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

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**Abstract**

This study examines whether the level of corruption determines the effect of oil prices on economic growth. I focus on 30 oil-rich economies and employ dynamic heterogeneous panel estimation techniques which address the issue of cross-sectional dependence. Evidence from the study reveals that the impact of oil prices on economic growth varies with the levels of corruption. In other words, the marginal effect of oil price increase on economic growth is positive at low levels of corruption, but it stifles immediate and long-term growth at high levels of corruption. Essentially, the results reveal that the simultaneous increase in oil price and the level of corruption will impair economic growth, but the increase in oil price coupled with the reduction in corruption would be of greater benefit to the economy. Using a disaggregated sample of countries based on the prevailing level of corruption, the results suggest that the adverse effect of the simultaneous increase in oil price and corruption is larger in oil-rich countries with relatively higher levels of corruption compared to countries with lower levels of corruption. The study implies that the level of corruption is an important channel through which the impact of oil price changes and is transmitted to long-term growth in oil-rich economies. Therefore, for long-term economic growth, an increase in oil prices must be complemented with a significant reduction in the level of corruption.

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# 1 Introduction

Crude oil is a fundamental impute in modern economic activities, as it accounts for more than one-third of the total energy demand in the world (Energy Institute, 2023). Thus, a large body of research has shown that changes in its price often have significant implications for economic activities. Moreover, the effect of the changes in oil prices often differs for oil-exporting and oil-importing countries, with positive changes in oil prices often considered good news in the former and bad news in oil-importing economies, and vice versa (Moshiri, 2015). For instance, in an oil-exporting economy, an increase in oil price is generally considered favourable because it brings in foreign exchange and investment opportunities which are beneficial to economic growth. In such an economy, negative oil price shocks are unfavourable because they restrain public revenue and halt investment projects, leading to a deceleration in economic growth (Kriskkumar and Naseem, 2019; Moshiri, 2015). The exact reverse is mostly the case for oil-importing countries which consider negative oil price changes favourable and abhor positive oil price shocks.

Nonetheless, evidence suggests that oil price changes might cause a non-standard effect on growth, with positive oil price changes also encouraging growth-retarding economic conditions such as exchange rate appreciation, stagflation due to high inflation, rising unemployment, rent-seeking, and poor policy-making, amongst others, in oil-exporting economies (Moshiri, 2015; Moshiri and Banijashem, 2012). Interestingly, despite years of favourable oil prices, which brought in a vast financial resource that is critical for growth, most oil-rich nations in the Middle East, Africa and Latin America have continued to record poor growth performance in comparison with the fast growth rates experienced in resource-poor East Asian countries (David *et al.*, 2024; Moshiri, 2015; Moshiri and Banijashem, 2012; Sachs and Warner, 1995).

One of the notable explanations for the adverse effect of positive oil price shocks in oil-dependent economies in the literature is the Dutch disease theory (Corden and Neary, 1982). The theory explains an economic phenomenon characterised by a shift in human and financial resources from tradable sectors (specifically, the manufacturing and agricultural sector) to the non-tradable sector (such as the oil sector) following the discovery of natural resources such as oil, gas and minerals and the boom in the revenue from its export, thus leading to the appreciation of the local currency, a reduction in net-export, the decline in non-resource tradable sector (manufacturing), and consequently the slowdown in economic growth (Kriskkumar and Naseem, 2019; Moshiri, 2015).

Essentially, the Dutch disease attributes the oil boom-induced economic destabilisation to the dependence on oil. In recent decades, evidence has shown that the dependence on natural resources, such as oil, themselves doesn't fully affect growth, rather it is the nature of the connection between the natural resource abundance and quality of institutions that determine how shocks in the price of the natural resources that affect growth (Boschini *et al.*, 2007; Brunnschweiler, 2008; Mehlum *et al.*, 2006). Given the well-documented strong relationship between oil price and corruption in the literature (Arezki and Brückner, 2009; Ashfaq *et al.*, 2023; Baragwanath, 2020), it is, however, suggestive that, rather than directly influencing growth, the impact of oil price change on long-term growth may be determined by the prevailing level of corruption. This argument hinges on the interesting findings of Baragwanath (2020) on the relationship between oil windfall, corruption and electoral outcomes in Brazil. The study highlighted that positive shock, such as large exogenous windfalls created by oil price increases, often create dynamic incentives for corrupt politicians to embezzle oil money, inflate the cost of social goods and services, and shift resources from growth-enhancing investments in favour of large, mostly non-productive, capital-intensive projects with opportunity for bribes and kickbacks. Consequently, the atmosphere of corruption ensures that the potential benefit of oil price increase on long-term growth is thwarted.

In this context, it is suggestive that while positive oil price shocks may lead to sluggish growth performance in an oil-rich economy with a high level of corruption, such windfalls will mostly benefit long-term economic growth in countries with a low level of corruption given that the accruing funds would most likely be channelled to productive activities (Moshiri, 2015). In other words, for oil-rich countries characterised by pervasive corruption, positive oil price changes tend to hamper growth but such positive shock is capable of stimulating growth in countries with low levels of corruption. In a way, this explains why some oil-rich countries such as Norway with a low level of corruption have done well while "fantastically corrupt" oil-endowed Nigeria and Venezuela have continued to contend with myriad economic challenges (Karabegović, 2009; Larsen, 2006; Olayungbo and Adediran, 2017).

