*Economic Change and Restructuring* 2024 doi: 10.1007/s10644-024-09808-5

# The role of corruption in the oil price-growth relationship: Insights from oil-rich economies

Joseph David

Lagos Business School, Pan-Atlantic University

**Abstract**

This study examines whether the effect of oil prices on economic growth is influenced by the level of corruption. I focus on 30 oil-rich economies and employ dynamic heterogeneous panel estimation techniques to address the issue of cross-sectional dependence. Evidence from the study reveals that the impact of oil prices on growth varies with corruption levels. Specifically, the marginal effect of oil prices on growth is positive at low levels of corruption but hampers immediate and long-term growth at high levels of corruption. Essentially, the results indicate that a simultaneous increase in oil prices and corruption impairs growth, whereas increase in oil prices coupled with a reduction in corruption benefits the economy more. Using a disaggregated sample of countries based on their corruption levels, the results suggest that the adverse effect of simultaneous increases in oil prices and corruption is more pronounced in oil-rich countries with higher levels of corruption compared to those with lower levels. The study implies that the level of corruption is a crucial factor in how changes in oil prices impact long-term growth in oil-rich economies. Therefore, for sustainable long-term economic growth, an increase in oil prices must be accompanied by a significant reduction in corruption.

**Keywords:** Economic growth, oil price, corruption, oil-rich economies, CS-ARDL

**JEL Classification:** O4, O43, O13, C23

## 1 Introduction

Crude oil is a crucial input in modern economic activities, accounting for more than one-third of global energy demand (Energy Institute 2023). Consequently, fluctuations in oil prices can have significant implications for economic performance. The impact of these changes varies between oil-exporting and oil-importing countries. For oil-exporting nations, rising oil prices are generally viewed positively, as they boost foreign exchange earnings and investment opportunities, thereby supporting economic growth. In contrast, negative price shocks reduce public revenue and investment, leading to slower economic growth (Kriskkumar and Naseem 2019; Moshiri 2015). Oil-importing nations often benefit from lower oil prices, as it reduces import costs and positively impact their economies. However, positive oil price increases are seen as detrimental in these countries due to its adverse effect on the economic stability of oil-importing economies (Moshiri 2015).

Evidence suggests that oil price changes may have non-standard effects on growth, with positive oil price changes potentially leading to growth-retarding conditions such as exchange rate appreciation, stagflation from high inflation, rising unemployment, rent-seeking, and poor policy-making in oil-exporting economies (Moshiri 2015; Moshiri and Banihashem 2012). This position is well accentuated by the sustained poor growth performance of many oil-rich nations in the Middle East, Africa, and Latin America despite periods of favourable oil prices providing significant financial resources critical for growth (David et al. 2024; Moshiri 2015; Moshiri and Banihashem 2012; Sachs and Warner 1995). A notable explanation for the adverse effects of positive oil price shocks in oil-dependent economies is the Dutch disease theory (Corden and Neary 1982). This theory describes an economic phenomenon where the discovery and export boom of natural resources, like oil, leads to a shift of resources from tradable sectors (e.g., manufacturing and agriculture) to the non-tradable sector (e.g., oil), causing local currency appreciation. This shift reduces net exports, declines the non-resource tradable sector, and ultimately slows economic growth (Kriskkumar and Naseem 2019; Moshiri 2015).

The Dutch disease theory attributes economic destabilisation caused by oil booms to an over-reliance on natural resources like oil. However, recent research highlights that it is not merely the presence of natural resources but also the quality of institutions that determines how price shocks affect economic growth (Boschini et al. 2007; Brunnschweiler 2008; Mehlum et al. 2006). Given the well-documented relationship between oil prices and corruption (Arezki and Brückner 2009; Ashfaq et al. 2023; Baragwanath 2020), it appears that corruption levels play a critical role in shaping the impact of oil price changes on long-term growth. Baragwanath (2020), for instance, illustrates how positive shocks, such as oil price increases, can create strong incentives for corrupt politicians to misappropriate funds. These politicians often inflate the costs of social goods and services and divert resources away from productive investments toward non-productive, capital-intensive projects that provide opportunities for bribes and kickbacks. As a result, this environment of corruption undermines the potential long-term growth benefits that could arise from rising oil prices, leading to growth-retarding conditions instead of fostering economic development (Abu at el. 2022).

In this context, it is evident that an atmosphere of corruption ensures that changes in oil prices, regardless of their direction, tend to have adverse impacts on growth. In other words, the effect of oil price fluctuations on economic growth depends heavily on the prevailing level of corruption. While positive oil price shocks may result in sluggish growth in oil-rich countries with high levels of corruption, they can stimulate long-term economic growth in countries with lower levels of corruption, where the resulting financial gains are more likely to be invested in productive activities (Moshiri 2015). For instance, countries like Norway, which maintain low corruption levels, have benefited significantly from positive oil price changes, using the additional revenues to foster sustainable growth. On the other hand, highly corrupt nations like Nigeria and Venezuela continue to struggle with economic challenges despite their vast oil wealth and multiple periods of favourable oil prices (Karabegović 2009; Larsen 2006; Olayungbo and Adediran 2017).

Therefore, I set out to explore whether the impact of oil prices on economic growth depends on the prevailing level of corruption. In addressing this question, this paper makes three important contributions to the literature. The first significant contribution lies in the pioneering effort to understand how the level of corruption determines the impact of oil prices on economic growth in oil-rich economies. The literature associated with the resource-curse hypothesis has generally focused on either exploring the relationship between oil price (or revenue/rent) and growth, or on how the adverse effect of oil abundance is transmitted through channels such as resource price variability, rent-seeking, human capital, saving-investment, and the money-inflation (Eregha and Mesagan 2020; Papyrakis and Gerlagh 2004). However, there is a noticeable dearth of empirical studies examining the role of corruption in this context. Thus, this attempt adds a crucial dimension to the resource-curse literature. Notably, this research aligns with and extends the findings of Moshiri (2015), which highlighted the role of quality institutions (which include control over corruption) in influencing the impact of oil price shocks and output growth in oil-rich economies.

The second contribution of the study is the use of a well-diverse sample of 30 oil-rich economies across different continents – including Africa, North Africa, Asia, South America, and Europe – with varying levels of income and corruption. This diverse sample allows for a robust and consistent analysis of how corruption levels determine the impact of oil price on growth. By examining how changes in oil prices affect growth at different levels of corruption and using multiple measures of corruption, this study provides valuable insights for policy-making. Thirdly, the paper employs the cross-sectional augmented autoregressive distributed lag (CS-ARDL) technique proposed by Chudik et al. (2016), alongwith the Dumitrescu and Hurlin (2012) heterogeneous panel causality test. By accounting for cross-sectional dependence and accommodating dynamic short-run and long-run relationships between oil price, growth and corruption, the CS-ARDL technique ensures that a robust outcome is obtained. Moreover, the adoption of the Dumitrescu-Hurlin causality tests also raises the confidence in the outcomes obtained, as it also accounts for possible cross-sectional dependence among variables. Lastly, by examining the role of corruption in the oil price-growth nexus in oil-rich countries, findings from the study are expected to rekindle the debate on the role of oil price and corruption on growth and expand the frontiers of knowledge among policymakers, researchers, and economists on the channels through which the adverse effect of oil price changes are transmitted into an oil-rich country.

Using a sample of 30 oil-rich economies, the CS-ARDL techniques demonstrate that oil prices stimulate short term and long-term growth, while corruption generally hinders economic growth in oil-rich economies. The Dumitrescu-Hurlin causality test also confirms this outcome. Importantly, the results reveal that the impact of oil prices on economic growth varies with corruption levels. Specifically, the marginal effect of oil prices on economic growth is positive at low levels of corruption but hampers growth at high levels of corruption. In other words, the results indicate that a simultaneous increase in oil prices and corruption impairs economic growth, whereas an increase in oil prices coupled with a reduction in corruption benefits the economy more. Using disaggregated analyses shows that the magnitude of the effects of of oil prices and corruption on growth is larger in countries perceived to have higher levels of public sector corruption. In addition, the adverse impact of a simultaneous increase in oil prices and corruption is more pronounced in oil-rich economies with relatively higher levels of corruption compared to those with lower levels. These outcomes are robust to various estimation techniques and alternative measures of corruption.

The rest of this paper is divided as follows. Section two presents a review of the theoretical and empirical literature. Section three contains methodology and data. The estimation results are presented and discussed in the fourth section. The conclusion and policy recommendation are provided in the last section.

## 2 Literature Review

### *2.1 Theoretical background*

A comprehensive theory explaining the relationship between oil prices, economic growth, and corruption is challenging to find. However, the link between oil prices, corruption, and economic growth can be understood through the well-known "resource curse" hypothesis (RCH) popularised by Sachs and Warner (1995). The RCH details the paradox of economies abundant in natural resources (such as oil, gas, coal, and ore) that should theoretically experience growth and development. Instead, these economies are often associated with negative growth, high poverty levels, poor health and education outcomes, weak institutions, and persistent civil conflict (David et al. 2024). While early development literature generally supports the role of natural resources in promoting growth (Rostow 1961), the notion that resources might be more of an economic curse than a blessing began to emerge in debates during the 1950s and 1960s, prompted by the economic problems of low- and middle-income countries (Ross 1999). In recent decades, this argument has gained traction, highlighted by the poor economic performance of resource-rich countries compared to the rapid growth of resource-poor East Asian countries (David et al. 2024; Sachs and Warner 2001).

The fact that the presence of natural resources has stimulated growth and social well-being in some countries (e.g., the United States, Canada, Australia, Norway, Botswana, and the six Gulf Cooperation Council (GCC) countries) has prompted numerous explanations to explain why natural resources appear to be a blessing in some contexts and a curse in others. Prominent among these explanations are the Dutch Disease, fluctuating terms of trade and prices of natural resources, and the quality of institutions and governance (Ben-Salha et al. 2021; Eregha and Mesagan 2020). The Dutch Disease explanation argues that a resource boom leads to diminished competitiveness in non-resource sectors (particularly industry), resulting in real exchange rate appreciation, higher wages and prices of non-tradable goods, a decline in net exports, and eventual dependence on a single product (Corden and Neary 1982; Corden 1984; Wijnbergen 1984). The second explanation concerns the volatility of primary commodity prices and their disruptive effects on growth. As primary product prices are generally determined by global markets, greater price volatility makes revenue for resource-dependent economies less predictable, complicating economic planning (Ben-Salha et al. 2021; David et al. 2024; Gylfason 2001).

The third explanation focuses on institutional weakness. It is generally argued that the institutional environment plays a crucial role in mediating the impact of natural resources on sustainable growth and development. When property rights are insecure and institutions are degraded, an abundance of natural resources can increase rent-seeking behaviour, intensify corruption, reduce transparency, and escalate conflicts (Leite and Weidmann, 1999). In other words, as institutional quality deteriorates, the flow of rents from natural resources fosters rent-seeking and diverts resources away from productive, growth-enhancing investments (Mehlum et al., 2006; Brunnschweiler, 2008).

Since the Dutch Disease syndrome is triggered by fluctuations in natural resource prices and export earnings (Kriskkumar and Naseem 2019), it is argued that Sachs and Warner's paradoxical findings can be attributed to changes in natural resource prices (such as oil prices) and weak institutions (corruption) (Olayungbo and Adediran 2017). Essentially, this implies that the adverse effects of oil on long-term growth can be better understood by examining the interplay between oil prices and corruption. Evidence of a strong relationship between oil prices and corruption is well-documented in the literature (Arezki and Brückner 2009; Ashfaq et al. 2023; Baragwanath 2020). For example, Baragwanath (2020) demonstrates that positive oil price shocks often create incentives for corrupt politicians to embezzle oil revenues, inflate the cost of social goods and services, and divert resources away from growth-enhancing investments in favour of large, non-productive projects with opportunities for bribes and kickbacks. This undermines any potential benefits of positive oil shocks and leads to unimpressive economic performance.

