and external events from restricting employment opportunities (Albassam 2015; Alhowais and Al-Shihri 2010; Auty 1994; Hesse 2008). Several studies also establish a positive link between innovation and diversification, since the latter tends to stimulate competition for scarce resources and development of new products. In other words, firms in markets with little diversification, especially in economies with excessive reliance on unprocessed primary commodities with little differentiation, have little incentive to innovate as a means of sustaining their market share; see Klinger and Lederman (2009). Herzer and Nowak-Lehnmann (2006) also emphasize the additional dynamic learning-by-doing (productivity) spillovers that arise when firms specializing in different sectors establish contacts with foreign purchasers and partners over a broader range of products. Some political economy scholars also link diversification to better institutions. Economic diversification prevents the concentration of power in the hands of few actors, with multiple economic stakeholders instead demanding accountable and transparent administrations (Acemoglu and Robinson 2012; Bjorvatn et al. 2012; Dunning 2005; Olander 2019). Naturally, there can also be reverse causality running from income levels to export diversification patterns—during the early stages of economic development, low-income levels and the corresponding limitations of skills and resources can hinder the transition to more diversified export structures (Fonchamnyo and Akame 2017; Papageorgiou and Spatafora 2012).

✉ Sabna Ali
ali@iss.nl

✉ Elissaios Papyrakis
papyrakis@iss.nl

[1] International Institute of Social Studies (ISS), Erasmus University Rotterdam (EUR), Kortenaerkade 12, 2518 AX The Hague, The Netherlands

[2] Centre for Financial and Corporate Integrity (CFCI), Coventry University, Priory Street, Coventry CV1 5FB, UK

Published online: 21 March 2022

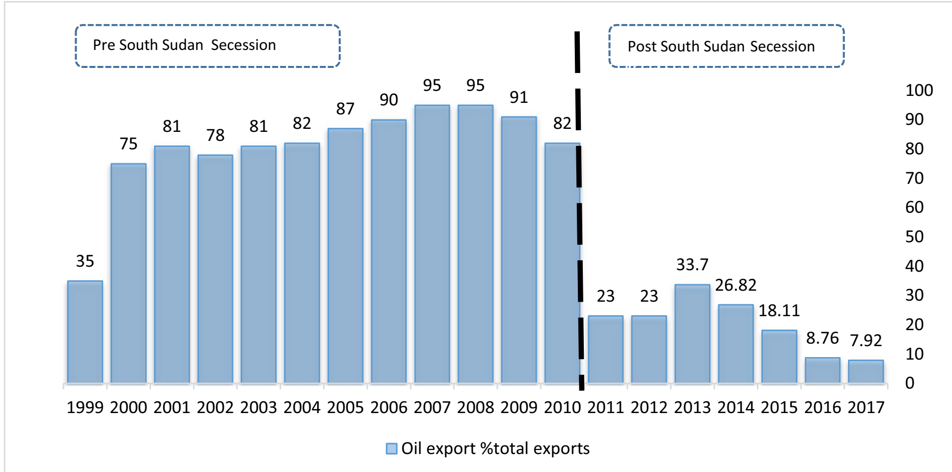


Fig. 1 Sudanese oil exports in total exports (1999–2017). 2020 **Source:** World Development Indicators ( )

At the same time, scholars working on the developmental effects of the extractive industry have highlighted the limited export diversification often observed in mineral-dependent economies (Alsharif et al. 2017; Bahar and Santos 2018; Omgba 2014). In other words, the lack of diversification is presented within this literature as a possible transmission channel of the so-called resource curse (i.e., the tendency of mineral-rich nations to underperform in long-term economic growth). A booming mineral sector often reduces export diversification through Dutch Disease effects (inflationary pressures, exchange rate appreciation, loss of competitiveness and wage premia in the extractive sector; see Corden and Neary 1982; Harding and Venables 2016; Ross 2019; John et al. 2020). Export concentration then worsens the growth prospects of mineral-dependent economies by further exacerbating their vulnerability to external price shocks and international market volatility and discouraging foreign direct investment (van der Ploeg and Poelhekke 2009). Furthermore, excessive economic dependence on the mineral sector enhances rent-seeking and frustrates the development of a pro-development institutional framework based on accountability and transparency (Baland and Francois 2000; Deacon and Rode 2015; Tsui 2010).

Sudan has also faced several of these macroeconomic and institutional challenges. Significant oil production commenced in 1999, during the presidency of Omar Al-Bashir, whose 30-year authoritarian regime started with a military coup in 1989. Oil exports grew steadily and accounted for the vast majority of total exports in the 2000s (more than 90% since the mid-2000s); see Fig. 1 and also Nour (2011) and Suliman (2016). Between 1999 and 2011, during the years when Sudan was still in control of the oil fields currently located in South Sudan, the economy grew rapidly at an average rate of 5.8%, higher than in the pre-oil extraction period beginning in the 1960s, when the growth rate was on average about 1% lower. During the same period, growth largely remained positive and stable. As the oil sector grew to dominate exports, the economy's vulnerability to external price shocks also increased, with 2010 being the first year when the economy contracted since the early 1990s as a result of the oil price collapse in the preceding year. The secession of South Sudan in 2011 triggered a major economic shock with a loss of approximately three quarters of all known oil reserves. As a result of this, Sudan's oil dependence decreased substantially and abruptly, and no other sector was able to compensate for the loss of oil revenues. Average growth since 2011 has been close to 2%, a third of the corresponding rate during the 1999–2011 period. This was largely attributed to the absence of policies aiming at diversifying the economy and export structure during the years of the oil boom, or attempts to revive traditional sectors that were competitive prior to the oil-boom, such as agriculture and livestock; see Suliman (2016). At the same time, Sudan has consistently scored poorly in international rankings of institutional performance, a common feature of many Sub-Saharan mineral-rich economies (Dwumfour and Ntow-Gyamfi 2018). Rampant corruption and the limited application of the rule of law may have dampened growth prospects and stifled opportunities for an alternative development model based on export diversification and private entrepreneurship.

Our analysis contributes to the literature by empirically investigating the simultaneous interaction between oil dependence captured by the share of oil rents in GDP, export diversification, economic growth and institutional quality for Sudan. We do this with the help of a VAR model using annual data between 1960 and 2018. Compared to earlier studies, ours uses more recent data that also cover Sudan's post-oil boom period after the cessation of South Sudan in 2011. The rest of the paper is organized as follows. Section 2 presents an overview of the literature on mineral dependence and economic diversification. The first part of Sect. 3 presents our data and methodological approach; the second half of Sect. 3 presents the results of our VAR analysis. We find that oil rents appear to have a statistically-significant and negative effect on export diversification although contemporaneously rather than in the long-term. However, in contrast to the resource curse hypotheses, we find no evidence of a statistically-significant impact of either oil dependence or export diversification on growth either in the short or long run. An extension of the VAR model including institutions (captured by a rule-of-law index) also shows no empirical support of an institutional resource curse. Finally, Sect. 4 concludes with some policy recommendations.

A Brief Review of the Literature on Minerals and Economic Diversification

While international trade theory typically emphasizes the benefits of specialization in those export commodities in which countries have a comparative advantage, also based on the relative abundance of certain factors of production, excessive reliance on the extractive sector is deemed counterproductive. Even in the early 1950s, Prebisch (1950) and Singer (1950) highlighted that resource-dependent economies experienced long periods of declining terms of trade (between primary commodities and manufactured goods); see also the study by Harvey et al. (2010). In addition, an initial resource boom (triggered by new discoveries or a sudden increase in prices) is likely to reduce export diversification through Dutch Disease effects (Edwik, 2007). These can materialize through two different channels (Corden and Neary 1982; Corden 1984; Harding and Venables 2016). First, there can be a "spending effect," the mineral-induced positive income shock can trigger inflationary pressures starting from an increased demand for goods, services and labor in the non-tradeable sector that reduces the competitiveness of other export sectors. Second, there can be a "resource movement effect," i.e., a relocation of scarce production factors toward the booming extractive sector (as a result of higher rewards) that crowds-out production elsewhere. Gelb (1988) also emphasizes the crowding-out effect mineral rents can have on local production, if mineral revenues are primarily spent on imports.

Indeed, much empirical work within the so-called resource curse literature highlights the limited export diversification often observed in mineral-dependent economies (Alsharif et al. 2017; Bahar and Santos 2018; Omgba 2014). Mineral dependence can accelerate what Rodrik (2013, 2016) describes as a process of "premature deindustrialization," the more recent trend of most developing economies (with the exception of Asian countries) experiencing diminished opportunities for industrialization at a low level of economic development, and certainly at a lower level in comparison to the earlier de-industrialization experience of wealthier economies. This can have significant repercussions for growth, when a dominant extractive sector exists at the expense of other economic activities characterized by stronger learning-by-doing externalities such as manufacturing (Aizenman and Lee 2010; Krugman 1987). A dominant mining sector that dwarfs all other economic activities is likely to frustrate incentives for innovation, either because production becomes concentrated across fewer firms and by limiting knowledge transfer from abroad unlike when more sectors are open to trade; see Herzer and Nowak-Lehmann (2006) and Klinger and Lederman (2009). Given the excessive volatility in international mineral prices, an almost exclusive dependence on mining (rather than a more diversified export structure) increases vulnerability to external price shocks, discourages foreign direct investment and translates into recurring macroeconomic boom-and-bust cycles (Auty 1988; Heidarian and Green 1989; Humphreys et al. 2007; van der Ploeg and Poelhekke 2009). Along these lines, Murshed and Serino (2011) explore the pattern of export specialization and economic growth in a panel dataset of resource-rich economies for the period 1960–2005 and confirm the growth-retarding effect stemming from a combination of an extensive extractive sector and lack of diversification in exports.