Therefore, I set out to explore whether the impact of oil price increases on economic growth is dependent on the prevailing level of corruption. In providing answers to 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 price changes 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 examining 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 exists a noticeable dearth of empirical studies on the role of corruption in influencing the relationship between oil price and growth. Thus, this attempt adds a crucial dimension to the literature associated with the resource-curse thesis. 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 important contribution of the study to the literature 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 different levels of income, as well as corruption. Using such a diverse sample to examine how the level of corruption determines the impact of oil price increase on growth provides an opportunity to obtain a robust and consistent outcome which may be applicable regardless of a county's level of corruption or income size. Besides exploring how changes in the price of oil generally impact growth at different levels of corruption in oil-rich countries, splitting the countries based on the prevailing magnitude of corruption also provides more insight into how the existing level of corruption plays a vital role in the relationship. Additionally, to improve the confidence and reliability of the outcome for policy making, different measures of corruption are applied.

Thirdly, the paper employs the cross-sectional augmented autoregressive distributed lag (CS-ARDL) technique proposed by Chudik *et al.* (2016) alongside the Dumitrescu and Hurlin (2012) heterogeneous panel causality test. By accommodating both the dynamic short-run and long-run relationship between oil price, growth and corruption, and a possible heterogeneous dynamic adjustment process, while also addressing such issues as the cross-sectional dependence, the CS-ARDL technique provides an opportunity to obtain a robust outcome while is plausible for policy formulation and implementation. Moreover, the adoption of the Dumitrescu-Hurlin causality tests also raises confidence in the outcomes obtained, given its incorporation of 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 2 presents a review of the empirical literature. Section 3 contains methodology and data. The estimation results are presented and discussed in section 4. The conclusion is provided in the last section.

# 2 Review of empirical literature

Over time, researchers have explored the 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) illustrates that oil price is not significant in influencing economic growth in six 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; Alkhathlan, 2013; Alley *et al.*, 2014; Berument *et al.*, 2010; Emami and Adibpour, 2012; Farzanegan and Markwardt, 2009; Mahmood, 2021; Mahmood and Murshed, 2021). 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 the empirical literature, although far from being conclusive, there are a plethora of studies on the direct impact of oil price change on growth. However, despite its undeniable manifestations in most oil-rich countries, researchers have paid little or no attention to exploring the roles of corruption in influencing the impact of oil price changes on growth. Given the unimpressive growth performance of most oil-rich economies, it is imperative to examine the relationship between oil price changes and growth from the lens of the pervasiveness of corruption. Interestingly, most oil-rich economies are notable for being fantastically corrupt. Moving from oil-rich countries like Nigeria, Venezuela, Angola, Gabon, and Libya, just to mention but few, this position is well accentuated by the plethora of corruption cases associated with the oil wealth and the sector. Notably, this research aligns with and extends the findings of Moshiri (2015), which highlighted that quality institutions play a vital role in influencing the effect of oil price shocks on growth in 11 oil-exporting countries (Algeria, Iran, Kuwait, Nigeria, Saudi Arabia, Venezuela, Canada, Norway, and the United Kingdom), with positive oil price shocks impeding growth in oil-exporting countries with low institutional quality, but not in countries with strong institutional quality. This research is, however, different from Moshiri (2015) and extends the literature by explicitly investigating whether the effect of oil price on growth is conditioned by the levels of corruption in 30 oil-rich economies which cut across the continents of Africa, Asia, North America, Europe and Latin America.

# 3 Data and methodology

## 3.1 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 (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:

$$lrgdp_{i,t} = \psi_1 op_{it} + \psi_2 co_{i,t} + \phi' Z_{i,t} + \mu_i + \eta_t + \varepsilon_{it} \tag{1}$$

$$lrgdp_{i,t} = \omega_1 op_{i,t} + \omega_2 \left(op_{i,t} \times co_{i,t}\right) + \phi' Z_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t}, \tag{2}$$

$$i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, T$$

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.

Through the oil price-corruption interaction term ($\omega_2$) in Equation (1), the marginal effect of changes in oil price on growth through the partial derivative of Equation (1) is as follows[2]:

[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.

$$\frac{\partial lrgdp_{it}}{\partial op_{it}} = \omega_1 + \omega_2 co_{it} \tag{3}$$

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 ($\omega_1 + \omega_2 co_{i,t}$) demonstrates 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, employment rate, 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 from corruption are collected from Transparency International (TI) and World Bank's World Governance Indicators (WGI). Lastly, the oil price data is gleaned from OPEC's annual statistical bulletin.

The summary statistics and correlation analysis of the variables are summarised in the upper and lower panel of Table 1, respectively. As shown in Table 1, the average real GDP of the 30 countries between 1996 and 2022 is US\$951.573 billion, and this varies significantly (as demonstrated by its standard deviation) from about US\$587 million (Equatorial Guinea, 1996) to US\$20.927 trillion (United States, 2022). This highlights the heterogeneity and diversity of the sample, as it includes both wealthy high-income economies and low-income economies. A more vivid picture of the diversity of the sample is outlined in Appendix Table A2, which shows the country-level average real GDP of the 30 countries. In addition, the average price of crude oil (per barrel) during the 1996-2022 period is US457.46 (per barrel), ranging from about US\$10.42 (per barrel) to US\$117.15 (per barrel).

