# Does Good Governance Moderate the Financial Development-CO2 Emissions Relationship?

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# Does good governance moderate the financial development-$CO_2$ emissions relationship?

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Abstract

This inquiry contributes to the previous literature by analyzing the empirical linkage between the development of the financial sector and carbon emissions in the presence of good governance. Specifically, we examine the ability of good governance in moderating the negative effect of financial development on environmental quality in the case of Saudi Arabia over the period 1996-2016. Different indicators of financial development and governance quality are included in the analysis. Using Dynamic Ordinary Least Squares (DOLS) estimator, we find that (i) an unconditional effect of the three indicators of financial development on increasing carbon emissions in the most models; (ii) the conditional impact of the indicators of governance quality increases carbon emissions in the most models; (iii) the interactions between the indicators of governance and the indicators of financial development are negative and statistically significant only in the models pertaining to political and institutional governance, meaning that the development of financial sector reduces carbon emissions if it is accompanied by good institutional and political governance.

Keywords: Good governance; Financial sector; $CO_2$ emissions.

## 1. Introduction

Environmental change, which has attracted the attention of policymakers, environmentalists as well as international organizations, has become a global concern over the past two decades. The result of massive energy pollution is climate variation and the global warming health of living beings ultimately affected by energy sources (Alzard et al., 2019; Danish and Ulucak, 2020). In 1992, the UNFCCC (Framework Convention on Climate Change) was created as a result of the unprecedented rise in global temperatures and its adverse climate effects. In 1997, the UNFCCC established the Kyoto Protocol and, in 2015, the Paris Agreement. Both were mainly aimed at mitigating global warming by curbing GHG emissions. The Paris Convention sets a limit of 2 °C over pre-industrial temperature. The recent report published by the IPCC states that global temperatures rise by an average of 1,5 ° C, which has been considered to be quite high ( Masson-Delmotte et al., 2018). So rapid measures to moderate CO2 emissions from the major states of polluting pollution have become necessary. A few weeks before the COP 21, Saudi Arabia, the world's top oil producer and 10th largest global emitter of fossil $CO_2$ announced its climate commitment. The Saudi Government promises a major decrease of 130 million tons of CO2 emissions by 2030 by year (Kingdom of Saudi Arabia, 2015). Besides, the Environmental Curve Kuznets Curve (EKC) offers a great deal of current literature on the determinants of environmental degradation. Although the EKC itself provides a reversed link between various environmental quality indicators and economic growth, recent works have expanded the model to include further environmental quality determinants. The EKC empirical evaluation has recognized that, in a reduced model, revenue serves as a proxy for too many other variables (e.g., economic structure, level of economic activity, etc.), resulting in an omitted variables bias (Bali Swain et al., 2020). This awareness has brought about efforts to expand the model by incorporating pertinent variables related to economic structure, energy markets, trade openness, etc. In this contribution, we try to examine the influence of governance quality and financial development on carbon emissions in the case of Saudi Arabia's country. The positioning of this article is justified by five literary strands: (i) the main reasons behind focusing on Saudi Arabia Country, (ii) the impact of financial development on carbon emissions, (iii) The relevance of governance quality in improving environmental quality, and (iv) the impact of governance quality on financial development. These concepts are discussed below in more detail.

First, We could focus on the Saudi economy based on different characteristics and motivations. Saudi Arabia ranks as the eighth largest emissions of CO2 worldwide (Omri et al., 2019; Alkhathlan and Javid, 2015). This makes reducing carbon dioxide emissions in the country harder, as the production process depends largely on fossil fuels. In this sense, we will attempt to determine the influence of both governance quality and financial development on national environmental improvement.

Second, the links between financial development and carbon emissions are investigated in a broad literature. Several researchers, including Jun et al. ( 2018), Wang et al. ( 2019), Gokmenoglu and Sadeghieh (2019), Kayani et al. (2020), have indicated that financial development has a direct and indirect impact on carbon emissions. Previous studies show that financial development drives growth and improves energy needs automatically (Gunasekaran et al., 2014). Moreover, the associations among financial sector, energy use, and environmental quality are discussed in different schools. One argument that financial development lowers carbon emissions through the consumption of energy efficient technology (Tamazian and Rao, 2010; Shahzad et al., 2017; Charfeddine and Kahia, 2019). The second thought school (Ito, 2017) indicates that financial development is increasing CO2 emissions as follows. Firstly, the companies listed on the stock market can receive low rate financing and invest this in projects like machinery purchases or in investment in projects that eventually increase carbon emissions investment (Kayani et al., 2020). Secondly, if any economy has a high financial development; consequently, it gives the opportunity to attract FDI (foreign direct investment) and augments CO2 emissions, unfortunately. Finally, the financial intermediation process has grown. Consumers can easily obtain loans for the purchase of high carbon emissions items like coolers, washing machines, cars and air conditioning (Cai et al. 2019).