### *2.2 Empirical literature*

Over time, researchers have explored the empirical relationship between oil prices and economic growth in oil-rich economies. Using different approaches, the conclusion is generally mixed, with some demonstrating a positive association between oil price and growth, while others established a negative link, and in some cases, an insignificant relationship. The relationship between oil price and growth has often been explored from different perspectives, including a group of countries within the same region, country-specific levels, and based on the level of development. For example, Akinlo and Apanisile (2015) used a sample of 10 oil-exporting Sub-Saharan African (SSA) countries during the 1986-2012 period to examine the impact of oil prices on growth and establish a positive relationship between oil prices and economic growth. Similarly, for the Gulf Cooperation Council (GCC) countries (including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, the UAE), Nusair (2016) discovered a similar outcome. More so, Matallah and Matallah (2016) established a positive relationship between oil rent and economic growth in 11 Middle East and North African (MENA) oil-dependent countries (Algeria, Bahrain, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia, the UAE, and Yemen) between 1996 and 2014. In addition, Mehrara (2008) show that oil prices are growth-enhancing in 13 oil-exporting countries (Algeria, Colombia, Ecuador, Indonesia, Iran, Kuwait, Libya, Mexico, Nigeria, Qatar, Saudi Arabia, the UAE and Venezuela) during the 1965-2004 period. In contrast, Moshiri and Banijashem (2012) illustrate that oil price is not significant in influencing economic growth in six (6) Organisation of Petroleum Exporting Countries (OPEC) member states (Algeria, Iran, Kuwait, Nigeria, Saudi Arabia, and Venezuela) in the 1970-2009 period.

At the country-specific level, studies have also explored the influence of oil prices on growth in oil-rich economies such as Algeria, Iran, Iraq, Kuwait, Libya, Nigeria, Norway, Oman, Qatar, Saudi Arabia, Syria, and the UAE (Abubakar and Akadiri 2022; Aimer 2016; Algahtani 2016; Alley et al. 2014; Alkhathlan 2013; Berument et al. 2010; Emami and Adibpour 2012; Farzanegan and Markwardt 2009; Jiménez-Rodríguez and Sánchez 2004; Mahmood 2021; Mahmood and Murshed 2021; Yusuf 2015). The conclusion is that the impact of oil prices on economic growth is positive and significant. In contrast, some studies reported a negative association in oil-rich economies such as Nigeria and the UK (Jiménez-Rodríguez and Sánchez 2004; Yakubu and Akanegbu 2019), while others established a positive nexus in the short-term and an inverse relationship in the long-run (Eregha and Mesagan 2020; Olayungbo and Adediran 2017). Finally, some other studies illustrate an insignificant relationship between oil prices and growth in countries such as Bahrain, Brunei, Malaysia, Tunisia and Vietnam (Berument et al. 2010; Kriskkumar and Naseem 2019).

From the survey of empirical literature, it is evident that while numerous studies have explored the direct impact of oil price changes on economic growth, there remains a notable gap in research concerning the role of corruption in moderating this relationship. Despite its significant manifestations in many oil-rich countries, the influence of corruption on the impact of oil price fluctuations on growth has not received adequate attention from researchers. Given the unimpressive growth performance observed in many oil-rich economies, examining the relationship between oil prices and economic growth through the lens of corruption is crucial. Interestingly, many oil-rich countries are renowned for their high levels of corruption. Moving from one oil-rich country to another, including Nigeria, Venezuela, Angola, Gabon, and Libya, evidence of massive corruption linked to oil wealth and the oil sector abound. This study aligns with and extends the findings of Moshiri (2015), which emphasised that institutional quality significantly affects the impact of oil price shocks on growth. Moshiri (2015) found that positive oil price shocks hindered growth in oil-exporting countries with low institutional quality, while the effect was less pronounced in countries with strong institutions. This research differs from Moshiri (2015) by specifically investigating whether the impact of oil price on growth is moderated by corruption levels across 30 oil-rich economies spanning Africa, Asia, North America, Europe, and Latin America. This approach provides a new perspective on the interaction between oil price changes, corruption, and economic growth.

## 3 Data and methodology

### *Model specification*

The main thrust of this study is to explore the role of corruption in the relationship between oil prices and economic growth in selected oil-rich economies. Relying on the resource curse hypothesis (Sachs and Warner 1995), and following the modelling approach adopted in some studies (Abu et al. 2022; David et al. 2023; Ehigiamusoe et al. 2019; Mahmood 2021; Moshiri 2015), cross-country econometric models indicating the relationships between oil rice, corruption and growth, as well as the effect of corruption on the oil price-growth relationship in oil-rich countries, is specified as follows:

$$lrgdp_{i,t} = \psi_1 op_{i,t} + \psi_2 co_{i,t} + \varphi' z_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t}, \quad (1)$$

$$lrgdp_{i,t} = \omega_1 op_{i,t} + \omega_2 (op_{i,t} \times co_{i,t}) + \varphi' z_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t}, \quad (2)$$

$$i = 1,2, \ldots, N; \; t = 1,2 \ldots, T$$

where $lrgdp$ is economic growth (proxy by real GDP), $op$ denotes oil price (proxy by relevant price of benchmark crude such as WTI, Brent, Bonny Light, Arab Light, Urals, etc.), $co$ represents corruption (proxy by Transparency International's corruption perception index, CPI. For robustness, World Banks's control of corruption index is also used)[1], and $Z$ is a set of control variables (such as fiscal balance, population size, financial development, and employment). $\mu_i$ and $\eta_t$ are unobserved country-specific and time-specific effects, respectively. $\varepsilon_{i,t}$ is the independent and identically distributed (IID) error term. $\psi_i$, $\omega_i$, and $\varphi$ are the slope coefficients to be estimated. To reduce skewness, I take the log of real GDP, oil price, and population size.

The expected signs of the coefficient of the regressors in equations (1) and (2) are as follows: $\psi_1$, $\psi_2$, $\omega_1$ and $\omega_2 > 0 > \psi_1$, $\psi_2$, $\omega_1$ and $\omega_2$, suggesting the coefficient of oil price, corruption and the interaction term could take a negative or positive sign, as suggested in the extant literature. A further description and definition of all the variables (including the control variables) is provided in Table 1.

Through the oil price-corruption interaction term ($\omega_2$) in Equation (2), the marginal effect of changes in oil price on growth through the partial derivative of Equation (2) is as follows[2]:

$$\frac{\partial lrgdp_{i,t}}{\partial op_{i,t}} = \omega_1 + \omega_2 co_{i,t} \qquad (3)$$

I focus on the signs of the two coefficients ($\omega_1$ and $\omega_2$). If $\omega_1 > 0$ and $\omega_2 < 0$, it suggests that oil price improves economic growth, but an increase in the level of corruption diminishes the favourable effect. If $\omega_1 < 0$ and $\omega_2 > 0$, it connotes that oil price impairs growth, but corruption mitigates the adverse effect. If $\omega_1 < 0$ and $\omega_2 < 0$, it signifies that oil prices slow economic growth and rising corruption levels aggravate the adverse impact. If $\omega_1 > 0$ and $\omega_2 > 0$, it denotes oil price is growth-enhancing, and the growing level of corruption intensifies that positive effect. However, a positive marginal effect ($\omega_1 + \omega_2 co_{i,t}$) demonstrate that a rise in oil prices and the level of corruption enhance economic growth, while a negative marginal effect connotes otherwise.

### *3.2 Data sources and description*

The study uses an annual dataset covering the 1996-2021 period for a panel of 30 oil-producing countries in Africa, Asia, Europe, North America, and South America (the selected countries are presented in Appendix Table A1). The data for real GDP, population size, financial development (ratio of credit to the private sector to the GDP), and employment rate (percentage of a country's population that is employed) are sourced from the World Bank's WDI, while the primary fiscal balance (the difference between total public revenue and expenditure, excluding net interest payments on public debt, relative to the GDP) is from the IMF's World Economic Outlook (WEO). Corruption data are collected from Transparency International (TI) and World Bank's World Governance Indicators (WGI). Lastly, oil price data is from OPEC's annual statistical bulletin.

<<Table 1>>

The summary statistics and correlation analysis of the variables are presented in the upper and lower panels of Table 2. The average real GDP of the 30 countries between 1996 and 2022 is approximately

[1] The TI's corruption perception index and World Bank's control of corruption index reflect the perceived extent of corruption in the public sector, and take values between 0 and 100, and -2.5 and 2.5, respectively, with higher values indicating a low level of corruption and vice versa. Following David et al. (2024), the corruption indices are rescaled by subtracting the country-level values of the index from the highest possible value (100 and 2.5) to reflect the "actual" extent of corruption and make interpretation straightforward. Therefore, the index will range from 0 (absence of corruption) to 100 (pervasive corruption), and 0 (not corrupt) to 5 (high level of corruption) for the TI CPI and World Bank corruption index, respectively.

[2] For notational brevity, I focus only on the contemporaneous effects, but the marginal effect at different time horizons ($t + i$ and $t - i$) are possible.

US$951.573 billion, with a wide range from about US$587 million (Equatorial Guinea, 1996) to US$20.927 trillion (United States, 2022). This variability underscores the heterogeneity of the sample, which includes both high-income and low-income economies. Appendix Table A2 provides a detailed view of the country-level average real GDP.

During the same period, the average crude oil price was US$457.46 per barrel, ranging from about US$10.42 to US$117.15 per barrel. As shown in Appendix Figure A1, oil prices have experienced significant fluctuations, influenced by major geopolitical crises and economic shocks. For instance, the price crash in 1998 resulted from a price war between Venezuela and Saudi Arabia, while the 2008 global economic downturn led to a drop from about US$97.37 per barrel to US$61.68 per barrel. Political unrest in the Middle East drove prices above US$100 per barrel from 2011 to 2013. The dramatic fall in prices during 2014-2016 was primarily due to weaker global demand and excess supply from shale oil production and Saudi Arabia's market share defense. A brief increase in 2018 was followed by a sharp decline due to the COVID-19 pandemic. Recent geopolitical tensions, particularly the Russian invasion of Ukraine, have contributed to rising oil prices in 2022.

<<Table 2 here>>

The average rescaled TI CPI and World Bank's corruption index for the 30 countries are 58.68 and 2.71, respectively. The wide range of values suggests a diverse sample, including countries perceived as highly corrupt and those considered relatively less corrupt. Appendix Table A2 shows average corruption perception scores for each country. The side-by-side comparison between corruption and real GDP indicates an interesting trend: countries with higher GDPs tend to have lower corruption scores. For instance, Norway, Canada, the US, and the UK, with large real GDP, also have lower corruption scores. Conversely, countries like Russia, Brazil, Nigeria, and Mexico, which also have significant GDP, are perceived as very corrupt. At the mid-point are countries such as the UAE, Bahrain, Malaysia, Oman, Qatar, and Kuwait, with moderate GDP and corruption scores. Most of these are absolute monarchies, which may limit exposure to corruption due to centralised political power. Brunei, though having a smaller GDP, is similarly low in corruption and practices an absolute monarchy. At the other extreme are countries with smaller GDP but high corruption perceptions. These include Congo, Azerbaijan, Equatorial Guinea, Libya, Sudan, and Gabon.

The summary statistics of the control variables are also presented in Table 2. Besides the summary statistics of the variables, the results of the correlation analysis summarised in Table 2 show that oil prices have a very weak positive but insignificant correlation with real GDP. Both corruption indices have a weak negative and significant correlation with real GDP. The correlation between oil prices and the corruption indices is also very weak and insignificant, albeit positive. In addition, financial development and population size have a moderate positive and significant correlation with real GDP, whereas the primary fiscal balance shows a weak negative correlation with real GDP. The employment rate has a weak positive correlation with real GDP.