Table 1: Summary of descriptive statistics and pairwise correlation

| | $rgdp$ | $op$ | $co^T$ | $co^W$ | $fd$ | $pop$ | $fbal$ | $empl$ |
|---|---|---|---|---|---|---|---|---|
| Mean | 951.57 | 57.46 | 58.68 | 2.71 | 49 | 55.57 | 0.44 | 56.62 |
| SD | 2978.44 | 30.69 | 22.12 | 1.05 | 47.95 | 77.84 | 9.07 | 11.91 |
| Min. | 0.59 | 10.42 | 8 | 0.21 | 1.27 | 0.31 | -35.39 | 30.79 |
| Max. | 20926.84 | 117.15 | 94 | 4.15 | 216.31 | 333.29 | 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.

As shown in Appendix Figure A1, the price of oil exhibits significant variations over time, often induced by major geopolitical crises in oil-producing countries, particularly the Middle East, and major economic shocks in the Global North. For instance, the pursuit of a price war between Venezuela and Saudi Arabia led to the crash of the oil price in 1998, unprecedented economic growth of newly industrialised countries, particularly China, and tensions in the Middle East fuelled the positive oil price shocks of 2000, while crash in the price from about US$97.37 (per barrel) in 2008 to about US$61.68 (per barrel) in 2009 was induced by the 2007/2008 global economic meltdown which led to the reduced energy demand and tight credit conditions. Similarly, the series of political unrest across the Middle East drove the oil price above US$100 (per barrel) during the 2011-2013 period. Eventually, during the 2014-2016 period, oil prices began to fall dramatically primarily due to weaker global demand and excess supply, driven by shale oil production in the United States and Saudi's decision to defend its market share. A brief increase in the price to a peak of about US$70 (per barrel) in 2018, due to increased global demand accompanied by sustained supply, was short-lived as the COVID-19 pandemic led to a dramatic cut in demand. The fall in demand led to an oil glut, thus dragging the price to less than US$40 (per barrel). Improved economic growth, easing of lockdown measures, and rising vaccination rates boosted the global demand. However, the inability of supply, particularly from OPEC states, to keep pace with the underlying increase in demand, coupled with the heightened geopolitical tensions around the Russian invasion of Ukraine led to the increase in oil prices in 2022.

Furthermore, the average values of the re-scaled TI CPI and World Bank's corruption index of the 30 countries are 58.68 and 2.71, respectively. Evidenced by the standard deviation and the wide disparity between the minimum and maximum values, it is suggestive that the sample includes a diverse sample of countries perceived to be very corrupt and those perceived to be relatively less corrupt or "clean". The average corruption perception scores of each of the countries over time are summarised in Appendix TableA2. The side-by-side summary of the country-specific average corruption index and the real GDP reveals an interesting trend in which counties with sizable real GDP are characterised by lower corruption scores, and vice versa. Specifically, As shown in Appendix Figure A2, countries such as Norway, Canada, the US and the UK with large real GDP also have relatively low corruption scores, while some other countries (Russia, Brazil, Nigeria, Mexico, Indonesia, Saudi, Iran, Egypt, and Mexico) with relatively large real GDP are perceived to be very corrupt. At the mid-point are countries such as the UAE, Bahrain, Malaysia, Oman, Qatar, and Kuwait, all with moderate-sized real GDP and moderate corruption scores. Besides Malaysia, which is a federal constitutional monarchy, all the other countries are absolute monarchies. Due to the restriction of the political power and decision-making to a very close cycle of royal family members and few associates, this tends to limit the risk of exposure of misappropriations, and thus the perception of political corruption in the whole country. Brunei may also be considered in this grouping, except it has a very smaller real GDP but also a low corruption score. Also, the country practices an absolute monarchy system of government. At the extreme are countries such as Congo, Azerbaijan, Equatorial Guinea, Libya, Sudan, and Gabon with relatively smaller real GDP but are perceived to be among the most corrupt countries in the world.

The summary statistics of the control variables are also presented in Table 1. Besides the summary statistics of the variables, the results of the correlation analysis summarised in Table 1 show that oil prices have a very weak positive, but insignificant correlation with real GDP, while both corruption indices have a weak negative, negative and significant correlation with real GDP. The correlation between oil price 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, with the correlation of primary fiscal balance and real GDP being weak and negative, and 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 *et al.*, 1999; Pesaran and Smith, 1995). 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) $(p, q_1, \ldots q_q)$ model specification of the form:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{it-j} + \sum_{j=0}^{q} \delta'_{ij} x_{it-j} + \mu_i + \varepsilon_{it} \tag{4}$$

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, $\lambda_{ij}$ are scalars for the lagged dependent variable, $\mu_i$ represents the group-specific fixed effect, and $\varepsilon_{it}$ is the stochastic error term. The index $i = 1, 2, \ldots, N$ denotes the number of groups, and $t = 1, 2, \ldots, T$ represents time periods.

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

$$\Delta y_{it} = \phi_i y_{it-1} + \beta'_i x_{it} + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta y_{it-j} + \sum_{j=0}^{q-1} \delta^*_{ij} \Delta x_{it-j} + \mu_i + \varepsilon_{it} \tag{5}$$

$$i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, T$$

where $\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij})$, $\beta_i = \sum_{j=0}^{q} \delta_{ij}$, $\lambda^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im}, j = 1, 2, \ldots p-1$, and