Third, the relationship between governance quality and environmental quality was defined and explained by many theories (Mineur, 2007; Bosselmann et al., 2008; Hope, 2009; Samimi et al. 2012, Kaufman et al., 2006). In general, the World Governance Indicators (WGI) define the concept of governance as the institutions and traditions through which the authority in the state is implemented. This contains the process of selecting, monitors, and superseding governments; the government's ability to effectively implement and formulate respect and good policies for the institutions governing their social and economic interactions (Omri and Ben Mabrouk, 2020). In this sense, while worldwide governments are still seeking solutions to promote sustainable development, the value of good governance[1] as a key instrument for achieving this goal has recently become popular with policymakers and academics (e.g., Bos and Gupta, 2019). In fact, the previous empirical literature has an interest in good governance as a key factor in achieving the goals of sustainable development. For instance, Samimi et al. (2012) investigate the effect of good governance on environmental degradation through using three governance proxies (i.e.,

[1] The perception of good governance consists of the opportunity to organize and create SDGs-related organizations (Güney, 2017) and the assurance of non-State, State actors, the civil society and private sector participation in decision making, accountability and the rule of law at all level, promoting transparency, and allowing effective human , natural, financial, and economic resources management for fairly sustainable development (Hallegatte et all., 2011; Omri and Ben Mabrouk, 2020).

control of corruption, regulatory quality, and government effectiveness for a panel of 21 economies in the MENA (the Middle East and North Africa) region during the period 2002-2007. Their results sustain a positive impact on environmental quality regarding government effectiveness. Expressly, good governance adversely affects the deterioration of the environment. Costantini and Monni (2008) analyze the effect on sustainable development of human development and quality governance, as assessed by the rule of law. The positive relationship among them is confirmed in their findings. Recently, Omri and Ben Mabrouk (2020) show that good governance can be successful in rebalancing social, environmental, and economic components of sustainable developments for a panel of 20 economies in the MENA (Middle East and North Africa) region during the period 1996-2014. In a study of 58 selected economies covering the period 1996-2011 by Bali Swain et al. (2020), it was confirmed that the degree of governance's impact relies essentially on the level of economic development, the pollutant type and the category of governance measure.

Fourth, a growing number of researchers have recently explored the effect of good governance on financial development. For instance, a study by Sayilir et al. (2018) analyzing the link between financial development and governance for countries listed in FDIWEF using the structural equation modeling approach finds that there exists a positive link between governance and financial development. Karikari (2010) showed a positive association between good governance and financial development for a panel of 37 SSA (Sub-Saharan African) countries during the period 1996-208. In a study of 19 selected emerging economies covering the period 2001-2014 by Omri (2020), it was found that good governance significantly improves the probably weak effect of financial development affecting both informal and formal entrepreneurship. In a panel data analysis of 53 companies from India and 53 companies from GCC (Gulf Corporation Council) countries covering the period from 1996 to 2016 by Al-ahdal et al. (2020), it was shown in general that good governance practices have a significant and positive impact on firms' financial performance. Likewise, Braune et al. (2020) confirmed that the adoption of good governance practices very significantly and favourably influences the financial performances of industrial companies.

By integrating these four strands of studies, this research contributes to the previous literature in the following ways. First, the prevailing literature currently on the subject has focused mainly either on the nexus between governance and environment (Costantini and Monni, 2008; Samimi et al., 2012; Omri and Ben Mabrouk, 2020) or financial development-environment linkage (Jun et al., 2018; Gokmenoglu and Sadeghieh, 2019; Kayani et al., 2020; Shahzad et al., 2017; Charfeddine and Kahia, 2019) without recognizing how macro-level governance conditions can develop the financial sector to improve environmental quality. In this study, we try to demonstrate how good governance moderates the negative impact of financial development on environmental quality. To the best of our knowledge, no empirical research took account of the combined effects of these variables (i.e., governance and financial development) on environmental quality, particularly in Saudi Arabia. As already stated, we consider that Saudi Arabia provides an important context for researching such interaction because improving environmental quality is central to the development and growth of its economy. Second, in some studies, governance measures are being proposed without distinguishing between governance forms and the different ways in which they are conducted. Thus, we consider as mentioned by Omri and Ben Mabrouk (2020), three categories and six measures of good governance, namely institutional governance (rule of low & control of corruption); economic governance (regulatory quality & government effectiveness); political governance (political stability & voice and accountability) in attempt to provide room for robust analyses. The investigation by the governance category permits us to comprehend which category is the best to achieve the aimed complementarity.

The remainder of the article is structured as follows. The next section explains the used methodology and data. Section 3 presents and discusses the main results. The last Section concludes and provides some policy implications.

## 2. Data and methodology

### *2.1. Variables and data description*

Using a time-series data for Saudi Arabia with datasets obtained from the World Development Indicators (WDI), the International Monetary Fund (IMF), and the World Governance Indicators (WGI) over the 1996–2016 period, this research examines how governance quality promotes financial development to reduce $CO_2$ emissions. The choice of the starting period is based on the availability of data on the indicators of governance. Table 1 summarizes the description and source of variables.