### *3.3 Estimation technique*

To estimate the relationship specified in Equations (1) and (2), I consider the mean group (MG) and the pooled mean group (PMG) estimators (Pesaran and Smith 1995; Pesaran et al. 1999). The main difference between the estimators lies in their treatment of the slope coefficients (Sakanko et al. 2024). The MG estimator, for instance, fits separate regression for each cross-section and then calculates a simple arithmetic average of the coefficients. Thus, the intercepts, slope coefficients, and error variances are all allowed to differ across groups. Meanwhile, the PMG estimator combines both pooling and averaging of slope coefficients. Particularly, the PMG assumes homogeneous long-run coefficients but allows the intercept, short-run slope coefficients, and error variance to vary across groups (as would the MG estimator). Besides the differences in their treatment of the slope coefficients, researchers also favour the use of these estimators due to, among other things, their ability to handle nonstationary dynamic panels, accommodate series with different orders of integration, and implement long-term equilibrium including a possible heterogeneous dynamic adjustment process (Blackburne and Frank 2007; Ehigiamusoe et al. 2019; Pesaran et al. 1999; Sakanko et al. 2024).

For notational convenience, I consider a bivariate autoregressive distributive lag (ARDL) ($p, q_1, \dots q_q$) model specification of the form:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij} x_{i,t-j} + \mu_i + \epsilon_{it}, \tag{4}$$

where $y_{it}$ is the dependent variable, $x_{it}$ is a $k \times 1$ vector of explanatory variables for group $i$; $\delta_i$ is a $k \times 1$ coefficient vector; the coefficient of the lagged dependent variable, $\lambda_{ij}$, are scalars; $\mu_i$ represent the group-specific fixed effect; $i = 1,2, \dots, N$ is the number of groups, and $t = 1,2 \dots, T$ denotes time periods, and $\epsilon_{it}$ is the stochastic error term that is independent and identically distributed across $i$ and $t$ with zero means and variances $\sigma^2 > 0$.

Suppose the regressors, $x_{i,t}$, are 1(1) or 1(0), and the order of integration of $y_{i,t}$ is at most equal to that of $x_{i,t}$, Equation (4) can be re-parameterised and expressed in an error correction representation as follows:

$$\Delta y_{it} = \phi_i y_{i,t-1} + \beta'_i x_{it} + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta'^*_{ij} \Delta x_{i,t-j} + \mu_i + \epsilon_{it}, \tag{5}$$

$i = 1,2, \dots, N$ and $t = 1,2 \dots, T$, where $\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij})$, $\beta_i = \sum_{j=0}^{q} \delta_{ij}$, $\lambda^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im}, j = 1,2, \dots p-1$, and $\delta'^*_{ij} = -\sum_{m=j+1}^{q} \lambda_{im}, j = 1,2, \dots q-1$.

$\phi_i$ is the error-correction speed of adjustment parameter which measures the speed of adjustment toward long-run equilibrium. The parameter is expected to be less than 1, negative and statistically significant for the long-run relationship between $y_{i,t}$ and $x_{i,t}$ to be established. If $\phi_i = 0$, then there is no evidence of a long-run relationship between the variables (Pesaran et al. 1999).

Assuming that $\phi_i < 0$ for all $i$, a long-run relationship between $y_{i,t}$ and $x_{i,t}$ is defined as follows:

$$y_{it} = -(\beta'_i / \phi_i) x_{it} + \eta_{it}, \tag{6}$$

for each $i = 1,2, \dots, N$, where $\eta_{it}$ is a stationary process. Based on the PMG estimator, Pesaran et al. (1999) proposed estimating the homogeneous long-run coefficients and the group-specific error-correction coefficients using the pooled maximum likelihood estimation, and the estimators are given as:

$\hat{\phi}_{PMG} = \frac{1}{N} \sum_{i=1}^{N} \tilde{\phi}_i$, $\hat{\beta}_{PMG} = \frac{1}{N} \sum_{i=1}^{N} \tilde{\beta}_i$, $\hat{\lambda}_{jPMG} = \frac{1}{N} \sum_{i=1}^{N} \tilde{\lambda}_{ij}, j = 1, \dots p-1$, $\hat{\delta}_{jPMG} = \frac{1}{N} \sum_{i=1}^{N} \tilde{\delta}_{ij}, j = 1, \dots q-1$, $\hat{\theta}_{PMG} = \frac{1}{N} \sum_{i=1}^{N} -(\tilde{\beta}_i / \tilde{\phi}_i)$

Based on the MG estimator proposed by Pesaran and Smith (1995), the mean of the short-and long-run coefficients is computed as:

$\hat{\phi}_{MG} = \frac{1}{N}\sum_{i=1}^{N}\hat{\phi}_i$, $\hat{\beta}_{MG} = \frac{1}{N}\sum_{i=1}^{N}\hat{\beta}_i$, $\hat{\lambda}_{jMG} = \frac{1}{N}\sum_{i=1}^{N}\hat{\lambda}_{ij}, j = 1, \dots p-1$, $\hat{\delta}_{jMG} = \frac{1}{N}\sum_{i=1}^{N}\hat{\delta}_{ij}, j = 1, \dots q-1$, $\hat{\theta}_{MG} = \frac{1}{N}\sum_{i=1}^{N} -(\hat{\beta}_i/\hat{\phi}_i)$,

where $\hat{\phi}$, $\hat{\beta}$, $\hat{\lambda}_{ij}$, and $\hat{\delta}_{ij}$ are the least squares estimates[3] derived individually from Equation (5).

While the MG and PMG estimators allow researchers to identify effects for each cross-section separately and the heterogeneity of short-run dynamics, they do not allow for error cross-section dependence (Ditzen 2018). In the literature, it is argued that wrongly assuming that the errors are cross-sectionally independently distributed tends to lead to incorrect inference and in some cases inconsistent estimates (Chudik et al. 2016). To address the issue of error cross-section dependence in a heterogenous dynamic panel model, Chudik and Pesaran (2015) proposed an estimator to estimate Equation (4) consistently by augmenting unit-specific ARDL specifications with cross-section averages to "filter out the effects of the unobserved common factors from which long-run effect can be indirectly estimated". In a dynamic model, the floor of $\sqrt[3]{T}$ lags of the cross-section averages are added for both the dependent and strictly exogenous variables in the specification. Chudik et al. (2016) refer to this approach as the cross-sectionally augmented ARDL (CS-ARDL).

Equation (4) can be generalised to an ARDL $(p_y, p_x)$ model by incorporating cross-section averages as:

$$y_{i,t} = \mu_i + \sum_{l=1}^{p_y}\lambda_{l,i}y_{i,t-l} + \sum_{l=0}^{p_x}\delta'_{l,i}x_{i,t-l} + \sum_{l=0}^{p}\gamma'_{i,l}\bar{z}_{t-l} + \epsilon_{i,t}, \tag{7}$$

where $\bar{z}_t = (\bar{y}_t, \bar{x}_t)' = \left(1/N\sum_{i=1}^{N}y_{i,t}, 1/N\sum_{i=1}^{N}x_{i,t}\right)'$ are the cross-section averages of the dependent and independent variables. $\gamma_{i,l} = \left(\gamma_{y,i,l}, \gamma_{x,i,l}\right)'$ are the estimated coefficients of the cross-section averages and are generally treated as nuisance parameters.

The individual long-run coefficients are thus calculated as:

$$\theta_{CS-ARDL,i} = \frac{\sum_{l=0}^{p_x}\hat{\delta}_{l,i}}{1-\sum_{l=1}^{p_y}\hat{\lambda}_{l,i}} \tag{8}$$

Following the inclusion of cross-sectional averages, Equation (7) can be estimated by either the mean group or pooled estimator. However, to determine the most appropriate estimator between the two, the test of homogenous slope is conducted based on the Delta test of Pesaran and Yamagata (2008). Both test tests the null hypothesis of (long-run) slope homogeneity against an alternative of (long-run) slope heterogeneity. The rejection of the null encourages the use of the MG estimator which allows for heterogeneous slope, and vice versa.

Before estimating the growth model, some tests, including the cross-sectional dependence (CSD), unit root, and slope heterogeneity tests are conducted. The CSD test is conducted on each of the series to determine whether the cross-sections are cross-sectionally dependent or otherwise. The weak cross-sectional dependence test proposed by Pesaran (2015, 2021) is employed for the cross-sectional dependence test. In addition, the Levin, Lin and Chu (2002) [LLC], Im, Pesaran and Shin (2003) [IPS], and Fisher-type ADF test [ADF-Fisher] of Maddala and Wu (1999), and the cross-sectional augmented Im-Pesaran-Shin (CIPS) test of Pesaran (2007) are employed to determine the stationarity properties of the series. In addition to the estimation, I employ the heterogeneous panel causality test

[3] See Pesaran and Smith (1995) and Pesaran et al. (1999) for more information on the derivation of the MG and PMG estimators.

*Economic Change and Restructuring* 2024 doi: 10.1007/s10644-024-09808-5

of Dumitrescu and Hurlin (2012) to explore the causal relationship between the variables in the specified model. The causality technique is preferred because it accounts for cross-sectional dependence (using bootstrap-generated critical values) and assumes slope heterogeneity.

## 4 Results and discussion

### 4.1 Preliminary data analysis

As indicated in the previous section, I performed cross-sectional and unit root tests on each of the variables in the model. The results are summarised in Tables 3 and 4, respectively. As shown in Table 3, there is strong evidence to reject the null hypothesis of weak cross-sectional dependence for all series, except for the corruption indices. However, the estimated exponent (alpha) of cross-sectional dependence is well above 0.5. This indicates that all variables are cross-sectionally dependent, meaning that all the countries in the sample share common paths for all variables. The presence of strong cross-sectional dependence demonstrates the interdependence among the countries, attributable to common shocks. Moreover, since the countries are major producers and exporters of crude oil and collectively account for more than 90 percent of global oil production, adjustments in oil prices often have a significant impact on their respective macroeconomic and fiscal policies, though the effects may vary. Thus, it is imperative to use tests and estimation techniques that account for cross-sectional dependence.

<<Table 3 here>>

To determine the stationarity properties of the series, I employ both first-generation panel unit root tests (LLC, IPS, and Fisher-type ADF tests) and the second-generation CIPS unit root test, which accounts for cross-sectional dependence among cross-sections. As shown in Table 4, the results of the stationarity tests are mixed. Specifically, all four tests confirm that TI's corruption index, population size, and fiscal balance are stationary, while the World Bank's corruption index, financial development, and employment rate are integrated of the I(1) process. However, the IPS, Fisher-type ADF, and CIPS tests show that the log of real GDP is stationary after taking its first difference, whereas LLC shows that the series is stationary without differencing. Similarly, while all three first-generation tests (LLC, ADF, and IPS) suggest that the log of oil price is integrated of the I(1) process, CIPS confirms otherwise. In summary, this indicates that the series are a mixture of I(0) and I(1) series.

Due to the issue of cross-sectional dependence and the different orders of integration of the series, the reliability of existing panel cointegration tests is compromised (Fuinhas et al. 2015)[4]. Interestingly, the CS-ARDL technique accounts for cross-sectional dependence and allows series to have different orders of integration. I present and discuss the estimation results in the next section.

<<Table 4 here>>

[4] I thank the anonymous reviewer for pointing this out. Besides the issue of cross-sectional dependence, evidence has shown that conventional cointegration tests are inadequate for estimating cointegrating regression models that include deterministic components, integrated processes (or unit root processes), and their powers as explanatory variables—such as in EKC modeling. This is due to the fact that these powers, being nonlinear functions of integrated processes, do not themselves constitute integrated processes of any order. While alternative estimation and testing techniques have been proposed in the literature for handling such models, they may not apply to the current study since Equation (1) includes interactions between variables that are a mixture of unit root processes ($lop_{i,p}$) and stationary processes ($co_{i,p}$), rather than the square of a unit root process. Therefore, the Westerlund (2007) cointegration test appears appropriate as it accounts for cross-sectional dependence. However, its application in this study is limited by the restriction on the number of covariates.

**4.2 Oil price, corruption and economic growth relationship**

Before estimating the models specified in Equations (1) and (2) using the CS-ARDL technique, I conduct Pesaran and Yamagata's (2008) Delta test on the long-run parameters to determine whether the slope coefficients are homogeneous or heterogeneous. This helps in selecting the appropriate estimator. As shown in Appendix Table A3, the Delta test results under different assumptions demonstrate that the long-run slope coefficients are heterogeneous. Therefore, the mean group estimator is used to estimate the models.