$\delta^*_{ij} = -\sum_{m=j+1}^{q} \delta_{im},\ j = 1, 2, \ldots q-1.$

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

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

$$y_{it} = -\frac{\beta_i'}{\phi_i} x_{it} + \eta_{it}, \tag{6}$$

$$\text{for each } i \ = \ 1, 2, \ \ldots, \ N$$

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. The estimators are given as:

$$\hat{\phi}_{PMG} = \tfrac{1}{N}\sum_{i=1}^{N} \widetilde{\phi}_i, \quad \hat{\beta}_{PMG} = \tfrac{1}{N}\sum_{i=1}^{N} \widetilde{\beta}_i, \quad \hat{\lambda}_{jPMG} = \tfrac{1}{N}\sum_{i=1}^{N} \widetilde{\lambda}_{ij},\ j = 1, \ldots, p-1,$$
$$\hat{\delta}_j^{PMG} = \tfrac{1}{N}\sum_{i=1}^{N} \widetilde{\delta}_{ij},\ j = 1, \ldots, q-1, \quad \hat{\theta}_j^{PMG} = \tfrac{1}{N}\sum_{i=1}^{N} -\left(\widetilde{\beta}_i / \widetilde{\phi}_i\right)$$

The Mean Group (MG) estimator proposed by Pesaran and Smith (1995) computes the mean of the short- and long-run coefficients as:

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

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

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

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:

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

where $\bar{z}_t = (\bar{y}_t, \bar{x}_t)' = \left(\frac{1}{N}\sum_{i=1}^{N} y_{it}, \frac{1}{N}\sum_{i=1}^{N} x_{it}\right)'$ are the cross-sectional averages the dependent and independent variables. $\gamma_{i,l} = (\gamma_{y,i,l}, \gamma_{x,i,l})'$ the estimated coefficients of the cross-section averages and are generally treated as nuisance parameters.

The individual long-run coefficients are given by:

$$\theta_{CS-ARDL,i} = \frac{\sum_{l=0}^{p_x} \delta_{li}}{1 - \sum_{l=1}^{p_y} \lambda_{li}} \tag{8}$$

With 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 *et al.* (2002) [LLC], Im *et al.* (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 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 the cross-section and unit root test on each of the variables in the model. The results are summarised in Tables 2 and 3, respectively. As shown in Table 2, there is strong evidence to reject the null hypothesis of weak cross-sectional dependence for all the series, except the corruption indices. However, the estimated exponent (alpha) of cross-sectional dependence is well above 0.5. Essentially, this shows that all the variables are cross-sectionally dependent, indicating that all the countries in the sample share common paths for all variables. The presence of strong cross-sectional dependence demonstrates the interdependence amongst the countries, attributable to sharing common shocks. Besides, given that the countries are major producers and exporters of crude oil, and jointly responsible for more than 90 percent of the global oil production, thus adjustments in the prices of the commodity often have a significant impact on their respective macroeconomic and fiscal policy, albeit differently. Thus, it is imperative to employ tests and estimation techniques which account for cross-sectional dependence.

Table 2: Results of cross-section dependence tests

| | $rgdp$ | $op$ | $co^T$ | $co^W$ | $fd$ | $pop$ | $fbal$ | $empl$ |
|---|---|---|---|---|---|---|---|---|
| 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. $\alpha = 0$ denotes weak cross-sectional dependence, $0 < \alpha < 0.5$ is semi-weak cross-sectional dependence, $0.5 \leq \alpha < 1$ is semi-strong semi-weak cross-sectional dependence, and $\alpha = 1$ 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.

To determine the stationarity properties of the series, I employ both the first-generation panel unit root tests (LLC, IPS, and Fisher-type ADF test) and the second-generation CIPS unit root test which assumes cross-sectional dependence among cross-sections. As shown in

Table 3, the results of the stationarity test are mixed. Specifically, all four tests confirmed that TI's corruption index, population size, and fiscal balance are stationary, and 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, while LLC shows that the series is stationary. 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 confirmed 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 order of integration of the series, the reliability of the existing panel cointegration tests is compromised (Fuinhas *et al.*, 2015).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.

## 4.2 Oil price, corruption and economic growth relationship

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

Consequently, I estimate six models, namely 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 the sub-samples of countries with relatively low level of corruption (Columns 3-4) and high level of corruption (Columns 5-6)[4]. The stepwise analysis provides an opportunity to determine 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 estimated models are summarised in panels A and B of Table 4[5], respectively.

Starting with the main results in column (1) of Table 4, oil price shows a significant long-

[4]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.

[5]Before estimating the models using the CS-ARDL approach, the models were also estimated using the "traditional" MG and PMG approach. The results were not presented or discussed because the results were characterised by strong cross-sectional dependence. They are, however, available upon request.

Table 3: 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 (1978) information criteria. The Stata `xtcips` command is used to compute the CIPS test.

run positive impact on economic growth at a 10 percent level, while the long-term impact of corruption[6] on growth is negative and significant at a 10 percent level. The short-run effect of oil price and corruption, though having the same sign as the long-run estimates, are not statistically significant. Table 4 demonstrates that a unit change in oil price and the level of corruption leads to changes in long-term growth by an average of 0.0692 percentage points (p.p.) and -0.0044 p.p., respectively, in the 30 oil-rich economies. These findings are consistent with the outcome of some existing studies which discovered that changes in oil prices stimulate economic growth in oil-rich countries (see Akinlo and Apanisile, 2015; Eregha and Mesagan, 2020; 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 *et al.*, 2022; Mauro, 1995; Mo, 2001; Uddin and Rahman, 2023).

In column (2), the oil price-corruption interaction term was introduced (substituted with the corruption variable). The coefficient of oil price will show the impact of oil price changes on growth when the level of corruption is zero. Meanwhile, the coefficient of the interaction term will indicate the variations in growth due to changes in both oil prices and the level of corruption. As shown in column 2 of Table 4, the short- and long-term impact of oil price is positive and significant, while the interaction term enters with a positive and significant coefficient, at 10 percent levels. This suggests that an increase in oil price will lead to an immediate and long-term improvement in growth by 0.0626% points and 0.3635% points, respectively, when the level of corruption is zero. However, the coefficient of the interaction term demonstrates that a simultaneous increase in oil price and the level of corruption will lead to the deceleration of long-term growth by 0.0019% points.