In general, less diversified economies are likely to develop inferior institutional frameworks; a more equitable distribution of power across multiple sectors and stakeholders enhances the demand for accountability, transparency and prudent governance (Acemoglu and Robinson 2012; Dunning 2005). The negative effect on institutions can be even more pronounced in the case of excessive economic dependence on minerals (Deacon and Rode 2015; Frankel 2010; Isham et al. 2005; Lederman and Maloney 2007; Tsui 2010); mineral wealth can incentivize politicians to dismantle well-functioning institutions in order to facilitate rent capture, increase rent-seeking competition among different stakeholder groups that vie for control of the resource revenues and create short-sighted governments that face reduced accountability for their actions as a result of extensive rent redistribution and lower taxation (see Besley and Persson 2010; López-Cazar et al. 2021; Ross 2001, 2015; Vahabi 2018). In addition, while economic diversification can lead to institutional improvements, this can be conditional on the type of diversification (e.g., if diversification is still based on alternative resource-dependent activities) as well as on existing elite incentives that might favor the status quo (Wiig and Kolstad 2012). Spending on patronage (supported by the abundance of mineral rents) can also allow low-quality public officials to remain in office for long periods of time (Brollo et al. 2013). Subsequently, this so-called institutional resource curse can impact negatively on the long-term growth prospects of mineral-dependent economies (Williams 2011). Some studies, instead, emphasize the conditioning role institutions can have in the minerals-growth nexus rather than looking at the effect of mineral resources on institutional quality (e.g., see Kaffine and Graham 2013; Mehlum et al. 2006; Papyrakis and Pellegrini 2019 and Robinson et al. 2006). Similarly, Albassam (2015), in his assessment of the development plans adopted by Saudi Arabia's government between 1970 and 2013, concludes that poor institutions inhibited attempts to diversify away from oil.

Other studies examine the possible impact of institutions on economic diversification. For instance, Starosta de Waldemar (2010) finds a negative effect of rent-seeking activity on export diversification based on a highly disaggregated export data of more than 5,000 commodities. Karshenas and Hakimian (2005) also blame the combination of rent-seeking, lack of democratic accountability and oil rents for the limited economic diversification of the Iranian economy. Moreover, Ahmadov (2012) uses a cross-country dataset of 170 resource-rich countries for the period between 1932 and 2010 and finds that institutional quality prior to the resource discovery has strong impact on a resource rich country's ability to achieve diversification subsequently; similarly, Alsharif and Bhattacharyya (2019) suggest that strong democratic institutions moderate the general tendency of oil-rich economies to experience reduced diversification due to the overall contraction of the non-extractive sector.

The Case of Sudan

Despite the substantial impact of the extractive sector on the Sudanese economy (both prior and following the secession of the oil-rich South Sudan), very little attention has been paid to exploring, in an analytical way, the associated structural transformation and concomitant changes in export diversification. In addition, earlier empirical studies do not make use of data from Sudan's post-oil boom period which coincides with the cessation of South Sudan.

An excellent overview of Sudan's manifestation of resource curse mechanisms is provided by Suliman (2016). In particular, he outlines the importance of Dutch Disease and fiscal mismanagement challenges for Sudan's macroeconomic performance and economic diversification (during the years of Sudan's oil boom). Export concentration (dominated by oil) led to a loss of competitiveness for other industries and the closure of many factories, especially in the case of cotton production, see also Konandreas (2009). Suliman uses a vector error correction model with aggregate public revenues and expenditures as endogenous variables to confirm an "institutional separation between the allocation and taxation functions of the government" and the presence of a state sector dominated by actors with conflicting interests (Suliman 2016: 450). He also demonstrates how the public sector benefitted through Sudan's budget allocation during the oil boom years (especially through a rise in public sector wages and security spending, see Suliman 2016: 453), revealing a budget allocation scheme based on patronage and bargaining instead of one that would strategically support private enterprise and economic diversification; see also Patey (2010: 620). While our study is related to the one by Suliman (2016), his time series analysis has a different focus; his analysis primarily deals with the interrelationship between government revenue and expenditure rather than focus on export diversification or institutions (although it touches indirectly upon diversification issues through his discussion on Dutch Disease, the exchange rate regime and the budget allocation changes over time). In addition, his 2016 book chapter does not incorporate any data beyond 2010 (i.e., after South Sudan's cessation).

Elbadawi et al. (2008) use a game-theoretic framework to explain how mineral rents and government budgets ended up supporting an arm race between Sudan and South Sudan. Nour (2011), in her qualitative study, claims that while oil accelerated growth in Sudan, it also induced a lack of export diversification. The lack of diversification in combination with fiscal dependence on oil resulted also in substantial macroeconomic and fiscal volatility (Nour 2012; Suliman 2016). Khalifa (2016) presents a simple econometric model demonstrating a crowding-out effect of the extractive sector on agricultural exports for the pre-secession period (see also Gadkarim 2010 for similar results). In several cases, oil exploration and extraction activities have resulted in environmental degradation leading to reduced agricultural potential and loss of livelihoods for local pastoral communities (Pantuliano 2010). One of the few domestic sectors that benefitted from oil extraction appears to be the domestic non-tradeable service sector (Hassan and Abdullah 2015); in line with what Dutch Disease theory would predict, the positive income shock stemming from oil increased the demand for domestic services (e.g., for the hospitality sector) and reduces the size of non-oil export activity. The need for a more diversified economy as a new engine for growth was evident after the cessation of South Sudan, with the government, however, failing to take measures in this regard (Sharfi 2014). This is also emphasized in the early political economy analysis by Patey (2010), who highlights the failure of Sudan's oil-driven growth prior to 2011 to develop other segments of the economy. He attributes this to excessive spending of resource rents on militarization rather than public investment in the form of educational, health and water services, the negligence of which also reinforces political grievances and tensions at all levels.

Oil and Export Diversification in Sudan—Main Analysis

Data and Estimation

We make use of a vector autoregressive (VAR) model to examine the interaction between oil dependence (proxied by the share of oil rents in GDP), export diversification and economic growth for Sudan. VAR models are often used for their predictive validity and consequently rely on parsimony, often using few variables, especially in the case of relatively small samples with several lagged coefficients to be estimated. Typically, VAR models do not contain more than 3–4 endogenous variables; for examples with VAR growth specifications see Sahoo et al. (2014), Wolde-Rufael (2012) and Yurdakul and Uçar (2015).

For the purpose of estimating the interactions between the aforementioned variables, we adopt a relatively long time span (1960–2018) as our period of analysis. We do this for several reasons. First, macroeconomic time series models typically need to estimate a large number of coefficients (and often rely on modestly sized samples when making use of annual data). Larger sample sizes increase the statistical power of the model (while smaller samples lead to a larger margin of error and less conclusive results). Second, given our interest on the potential effects of oil rents on other outcome variables, we wish to examine a period during which dependence on oil rents exhibits substantial time variability. Along these lines, the 1960–2018 period allows us to combine data across three specific periods, i.e., the oil-boom period, as well as the pre and post oil-boom ones. In relative terms, the oil-boom period has a duration close to a quarter of the overall study time span. Third, it is worth noting that even prior to the oil-boom period, there was some oil production (albeit of a small size). The first oil rents started materializing already since 1992 (although small in relation to GDP, e.g., 0.017% in 1992 gradually increasing to 0.127% by 1998). Since 2011 (after the cessation of South Sudan), dependence on oil decreased significantly, although in recent years oil rents still contribute to about 1% of Sudan's GDP. Please note that the starting year of our analysis is determined by data availability, given that the World Bank's World Development Indicators dataset only provides macroeconomic data since 1960.

We run a series of Granger causality tests to establish the time ordering of effects that need to be adopted for our VAR estimations. Based on the VAR estimates, the orthogonalized impulse response functions (OIRFs) will allow us to assess the magnitude and statistical significance of impacts over time, arising from any shock to the system. It has become standard in VAR models to assume a recursive time ordering of effects (shocks) within the system of endogenous variables, guided by the corresponding Granger causality tests (and to focus, hence, on orthogonalized impulse response functions rather than the generalized ones). In other words, OIRFs assume that shocks do not affect all variables simultaneously, but only those appearing later in the adopted time ordering (see Becketti 2013). The setup of our VAR model aims to test empirically the relationship between oil dependence, economic growth and diversification for the case of Sudan. In other words, we evaluate whether oil rents have a negative impact on the other two variables, as is often suggested in the resource curse literature (Alsharif et al. 2017; Bahar and Santos 2018; Gylfason and Zoega 2006; Murshed 2004, 2018). The case of Sudan is a particularly interesting case to examine given the significant dependence of the economy on oil rents until 2010, and the subsequent decline of the oil sector thereafter.