Consequently, I estimate six models: the model without the oil price-corruption interaction (Model I) and the model with the oil price-corruption interaction (Model II), using the full sample (Columns 1-2) and sub-samples of countries with relatively low levels of corruption (Columns 3-4) and high levels of corruption (Columns 5-6)[5]. This step-wise analysis allows for the examination of the specific role of corruption in the oil price-growth nexus across countries with different levels of corruption. The long-run and short-run estimates of the models are summarised in Panels A and B of Table 5[6], respectively.

Starting with the main results in column (1) of Table 5, oil prices show a significant long-run positive impact on economic growth at the 10 percent level, while the long-term impact of corruption on growth is negative and significant at the 10 percent level. The short-run effects of oil prices and corruption are consistent with this pattern. Specifically, Table 5 demonstrates that a unit change in oil prices and the level of corruption leads to changes in long-term growth of 0.0692 percentage points (p.p.) and -0.0044 p.p., respectively, across the 30 oil-rich economies. These findings are consistent with existing studies that found changes in oil prices stimulate economic growth in oil-rich countries (see Eregha and Mesagan 2020; Akinlo and Apanisile 2015; Fuinhas et al. 2015; Matallah and Matallah 2016; Mehrara 2008; Nusair 2016). Similarly, the negative relationship between corruption and growth supports the "sanding the wheels" hypothesis (see Afonso and de Sá Fortes Leitão Rodrigues 2022; Mauro 1995; Mo 2001; Uddin and Rahman 2023).

<<Table 5 here>>

In column (2), the oil price-corruption interaction term is introduced (substituted for the corruption variable). The coefficient of oil price reflects the impact of oil price changes on growth when the level of corruption is zero. Meanwhile, the coefficient of the interaction term indicates the variations in growth due to changes in both oil prices and the level of corruption. As shown in column (2) of Table 5, the short- and long-term impacts of oil prices are positive and significant, while the interaction term has a positive and significant coefficient at the 10 percent level. This suggests that an increase in oil prices will lead to an immediate and long-term improvement in growth by 0.0626 percentage points and 0.3635 percentage points, respectively, when the level of corruption is zero. However, the coefficient of the interaction term shows that a simultaneous increase in oil prices and the level of corruption will decelerate long-term growth by 0.0019 percentage points.

[5] The determination of whether a country is less corrupt or more corrupt is based on its average corruption perception index (CPI) score over time. Countries with CPI scores between 0 and 49 are considered to be more corrupt, while countries with CPI scores between 50 and 100 are classified as less corrupt countries.

[6] Before estimating the models using the CS-ARDL approach, I first estimated the models using the traditional Mean Group (MG) and Pooled Mean Group (PMG) approaches. The results from these approaches are not presented or discussed here due to their strong cross-sectional dependence. However, they are available upon request.

Disaggregating the sample based on the level of corruption, columns (3) and (4) show that in oil-rich countries with relatively low levels of corruption, oil prices have a significant immediate and long-run impact on economic growth at the 5 percent level, while the interaction term has a negative and significant coefficient at the 5 percent level. However, in these countries, there is no significant relationship between corruption and growth. Meanwhile, columns (5) and (6) reveal that in countries with higher levels of corruption, the long-run impact of oil prices on growth is positive and significant. Corruption has a negative and significant immediate and long-term effect on growth in countries with higher levels of corruption, and the coefficient of the interaction term is negative and significant at the 10 percent level, both in the short and long runs. These results suggest that the magnitude of the immediate and long-term impact of oil price on growth is larger for oil-rich countries with higher levels of corruption. Additionally, the deleterious effect of corruption is only significant in oil-rich countries with higher levels of corruption. Interestingly, while the simultaneous increase in oil prices and the level of corruption has a significant adverse effect on short- and long-term growth, the magnitude of this impact is much larger in oil-rich economies with higher levels of corruption.

Moving from columns (1) to (6), the results indicate a stable cointegrating relationship between the variables in the model. This is supported by the negative signs, magnitude (less than 1), and statistical significance of the convergence coefficient (error correction term), which shows the speed of adjustment to long-run equilibrium after a short-term disequilibrium. The magnitude of the adjustment coefficient ranges between -0.486 and -0.782, suggesting that an average of between 48.6 percent and 78.2 percent of short-term disequilibrium is adjusted each period.

Meanwhile, given that the signs of the coefficients for oil prices and the interaction term differ across the models, I compute the marginal effect of oil prices on long-term growth based on the full sample, least corrupt countries, and more corrupt countries using the estimated coefficients from columns (2), (4), and (6) as follows[7]:

$$\frac{\partial lrgdp_{i,t}}{\partial lop_{i,t}} = 0.3635 - 0.0019co_{i,t},$$

$$\frac{\partial lrgdp_{i,t}}{\partial lop_{i,t}} = 0.0914 - 0.00003co_{i,t},$$

$$\frac{\partial lrgdp_{i,t}}{\partial lop_{i,t}} = 0.2213 - 0.0015co_{i,t},$$

The marginal effect of oil prices on long-term economic growth, calculated at the minimum, average, and maximum levels of the corruption index[8], are 0.3481, 0.2501, and 0.1818, respectively, for the whole sample. For countries with relatively lower levels of corruption, the computed marginal effects of oil prices at the minimum, average, and maximum levels of the corruption index are 0.0911, 0.0905, and 0.0896, respectively. In contrast, for countries with relatively higher levels of corruption, the marginal effects are 0.1614, 0.1135, and 0.0769, respectively. These results indicate that the long-term positive impact of an oil price increase is larger when the level of corruption is low, regardless of a country's current level of corruption. In other words, an increase in oil prices combined with a

[7] While I use the long-run estimates to compute the marginal effect of oil prices on long-term growth, the short-run estimates could also be used to calculate the marginal effect of oil prices on short-term growth.

[8] The minimum, average, and maximum corruption index used to compute the marginal effect are presented in the descriptive statistics presented in Table 2.

reduction in the level of corruption will have greater benefits for long-term economic growth than a simultaneous increase in oil prices and the level of corruption.

Regarding the control variables, I find evidence of an immediate and long-term positive impact of primary fiscal balance, population size, and employment rate on economic growth in oil-rich economies, regardless of the level of corruption (although the magnitude of the impact varies). However, the impact of financial development (measured by the ratio of credit to the private sector to GDP) on growth is negative but statistically insignificant, except in oil-rich economies with high levels of corruption. These outcomes are consistent with existing studies (see Adam and Bevan 2005; Azam 2022; Rahman et al. 2017).

### 4.3 Robustness and consistency checks

To determine the robustness and consistency of the results obtained, I performed two types of robustness checks. The first robustness check involves computing the cross-sectional dependence and the exponent (alpha) of the cross-sectional dependence of the residuals from the estimated model. As shown in the lower panel of Table 5, the null hypothesis of weak cross-sectional dependence cannot be rejected for all models. Additionally, the estimated exponents of cross-sectional dependence are all close to the threshold of 0.5, suggesting that the issue of cross-sectional dependence is adequately addressed in the estimated models.

The second robustness check involves using the World Bank's control of corruption index[9] as an alternative measure of corruption. The CS-ARDL estimation results presented in Appendix Table A4 reveal that using the World Bank's corruption index did not change the signs of the coefficients of the variables of interest (oil price, corruption, and the oil price-corruption interaction) nor did it affect their statistical significance. Moreover, the magnitude of the impact is very similar to the main results in Table 5. Specifically, in all models, oil price enters with a positive and significant coefficient, while the coefficient of corruption is negative and significant. The magnitude of the impact of oil prices on long-term growth is also larger for oil-rich countries with higher levels of corruption, and the adverse impact of corruption is more pronounced in such economies. Additionally, the interaction term enters with a negative and significant coefficient, further reinforcing the main results that an increase in oil prices amid pervasive corruption erodes the potential benefits associated with positive oil price changes in oil-rich economies.

As expected, in all estimations, the coefficient of the error correction term is negative, less than one, and statistically significant at the 1 percent level. Furthermore, the signs and significance of the control variables are consistent with the main estimation results using the TI corruption index. The coefficient of financial development is negative and insignificant, while primary fiscal balance, population size, and employment rate each enter with a positive and significant coefficient in all models.

### 4.4 Discussions and policy implications

The empirical findings of this study are quite revealing and have significant policy implications. They can be summarised as follows. First, regardless of the specification, oil prices have significant positive impact on long- and short term economic growth. This outcome suggests that rising oil prices play a critical role in stimulating the growth and development of oil-rich economies. Specifically, the growth impact of oil prices can be explained by the boost in public revenue from oil sales or production (including taxes and royalties), which provides the government with more resources to invest in physical and human capital, thereby stimulating growth. Given the volatile nature of oil prices and the limited control countries have over oil prices (with unilateral increases in production often

[9] I also use the rescaled World Bank's control of corruption index (to reflect corruption) so that interpretation can be straightforward.

exacerbating problems, as seen during the 1990s price crash), oil-rich economies may need to adopt fiscal discipline (such as saving and/or investing excess oil windfalls), employ efficient technology to maximise production capacity, and liberalise their oil and gas sectors. The largest impact is observed in economies with relatively higher levels of corruption (which are often low-income countries), highlighting the need for these countries to reposition their economies to capitalise on the potential of oil.

Secondly, the study shows that corruption stifles economic growth both in the short- and long-term, with the magnitude of this impact being more pronounced in oil-rich economies with high levels of perceived corruption. This finding is consistent with the "sand in the wheels" hypothesis, which posits that corruption impedes sustainable economic growth and development by reducing investment in human and physical capital, promoting inefficient resource allocation, and increasing levels of inequality and poverty (David et al. 2023, 2024). Interestingly, the greatest adverse effects of corruption are seen in countries perceived as more corrupt, which also tend to experience slower and less impressive economic growth. This outcome underscores how pervasive corruption continues to hinder growth and development in these countries despite their natural resource wealth. Empirical studies confirm that pervasive corruption slows economic performance in resource-rich economies (see Abubakar and Akadiri 2022; Papyrakis and Gerlach 2004; Rotimi et al. 2022). Therefore, governments and policymakers must implement policies and strategies to reduce corruption. Corruption can be mitigated and growth enhanced by simplifying cumbersome regulations, promoting greater freedom of expression, strengthening the rule of law and legal system efficiency, adequately funding anti-corruption agencies, and increasing the income and wages of civil servants.

Lastly, the study reveals that corruption adversely moderates the impact of oil prices on economic growth in oil-rich economies. In other words, the impact of oil prices varies with the level of corruption, with the increase in oil prices having a larger positive impact on growth at lower levels of corruption and stifling growth at higher levels. Moreover, as shown in column (6) of Table 5, the simultaneous increase in oil prices and corruption has more severe consequences in oil-rich economies with higher levels of corruption. The potential positive impact of oil prices is thus dependent on maintaining low levels of corruption. Empirical studies demonstrate that while natural resource abundance and its windfalls can stimulate growth in countries with strong institutions (including low corruption), they tend to stifle growth in economies characterised by weak institutions and high corruption (see Acemoglu et al. 2002; David et al. 2023; Olayungbo and Adediran 2017). As noted by Baragwanath (2020), the adverse effects of oil price shocks on growth are often driven by the incentives they create for corrupt politicians and public servants to embezzle funds, inflate the cost of social goods and services, or divert resources to large, unproductive, capital-intensive projects with significant opportunities for bribes. Over time, the prevalence of embezzlement, under-remittance of oil revenue, illegal diversion, and other sharp practices in the oil and gas sector of oil-rich economies with high levels of corruption (such as Nigeria, Venezuela, Angola, and Libya) has often led to a loss of public revenue, thereby limiting the state's ability to invest in growth-enhancing human and physical capital, regardless of changing oil prices.