Disaggregating the sample based on the level of corruption, columns (3) and (4) show that in oil-rich countries with a relatively low level of corruption, the oil price has a significant immediate and long-run impact on economic growth at a 5 percent level, while the interaction term enters with a negative and significant coefficient at 5 percent level. However, in such countries, there is no evidence of a significant relationship between corruption and growth. Meanwhile, as shown in columns (5) and (6), in countries with a higher level of corruption the long-run impact of oil price on growth is positive and significant, corruption has a significant immediate and long-term effect on growth in countries with a relatively low level of corruption, and the coefficient of the interaction term is negative and significant at 10

[6]The TI's corruption index is used for the analysis. The index is rescaled to make interpretation straightforward. To ensure that the rescaling does not lead to a misleading outcome I also used the "original" index for all the analysis. Interestingly, except for the switch in the signs of the coefficient, the **same outcome** (both in terms of size and significance of the coefficient) was obtained.

Table 4: 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:** $\Delta$ is the first-difference operator. Asterisks (***), (**) and (*) denotes statistical significance at 1%, 5% and 10% levels, respectively. Model I is the estimation without the oil price-corruption interaction term, and Model II includes the interaction term. The optimal lag length is suggested by AIC. Values in (.) are standard error and [.] are probability values. *ect* is the error correction term, it represents the speed of adjustment speed to long-term equilibrium. CD test is Pesaran (2015, 2021) test for weak cross-sectional dependence (among the error terms). $\alpha$ 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.

percent level, both in the short- and long-run model. Comparatively, the results suggest that the magnitude of the immediate and long-term impact of oil price increases on growth is larger for oil-rich countries with a higher level of corruption. Also, the deleterious effect of corruption is only relevant in oil-rich countries with higher levels of corruption. Interestingly, while the simultaneous increase in oil price and the level of corruption has a significant adverse effect on short- and long-term growth, regardless of the existing levels of corruption, the magnitude of the impact is much larger and pronounced in oil-rich economies with higher levels of corruption.

Moving from columns (1) to (6), the results present evidence of 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 (average) convergence coefficient (error correction term) that 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 48.61 percent and 78.2 percent of short-term disequilibrium is adjusted every period.

Meanwhile, given that the signs of the coefficient of oil price and the interaction term are different for all three models, I compute the margin effect of oil price on long-term growth based on the full sample, least corrupt countries, and more corrupt countries using the estimated coefficients in 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 price on long-term economic growth calculated at the minimum, average, and maximum level of corruption index are 0.3481, 0.2501, and 0.1818, respectively, for the whole sample. For countries with a relatively lower level of corruption, the computed marginal effects of oil price at the minimum, average, and maximum level of corruption index are 0.0911, 0.0905, and 0.0896, respectively, while it is 0.1614, 0.1135, and 0.0769, respectively, for countries with relatively higher levels of corruption. Based on the computed marginal effects, it is indicative that the long-term positive impact of an oil price increase is

[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.

larger when the level of corruption is low, regardless of a country's current level of corruption. In other words, it is suggestive that an increase in oil price matched with the reduction in the level of corruption will have greater benefits for long-term economic growth than a simultaneous increase in oil price and the level of corruption.

Concerning 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 differs.) However, the impact of financial development (measured by the ratio of credit to the private sector to the GDP) on growth is negative, but statistically insignificant (except for oil-rich economies with high levels of corruption). These outcomes are all consistent with existing studies (see Adam and Bevan, 2005; Azam, 2022; Rahman *et al.*, 2017).

### 4.2.1 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 the computation of the cross-sectional dependence and exponent (alpha) of the cross-sectional dependence of the residuals of the estimated model. As shown in the lower panel of Table 4, the null of weak cross-sectional dependence cannot be rejected for all the models. Also, the estimated exponents of cross-sectional dependence are all close to the threshold of 0.5. Thus, it is suggestive that the problem of cross-sectional dependence is adequately addressed in the estimated models.

The second robustness check includes the use of the World Bank's control of corruption index[8] 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 oil price-corruption interaction) nor did they lose their statistical significance. Moreover, the magnitude of the impact is very similar to the main result in Table 4. Specifically, in all the 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 price increase on long-term growth is also larger for oil-rich countries with higher levels of corruption, even as the adverse impact of corruption is also more pronounced in such economies. In addition, the interaction term enters with a negative and significant coefficient, thus further reinforcing the outcome from the main results that an increase in oil price amid pervasiveness corrup-

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

tion erodes whatever potential benefits associated with positive oil price changes in oil-rich economies.

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

### 4.2.2 Discussions and policy implications

The empirical findings of this study are quite revealing and have some important policy implications. They can be summarised as follows. First, regardless of the specification, an increase in oil price has a significant positive long-term and short-run impact on economic growth. This outcome suggests that an increase in the price of oil plays a critical role in stimulating the growth and development of oil-rich economies. Essentially, the growth impact of the oil price increase can be explained through the increase in public revenue accrued from the sales or production of crude oil (including taxes and royalties), which thus provide the government with more resources to invest in physical and human capital which stimulate growth. Given the volatile nature of oil prices and the fact that countries have very little control over the price of oil (unilaterally increasing production often achieves the opposite as seen during the 1990s price crash). Hence, to ensure that the economy benefits oil-rich economies may need to embark on fiscal discipline (for instance by saving and/or investing its "excess" oil windfall), adopt efficient technology to maximise its production capacity, and liberalise its oil and gas sector. The largest impact is among economies with a relatively higher level of corruption (who are also ironically low-income countries) perhaps highlighting the need for these countries to re-position their economies to benefit from the potential of the product.