#### *2.1.1. Dependent variable*

An emission of carbon dioxide is the release of this gas into the earth's atmosphere, regardless of the source. Carbon dioxide ($CO_2$) is the second most important greenhouse gas in the atmosphere after water vapour. 97% of $CO_2$ emissions into the atmosphere are of natural origin and 3% of anthropogenic origin, i.e. resulting from human activities (Raupach et al., 2013). Following Omri (2013), Ben Youssef et al. (2016), Kahia et al. (2019), we use per capita CO2 emissions in metric tons as a measure of environmental degradation. The data on this indicator is collected from the WDI online database.

#### *2.1.2. Independent variables*

As mentioned in the first section, two independent variables are included in the analysis as determinants of $CO_2$ emissions:

- *Financial development (FiD)*: Following Vithessonthi and Kumarasinghe (2016), Bokpin (2017), Omri e al. (2019), we used three measures of financial development in this study, namely financial development index (FDI), domestic credit to the private sector as % of GDP (DCPS), and private credit by deposit money banks and other financial institutions as % of GDP (PCFI). The data on these indicators is collected from the WDI and IMF online databases. Based on the existing literature, we expect a negative impact of financial development on environmental quality (e.g., Boutabba, 2014; Bokpin, 2017; Adams and Klobodu, 2018; Omri and Belhadj, 2020).
- *Governance quality (Gov)*: The governance quality variable is included in the model as a policy variable, which complements financial development to reduce $CO_2$ emissions. Six measures of governance quality are included in the analysis as determinants of $CO_2$ emissions, namely voice & accountability (V&A), political stability (PS), government effectiveness (GE), regulatory quality (RQ), rule of law (RL), and control of corruption (CC). Following Omri (2020), these indicators are grouped into three classes: political governance includes voice & accountability and political stability, economic governance includes government effectiveness and regulatory quality, and institutional governance includes control of corruption and rule of law). The data on these indicators is collected from the WGI online database. Good governance is expected to lessen carbon emissions (Tamazian and Rao, 2010; Abid, 2016; Omri and Belhadj, 2020).

*2.1.2. Control variables*

In addition to these two independent variables, other determinants of $CO_2$ emissions are included in the model, namely, GDP per capita (GDP), squared GDP per capita ($GDP^2$), energy consumption (EnC), and trade openness (TO). GDP per capita is expressed in constant 2010 US$, energy consumption or use is expressed in kg of oil equivalent per $1,000 GDP (constant 2011 PPP), and trade openness is defined as the sum of exports and imports of goods and services measured as a share of gross domestic product. The data on these indicators is collected from the WDI online database. It is expected that these variables increase the level of $CO_2$ emissions (Soytas et al., 2007; Halicioglu, 2009; Omri et al., 2015; Ben Youssef et al., 2016; Kalayci and Hayaloglu, 2019).

**Table 1**
Dfinition and source of the used data.

| Variables | Definition | Source |
|---|---|---|
| $CO_2$ emissions per capita ($C_{pc}$) | $CO_2$ emissions (metric tons per capita) | WDI |
| Financial development (FD) | Financial development index | IMF |
| | Domestic credit to private sector as % of GDP | WDI |
| | Private credit by deposit money banks and other financial institutions as % of GDP | WDI |
| Voice and accountability (V&A) | Measured as to what extent do citizens really participate in the choice of their rulers, whether through the extent of their freedom of expression, of association, or that of the media? | WGI |
| Political stability (PS) | Measures the perception of the probability that the government could be destabilized, overthrown either by unconstitutional means or by violence (political violence or terrorism). | WGI |
| Government effectiveness (GE) | Measures the quality of public services, civil servants, and their degree of independence from political pressures; quality of public policies, both in their definition and in their application, but also the effective responsibility of the government with regard to these public policies. | WGI |
| Regulation quality (RQ) | Measures the government's capacity to formulate and enforce appropriate policies and regulations that promote private sector development. | WGI |
| Rule of law (RL) | Measured as to what extent do citizens trust and respect the rules set by society; and, in particular, the quality of the social contract, across the police and the courts, but also the rate of crime and violence. | WGI |
| Control of corruption (CC) | Measured as whether and to what extent public power is exercised for private gain including both small and large forms of corruption, as well as how the state has been "captured" by elites and private interests. | WGI |
| GDP per capita (GDP) | GDP per capita (constant 2010 US$) | WDI |
| Trade Openness | Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product. | WDI |
| Energy Consumption | Energy use (kg of oil equivalent) per $1,000 GDP (constant 2011 PPP) | WDI |

*2.2. Econometric model and estimation procedures*

Based on the above-discussed arguments, we propose the following model to examine the influence of various aspects of financial development and governance quality, among other control variables, on $CO_2$ emissions in Saudi Arabia over the period 1996-2016.

$$CO_t = \alpha_0 + \alpha_1 \mathrm{FD_t} + \alpha_2 \mathrm{GoV_t} + \alpha_3 \mathrm{GDP_t} + \alpha_4 \mathrm{EC_t} + \alpha_6 \mathrm{T_t} + \varepsilon_{it} \quad (1)$$