The policy implication of this finding is that reducing corruption is crucial for oil prices to stimulate short and long term economic growth in oil-rich economies. In other words, an increase in oil price combined with a reduction in corruption offers greater benefits for stimulating immediate and long-term economic growth compared to a simultaneous increase in oil prices and corruption. Besides its direct negative effect on economic growth, corruption also impairs growth through dependence on oil and windfalls from oil sales and production. Therefore, governments and policymakers in oil-rich countries must intensify their efforts to reduce corruption to mitigate its impact on both immediate and long-term growth and oil wealth. Regardless of the current level of corruption, oil-rich countries must work towards eradicating corruption from all sectors and aspects of their economy and society. It is crucial that oil-rich countries with relatively high levels of corruption sustain efforts to reduce corruption to ensure that oil wealth benefits their economy.

**4.5 Causality tests**

In addition to the CS-ARDL, I also employ the Dumitrescu and Hurlin (2012) heterogeneous panel causality test to determine the causal relationships between the variables in the growth model. Due to the issue of cross-sectional dependence among most of the series, as shown in Table 3, I implement a block bootstrap procedure proposed by Dumitrescu and Hurlin (2012) to compute bootstrapped critical values for the test statistics, rather than using asymptotic critical values. The test statistics, computed based on 1,000 bootstrap replications, are summarised in Table 6. The results suggest that there is strong evidence to reject the null hypothesis of Granger no-causality from oil price to real GDP (for at least one cross-section) at the 5 percent significance level. However, the null hypothesis of no Granger causality from real GDP to oil price (for at least one cross-section) cannot be rejected. Thus, it can be concluded that there is unidirectional heterogeneous causality from oil price to real GDP, but not vice versa. Additionally, as shown in Table 6, there is significant bidirectional heterogeneous causality between corruption and economic growth (real GDP) at the 5 percent level, while a one-way causal relationship from oil price to corruption is observed at the 10 percent level.

Regarding the control variables, Table 6 presents evidence of unidirectional heterogeneous causality from primary fiscal balance (and employment rate) to growth (real GDP) at the 1 percent and 5 percent levels, respectively. Additionally, the null hypothesis of Granger no-causality from financial development to real GDP can be rejected at the 5 percent level of significance. However, there is no evidence of a heterogeneous causal relationship (for at least one cross-section) between population size and economic performance (real GDP). These outcomes provide strong support for the estimation results, highlighting the important connections between oil price changes, corruption, and economic growth dynamics. Moreover, the direction of causality between oil prices and corruption illustrates the critical role that changes in oil prices play in fueling corruption, especially in resource-rich and dependent economies.

**5 Conclusion**

The study seeks to establish the role of corruption in the oil price-growth nexus in oil-rich countries. Focusing on 30 oil-rich economies in Africa, Europe, Asia, and the Americas between 1996 and 2022, and employing several methodologies, the evidence demonstrates that oil prices promote both long-term and immediate economic growth, while corruption impedes growth in these economies. Additionally, the study shows that the marginal impact of oil prices on economic growth varies with the level of corruption. Specifically, the positive long-term impact of oil prices on economic growth is greater at low levels of corruption than at higher levels. By splitting the 30 countries based on their perceived level of corruption, the study demonstrates that the magnitude of the positive impact of oil prices and the adverse impact of corruption on growth is larger in countries perceived to have higher levels of corruption. Moreover, the adverse consequence of a simultaneous increase in oil prices and corruption is more pronounced in oil-rich economies with relatively higher levels of corruption compared to those with lower levels. These outcomes are robust to various estimation techniques and alternative measures of corruption.

The economic implication of this study is that corruption is a crucial channel through which the effect of oil prices is transmitted to long-term economic growth in oil-rich countries. In other words, the potential positive impact of oil prices on long-term growth is unlikely to materialise when corruption levels are very high. Therefore, oil-rich economies are encouraged to adopt appropriate strategies to reduce corruption and thus benefit from windfalls associated with positive oil price shocks. Corruption can be reduced and growth enhanced by removing operational red tape, simplifying cumbersome regulations in the bureaucratic system, raising the income and wages of civil servants, promoting greater freedom of expression, entrenching the rule of law and efficiency in the legal system, and adequately funding anti-corruption agencies. Despite the seemingly positive impact of oil price increases on growth, policymakers in oil-rich countries are also encouraged to implement strategies to diversify their economies and public revenues away from oil. This can be achieved through increased investment in human and physical capital, and critical non-oil sectors such as services, manufacturing, and agriculture, to foster sustained growth and development.

**References**

Abu N, David J, Sakanko MA, Amaechi BOO (2022) Oil price and public expenditure relationship in Nigeria: does the level of corruption matter? Economic Studies 31(3):59-80.

Abubakar IS, Akadiri SS (2022) Revisiting oil-rent-output growth nexus in Nigeria: Evidence from dynamic autoregressive lag model and kernel-based regularised approach. Environ Sci Pollut Res 29:45461-45473. https://doi.org/10.1007/s11356-022-19034-z

Acemoglu D, Johnson S, Robinson JA (2002) An African success: Botswana. In D. Rodriquez, Analytic development narratives. Princeton University Press, Princeton.

Adam CS, Bevan DL (2005) Fiscal deficits and growth in developing countries. Journal of Public Economics 89(4):571-597. https://doi.org/10.1016/j.jpubeco.2004.02.006

Afonso A, de Sá Fortes Leitão Rodrigues E (2022) Corruption and economic growth: does the size of the government matter? Econ Change Restruct 55:543-576. https://doi.org/10.1007/s10644-021-09338-4

Aimer NM (2016) The effects of fluctuations of oil price on economic growth of Libya. Energy Econ Lett 3(2):17-29. https://doi.org/10.18488/journal.82/2016.3.2/82.2.17.29

Akinlo T, Apanisile OT (2015) The impact of volatility of oil price on the economic growth in Sub-Saharan Africa. British Journal of Economics, Management & Trade 5(3):338-349. https://doi.org/10.9734/BJEMT/2015/12921

Algahtani GJ (2016) The effect of oil price shocks on economic activity in Saudi Arabia: Econometric approach. Int J Bus Manag 11(8):124-133

Alkhathlan K (2013) Contribution of oil in economic growth of Saudi Arabia. Appl Econ Lett 20:343-348. https://doi.org/10.1080/13504851.2012.703310

Alley I, Asekomeh A, Mobolaji H, Adeniran YA (2014) Oil price shocks and Nigerian economic growth. Eur Sci J 10(19):375-391

Arezki R, Brückner M (2009) Oil rents, corruption, and state stability: Evidence from panel data regressions. IMF Working Papers 09/267

Ashfaq H, Zafar M, Zahid B, Khan HMR, (2023). Oil price shocks drive corruption: A bibliometric analysis. iRASD Journal of Economics 5(2):338-363. https://doi.org/10.52131/joe.2023.0502.0132

Azam M (2022) Governance and economic growth: evidence from 14 Latin America and Caribbean countries. J Knowl Econ 13:1470-1495. https://doi.org/10.1007/s13132-021-00781-2

Baragwanath KV (2020) The effect of oil windfalls on corruption: Evidence from Brazil. American Political Science Association (APSA). Cambridge University Press (CUP). https://doi.org/10.33774/apsa-2020-wpt3g

Ben-Salha O, Dachraoui H, Sebri M. (2021) Natural resource rents and economic growth in the top resource-abundant countries: A PMG estimation. Resources Policy 74:101229. https://doi.org/10.1016/j.resourpol.2018.07.005

Berument MH, Ceylan NB, Dogan N. (2010) The impact of oil price shock on the economic growth of MENA countries. Energy J 31(1-7). https://doi.org/10.5547/ISSN0195-6574-EJ-Vol31-No1-7.

Blackburne EF, Frank MW (2007) Estimation of nonstationary heterogeneous panels. The Stata Journal 7(2):197-208. https://doi.org/10.1177/1536867X0700700204

Boschini A, Pttersson J, Roine J (2007) Resource curse or not: A question of appropriability. Scand. J. Econ 109(3):593-617. https://doi.org/10.1111/j.1467-9442.2007.00509.x

Brunnschweiler CN (2008) Cursing the blessings? Natural resource abundance, institutions, and economic growth. World Dev 36(3):399-419

Chudik A, Mohaddes K, Pesaran MH, Raissi H (2016) Long-run effects in large heterogeneous panel data models with cross-sectionally correlated errors. In Essays in Honor of Aman Ullah (Advances in Econometrics, Volumn 36), Eds. RC Hill, G GonzAlez-Rivera, T-H Lee, 85–135. Emerald Group Publishing Limited. http://doi.org/10.1108/S0731-905320160000036013

Chudik A, Pesaran MH (2015) Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. Journal of Econometrics 188:393-420.

Corden WM (1984) Booming sector and Dutch disease economics: survey and consolidation. Oxf Econ Pap 36:359-380. https://doi.org/10.1093/oxfordjournals.oep.a041643

Corden WM, Neary JP (1982) Booming sector and de-industrialisation in a small open economy. Econ J 92:825-848

David J, Abu N, Owolabi A (2024) The moderating role of corruption in the oil price-economic growth relationship in an oil-dependent economy: evidence from bootstrap ARDL with a Fourier function. Economic Alternatives, Forthcoming. http://doi.org/10.13140/RG.2.2.32652.28800/1

David J, Gamal AAM, Mohd Noor MA, Zakariya Z (2024) Oil rent, corruption and economic growth relationship in Nigeria: evidence from various estimation techniques. J. Money Laund. Control. https://doi.org/10.1108/JMLC-10-2023-0160

Ditzen J (2018) Estimating dynamic common-correlated effects in Stata. The Stata Journal, 18(3):585-617. https://doi.org/10.1177/1536867X1801800306

Dumitrescu EI, Hurlin C (2012) Testing for Granger non-causality in heterogeneous panels. Econ Model 29(4):1450-1460. https://doi.org/10.1016/j.econmod.2012.02.014

Ehigiamusoe KU, Lean HH Lee C-C (2019) Moderating effect of inflation on the finance–growth nexus: insights from West African countries. Empir Econ 57:399-422. https://doi.org/10.1007/s00181-018-1442-7

Emami K, Adibpour M (2012) Oil income shocks and economic growth in Iran. Econ model 29:1774-1779. https://doi.org/10.1016/j.econmod.2012.05.035

Energy Institute (2023) Statistical review of world energy (72nd edition). London, UK: Energy Institute.

Eregha PB, Mesagan EP (2020) Oil resources, deficit financing and per capita GDP growth in selected oil-rich African nations: A dynamic heterogeneous panel approach. Resources Policy 66:101615. https://doi.org/10.1016/j.resourpol.2020.101615

Farzanegan MR, Markwardt G (2009) The effects of oil price shocks on the Iranian economy. Energy Econ 31(1):134-151. https://doi.org/10.1016/j.eneco.2008.09.003

Fuinhas JA, Marques AC, Couto AP (2015) Oil rents and economic growth in oil producing countries: evidence from a macro panel. Econ Change Restruct 48:257-279. https://doi.org/10.1007/s10644-015-9170-x

Gylfason T (2001) Natural resources, education, and economic development. European economic review 45(4-6):847-859. https://doi.org/10.1016/S0014-2921(01)00127-1

Im KS, Pesaran MH, Shin Y (2003) Testing for unit roots in heterogeneous panels. J Econom 115(1):53-74. https://doi.org/10.1016/S0304-4076(03)00092-7

Jiménez-Rodríguez R, Sánchez M (2004) Oil price shocks and real GDP growth: empirical evidence for some OECD countries. ECB Working Paper 362

Karabegović A (2009) Institutions, economic growth, and the "curse" of natural resources. Fraser Institute, Vancouver

Kriskkumar K, Naseem NA (2019) Analysis of oil price effect on economic growth of ASEAN net oil exporters. Energies 12(17):1-19. https://doi.org/10.3390/en12173343

Larsen ER (2006) Escaping the resource curse and the Dutch disease? When and why Norway caught up with and forged ahead of its neighbors. Am J Econ Sociol 65(3):605-640.