For this purpose, the following system of equations is estimated as part of our VAR model:

$$lpcgdp_t = \sigma + \sum_{i=1}^{k} \beta_i lpcgdp_{t-i} + \sum_{i=1}^{k} \varphi_j HHI_{t-i} + \sum_{i=1}^{k} \varepsilon_n oilrent_{t-i} + \mu_{1t} \tag{1}$$

$$HHI_t = a + \sum_{i=1}^{k} \gamma_i lpcgdp_{t-i} + \sum_{i=1}^{k} \chi_j HHI_{t-i} + \sum_{i=1}^{k} \zeta_n oilrent_{t-i} + \mu_{2t} \tag{2}$$

$$oilrent_t = c + \sum_{i=1}^{k} \delta_i lpcgdp_{t-i} + \sum_{i=1}^{k} \psi_j HHI_{t-i} + \sum_{i=1}^{k} \eta_n oilrent_{t-i} + \mu_{3t}, \tag{3}$$

where *lpcgdp* corresponds to the natural logarithm of real GDP per capita values (with 2010 as the base year), *oilrent* refers to the value of oil rents as a share of the Sudanese GDP, *HHI* is the Herfindahl–Hirschman index of export concentration and μ's capture the error component of each equation. As an extension of our analysis, we also estimate an extension of the VAR model including institutions (captured by a rule-of-law index) to see whether there is empirical support in favor of an institutional resource curse for Sudan (again in line with several papers in the literature that suggest that mineral rents may erode institutional quality, (Corrigan 2014; Dunning 2005; Ross 2015; Stevens and Dietsche 2008; Vahabi 2018). A detailed description of all variables (with summary statistics) is provided in Appendix 1 (Table 3). Appendix 1 also presents the time line plots for the same variables (Figures 5 and 6). Data on GDP per capita and oil rents are provided by the World Development Indicators (WDIs) database of the World Bank (2020). Data on the rule of law are available from the Varieties of Democracy (V-Dem) project, led by the Kellog institute (University of Indiana) and the University of Gothenburg (V-Dem 2020): the rule of law index takes values between 0 and 16 (with higher values corresponding to better performance in this institutional domain). The Herfindahl–Hirschman index of export concentration (HHI) was constructed based on WDI data on the sectoral composition of exports, using the following formula:

$$HHI = \sum_{i=1}^{n} x_i^2,$$

where the x_i is the percentage share of each category i of export commodities (metals, oil, agriculture, food, manufactured commodities, etc.) in Sudan's total merchandise exports.

Analysis and Results

As a first step, we check for the stationarity of the variables entering our VAR system. As can be seen from the unit root tests presented in Table 4 of Appendix 2, all variables (in levels) appear be non-stationary. We, hence, first-difference all variables and control once again for stationarity (Table 5 of Appendix 2); since the first differences of all variables are stationary, it is the latter set of variables that will be included in our VAR specifications. Given that all our variables are non-stationary in levels but stationary in first differences, a vector error correction model (VECM) could have been chosen as an alternative estimation technique. However, the corresponding Johansen test provides no support for the existence of a cointegrating (long-term) relationship between the variables of our analysis (see Appendix 3, Table 6). For this reason, typically one opts for a VAR rather than a VECM specification in the absence of cointegration (see, for example, Jenkins and Katircioglu 2010; Shaw et al. 2016).[1]

Secondly, we need to decide on the optimal lag length of our VAR system. There are several selection-order statistics and criteria to help decide on the appropriate lag length; these do not always agree with one another, due to the importance they assign to model complexity versus goodness of fit. Given the relatively limited time coverage of our time series data, we opted for one lag, as also suggested by the vast majority of criteria (with the exception of the Schwarz's Bayesian information criterion (SBIC) that is in favor of no lags; see Appendix 3, Table 7). Next, we need to characterize the temporal relationships in our VAR model (i.e., some disturbances may impact some of the endogenous variables earlier than others). Granger causality tests help us decide on the temporal ordering of such effects (these are presented in Appendix 4, Table 8). Results are more supportive of a recursive order, where the effect of oil rents on diversification (HHI) precedes any reverse effects in the opposite direction; the other Granger-causing effects appear to be statistically insignificant. For this reason, we adopt the following ordering for our VAR model: $oilrent \rightarrow HHI \rightarrow lpcgdp$.[2] The VAR estimates are presented in Table 1. Although it is not meaningful to interpret directly the coefficients appearing in Table 1 (due to the simultaneous interactions across the system of 3 equations), column (2) already provides some indicative evidence of a positive (negative) and statistically-significant link between export concentration (diversification) and past oil rents; note, that column (3) suggests a relationship of the same sign (albeit less statistically significant) between oil rents and past export concentration. At the same time, although column (1) depicts a negative association between export concentration and growth, the corresponding coefficient is not statistically significant.

Table 1 VAR model results for GDP growth, HHI and oil rents

Dependent Variable	$dlpcgdp_t$ (1)	$dHHI_t$ (2)	$doilrent_t$ (3)
Constant	0.01	0.002	0.07
$dlpcgdp_{t-1}$	0.33*** (0.12)	0.17 (0.11)	-7.03 (7.44)
$doilrent_{t-1}$	0.003 (0.002)	0.005*** (0.002)	-0.28** (0.13)
$dHHI_{t-1}$	-0.05 (0.13)	-0.36*** (0.12)	13.68* (7.91)
R^2	0.13	0.22	0.12
Number of observations	56	56	56

Standard errors in parenthesis. *, **, *** correspond to 10, 5 and 1% level of significance

We also replicate the VAR estimations for the fuller specification that includes the Rule of Law variable. The Granger causality tests support a similar time ordering, institutions neither seem to Granger-cause any of the other endogenous variables nor to be Granger-caused by any of them, see Appendix 5, Table 9. Again, results are more supportive of a recursive order, where the effect of oil rents on diversification (HHI) precedes any reverse effects in the opposite direction. For this reason, we adopt the following ordering for our VAR model: $oilrent \rightarrow HHI \rightarrow lpcgdp \rightarrow RuleofLaw$. The VAR estimates of the fuller model with institutions are presented in Table 2. While again it is not meaningful to directly interpret the VAR coefficients, the positive (and statistically significant) relationship between oil rents and export concentration still holds. Column (4) provides no indication of an institutional resource curse for Sudan; i.e., the coefficient of oil rents in column (4) is neither negative

[1] When there are variables of a mixed order of integration (which is not the case for our variables and specifications), one can alternatively estimate an AutoRegressive Distributive Lag (ARDL) model. For a discussion on the use of alternative time series modes, see Shrestha and Bhattab (2018).

[2] This ordering of effects is not surprising, given the earlier literature suggesting that limited economic diversification is a potential resource curse mechanism through which oil rents can influence economic growth (see Sect. 2). We also experimented with alternative orderings, that yielded very similar results; results available from the authors upon request.

Table 2 VAR model results for GDP growth, HHI, oil rents and rule of law

Dependent Variable	$dlpcgdp_t$ (1)	$dHHI_t$ (2)	$doilrent_t$ (3)	$druleoflaw_t$ (4)
Constant	0.01	0.002	0.12	-0.003
$dlpcgdp_{t-1}$	0.34*** (0.12)	0.17 (0.11)	-6.76 (7.4)	0.010 (0.14)
$dloilrent_{t-1}$	0.003 (0.002)	0.005*** (0.002)	-0.27*** (0.13)	0.0006 (0.002)
$dHHI_{t-1}$	-0.05 (0.13)	-0.36*** (0.12)	13.51** (7.87)	-0.05 (0.14)
$druleoflaw_{t-1}$	0.11 (0.13)	0.076 (0.11)	4.96 (7.01)	0.40*** (0.13)
R^2	0.14	0.23	0.13	0.15
Number of observations	56	56	56	56

Standard errors in parenthesis. *, **, *** correspond to 10, 5 and 1% level of significance

nor statistically significant. As a robustness check, we also re-estimated our VAR model by substituting the rule of law index with alternative institutional proxies from the V-DEM dataset (namely, executive corruption, electoral/participatory democracy, regime corruption and clientelism indices, see V-DEM 2020); the institutional indicators are highly correlated with one another, and, as a result of this, there are small differences in the VAR estimates and corresponding OIRFs (results available from the authors upon request). In other words, similar to our earlier results, we did not find evidence of a negative and statistically significant relationship between institutional quality and growth (or export diversification). In general, the institutional variables exhibit limited time variability over time and are hence less likely to be influenced by or influence other endogenous variables.

Finally, we conduct a series of diagnostic tests, a residual autocorrelation and a VAR stability test, to check for the adequacy of our model specification.[3] The results of these tests (for our main model without institutions) are presented in Appendix 6. Table 10 and the corresponding Lagrange-multiplier tests provide support to a white noise error term, for both first- and second-order autocorrelation in the residuals, and we cannot confidently reject the null hypothesis of no autocorrelation. Table 11 shows that all eigenvalues lie within the unit circle (i.e., their absolute values is less than one), suggesting hence that the VAR system as a whole is stable and that any shocks die out relatively quickly. The same results also hold when replicating the tests for the augmented VAR model with institutions.

Appendix 7 (Table 12) replicates our main VAR specification with the inclusion of a post-2010 dummy as an exogenous variable (i.e., a dummy variable referring to the post-cessation years of South Sudan). There are no substantial differences in relation to our earlier findings and there is still tentative evidence of a positive link between oil and export concentration for Sudan. The coefficient of the post-2010 dummy is only statistically significant for the HHI specification, suggesting a reduction of export concentration in the post-2010 period, other things being equal.

Impulse response Functions

As mentioned earlier, while individual coefficients of the estimated VAR system can provide indications of the sign and size of relationships between variables, it is not meaningful to interpret them in isolation (given the multiplicity of interactions captured within the system). The orthogonalized impulse response functions (OIRFs) are much more useful in that respect and allow us to measure the effect of a single disturbance (shock / impulse) of one variable on another response variable (or itself) over time, after taking into considerations all possible interactions captured by the equations of the VAR system. For instance, the OIRFs can help us assess how an oil shock (e.g., in the form of a sudden drop in oil revenues in Sudan) may affect the extent of export diversification (or other variables in the system) in the short and long term.