To investigate the joint impact of governance quality and financial development on reducing $CO_2$ emissions, we rewrite Eq. (1) as follows:

$$CO_t = \alpha_0 + \alpha_1 \mathrm{FD_t} + \alpha_2 \mathrm{GoV_t} + \alpha_3 \mathrm{Gov_t} * \mathrm{FD_t} + \sum_{j=1}^{K} \lambda_j X_{jt} + \varepsilon_{it} \quad (2)$$

where the subscript t (t = 1, ……, 21) is the time period considered in this study (26 years), *CO* is $CO_2$ emissions per capita, FD is the indicators of financial development, Gov indicates the three categories of governance quality, Gov*FD is the interaction between the indicators of governance quality and the indicators of financial development, X is the vector of control variables, including GDP per capita and trade openness, $\alpha_0$ is a constant, j is the number of control variables, $\varepsilon$ is the error term. Hence, we expect that the indicators of financial development positively influence $CO_2$ emissions; however, governance quality mitigates $CO_2$ emissions. Regarding the interaction terms, we expect that good governance complements financial development to reduce $CO_2$ emissions.

Before estimating Eq. (2), we first check the stationary properties of our series. We then test the long-run equilibrium linkages among variables using the Johansen's cointegration test. Finally, we estimate the long-term relationships by means the DOLS estimator, which take care of endogeneity bias by taking the leads and lags of the first-differenced regressors.

*2.2.1. Unit Root Tests*

Our analytical approach starts with stationary checking of the variables. First of all, checking the stationary of the series under consideration has been carried out in three different types of root-test units: the KPSS test (Kwiatkowski et al. 1992); the PP test (Phillips and Perron 1988), and the ADF test (Dickey and Fuller 1981, the Augmented Dickey Fuller). The root unit tests are performed to analyze the integration order in the considered variables. For time series cointegration models, this is a prerequisite. If the variables are cointegrated of one order (I (1), it can be inferred that at their first difference, the variables evaluated are stationary, indicating that the groups of variables are long term cointegrated. Specifically, the ADF test results in a specification of the first differences of the variable against the lagged differences and series lagged once, with the optional time trend and constant conditions as follows:

$$\Delta X_t = b_0 + b_1 t + \theta X_{t-1} + \sum a_i \Delta Y_{t-i+1} + \varsigma_t \quad (3)$$

where $\Delta$ the operator of first difference, $b_0$ is an intercept symbol, $b_1t$ represents a linear trend of time, *i* refers to the number of lagged terms in first difference and refers $\varsigma_t$ to the error term. The null assumption is that $\theta = 0$. If the coefficient differs considerably from zero, the hypothetical of containing a unit root is not accepted. The ADF approach is performed to the first differences when the test on the level series fails to reject. Rejecting the null assumption signify that the series is integrated in order one (i.e., I (1)). The ADF test was generalized by Phillips and Perron (PP) in 1988 as follows:

$$X_t = a_0 + a_1 X_{t-1} + b_2 \left(t - T/2\right) + \tau_t \tag{4}$$

where T refers to the number of observations, $\tau_t$ refers to the error term with $E(\tau_t) = 0$, however there is no prerequisite for both homogenous or serially uncorrelated concept of disturbance term.

Regarding the KPSS test (Kwiatkowski et al. 1992), the idea is based on the view that the time-series around a deterministic trend is stationary and is measured as sum of a random walk, stationary random error and deterministic trend. It is based on the following model:

$$\begin{aligned} X_t &= d_t + r_t + \mu_t \\ r_t &= r_{t-1} + \eta_t \end{aligned} \tag{5}$$

where $d_t$ comprises deterministic model parts such as deterministic trend or intercept, $r_t$ refers to a random walk and $\mu_t, \eta_t$ represent the disturbance terms. The KPSS test is founded on the LM test, which assumes that the random walk has a null variance. The statistic of the KPSS test is specified as follows:

$$LM = \sum_{t=1}^{T} k_t^2 / \hat{\sigma}_\mu^2 \tag{6}$$

where $k_t = \sum_{t=1}^{T} \hat{\mu}_t$ and $\hat{\sigma}_\mu^2$ refers to the variance estimation of the disturbance term $\mu_t$ in Eq.(5). A simulation derived critical values that are described in Kwiatkowski et al. (1992). The findings of unit root tests are shown in Table 3.

### *2.2.2. Cointegration Tests*

A co-integration association between the underlying variables must be checked before estimating the long-term models and after verifying that the Kwiatkowski et al. (1992), Augmented Dickey and Fuller (1981) and Phillips and Perron (1988) unit root tests confirmed the stationarity of the considered series. The co-integration method allows a stable long-term relationship, including delay and exogenous variables, to be formed between two nonstationary series. Regardless of the selected test, it is only necessary for long non-stationary variables. The cointegration analysis therefore allows the real correlation between two variables to be clearly defined by looking for the presence of a cointegration vector and, if necessary, by removing its influence (Omri et al., 2019). In testing cointegration between variables, we have employed co-integration of Johansen (1988), which takes two statistical tests into consideration: the maximum eigenvalue and the trace statistics. Both may be performed to classify the existing number of cointegrating vectors, but they do not necessarily mean the same number of vectors. While using the cointegartion test of Johansen (1988), if the results of the two statistical tests are different, in our context the outcome of the maximum eigenvalue test is favored to the trace statistic, because of the advantage of distinct testing on each eigenvalue. Formally, this technique depends on the link between the matrix rank and its eigenvalues (i.e., characteristic roots). Considering $Z_t$ as a vector of n variables that are individually integrated of order one (I(1)), and suppose that $Z_t$ can be specified by the following VAR (Vector Autoregression):