Leite C, Weidmann J (1999) Does mother nature corrupt? Natural resources, corruption, and economic growth. IMF Working Paper (99/85). https://doi.org/10.5089/9781451850734.001

Levin A, Lin CF, Chu CSJ (2002) Unit root tests in panel data: asymptotic and finite-sample properties. J Econom 108(1):1-24. https://doi.org/10.1016/S0304-4076(01)00098-7

Maddala GS, Wu S (1999) A comparative study of unit root tests with panel data and a new simple test. Oxford B Econ Stat 61(S1):631-652. https://doi.org/10.1111/1468-0084.0610s1631

Mahmood H (2021) Oil prices, control of corruption, governance, and economic growth nexus in Saudi Arabia. Int J Energy Econ Policy 11(4):91-96. https://doi.org/10.32479/ijeep.11181

Mahmood H, Murshed M (2021) Oil price and economic growth nexus in Saudi Arabia: Asymmetry analysis. Int J Energy Econ Policy 11(1):29-33. https://doi.org/10.32479/ijeep.10382

Matallah S, Matallah A (2016) Oil rents and economic growth in oil-abundant MENA countries: Governance is the trump card to escape the resource trap. Topics in Middle Eastern and African Economies 18(2):87-116

Mauro P (1995) Corruption and growth. Q J Econ 110(3):681-712. https://doi.org/10.2307/2946696

Mehlum H, Moene K, Torvik R (2006) Institutions and the resource curse. Econ J 116(508):1-20. https://doi.org/10.1111/j.1468-0297.2006.01045.x

Mehrara M. (2008) The asymmetric relationship between oil revenues and economic activities: The case of oil-exporting countries Energy Policy 36(3):1164-1168. https://doi.org/10.1016/j.enpol.2007.11.004

Mo PH (2001) Corruption and economic growth. J Comp Econ 29(1):66-79. https://doi.org/10.1006/jcec.2000.1703

Moshiri S (2015) Asymmetric effects of oil price shocks in oil-exporting countries: the role of institutions. OPEC Energy Rev 39(2):222-246. https://doi.org/10.1111/opec.12050

Moshiri S, Banihashem A (2012) Asymmetric effects of oil price shocks on economic growth of oil-exporting countries. USAEE Working Paper 12-140. https://doi.org/10.2139/ssrn.2163306

Nusair SA (2016) The effects of oil price shocks on the economies of the Gulf Co-operation Council countries: Nonlinear analysis. Energy Policy 91:256-267. https://doi.org/10.1016/j.enpol.2016.01.013

Olayungbo DO, Adediran KA (2017) Effects of oil revenue and institutional quality on economic growth with an ARDL approach. Energy Policy Res 4(1):44-54. https://doi.org/10.1080/23815639.2017.1307146

Papyrakis E, Gerlagh R (2004) The resource curse hypothesis and its transmission channels. Journal of Comparative Economics 32(1):181-193. https://doi.org/ 10.1016/j.jce.2003.11.002

Pesaran MH (2007) A simple panel unit root test in the presence of cross-section dependence. J Appl Econom 22(2):265-312. https://doi.org/10.1002/jae.951

Pesaran MH (2021) General diagnostic tests for cross-sectional dependence in panels. Empirical Economics 60:13-50.
Pesaran MH, Shin Y, Smith RP (1999) Pooled mean group estimation of dynamic heterogeneous panels. J Am Stat Assoc 94(446):621-634.
Pesaran MH, Smith RP (1995) Estimating long-run relationships from dynamic heterogeneous panels. J Econom 68(1):79-113.
Pesaran MH, Yamagata T, (2008) Testing slope homogeneity in large panels. J Econom 142(1):50-93
Pesaran, MH (2015) Testing weak cross-sectional dependence in large panels. Econometric Reviews 34(6-10):1089-1117.
Rahman MM., Saidi K, Ben Mbarek M (2017) The effects of population growth, environmental quality and trade openness on economic growth: A panel data application. Journal of Economic Studies 44(3): 456-474. https://doi.org/10.1108/JES-02-2016-0031
Ross ML (1999) The political economy of the resource curse. World Politics 51(2):297-322. https://doi.org/10.1017/S0043887100008200
Rostow W (1961) The stages of economic growth: A non-communist manifesto. Cambridge University Press, Cambridge.
Rotimi ME, IseOlorunkanmi OJ, Rotimi GG, Doorsamy M (2021) Re-examining corruption and economic growth in oil dependent economy: Nigeria's case. J Money Laund 25(3):526-539. https://doi.org/10.1108/JMLC-06-21-0057
Sachs DJ, Warner AM (2001) Natural resources and economic development: the curse of natural resources. European Economic Review 45(4/6): 827-838. https://doi.org/10.1016/S0014-2921(01)00125-8.
Sachs JD, Warner AM (1995) Natural resource abundance and economic growth. NBER Working Paper 5398. https://doi.org/10.3386/w5398.
Sakanko MA, David J, Abu N, Gamal AAM (2024) Financial inclusion and underground economy nexus in West Africa: Evidence from dynamic heterogeneous panel techniques. Econ. Change Restructuring 57(8):1-20. https://doi.org/10.1007/s10644-024-09589-x
Schwarz GE (1978) Estimating the dimension of a model. Ann Stat 6(2):461-464. https://doi.org/10.1214/aos/1176344136
Uddin I, Rahman KU (2023) Impact of corruption, unemployment and inflation on economic growth evidence from developing countries. Qual Quant 57:2759-2779. https://doi.org/10.1007/s11135-022-01481-y
Westerlund J (2007) Testing for error correction in panel data. Oxf B Econ Stat 69(6):709-748. https://doi.org/10.1111/j.1468-0084.2007.00477.x
Wijnbergen SV (1984) The 'Dutch disease': a disease after all? Econ J 94:41-55. https://doi.org/10.2307/2232214
Yakubu MM, Akanegbu BN (2019) Oil price volatility and economic growth in Nigeria. Advances in Management & Applied Economics 9(6):1-10

**Tables**

**Table 1** Description of variables

| Variable | Description | Source | Expected effect |
|---|---|---|---|
| Economic growth ($rgdp$) | $rgdp$ is the sum of all goods and services produced during a period adjusted for inflation. | World Bank's WDI | – |

| | | | |
|---|---|---|---|
| Oil price ($op$) | $op$ is the average annual spot price of crude oil per barrel (in US$). | OPEC's annual statistical bulletin | Positive |
| Corruption ($co$) | $co$ measures the perceptions of "the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as state 'capture' by elites and private interests." Two corruption indices are used to ensure the robustness of the results. $co^T$ is the CPI from Transparency International and $co^W$ is the World Bank's control of corruption index. | World Bank's WGI and Transparency International | Negative |
| Oil price-corruption interaction ($op \times co$) | ($op \times co$) is the oil price-corruption interaction. The interaction variable is computed by simply multiplying oil price by corruption (corruption index). | WDI, TI, and WGI | Negative |
| Financial development ($fd$) | $fd$ is measured using the ratio of domestic credit to the private sector to the GDP. It is an important indicator of the development of the financial sector of an economy | World Bank's WDI | Positive |
| Population ($pop$) | $pop$ is the midyear estimate of the total population number of residents (regardless of legal status or citizenship) in a territory. | World Bank's WDI | Positive |
| Fiscal balance ($fbal$) | $fbal$ is the difference between total public revenue and expenditure, excluding net interest payments on public debt, relative to the GDP). | IMF's WEO | Positive |
| Employment rate ($empl$) | $empl$ is the proportion of a country's population that is employed. | World Bank's WDI | Positive |

**Notes:** WEO is World Economic Outlook. WDI represent the World Bank's World Development Indicators. WGI is the World Bank's World Governance Indicators. CPI is the corruption perception index.

**Table 2** Summary of descriptive statistics and pairwise correlation

| | $rgdp$ | $op$ | $co^T$ | $co^W$ | $fd$ | $pop$ | $fbal$ | $empl$ |
|---|---|---|---|---|---|---|---|---|
| Mean | 951.573 | 57.46 | 58.68 | 2.71 | 49 | 55.568 | 0.44 | 56.62 |
| SD | 2,978.439 | 30.69 | 22.12 | 1.05 | 47.95 | 77.835 | 9.07 | 11.91 |
| Min. | 0.587 | 10.42 | 8 | 0.21 | 1.27 | 0.306 | -35.39 | 30.79 |
| Max. | 20,926.835 | 117.15 | 94 | 4.15 | 216.31 | 333.288 | 43.30 | 88.52 |
| $op$ | 0.022 | 1.000 | | | | | | |
| $co^T$ | -0.369$^{***}$ | 0.059 | 1.000 | | | | | |
| $co^W$ | -0.357$^{***}$ | 0.003 | 0.983$^{***}$ | 1.000 | | | | |
| $fd$ | 0.638$^{***}$ | 0.038 | -0.810$^{***}$ | -0.793$^{***}$ | 1.000 | | | |
| $pop$ | 0.664$^{***}$ | 0.039 | -0.015 | -0.036 | 0.328$^{***}$ | 1.000 | | |
| $fbal$ | -0.163$^{***}$ | 0.109$^{***}$ | -0.083$^{**}$ | -0.108$^{***}$ | -0.075$^{**}$ | -0.266$^{***}$ | 1.000 | |
| $empl$ | 0.069$^{**}$ | 0.044 | -0.449$^{***}$ | -0.464$^{***}$ | 0.396$^{***}$ | -0.024 | 0.170$^{***}$ | 1.000 |

**Notes:** Asterisks $^{***}$ and $^{**}$ represent statistical significance at 1% and 5% levels, respectively. $rgdp$ = real GDP (in billions of US$); $op$ = crude oil prices (in US$/barrel); $co^T$ = rescaled TI's corruption perception index; $co^W$ = rescaled World Bank's control of corruption index; $fd$ = financial development (ratio of credit to the private sector to GDP); $pop$ = population size (in millions of people); $fbal$ = primary fiscal balance; $empl$ = employment rate.

**Table 3** Results of cross-section dependence tests

| | $lrgdp$ | $lop$ | $co^T$ | $co^W$ | $fd$ | $lpop$ | $fbal$ | $empl$ |
|---|---|---|---|---|---|---|---|---|
| CD test stat. | 93.42*** | 108.21*** | -0.11 | 0.15 | 16.41*** | 94.47*** | 35.36*** | 5.45*** |
| Correlation | 0.86 | 0.99 | -0.001 | 0.001 | 0.15 | 0.87 | 0.33 | 0.05 |
| $\alpha$ | 1.006 | 1.005 | 0.733 | 0.733 | 0.943 | 1.006 | 0.838 | 0.672 |

**Notes:** CD test stat. is Pesaran's (2015, 2021) cross-section dependence test statistic. Correlation is the averaged correlation coefficient. $H_0$: no (weak) cross-section dependence (correlation). Asterisk (***) denote rejection of $H_0$ at 1% level. $\alpha$ (alpha) is the exponent of cross-sectional dependence. α = 0 denotes weak cross-sectional dependence, 0 < α < 0.5 is semi-weak cross-sectional dependence, 0.5 ≤ α < 1 is semi-strong semi-weak cross-sectional dependence, and α = 1 is strong cross-sectional dependence. $lrgdp$ = log of real GDP; $lop$ = log of crude oil price; $lpop$ = log of population size. Stata community-contributed commands `xtcd`, `xtcd2`, and `xtcse2` are used to compute the Pesaran (2015, 2021) cross-sectional dependence test statistics.