Secondly, I show that corruption stifles economic growth, but in the short- and long-term, and the magnitude of the impact is more pronounced in oil-rich economies with existing high levels of perceived corruption. This outcome is consistent with the "sand the wheel hypothesis", which posits that corruption impedes sustainable economic growth and development through its role in reducing human and physical capital investment, promoting inefficient resource allocation, and raising the levels of inequality and poverty (David *et al.*, 2023, 2024). It is quite interesting that the largest magnitude of the adverse effect of corruption is attributed to countries perceived to be relatively more corrupt. Interestingly, besides being perceived to be more corrupt, most of the economies have continued to contend with slower and unimpressive economic growth performance. The outcome, therefore, highlights how the pervasiveness of corruption has continued to impede the growth and development of these countries despite the abundance of natural resources. Empirical studies have shown that the pervasiveness of corruption slows down the economic performance of natural resource-rich economies (see, Abubakar and Akadiri, 2022; Papyrakis and Gerlagh, 2004; Rotimi *et al.*, 2021). Thus, governments and policymakers must embark on policies and strategies aimed at reducing the level of corruption. Corruption could be reduced and growth achieved by simplifying cumbersome regulations in the bureaucratic system and removing operational red tape, promoting greater freedom of expression, and entrenching the rule of law and efficiency in the legal system. Corruption can also be prevented by funding anti-graft agencies adequately and raising the income level and wages of civil servants.

Lastly, the study reveals that corruption adversely moderates the impact of oil price increases on economic growth in oil-rich economies. In other words, the impact of oil price varies with the level of corruption, with oil price increase having a larger positive impact on growth at lower levels of corruption, while stifling growth at higher levels of corruption. Moreover, as shown in column (6) of Table 4, the simultaneous increase in oil price and the level of corruption has more far-reaching consequences in oil-rich economies with a relatively higher level of corruption. The potential positive impact of oil price increases is thus dependent on how low the level of corruption is in the economy. Empirical studies demonstrate that while the abundance of natural resources and its windfalls is capable of stimulating growth in countries with strong institutions (including low corruption), it stifles growth in economies characterised by weak institutions and massive corruption (see, Acemoglu *et al.*, 2002; David *et al.*, 2023; Olayungbo and Adediran, 2017). As pointed out by Baragwanath (2020), the adverse effect of windfalls created by positive oil price shocks on growth is often induced by the dynamic incentive which it (windfall) generates for corrupt politicians and public servants to embezzle funds, inflate the cost of social goods and services, or divert resource to large unproductive capital-intensive projects which offer huge opportunity for bribes. Over time, the ubiquity of embezzlement and under-remittance of proceeds from oil revenue, illegal diversion, and other sharp practices in the oil and gas sector of oil-rich economies with high-level of corruption (such as Nigeria, Venezuela, Angola, and Libya) has often led to loss of public revenue, thus limiting the ability of the state to adequately invest in growth-enhancing human and physical capital regardless of changing oil price.

The policy implication of this finding is that reducing the level of corruption is imperative for oil price increases to stimulate short- and long-term economic growth in oil-rich economies.

In other words, an increase in oil price and a reduction in the level of corruption have more benefits in stimulating immediate and long-term economic growth compared to the simultaneous increase in oil price and level of corruption. Besides its direct deleterious effect on economic growth, the pervasiveness of corruption also impairs economic growth through the dependence on oil and windfall from oil sales and production. Thus, governments and policymakers in oil-rich countries must intensify and strengthen their efforts to reduce the level of corruption in an attempt 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 ensure that the malaise is completely eradicated from every sector and facet of their economy and society. It is, however, very important that oil-rich countries with a relatively high level of corruption sustain the reduction in the levels of corruption to enable the wealth accruing from oil to benefit their economy.

### 4.3 Causality tests

In addition to the CS-ARDL, I also employ the Dumitrescu and Hurlin (2012) heterogeneous panel causality test to determine the causal relationship between the variables in the growth model. Due to the issue of cross-sectional dependence amongst most of the series, as shown in Table 2, I implemented a block bootstrap procedure proposed by Dumitrescu and Hurlin (2012) to compute bootstrapped critical values for the test statistics instead of using asymptotic critical values to deal with the issue. The test statistics computed based on 1,000 bootstrap replications are summarised in Table 5. 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 a 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 a unidirectional heterogenous causality from oil price to real GDP, but not vice versa. In addition, as shown in Table 5, there is a significant bi-directional heterogenous causality between corruption and economic growth (real GDP) at a 5 percent level, while a one-way causal relationship holds from oil price to corruption at a 10 percent level.