Figure 2 presents the impact of a one-standard-deviation (close to a 3.1 percentage points change) oil impulse on export concentration (HHI). We observe that oil rents appear to have a statistically significant and positive (although contemporaneous rather than long-term) effect on export concentration. The HHI index increases by approximately 0.012 units in line with the rise in oil rents, with the effect though decreasing in size (and statistical significance) after just one year (and gradually dying out). South Sudan shifted within a relatively short period of time from being an economy that had almost no oil revenues in the early 1990s, to one that was largely oil dependent (with oil rents accounting for about 23% of GDP by 2008); by the beginning of the 2010s, the contribution of the oil sector to the overall economy became again minimal (e.g., close to 3.5% in 2012). This suggests that an oil shock of that size (e.g., an increase/decrease of the ratio of oil rents in GDP by about 20%) would correspond to an increase/decrease of the HHI index (i.e., in export concentration) by approximately $(20/3.1)\times 0.012=0.08$ units.

Figure 3 depicts how per capita growth responds to an oil rent shock. While the impulse-response function is suggestive of a positive link (i.e., of a beneficial impact of an oil boom on growth), the effect is consistently statistically insignificant. Figure 4 presents the growth impact of an export concentration (HHI) shock. While an increase in

[3] More information on these diagnostic tests can be found in Hamilton (1994).

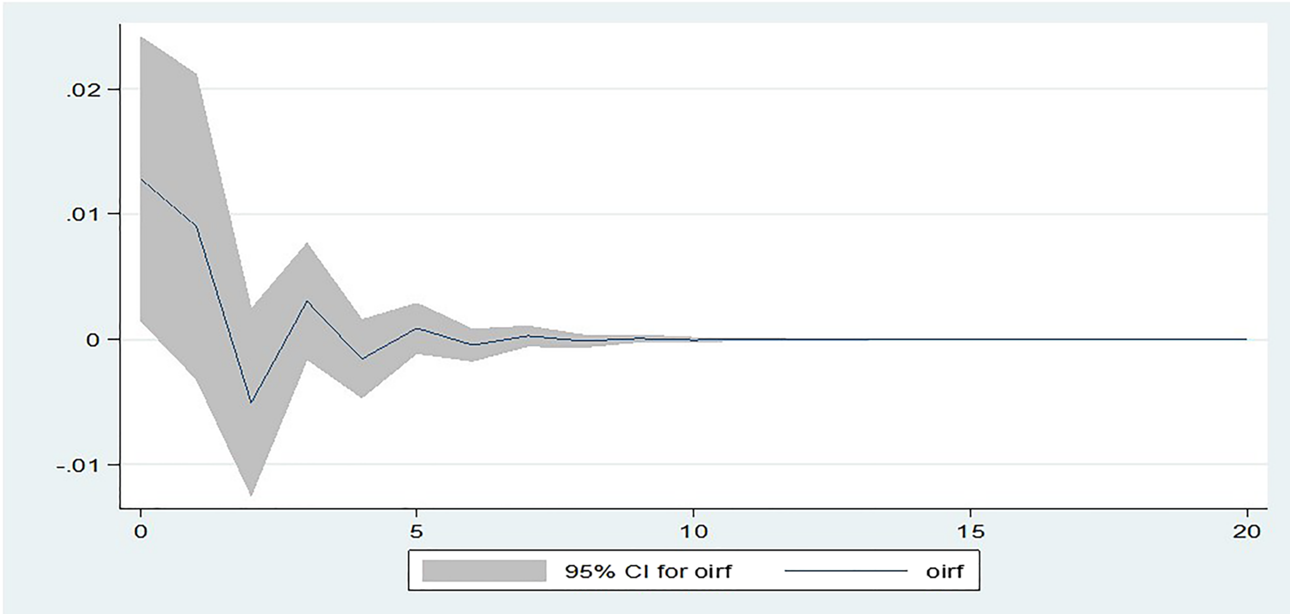


Fig. 2 OIRF (oil impulse, HHI response)

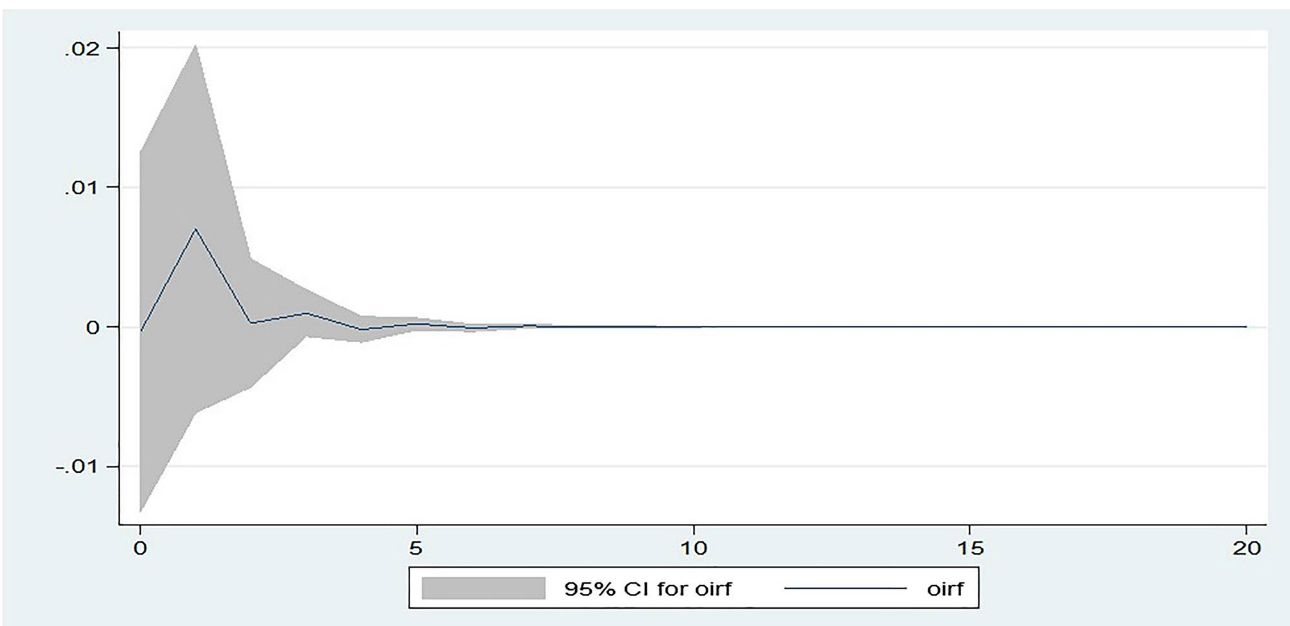


Fig. 3 OIRF (oil impulse, economic growth response)

export concentration (i.e., a less diversified export structure) appears to have a growth-contracting impact, the effect is again not statistically significant. Appendix 8 (Figures 7, 8, 9, 10, 11, and 12) presents all other impulse-response functions of the VAR system, which again do not provide evidence of statistically significant impulses.

The impulse-response functions for the augmented VAR model with institutions (rule of law) produce very similar findings. The only statistically effect (and of almost identical magnitude to the one of the more parsimonious model, see Fig. 2) is the one running from oil to HHI (results available from the authors upon request). In Appendix 9, we indicatively present some of the impulse-response graphs

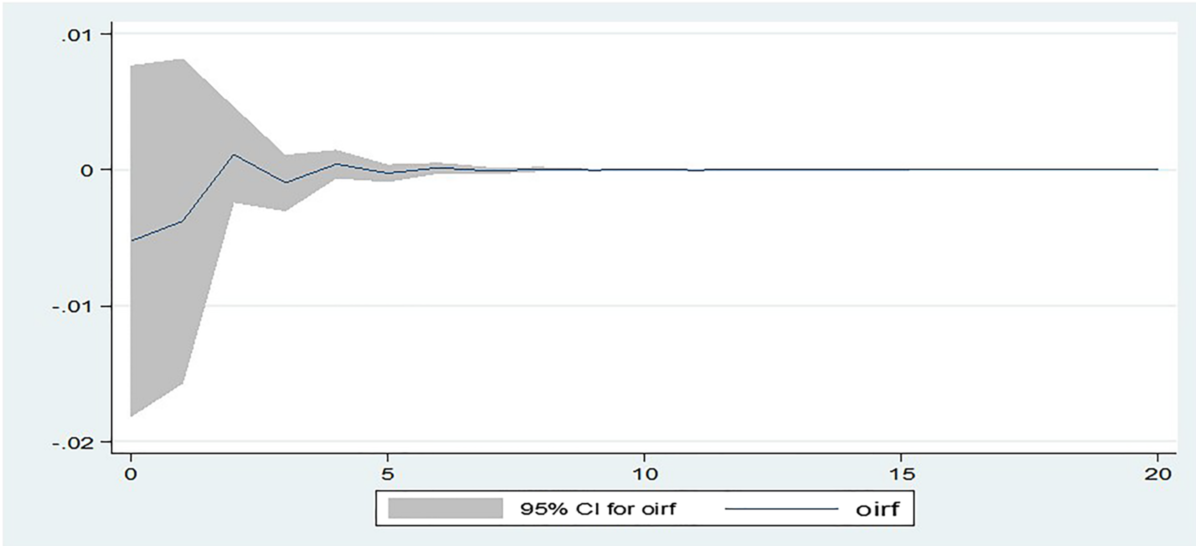


Fig. 4 OIRF (HHI impulse, economic growth response)

for the augmented VAR model. Figures 13, 14, and 15 present the "rule-of-law impulse—HHI response," "rule-of-law impulse—growth response" and "oil impulse—rule-of-law response" functions, respectively. None of them correspond to statistically significant impacts.

Conclusions and Policy Recommendations

Many studies emphasize the importance of export diversification for sustainable long-run growth, especially in the context of oil-rich economies where the extractive sector tends to dominate export trade. Export concentration renders oil-rich countries vulnerable to price fluctuations, often generating macroeconomic volatility and uncertainty. In addition, Dutch Disease effects in oil-rich economies typically further increase the dominance of the extractive sector at the expense of other economic activities. Our analysis has been a first attempt to examine through time-series modeling the links between oil dependence, export diversification and economic growth for the case of Sudan.