$$Z_t = C_1 Z_{t-1} + \ldots + C_p Z_{t-p} + \zeta_t \tag{7}$$

The VAR model can be rewritten as:

$$\Delta Z_t = \Pi Z_{t-1} + \sum \Gamma \Delta Z_{t-i} + \xi_t \tag{8}$$

Where $\Pi = \sum C_i - I, \Gamma_i = -\sum C_i$. When the matrix of coefficients $\Pi$ is presented as restrained rank (r < k), there exist matrices $\alpha_{k \times r}$ and $\beta_{k \times r}$ each with r as rank such that $\Pi = \alpha\beta'$ and $\beta' Z_t$ is stationary. The cointegration relation number is defined by r, and each column of represents the cointegrating vector $\beta$. We use two statistics to determine the number of eigenvalues that are not distinct from a unit, the trace test and the maximum eigenvalues test:

$$\lambda_{trace}(r) = -T \sum \ln(1 - \lambda_i) \tag{9}$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \lambda_{r+1}) \tag{10}$$

Where $\lambda_i$ represent the assessed value of eigenvalue derived from the estimation of the $\Pi$ matrix, r is the number of cointegrating vectors and T represents the number of observation. The findings of the Johansen's (1988) cointegartion test of are exposed in Table 4.

*2.2.3. Long-Run Estimates*

If all variables are co-integrated, the long-term coefficient estimates of the explanatory variables require to be calculated. The outcome elasticities in the long-term are assessed by means of DOLS (Dynamic OLS) procedures. The benefit of using these estimators is that the endogeneity problems in serial correlations in error and regressors are often removed in a very successful manner and so the series have asymptotic properties as well (Omri et al., 2019). The DOLS estimator removes the problem of correlation among explanatory series. The specification for DOLS estimator (Stock and Watson, 1993) is identified as follows:

$$Y_t = \beta + \vec{\beta} X + \sum_{j=-q}^{p} \vec{d}_j \Delta X_{t-j} + u_t \tag{1}$$

where $Y_t, X, \vec{\beta}, p, q$ represent the dependent variable, the matrix of independent series, the cointegrating vector (The long-term impact of a fluctuation in X on Y), lag length and lead length, respectively. The lag and lead terms used in DOLS specification are structured to distinguish its stochastic error term from all previous innovations in stochastic regressors. Table 5 reports the results of long-run estimates.

## 3. Empirical Analysis

Table 2 displays summary statistics and correlations between the investigated proxies. During the sample time, Table 2 demonstrates, for instance, that the per capita $CO_2$ emissions variation is between 10.49 and 20.40 metric tons per capita; GDP per capita varies between 16696.41 US$ and 21399 US$; the variation for FD proxies are between 0.23 and 0.55 for FD index, between 20.79% and 58.11% of GDP for DCPS and between 45.35% and 68.36% of GDP for PCFI; the governance quality variables range from -1.90, -0.65, -0.37, -0.30, -0.15 and -0.30 to -1.32, 0.22, 0.26, 0.16, 0.33 and 0.23 for V&A, PS, GE, RQ, RL and CC, respectively; the energy consumption ranges from 104.48 to 148.90 kg of oil equivalent energy use, and trade openness varies from 56.08% to 96.10 % of GDP. Besides, the table shows that FDI series has the highest correlation with CO2 per capita, while PCFI variable has the lowest one.

Before running the cointegration relationships, we first the stationary of the used variables using two unit root tests, namely ADF (Dickey and Fuller 1981, the Augmented Dickey Fuller) and PP (Phillips and Perron 1988) tests. Table 3 reports the results of these tests at levels and first difference. The table shows that all our investigated variables are integrated at order one (I(1)), which gives rise to the opportunity of cointegration associations between the considered series. We can therefore use the cointegration test of Johansen (1988) to verify the long-run equilibrium between the underlying proxies in the three approximate models. Table 4 reports the results of this test that shows that all models do not reject the hypothesis of cointegration. The examined indicators are, therefore, cointegrated so that the long-term parameters can be estimates in the following step.