With regards to the control variables, Table 5 presents evidence of unidirectional heterogenous causality from primary fiscal balance (and employment rate) to growth (real GDP) at a 1 percent (5 percent) level. Additionally, the null of Granger no-causality from financial development to real GDP can be rejected at a 5 percent level of significance. However, there is no evidence of a heterogenous causal relationship (for a least one cross-section) between population size and economic performance (real GDP). Essentially, these outcomes provide

Table 5: 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 standardized Z statistic (because $N > T$). A block bootstrap procedure with 1000 replications is employed to compute bootstrapped critical values due to the issue of cross-sectional dependence. Asterisks (***) (**) and (*) denote rejection of the null hypothesis at 1%, 5%, and 10% levels, respectively. The optional lag length is determined by Schwarz Information Criterion (SIC). The test statistics are computed using the community-contributed Stata command `xtgcause`.

strong support for the estimation results, highlighting the important connection between oil price changes, corruption and economic growth dynamics. Moreover, the direction of casual between oil prices and corruption illustrates the critical roles which 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 using several methodologies, evidence from the study demonstrates that both oil prices promote long-term and immediate economic growth, while corruption impedes growth in the oil-rich economies. In addition, the study shows that the marginal impact of oil price increases on economic growth varies with the level of corruption. In essence, the positive long-term impact of oil price increases on economic growth is larger at low levels of corruption than at higher levels of corruption. Splitting the 30 countries based on the perceived level of corruption, the study demonstrates that the magnitude of the positive impact of an oil price increase and the adverse impact of corruption on growth is larger for countries perceived to have a higher level of corruption. Also, the adverse consequence of the simultaneous increase in oil price and the level of corruption is larger for oil-rich economies with a relatively higher level of corruption than their counterpart with a relatively low level of corruption. The outcomes are robust to various estimation techniques and alternative proxy of corruption.

The economic implication of this study is that corruption is an important channel through which the effect of oil price increases is transmitted to the long-term economic growth of oil-rich countries. In other words, the potential positive impact of oil prices on long-term growth will never materialise when the level of corruption is very high. Therefore, oil-rich economies are encouraged to adopt appropriate strategies to reduce the level of corruption to enable them to benefit from windfalls associated with positive oil price shocks. The level of corruption can be reduced and growth enhanced by removing operational red tape and simplifying cumbersome regulations in the bureaucratic system. Also, the malaise can be curbed by raising the income level and wages of civil servants, promoting greater freedom of expression, entrenching the rule of law and efficiency in the legal system, and adequate funding of anti-graft agencies. Notwithstanding the seemingly positive impact of oil price increases on growth, policymakers in oil-rich countries are encouraged to implement policies to diversify their economy and public revenue away from oil. This can be achieved through increased investment in human and physical capital, and critical non-oil sectors such as the service, manufacturing, agricultural, et cetera, to spur sustained growth and development.

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# A Appendices

## A.1 Appendix Table

Appendix Table A1: List of countries

| More corrupt countries | | | Less corrupt countries |
|---|---|---|---|
| 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" is based on their average Corruption Perception Index (CPI) score over time. Countries with CPI scores between 0 and 49 are classified as "More Corrupt," while countries with CPI scores between 50 and 100 are classified as "Less Corrupt."

Appendix Table A2: Average real GDP and corruption perception of selected countries (1996-2022)

| Country | Real GDP | $TI\ CPI^R$ | $WB\ CC^R$ | Country | Real GDP | $TI\ CPI^R$ | $WB$ CC$^R$ |
|---|---|---|---|---|---|---|---|
| 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 | 1541.083 | 62.15 | 2.66 | Mexico | 1072.744 | 67.00 | 3.05 |
| Brunei Darussalam | 12.532 | 42.00 | 1.92 | Nigeria | 351.459 | 78.72 | 3.68 |
| Canada | 1392.501 | 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 | Russia | 1153.838 | 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 | 2657.742 | 18.87 | 0.68 |
| Iraq | 127.232 | 81.70 | 3.89 | United States | 16374.097 | 26.55 | 1.08 |

**Notes:** Real GDP is in billions of US dollars (US\$). $TI\ CPI^R$ and $WB\ CC^R$ refer to the rescaled Transparency International (TI) Corruption Perception Index and World Bank's Control of Corruption Index, respectively.

Appendix Table A3: Slope homogeneity test result

| Models | N | Without Interaction Term | | With Interaction Term | |
|---|---|---|---|---|---|
| | | $\widetilde{\Delta}$ | $\widetilde{\Delta}$ Adjusted | $\widetilde{\Delta}$ | $\widetilde{\Delta}$ 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*** |