**Table 5** Results of unit root tests

| | First generation tests | | | | | | Second generation test | |
|---|---|---|---|---|---|---|---|---|
| | LLC | | IPS | | ADF-Fisher | | CIPS | |
| | Level | 1st diff. | Level | 1st diff. | Level | 1st diff. | Level | 1st diff. |
| $lrgdp$ | -5.59*** | – | -0.48 | -13.86*** | 64.36 | 298.64*** | -1.859 | -3.963*** |
| $lop$ | -1.33* | -19.712*** | 0.99 | -17.74*** | 32.04 | 376.26*** | -2.913*** | – |
| $co^T$ | -8.48*** | – | -5.26*** | – | 143.82*** | – | -2.317** | – |
| $co^W$ | 0.09 | -19.01*** | 0.53 | -19.47*** | 60.33 | 424.37*** | -1.444 | -4.643*** |
| $fd$ | -2.13 | -10.83*** | 0.67 | -11.18*** | 52.95 | 227.19*** | -0.888 | -3.355*** |
| $lpop$ | -5.85*** | – | -1.22* | – | 116.01*** | – | -2.360*** | – |
| $fbal$ | -6.14*** | – | -7.29*** | – | 154.43*** | – | -2.966*** | – |
| $empl$ | -0.987 | -11.034*** | 0.75 | -13.76*** | 66.36 | 306.65*** | -1.452 | -3.393*** |

**Notes:** Asterisks (***), (**) and (*) denote the rejection of the null hypothesis of unit root at 1%, 5% and 10% levels respectively. LLC, IPS, ADF-Fisher, and CIPS denote the Levin-Lin-Chu test, the Im-Pesaran-Shin test, the Fisher-type ADF test, and the Cross-sectionally Augmented IPS. LLC, IPS and ADF tests consider the individual intercept. The LLC tests the null hypothesis of unit root (and assumes common unit root process), while the IPS and ADF panel tests the null hypothesis of unit root (and assumes individual unit root process). CIPS tests the null hypothesis of homogeneous non-stationary process. CIPS's critical values at 1%, 5%, and 10% levels are -2.3, -2.15, and -2.07, respectively. LLC's bandwidth is automatically determined by the Newey-West method using the Bartlett kernel. For all tests, the maximum lag is set to 10, while the optimal lag length is determined by Schwarz's (1978) information criteria. The Stata `xtcips` command is used to compute the CIPS test.

*Economic Change and Restructuring* 2024 doi: 10.1007/s10644-024-09808-5

**Table 5** Estimation results of oil price, corruption and economic growth relationship

| **Regressors** | Dependent variable: $\Delta lrgdp$ | | | | | |
|---|---|---|---|---|---|---|
| | Full sample | | Less corrupt countries | | More corrupt countries | |
| | Model I (1) | Model II (2) | Model I (3) | Model II (4) | Model I (5) | Model II (6) |
| **Panel A: Long-run estimates** | | | | | | |
| $lop$ | 0.0692 (0.046)$^{*}$ | 0.3635 (0.205)$^{*}$ | 0.0726 (0.020)$^{***}$ | 0.0914 (0.046)$^{**}$ | 0.0807 (0.054)$^{*}$ | 0.2213 (0.087)$^{**}$ |
| $co^{T}$ | -0.00437 (0.003)$^{*}$ | | 0.0007 (0.002) | | -0.0042 (0.002)$^{*}$ | |
| $lop \times co^{T}$ | | -0.0019 (0.001)$^{*}$ | | -0.00003 (0.000)$^{**}$ | | -0.0015 (0.001)$^{*}$ |
| $fd$ | -0.0005 (0.002) | 0.0018 (0.004) | -0.0008 (0.001) | -0.0003 (0.001 | -0.0052 (0.004)$^{*}$ | -0.0055 (0.001) |
| $lpop$ | 0.5123 (0.283)$^{*}$ | 1.1525 (0.548)$^{**}$ | 0.7146 (0.499)$^{*}$ | 1.1813 (0.332)$^{***}$ | 0.2136 (1.694) | 0.4889 (0.469) |
| $fbal$ | 0.0052 (0.002)$^{**}$ | 0.0068 (0.005)$^{*}$ | 0.0015 (0.001)$^{*}$ | 0.0037 (0.002)$^{**}$ | 0.0036 (0.002)$^{**}$ | 0.0042 (0.002)$^{**}$ |
| $empl$ | 0.0279 (0.007)$^{***}$ | 0.0483 (0.025)$^{**}$ | 0.0194 (0.008)$^{**}$ | 0.0139 (0.007)$^{**}$ | 0.0548 (0.019)$^{***}$ | 0.048 (0.014)$^{***}$ |
| $ect$ | -0.6064 (0.044)$^{***}$ | -0.6702 (0.062)$^{***}$ | -0.7065 (0.123)$^{***}$ | -0.4861 (0.051)$^{***}$ | -0.7817 (0.044)$^{***}$ | -0.6008 (0.121)$^{***}$ |
| **Panel B: Short-run estimates** | | | | | | |
| $\Delta lrgdp_{t-1}$ | 0.3936 (0.045)$^{***}$ | 0.3298 (0.062)$^{***}$ | 0.294 (0.123)$^{**}$ | 0.5139 (0.051)$^{***}$ | 0.2183 (0.044)$^{***}$ | 0.3992 (0.121)$^{***}$ |
| $\Delta lop$ | 0.0162 (0.016) | 0.0626 (0.040)$^{*}$ | 0.0421 (0.009)$^{***}$ | 0.0454 (0.019)$^{**}$ | 0.0474 (0.035) | 0.0699 (0.033)$^{**}$ |
| $\Delta co^{T}$ | -0.0022 (0.002) | | -0.0001 (0.001) | | -0.0031 (-0.002)$^{**}$ | |
| $\Delta lop \times co^{T}$ | | -0.0004 (0.001) | | -0.00002 (0.000)$^{*}$ | | -0.0005 (0.000)$^{*}$ |
| $\Delta fd$ | -0.0009 (0.001) | -0.0015 (0.002) | -0.0003 (0.000) | -0.0003 (0.001) | -0.0039 (0.003)$^{*}$ | -0.0013 (0.001 |
| $\Delta lpop$ | 0.2189 (0.145)$^{*}$ | 0.4334 (0.199)$^{**}$ | 0.6778 (0.599) | 0.8703 (0.401)$^{**}$ | 0.4573 (1.055) | 0.3862 (0.137)$^{***}$ |
| $\Delta fbal$ | 0.0019 (0.001)$^{***}$ | 0.0016 (0.001)$^{**}$ | 0.0010 (0.001)$^{*}$ | 0.0019 (0.001)$^{*}$ | 0.0023 (0.001)$^{**}$ | 0.0019 (0.001)$^{**}$ |
| $\Delta empl$ | 0.0143 (0.004)$^{***}$ | 0.0155 (0.004)$^{***}$ | 0.0133 (0.004)$^{***}$ | 0.0088 (0.003)$^{***}$ | 0.0419 (0.014)$^{***}$ | 0.0207 (0.007)$^{***}$ |
| No. of countries | 30 | 30 | 8 | 8 | 22 | 22 |
| Observations | 810 | 810 | 216 | 215 | 594 | 594 |
| CD test | 0.604 [0.546] | 0.633 [0.527] | 1.560 [0.119] | 0.282 [0.778] | 1.34 [0.179] | 0.482 [0.629] |
| $\alpha$ | 0.545 (0.020) | 0.575 (0.021) | 0.529 (0.050) | 0.500 (0.050) | 0.575 (0.020) | 0.538 (0.028) |

**Notes:** Δ is the first-difference operator. Asterisks (***), (**) and (*) denote statistical significance at 1%, 5% and 10% levels, respectively. Model I is the estimation without the oil price-corruption interaction term, and Model II is the estimation with the interaction term. The optimal lag length is suggested by AIC. Values in (.) are standard error and [.] are probability values. $ect$ is error correction term; it which the speed of adjustment speed to long-term equilibrium. CD test is Pesaran's (2015, 2021) test for weak cross-sectional dependence (among the error terms). The $\alpha$ is the exponent of the cross-sectional dependence (among the error terms). $0.5 \leq \alpha < 1$ implies strong cross-sectional dependence. The CS-ARDL is computed using the Stata `xtdcce2` command.

**Table 6** Results of Dumitrescu-Hurlin panel causality test

| | $lrgdp$ | $lop$ | $co^T$ | $co^W$ | $fd$ | $lpop$ | $fbal$ | $empl$ |
|---|---|---|---|---|---|---|---|---|
| $lrgdp$ | – | 1.922 | 6.487* | 8.006** | 15.578** | 1.7479 | 1.838 | 5.269 |
| $lop$ | 8.628** | – | 8.349** | 4.136* | 2.125** | 3.587* | 4.190* | 4.565 |
| $co^T$ | 6.392*** | 5.964 | – | 4.841** | 1.176* | 2.459 | 2.080 | 7.174* |
| $co^W$ | 3.692** | -0.333 | 8.419*** | – | 0.967** | 1.573 | 2.760 | 5.235** |
| $fd$ | 3.355 | 2.892 | 3.154 | 4.344 | – | 2.177 | 0.925 | 4.773 |
| $lpop$ | 7.749 | 1.974 | 7.565** | 5.051* | 1.469* | – | 0.849 | 6.330** |
| $fbal$ | 5.922*** | 2.256 | -0.971 | -0.416 | 1.784*** | 3.709** | – | 1.786 |
| $empl$ | 4.741** | 0.606 | 1.938 | 5.732*** | 1.241** | 1.202 | 4.330** | – |

**Notes:** $H_0$: $x_{it}$ does not Granger-cause $y_{it}$ for at least one cross-section. The values are the standardised $\tilde{Z}$ statistic (because $N > T$). Due to the issue of cross-sectional dependence amongst the series, a block bootstrap procedure (with 1,000 replications) is employed to compute bootstrapped critical values. Asterisks (***), (**) and (*) denote rejection of the null hypothesis at 1%, 5% and 10% levels based on bootstrap-generated critical values. For all tests, the optional lag length is determined by Schwarz Information Criterion (SIC). The community-contributed Stata command computed using Stata `xtgcause` is used to compute the test statistics.

## Appendix

### Appendix Table

**Table A1** List of countries

| More corrupt | | | Less corrupt |
|---|---|---|---|
| Algeria | Equatorial Guinea | Malaysia | Brunei Darussalam |
| Angola | Gabon | Mexico | Canada |
| Azerbaijan | Indonesia | Nigeria | Norway |
| Bahrain | Iran | Russia | Oman |
| Brazil | Iraq | Saudi Arabia | Qatar |
| Congo, Rep. | Kazakhstan | Sudan | United Arab Emirates |
| Ecuador | Kuwait | | United Kingdom |
| Egypt | Libya | | United States |

**Notes:** The classification of countries as either "more corrupt" or "less corrupt" groups is based on their average corruption perception index (CPI) score over time. Countries with CPI scores between 0 and 49 and classified as "more corrupt" countries while countries with CPI scores between 50 and 100 are classified as "less corrupt" countries.

**Table A2** Average real GDP and corruption perception of countries (1996-2022)

| Country | Real GDP | TI CPI$^R$ | WB CC$^R$ | Country | Real GDP | TI CORR$^R$ | WB CORR$^R$ |
|---|---|---|---|---|---|---|---|
| Algeria | 136.024 | 67.95 | 3.18 | Kazakhstan | 138.034 | 71.92 | 3.38 |
| Angola | 62.697 | 78.95 | 3.73 | Kuwait | 92.883 | 56.00 | 2.27 |
| Azerbaijan | 35.419 | 75.92 | 3.61 | Libya | 63.165 | 79.85 | 3.71 |
| Bahrain | 24.481 | 51.35 | 2.27 | Malaysia | 237.203 | 50.76 | 2.29 |
| Brazil | 1,541.083 | 62.15 | 2.66 | Mexico | 1,072.744 | 67.00 | 3.05 |
| Brunei Darussalam | 12.532 | 42.00 | 1.92 | Nigeria | 351.459 | 78.72 | 3.68 |
| Canada | 1,392.501 | 15.21 | 0.59 | Norway | 354.494 | 13.49 | 0.40 |
| Congo, Rep. | 9.025 | 78.70 | 3.68 | Oman | 62.607 | 48.70 | 2.10 |
| Ecuador | 78.272 | 71.80 | 3.19 | Qatar | 111.988 | 36.05 | 1.74 |
| Egypt | 274.259 | 67.81 | 3.08 | Russian | 1,153.838 | 74.12 | 3.46 |
| Equatorial Guinea | 9.288 | 82.00 | 3.86 | Saudi Arabia | 525.747 | 55.30 | 2.50 |
| Gabon | 12.086 | 68.32 | 3.34 | Sudan | 78.558 | 83.30 | 3.80 |
| Indonesia | 674.544 | 71.72 | 3.24 | United Arab Emirates | 295.781 | 34.45 | 1.64 |
| Iran | 364.315 | 74.25 | 3.17 | United Kingdom | 2,657.742 | 18.87 | 0.68 |
| Iraq | 127.232 | 81.70 | 3.89 | United States | 16,374.097 | 26.55 | 1.08 |

**Notes:** Real GDP is real GDP in billions of US$. TI CPI$^R$ and WB CC$^R$ are the rescaled Transparency International (TI) corruption perception index (CPI) and World Bank's control of corruption (CC) index.