Table 5 reports the results of the DOLS long-run estimator related to the empirical linkages between the indicators of financial development, the indicators of governance quality and $CO_2$ emissions. The following are the main findings. First, in the most estimated models, the indicators of financial development have positive impacts on increasing $CO_2$ emissions, ranging from 0.73 to 329 percent for the models pertaining to financial development index, from 0.79 to 316 percent for the models pertaining to domestic credit to private sector (DCPS), and from 0.089 to 0.240 percent for the models pertaining to private credit by deposit money banks and other financial institutions (PCFI). These results indicate that an increase in financial development leads to deteriorating environmental quality. Shahbaz and Lean (2012) explain the positive impact of financial development on environmental degradation by the fact that the development of financial sector encourages savings and investment and then economic growth, which, in turn, increases $CO_2$ emissions. Gök (2020) also argue that financial development increases carbon emissions via the channels of industrialization and energy consumption, which generally increases industrial pollution and the level of greenhouse gas emissions. The positive effect of financial development on increasing $CO_2$ emissions is in line with Zhang (2011) who find that financial development appears to be an important driver of increasing per capita $CO_2$ emissions in China. In the same spirit, Gök (2020) conducts a meta-regression analysis on the relationship between financial development and carbon emissions. Its findings reveal that the effects of financial development on carbon emissions depend on the used indicator of financial development, on the employed estimation technique, on the included countries or region in the analysis. To reduce carbon emission, the author suggests to proliferating renewable energy use as a green trading policy.

**Table 2**
Summary statistics and correlations (1996-2016).

| 1 | CO | FDI | DCPS | PCFI | V&A | PS | GE | RQ | RL | CC | GDP | EC | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 16.68 | 0.44 | 36.74 | 52.21 | -1.71 | -0.30 | -0.10 | 0.01 | 0.08 | -0.07 | 19546.97 | 124.16 | 77.61 |
| Standard deviation | 2.43 | 0.09 | 9.75 | 6.94 | 0.15 | 0.26 | 0.19 | 0.13 | 0.09 | 0.15 | 1279.99 | 12.49 | 11.39 |
| Min | 10.49 | 0.23 | 20.79 | 45.35 | -1.90 | -0.65 | -0.37 | -0.30 | -0.15 | -0.30 | 16696.41 | 104.48 | 56.08 |
| Max | 20.40 | 0.55 | 58.11 | 68.36 | -1.32 | 0.22 | 0.26 | 0.16 | 0.33 | 0.23 | 21399.10 | 148.90 | 96.10 |
| CO | 1 | | | | | | | | | | | | |
| FDI | 0.812 | 1 | | | | | | | | | | | |
| DCPS | 0.673 | 0.802 | 1 | | | | | | | | | | |
| PCFI | -0.093 | 0.003 | 0.503 | 1 | | | | | | | | | |
| V&A | -0.562 | -0.554 | -0.510 | -0.008 | 1 | | | | | | | | |
| PS | -0.709 | -0.734 | -0.603 | 0.070 | 0.255 | 1 | | | | | | | |
| GE | 0.558 | 0.517 | 0.780 | 0.391 | -0.597 | -0.369 | 1 | | | | | | |
| RQ | 0.673 | 0.775 | 0.530 | -0.079 | -0.351 | -0.410 | 0.194 | 1 | | | | | |
| RL | 0.317 | 0.448 | 0.608 | 0.388 | -0.341 | -0.344 | 0.694 | 0.243 | 1 | | | | |
| CC | 0.403 | 0.321 | 0.611 | 0.472 | -0.398 | -0.070 | 0.647 | 0.338 | 0.505 | 1 | | | |
| GDP | 0.661 | 0.654 | 0.702 | 0.030 | -0.542 | -0.618 | 0.750 | 0.272 | 0.576 | 0.208 | 1 | | |
| EC | 0.690 | 0.568 | 0.372 | -0.151 | -0.685 | -0.344 | 0.373 | 0.643 | 0.240 | 0.426 | 0.248 | 1 | |
| T | 0.509 | 0.576 | 0.140 | -0.674 | -0.376 | -0.527 | 0.028 | 0.546 | -0.094 | -0.1257 | 0.263 | 0.551 | 1 |

**Table 3**
Results of unit root tests.

| Variables | ADF | | PP | |
|---|---|---|---|---|
| | Level | $1^{st}$ difference | Level | $1^{st}$ difference |
| lnCO | -2.281 | -4.370* | -2.417 | -6.001 * |
| FDI | -6.772* | -4.996 * | -2.098 | -5.251 * |
| lnDCPS | -3.079** | -8.195* | -3.047** | -8.180* |
| lnPCFI | -2.485 | -5.709* | -2.479 | -5.709* |
| V&A | -1.449 | -5.596* | -1.449 | -5.593* |
| PS | -1.783 | -7.039* | -1.783 | -7.035* |
| GE | -5.367* | -4.367* | -3.894* | -5.087* |
| RQ | -1.020 | -6.636* | -1.020 | -6.634* |
| RL | -2.993** | -7.891* | -3.029** | -8.176* |
| CC | -1.182 | -3.362** | -1.182 | -3.304** |
| lnGDP | -2.287 | -6.284* | -2.326 | -6.265* |
| lnEC | -1.689 | -5.837* | -1.632 | -5.893* |
| lnT | -0.016 | -5.817* | -0.344 | -12.761* |

Note: *and ** indicate significance at 1% and 5% levels, respectively.