Sudan is a particularly interesting case to examine. Sudan was not always an oil-rich or oil-dependent economy. Significant oil production started in 1999 during the presidency of Omar Al-Bashir; shortly after, the extractive industry accounted for the vast majority of exports. Between 1999 and 2011, the years when Sudan was still in control of the oil fields currently located in South Sudan), the economy grew impressively at an average annual rate of 5.8%. However, the secession of South Sudan in 2011 rather abruptly transformed Sudan once again into a less oil-dependent economy and triggered a major economic shock given the absence of earlier successful policies to diversify the export structure.

Our analysis contributes to the literature by empirically investigating with the help of a VAR model using annual data between 1960 and 2018 the interaction between oil dependence, export diversification, institutional quality and economic growth for Sudan. We find that oil rents appear to have a statistically significant and negative effect on export diversification, although contemporaneously rather than in the long term. However, we find no evidence of a statistically-significant impact of either oil rents or export diversification on growth either in the short or long run as suggested by the resource curse hypothesis; similarly, we also find no empirical support of an institutional resource curse.

The results have important policy implications for Sudan. While oil shocks influence export diversification in the short term, it is not the extractive sector that is to blame for the unsuccessful attempts to diversify the economy in the medium to long term. Oil and raw agricultural products (as well as gold production more recently) still dominate the export structure of the economy; dedicated government efforts in the form of an agricultural-based industrialization policy should support a more balanced export mix with participation of manufactured commodities.

This has been a first empirical attempt to examine the link between oil shocks, export diversification, growth and institutions for Sudan using a VAR specification. Future research could replicate our time-series specification to evaluate the impacts of drastic oil shocks for other oil-dependent economies, or even subnational differences in oil effects, assuming that regional data coverage permits this type of analysis. Along these lines, and once data availability improves, one could also evaluate how the economy of South Sudan was impacted by oil following its own independence.

Appendix 1

Table 3 Variable definitions and summary statistics

Variable	definition	Mean; Standard deviation (statistics for differenced variables in parenthesis)	Min; Max (statistics for differenced variables in parenthesis)
lpcgdp	Natural logarithm of GDP per capita values (real, 2010 base year)	6.889; 0.294 (0.014; 0.053)	6.552; 7.580 (-0.095; 0.122)
oilrent	Oil rents as a share of GDP. A detailed definition is given by the World Bank (2020): "Oil rents are the difference between the value of crude oil production at regional prices and total costs of production… This is done by estimating the price of units of specific commodities and subtracting estimates of average unit costs of extraction or harvesting costs. These unit rents are then multiplied by the physical quantities countries extract or harvest to determine the rents for each commodity as a share of gross domestic product (GDP)"	3.092; 5.959 (0.017; 3.119)	0; 22.913 (-14.804; 8.135)
HHI	Herfindahl–Hirschman export diversification index. Range between 0 and 1, where higher values correspond to higher levels of export concentration	0.592; 0.132 (0.003;0.050)	0.427; 0.893 (-0.155; 0.198)
ruleoflaw	Rule of law index taking values between 0 and 16 (with higher values corresponding to superior performance). The variable captures a wide range of interrelated institutional qualities. It measures the independence of the judiciary, the extent to which rule of law prevails in civil and criminal matters, the existence of direct civil control over the police, the protection from political terror, unjustified imprisonment, exile and torture; absence of war and insurgencies, and the extent to which laws, policies and practices guarantee equal treatment of various segments of the population	0.268; 0.201 (-0.007; 0.058)	0.045; 0.667 (-0.276; 0.110)

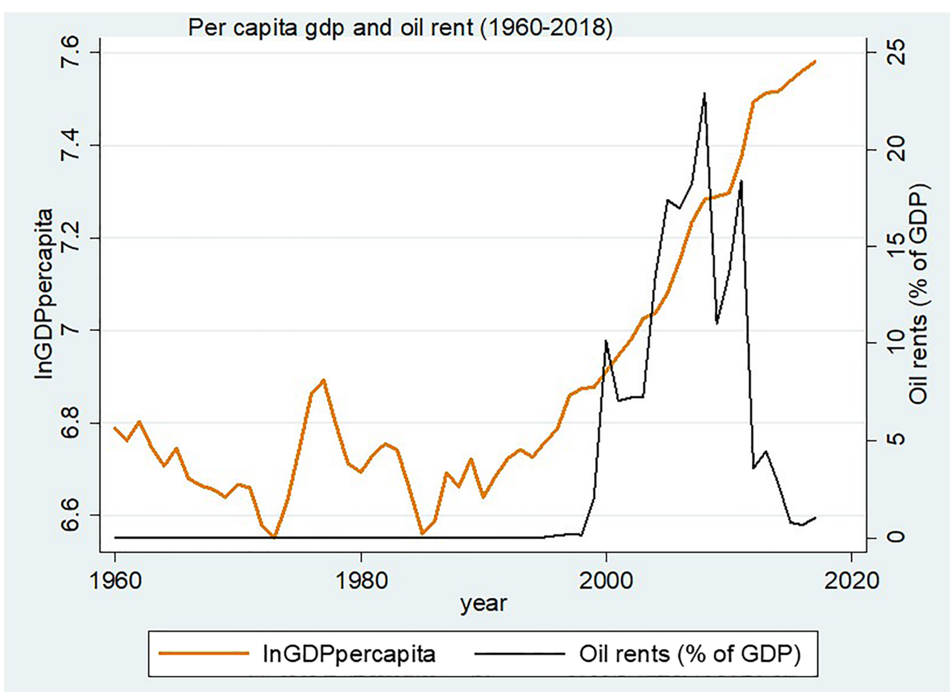
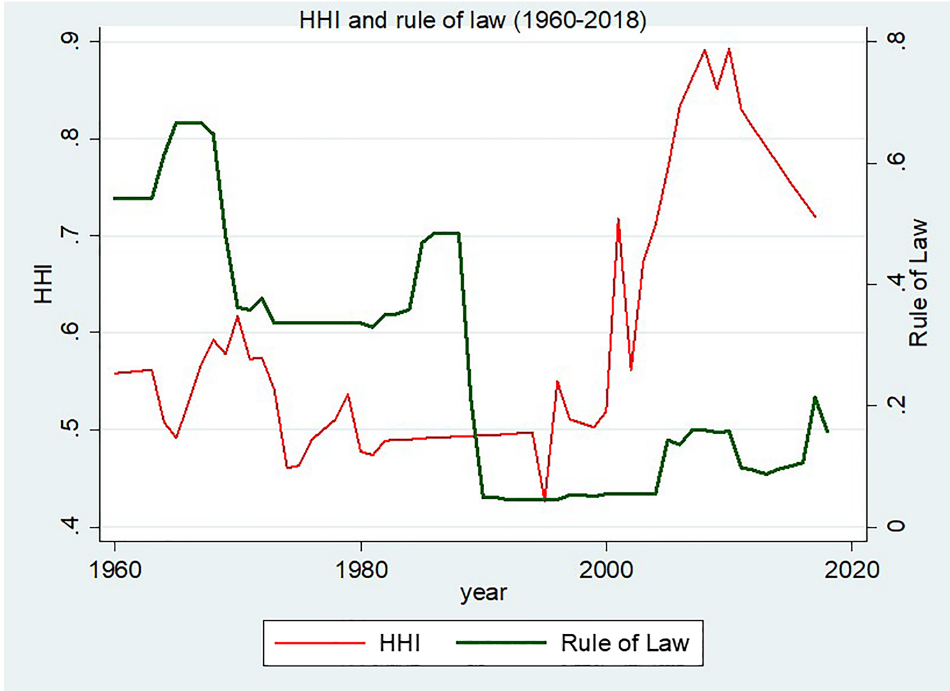


Fig. 5 GDP per capita and oil rents (time line plots)

Fig. 6 HHI and rule of law (time line plots)



Appendix 2

Table 4 ADF unit root tests (variables in levels)

Variable	ADF test statistic	1% Mackinnon Critical Value	5% Mackinnon Critical Value	P values	Remarks	Order of integration
$lpcgdp_t$	0.537	-3.572	-2.925	0.9860	non-stationary	I(1)
HHI_t	-0.765	-3.572	-2.925	0.8291	non-stationary	I(1)
$oilrent_t$	-1.598	-3.572	-2.925	0.4846	non-stationary	I(1)
$ruleoflaw_t$	-1.840	-3.572	-2.925	0.3607	non-stationary	I(1)

Table 5 ADF unit root tests (first differences)

Variable	ADF test statistic	1% Mackinnon Critical Value	5% Mackinnon Critical Value	P values	Remarks	Order of integration
$dpcgdp_t$	-5.001	-3.573	-2.926	0.0000	stationary	I(0)
$dHHI_t$	-5.263	-3.573	-2.926	0.0000	stationary	I(0)
$doilrent_t$	-6.245	-3.573	-2.926	0.0000	stationary	I(0)
$druleoflaw_t$	-4.775	-3.573	-2.926	0.0001	stationary	I(0)

Appendix 3

Table 6 Johansen co-integration test

maximum rank	parms	LL	eigenvalue	Trace statistic	5% critical value
0	20	39.285683		31.4815*	47.21
1	27	48.825963	0.54843	12.4010	29.68
2	32	51.969644	0.23047	6.1136	15.41
3	35	54.766664	0.20791	0.5196	3.76
4	36	55.026448	0.02142		