**Table A3** Slope homogeneity test

| Models | $N$ | Without interaction term | | With interaction term | |
|---|---|---|---|---|---|
| | | $\tilde{\Delta}$ | $\tilde{\Delta}_{Adjusted}$ | $\tilde{\Delta}$ | $\tilde{\Delta}_{Adjusted}$ |
| Full sample | 30 | 5.910*** | 7.387*** | 5.875*** | 7.343*** |
| Less corrupt nations | 8 | 2.654*** | 3.317*** | 2.711*** | 3.389*** |
| More corrupt nations | 22 | 4.835*** | 6.043*** | 5.011*** | 6.263*** |

**Notes:** $H_0$: slope coefficients are homogenous. Asterisks (***) denote the rejection of the null hypothesis at a 1 percent level. $\tilde{\Delta}$ and $\tilde{\Delta}_{Adjusted}$ are the standard Delta homogeneity slope test statistics of Pesaran and Yamagata (2008) and the adjusted Delta statistics, respectively. Stata community-contributed command `xthst` is used to compute the Delta test statistics.

**Table A4** CS-ARDL estimation results using an alternative measure of corruption

| Regressors | Dependent variable: $\Delta lrgdp$ | | | | | |
|---|---|---|---|---|---|---|
| | Full sample | | Less corrupt countries | | More corrupt countries | |
| | (I) | (II) | (I) | (II) | (I) | (II) |
| **Panel A: Long-run estimates** | | | | | | |
| $lop$ | 0.1158 (0.033)*** | 0.5260 (0.249)** | 0.0656 (0.038)* | 0.0851 (0.049)* | 0.3678 (0.225)* | 0.3483 (0.168)** |
| $co^W$ | 0.0369 (0.094)* | | 0.0217 (0.053)* | | 0.2885 (0.198)* | |
| $lop \times co^W$ | | -0.0019 (0.001)* | | -0.0009 (0.001)* | | -0.0017 (0.0013)* |
| $fd$ | 0.00003 (0.003) | 0.0029 (0.004) | -0.0027 (0.001)** | -0.00002 (0.001) | -0.0015 (0.008) | -0.0031 (0.005) |
| $lpop$ | 0.5299 (0.302)* | 0.7189 (0.418)* | 0.9227 (0.537)* | 1.1893 (0.287)*** | 0.8206 (0.417)* | 0.4140 (0.623) |
| $fbal$ | 0.0051 (0.002)*** | 0.0102 (0.004)** | 0.0028 (0.001) *** | 0.0035 (0.001)*** | 0.0129 (0.009) | 0.0075 (0.004)* |
| $empl$ | 0.0466 (0.014)*** | 0.1377 (0.098) | 0.0134 (0.004)*** | 0.0146 (0.006)** | 0.0872 (0.036)** | 0.0671 (0.015)*** |
| $ect$ | -0.4147 (0.047)*** | -0.4541 (0.057)*** | -0.8502 (0.168) *** | -0.7065 (0.126)*** | -0.3703 (0.059) *** | -0.4067 (0.048)*** |
| **Panel B: Short-run estimates** | | | | | | |
| $\Delta lrgdp_{t-1}$ | 0.5853 (0.047)*** | 0.5459 (0.057)*** | 0.1498 (0.168) | 0.2935 (0.126)*** | 0.6297 (0.059)*** | 0.5933 (0.048)*** |
| $\Delta lop$ | 0.0309 (0.009)*** | 0.0694 (0.019)*** | 0.0277 (0.029) | 0.0546 (0.025)** | 0.0475 (0.029)* | 0.0516 (0.024)** |
| $\Delta co^W$ | 0.0326 (0.032) | | 0.0313 (0.044) | | 0.0355 (0.064) | |
| $\Delta lop \times co^W$ | | -0.0003 (0.000)** | | -0.0005 (0.000)* | | -0.0005 (0.001) |
| $\Delta fd$ | -0.0008 (0.001) | -0.0012 (0.000) | -0.0016 (0.001)** | -0.0009 (0.001) | -0.0016 (0.002) | -0.0017 (0.002) |
| $\Delta lpop$ | 0.3730 (0.147)** | 0.4452 (0.935)*** | 0.8019 (0.635) | -0.1465 (0.395)** | 0.3439 (0.125)** | 0.3926 (0.127)*** |
| $\Delta fbal$ | 0.0018 (0.001)** | 0.0019 (0.002)*** | 0.0026 (0.001)** | -0.0006 (0.001)** | 0.0021 (0.001)** | 0.0022 (0.001)*** |
| $\Delta empl$ | 0.0166 (0.005)*** | 0.0175 (0.011)*** | 0.0118 (0.004)*** | -0.0047 (0.004)** | 0.0188 (0.004)*** | 0.0271 (0.007)*** |
| No. of countries | 30 | 30 | 8 | 8 | 22 | 22 |
| Observations | 810 | 810 | 216 | 215 | 594 | 594 |
| CD test | 1.519 [0.129] | 1.602 [0.109] | 1.350 [0.177] | -0.551 [0.581] | 1.575 [0.115] | -0.333 [0.739] |
| $\alpha$ | 0.529 (0.020) | 0.537 (0.017) | 0.528 (0.058) | 0.500 (0.052) | 0.537 (0.023) | 0.517 (0.026) |

**Notes:** Δ is the first-difference operator. Asterisks (***), (**) and (*) denote statistical significance at 1%, 5% and 10% levels, respectively. Model I is the estimation without the oil price-corruption interaction term, and Model II is the estimation with the interaction term. The optimal lag length is suggested by AIC. Values in (.) are standard error and [.] are probability values. $ect$ is error correction term; it which the speed of adjustment speed to long-term equilibrium. CD test is Pesaran's (2015, 2021) test for weak cross-sectional dependence (among the error terms). The $\alpha$ is the exponent of the cross-sectional dependence (among the error terms). $0.5 \leq \alpha < 1$ implies strong cross-sectional dependence.

## Appendix Figure

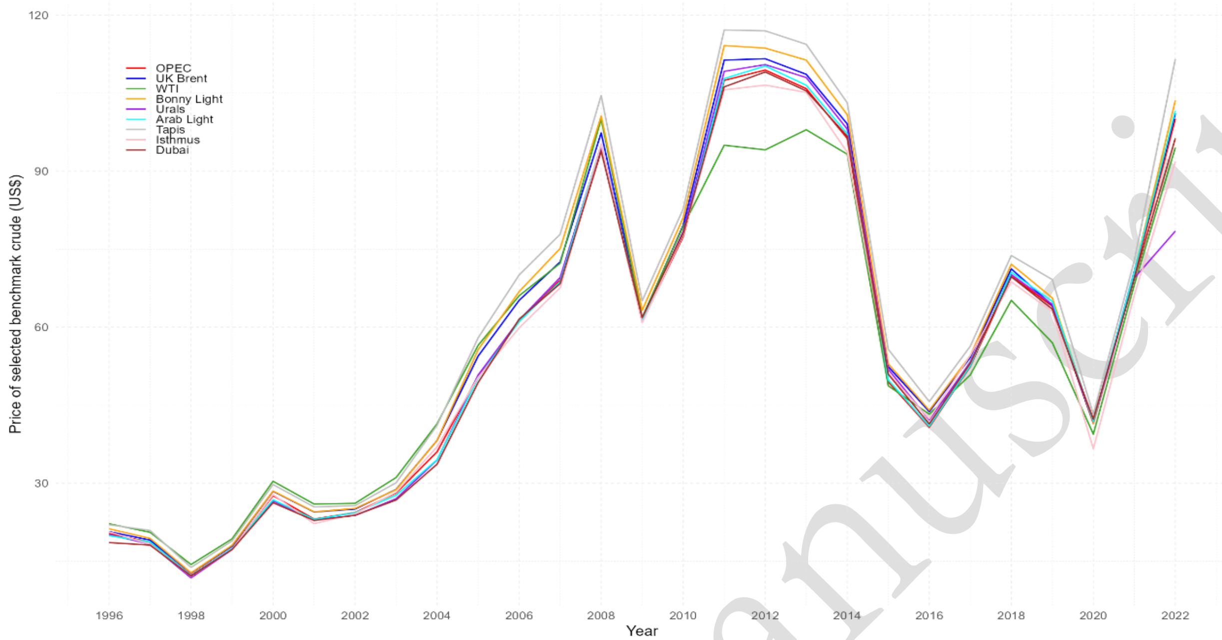


**Figure A1** Trend of global crude oil price

**Notes:** The plot shows the trend of the prices of major global benchmark crude oil between 1996 and 2022. "OPEC" is the OPEC reference basket; UK Brent is the benchmark used primarily in Europe. WTI is West Texas Intermediate, it is used primarily in the US; Bonny Light is the benchmark for Nigerian crude; Urals is the reference oil brand used as a basis for pricing of the Russian export oil mixture; Arab Light is the marker crude for Saudi oil; Tapis is Malaysian crude oil used as a pricing benchmark in Singapore; Ishmus is used for Mexican oil; and Dubai is the benchmark for Persian Gulf crude oil.

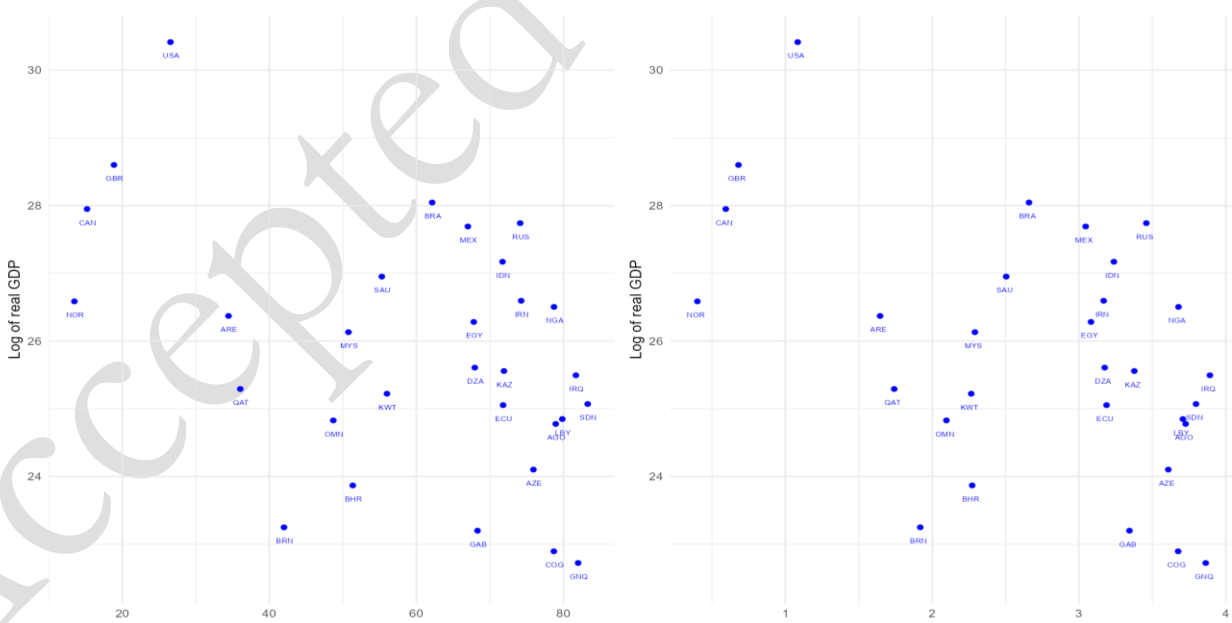


**Figure A2** Relationship between real GDP and corruption indices