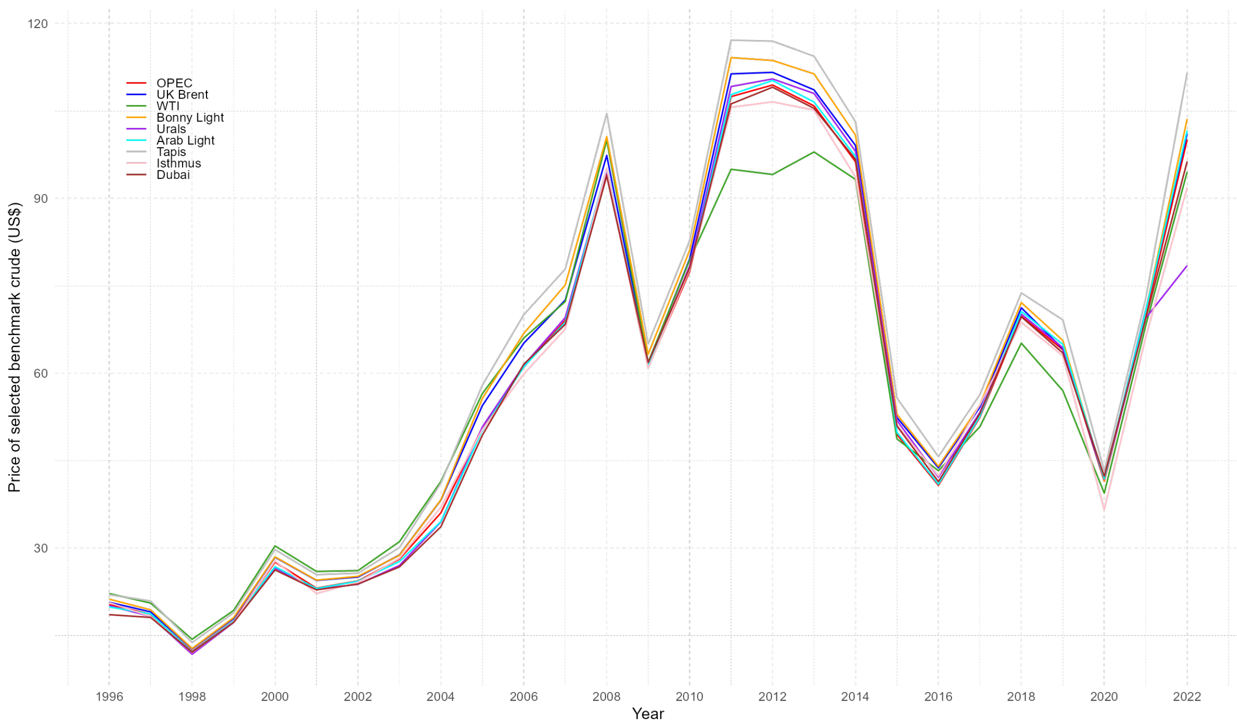
**Notes:** $H_0$: slope coefficients are homogenous. Asterisks (***) denote the rejection of the null hypothesis at a 1% level. $\widetilde{\Delta}$ and $\widetilde{\Delta}$ Adjusted are the standard Delta homogeneity slope test statistics of Pesaran and Yamagata (2008) and the adjusted Delta statistics,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

Appendix 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 | |
| | Model I (1) | Model II (2) | Model I (3) | Model II (4) | Model I (5) | Model II (6) |
| **Panel A: Long-run Estimates** | | | | | | |
| $lop$ | 0.1158 (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) |

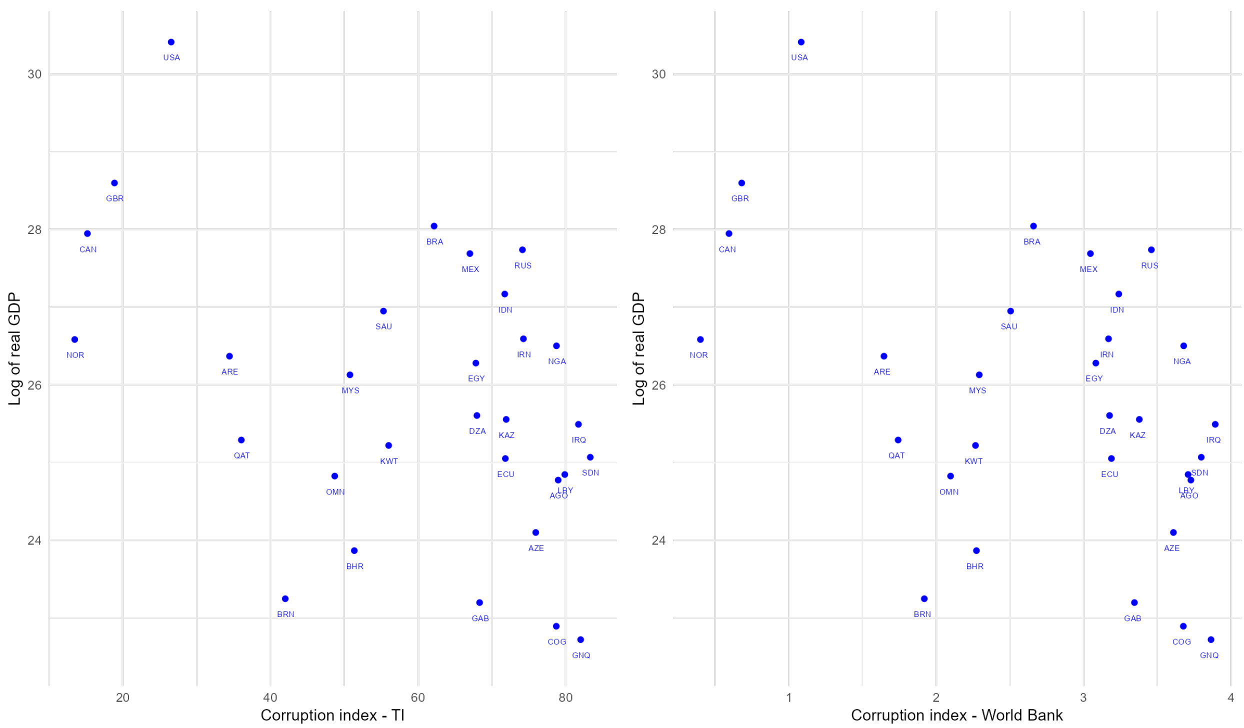
**Notes:** $\Delta$ is the first-difference operator. Asterisks (***), (**) and (*) denotes statistical significance at 1%, 5% and 10% levels, respectively. Model I is the estimation without the oil price-corruption interaction term, and Model II includes the interaction term. The optimal lag length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

## A.2 Appendix Figure




Appendix 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.




Appendix Figure A2: Relationship between real GDP and corruption indices