Table 7 VAR lag order selection criteria

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	26.2468		0.000083	-0.877239	-0.834352	-0.765713*
1	42.5083	32.523*	0.000064*	-1.15126*	-0.979705*	-0.705151
2	50.721	16.425	0.000066	-1.12155	-0.821333	-0.340864
3	58.1156	14.789	0.00007	-1.06097	-0.63209	0.054294
4	60.1507	4.0702	0.000093	-0.798138	-0.240601	0.651699

Appendix 4

Table 8 Granger causality tests

Equation	Excluded	chi2	df	Prob > chi2
$doilrent_t$	$dHHI_t$	2.9912	1	0.084
$doilrent_t$	$dlpcgdp_t$	0.8903	1	0.345
$doilrent_t$	ALL	3.7995	2	0.150
$dHHI_t$	$doilrent_t$	6.0115	1	0.014
$dHHI_t$	$dlpcgdp_t$	2.2405	1	0.134
$dHHI_t$	ALL	7.6769	2	0.022
$dlpcgdp_t$	$doilrent_t$	1.5551	1	0.212
$dlpcgdp_t$	$dHHI_t$	0.12999	1	0.718
$dlpcgdp_t$	ALL	1.6212	2	0.445

Appendix 5

Table 9 Granger causality tests for full model with rule of law

Equation	Excluded	chi2	df	Prob > chi2
$dlpcgdp_t$	$doilrent_t$	1.5455	1	0.214
$dlpcgdp_t$	$dHHI_t$	0.1537	1	0.695
$dlpcgdp_t$	$druleoflaw_t$	0.9108	1	0.340
$dlpcgdp_t$	ALL	2.5584	3	0.465
$doilrent_t$	$dlpcgdp_t$	0.8292	1	0.363
$doilrent_t$	$dHHI_t$	2.9414	1	0.086
$doilrent_t$	$druleoflaw_t$	0.5011	1	0.479
$doilrent_t$	ALL	4.3347	3	0.228
$dHHI_t$	$dlpcgdp_t$	2.3668	1	0.124
$dHHI_t$	$doilrent_t$	6.0146	1	0.014
$dHHI_t$	$druleoflaw_t$	0.5194	1	0.471
$dHHI_t$	ALL	8.2676	3	0.041
$druleoflaw_t$	$dlpcgdp_t$	0.00522	1	0.942
$druleoflaw_t$	$doilrent_t$	0.06963	1	0.792
$druleoflaw_t$	$dHHI_t$	0.14462	1	0.704
$druleoflaw_t$	ALL	0.20074	3	0.977

Appendix 6

Table 10 Residual autocorrelation test

Lagrange-multiplier test			
lag	chi2	df	Prob > chi2
1	14.029	9	0.121
2	8.708	9	0.465

Table 11 VAR stability test

Eigenvalue	Modulus
-0.567	0.567
0.316	0.31273
-0.067	0.066

All the eigenvalues lie inside the unit circle. VAR satisfies stability condition

Appendix 7

Table 12 VAR model results for GDP growth, HHI and oil rents (with post-2010 dummy)

Dependent variable	$dlpcgdp_t$ (1)	$dHHI_t$ (2)	$doilrent_t$ (3)
Constant	0.013	0.007	0.46
$dlpcgdp_{t-1}$	0.34**	0.22*	-6.10
	(0.13)	(0.12)	(8.70)
$doilrent_{t-1}$	0.003	0.004**	-0.32**
	(0.002)	(0.002)	(0.14)
$dHHI_{t-1}$	-0.04	-0.43***	12.46
	(0.13)	(0.13)	(8.97)
post2010dummy	0.01	-0.041**	-2.29
	(0.021)	(0.019)	(1.35)
R^2	0.17	0.32	0.18
Number of observations	56	56	56

Standard errors in parenthesis. *, **, *** correspond to 10, 5 and 1% level of significance

Appendix 8

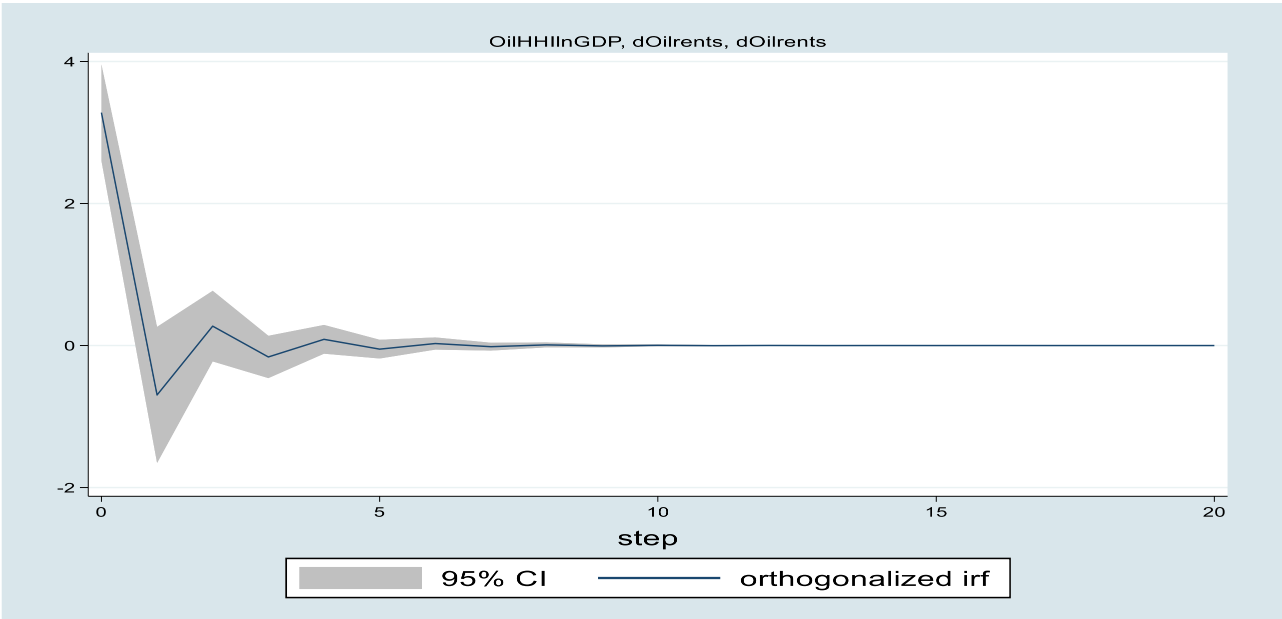


Fig. 7 OIRF (oil impulse, oil response)

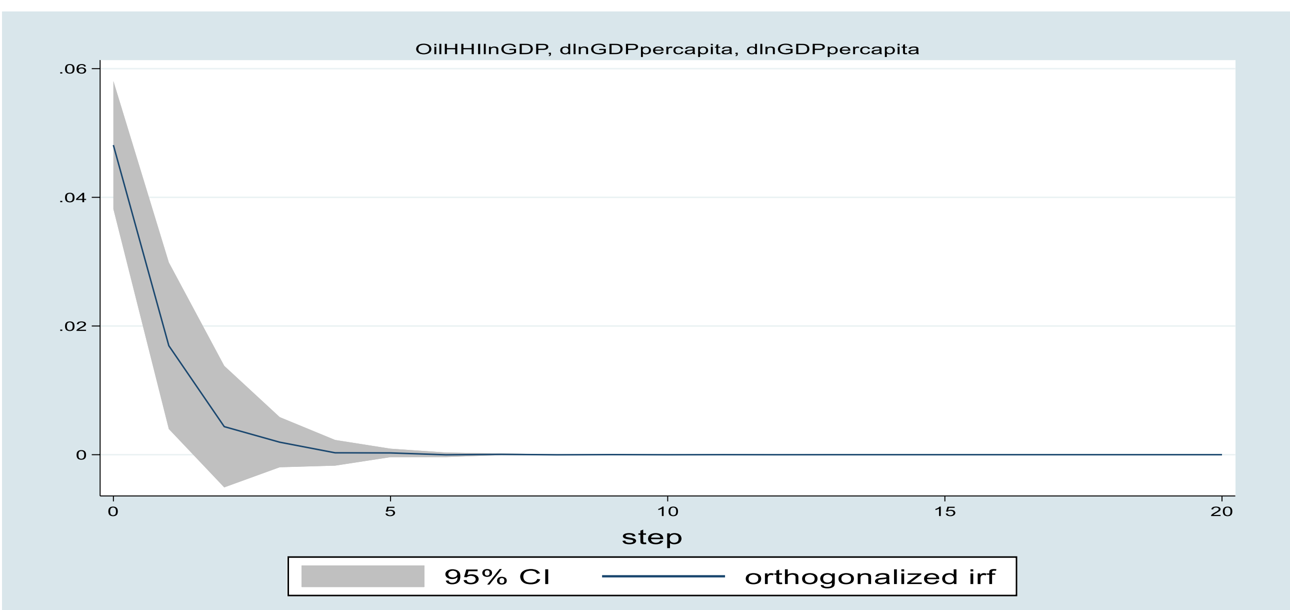


Fig. 8 OIRF (growth impulse, growth response)