**Table 4**

Reslts of Johansen's cointegration test.

| | Models | Model A: FDI | | Model B: DCPS | | Model C: PCFI | |
|---|---|---|---|---|---|---|---|
| | Number of cointegrating equations | Trace test | Max-Eigen statistic | Trace test | Max-Eigen statistic | Trace test | Max-Eigen statistic |
| V&A | None | 161.862* | 62.329* | 94.300* | 77.213* | 202.109* | 113.922* |
| | At most 1 | 100.462* | 42.037* | 66.501* | 46.215* | 88.922* | 72.502* |
| | At most 2 | 59.101* | 29.483* | 37.374* | 26.428** | 47.811* | 29.483* |
| | At most 3 | 29.279** | 16.169 | 18.228 | 14.781 | 23.057 | 20.094 |
| | At most 4 | 14.338 | 7.362 | 12.116 | 9.726 | 14.344 | 10.078 |
| | At most 5 | 5.220 | 5.220 | 0.478 | 0.478 | 8.171 | 8.171 |
| PS | None | 139.376* | 51.368* | 150.729* | 92.072* | 125.820* | 54.029* |
| | At most 1 | 89.814** | 25.027 | 103.443* | 51.760* | 72.190* | 32.366* |
| | At most 2 | 51.463** | 21.268 | 44.560* | 28.049** | 39.224* | 19.446 |
| | At most 3 | 27.299 | 16.342 | 26.093** | 17.222 | 20.115 | 15.613 |
| | At most 4 | 11.237 | 6.372 | 11.099 | 6.504 | 12.562 | 9.460 |
| | At most 5 | 5.003 | 5.003 | 2.116 | 2.116 | 7.359 | 7.359 |
| GE | None | 1260.272* | 614.853* | 352.991* | 172.094* | 284.347* | 91.220* |
| | At most 1 | 657.466* | 593.038* | 165.294* | 94.649* | 127.920* | 56.450* |
| | At most 2 | 159.503* | 71.814* | 97.448* | 50.150* | 88.631* | 31.376* |
| | At most 3 | 75.796* | 50.313* | 49.552* | 34.611* | 44.273* | 18.428 |
| | At most 4 | 26.594* | 17.715** | 22.008** | 19.982 | 19.904 | 11.726 |
| | At most 5 | 6.768 | 6.768 | 9.283 | 9.287 | 7.374 | 7.374 |
| RQ | None | 228.714* | 67.231* | 134.237* | 67.390* | 181.237* | 99.273* |
| | At most 1 | 170.683* | 61.194* | 50.338* | 39.462* | 70.338* | 46.682* |
| | At most 2 | 109.381* | 40.240* | 39.761* | 22.873** | 36.761* | 29.009** |
| | At most 3 | 66.148* | 34.870** | 18.093 | 11.323 | 20.093 | 16.827 |
| | At most 4 | 30.250** | 20.656 | 10.227 | 7.004 | 15.227 | 11.366 |
| | At most 5 | 8.328 | 8.328 | 3.239 | 3.234 | 9.730 | 9.730 |
| RL | None | 188.267* | 62.478* | 122.533* | 70.719* | 99.248 | 49.279 |
| | At most 1 | 96.337* | 48.236* | 54.269* | 40.704* | 50.289* | 33.548* |
| | At most 2 | 55.822* | 26.572** | 31.229* | 19.238 | 28.770** | 17.380 |
| | At most 3 | 30.660** | 18.365 | 17.088 | 12.929 | 21.384 | 13.349 |
| | At most 4 | 14.026 | 10.832 | 10.782 | 7.440 | 13.334 | 9.936 |
| | At most 5 | 6.103 | 6.103 | 4.233 | 4.233 | 7.649 | 7.649 |
| CC | None | 104.358* | 50.927* | 196.049* | 77.839* | 144.884* | 62.726* |
| | At most 1 | 42.467* | 25.703** | 87.924* | 51.325* | 67.228* | 39.193* |
| | At most 2 | 29.026* | 21.826 | 48.510* | 33.114* | 35.226* | 22.099 |
| | At most 3 | 18.379 | 14.056 | 30.882** | 24.922 | 29.627** | 16.551 |
| | At most 4 | 10.277 | 6.680 | 17.489 | 12.284 | 13.368 | 9.926 |
| | At most 5 | 4.336 | 4.336 | 9.297 | 9.297 | 6.672 | 96.672 |

Note: * and ** indicate the rejection of the null hypothesis at 1% and 5% level of significance, respectively.