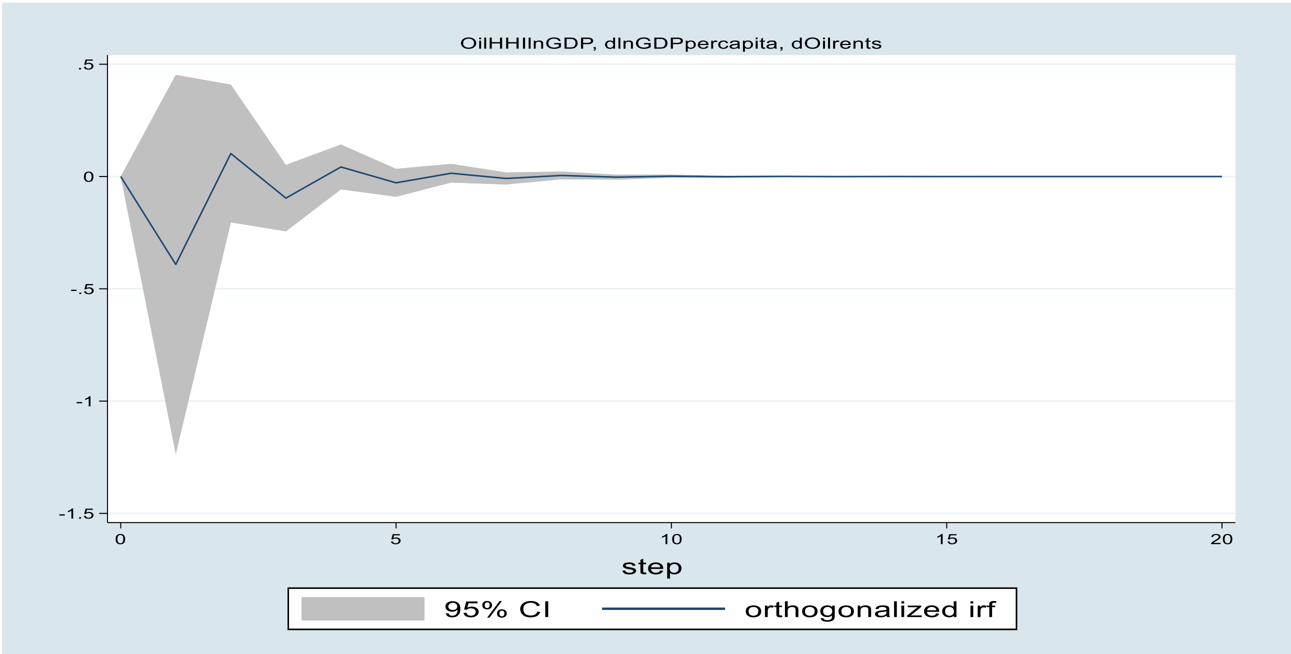


Fig. 9 OIRF (growth impulse, oil response)

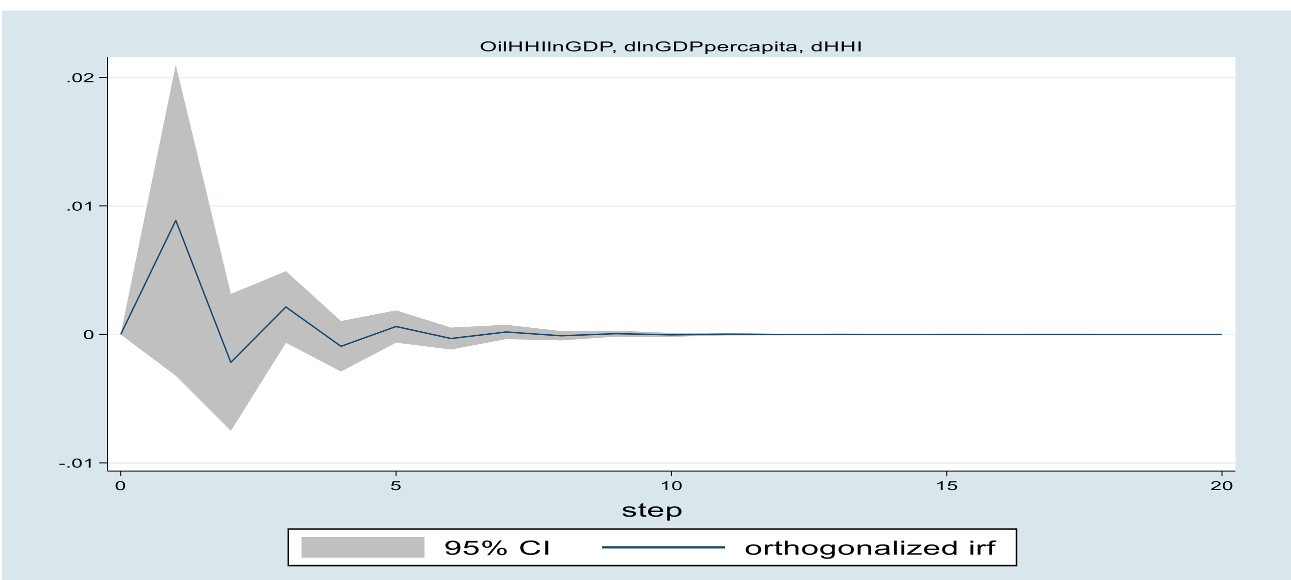


Fig. 10 OIRF (growth impulse, HHI response)

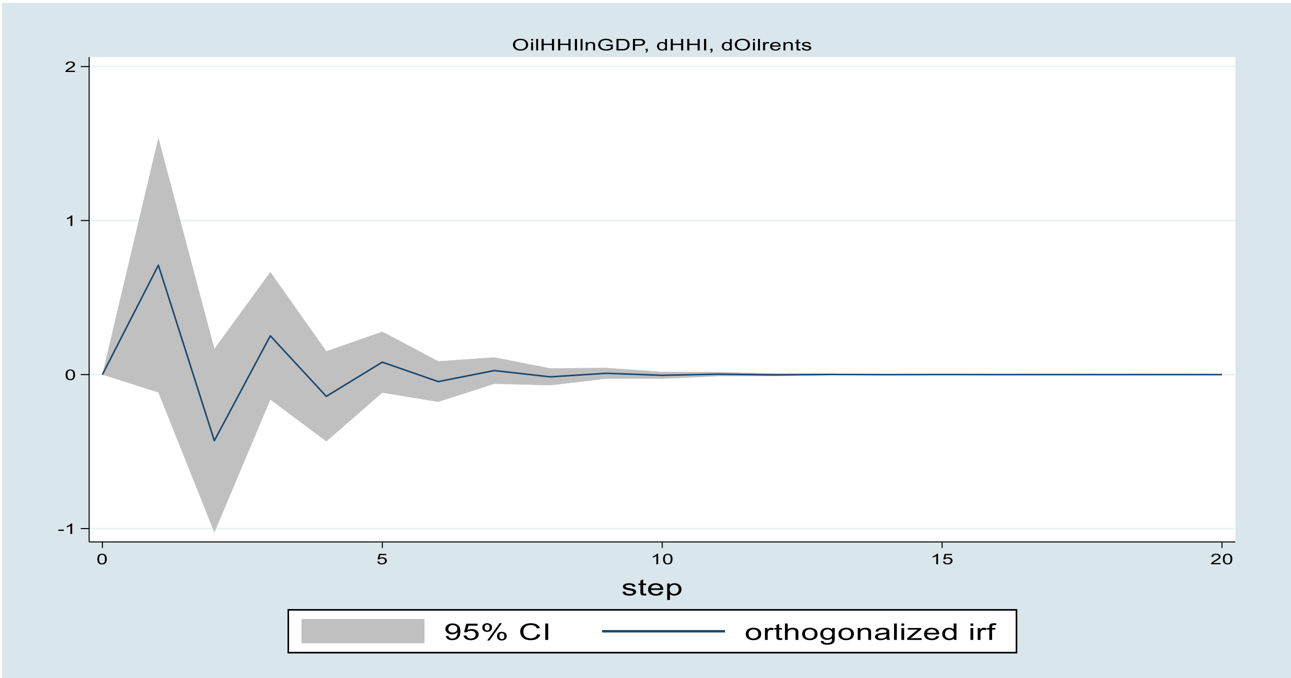


Fig. 11 OIRF (HHI impulse, oil response)

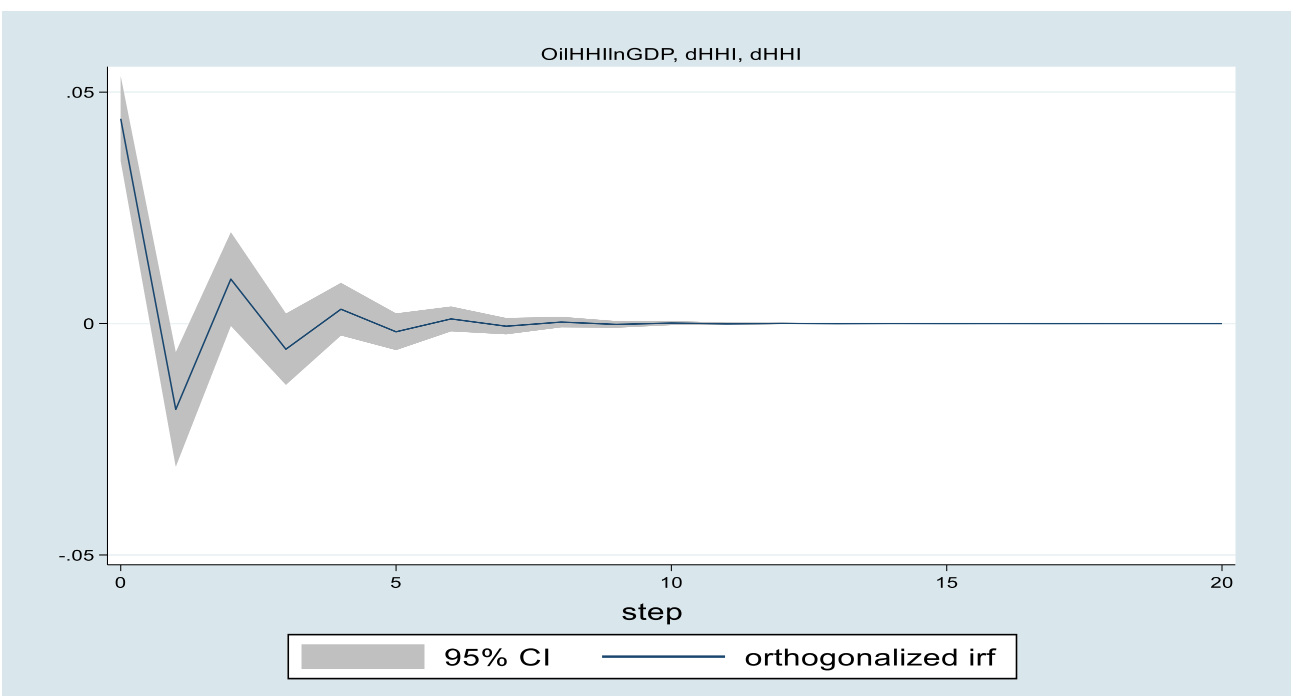


Fig. 12 OIRF (HHI impulse, HHI response)

Appendix 9

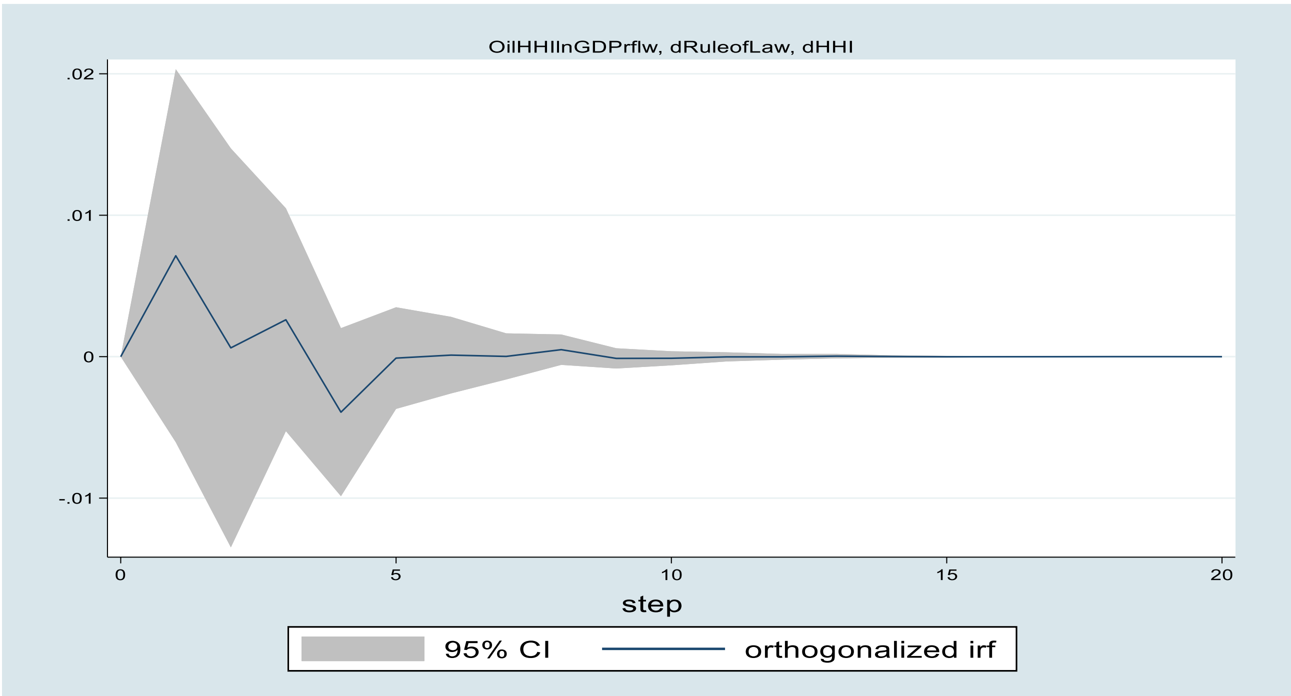


Fig. 13 OIRF (rule of law impulse, HHI response)

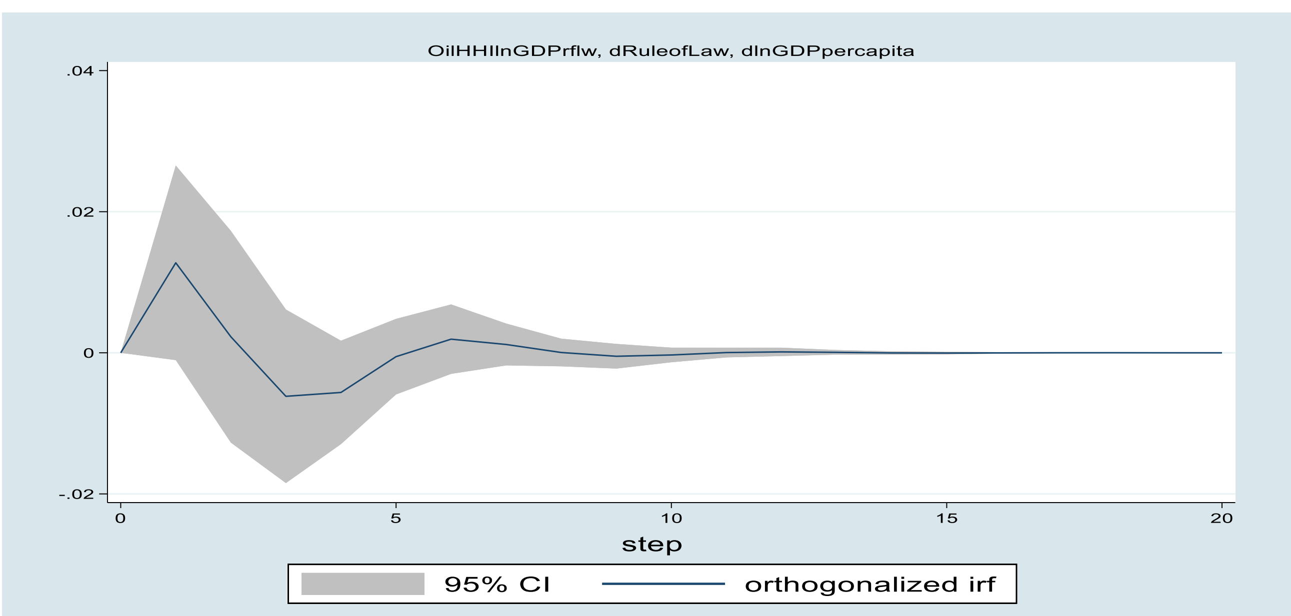


Fig. 14 OIRF (rule of law impulse, growth response)

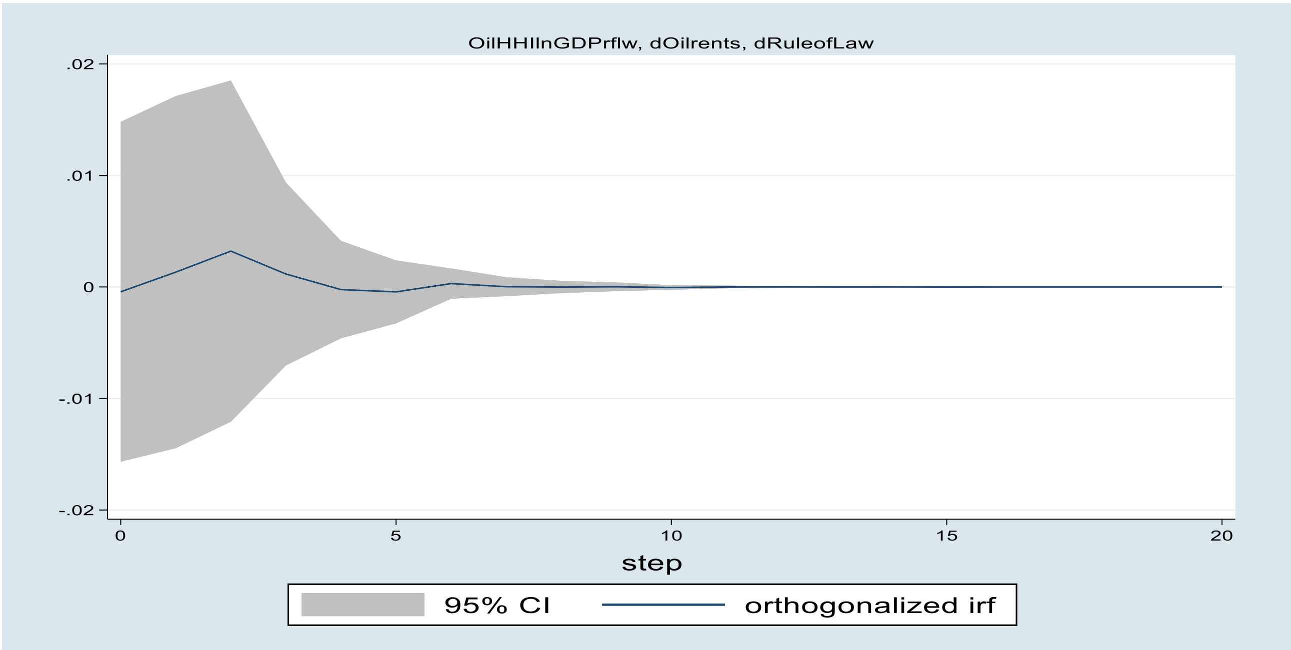


Fig. 15 OIRF (oil impulse, rule of law response)

Declarations

Conflict of interest The authors have no conflicts of interest to declare.

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