Model A: *CO =f(FDI, Gov, GDP, EC, T)*

Model B: *CO =f(DCPS, Gov, GDP, EC, T)*

Model C: *CO =f(PCFI, Gov, GDP, EC, T).*

Second, regarding the conditional impact of governance quality, it is clear from most of the estimated models that, as expected, good governance reduces per capita $CO_2$ emissions, ranging from -0.076 to -0.202 percent for the models pertaining to financial development index, from -0.091 to -0.211 percent for the models pertaining to domestic credit to private sector (DCPS), and from -0.099 to -0.210 percent for the models pertaining to private credit by deposit money banks and other financial institutions (PCFI). Panayotou (1997: p.468) claims in this context that "whether environmental quality improvements (or reduced degradation) materialize or not, when and how depends critically on government policies, social institutions and the completeness and functioning of markets." North (1991) also argues that good governance reduces CO2 emissions through its encouragement for the sustainable use of natural resources. The negative impact of governance quality on carbon emissions confirms the results of previous works on this relationship, such as Omri and Belhadj (2020) who examine the impact of governance quality, innovation, and FDI on four indicators of environmental degradation and their findings show that good governance negatively influences these indicators for 23 emerging economies. The authors suggest that enhancing governance quality allows mitigating carbon emissions and improves environmental quality through providing solid rules and laws that help to fight corruption. Accompanied

Third, we emphasis on the central contribution of this research, i.e., demonstrating the complementarity relationship between good governance and financial development in enhancing environmental quality. Table 5 also shows that the impact of the interaction among the indicators of governance quality and the indicators of financial development are negative and significant in most of the estimated models, except models 3, 4, 9, 10, 15, and 16 pertaining to economics governance. The negative sign of the interaction between governance and financial development indicates that good governance boosts financial sector, which, in turn, reduces $CO_2$ emissions, meaning that good governance could be a part of the solution to reduce emissions with financial sector development. Specifically, political and institutional governance plays a policy variable that moderates the negative impact of financial development on environmental quality. These results are in line with Girma and Shortland (2008) and Huang (2010), among others, who show that good governance and institutions foster the development of the financial sector, which, in turn, reduces $CO_2$ emissions and improves environmental quality (Omri et al., 2019). These results suggest that the development of financial sector improves environmental quality if it is accompanied with good political and institutional governance, such as voice and accountability, political stability, the rule of law, and control of corruption. So, steps should be taken to establish good governance and to enhance the financial sector.

Finally, regarding the control variables, we find that per capita GPD, energy consumption, and trade have positive impacts on increasing carbon emissions in most of the estimated models. Per capita GDP has a positive and significant impact on carbon emissions in all the estimated models at 1 percent level, ranging from 0.180 to 0.429 percent. Energy consumption has also a positive contribution on increasing carbon emissions in all the estimated models at 1 percent level, ranging from 0.331 to 0.611 percent. Trade openness contributes also to increase carbon emissions in most of the estimated models, ranging from 0.092 to 0.273 percent. It is clear from these results that energy consumption has the highest contribution on increasing carbon emissions in the Saudi's economy.

**Table 5**
Results of long-run DOLS estimates.

| Independent variables | Dependent variable : $CO_2$ emissions | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FDI | | | | | | DCPS | | | | | | PCFI | | | | | |
| | Political governance | | Economic governance | | Institutional governance | | Political governance | | Economic governance | | Institutional governance | | Political governance | | Economic governance | | Institutional governance | |
| | Model 1 V&A | Model 2 PS | Model 3 GE | Model 4 RQ | Model 5 RL | Model 6 CC | Model 7 V&A | Model 8 PS | Model 9 GE | Model 10 RQ | Model 11 RL | Model 12 CC | Model 13 V&A | Model 14 PS | Model 15 GE | Model 16 RQ | Model 17 RL | Model 18 CC |
| FDI | 0.187** | 0.094 | 0.169** | 0.218* | -0.116 | 0.073*** | 0.262* | 0.193** | 0.187* | 0.281* | -0.161** | 0.155* | 0.227* | 0.329* | 0.189** | 0.202** | 0.167*** | 0.185** |
| DCPS | 0.203* | 0.180* | 0.106 | 0.261* | 0.169** | 0.191** | 0.308* | 0.099*** | 0.080 | 0.111 | 0.144*** | 0.203* | 0.197* | 0.112*** | 0.250* | 0.316* | 0.222* | 0.079*** |
| PCFI | 0.240** | 0.089*** | 0.272* | 0.121** | 0.230* | 0.244* | 0.112*** | 0.238* | 0.164 | 0.099** | 0.161* | 0.099*** | 0.180** | 0.277* | 0.092 | 0.136*** | 0.150** | 0.191* |
| V&A | -0.125* | - | - | - | - | - | -0.202* | - | - | - | - | - | -0.152*** | - | - | - | - | - |
| PS | - | -0.108** | - | - | - | - | - | -0.183* | - | - | - | - | - | -0.210** | - | - | - | - |
| GE | - | - | -0.035 | - | - | - | - | - | -0.091*** | - | - | - | - | - | -0.060 | - | - | - |
| RQ | - | - | - | -0.076** | - | - | - | - | - | -0.106** | - | - | - | - | - | -0.088 | - | - |
| RL | - | - | - | - | -0.202* | - | - | - | - | - | -0.191** | - | - | - | - | - | -0.099*** | - |
| CC | - | - | - | - | - | -0.195** | - | - | - | - | - | -0.211* | - | - | - | - | - | -0.129** |
| V&A * FDI | -0.078** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| PS * FDI | - | -0.093*** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| GE * FDI | - | - | 0.003 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| RQ * FDI | - | - | - | 0.038 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| RL * FDI | - | - | - | - | -0.102*** | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CC * FDI | - | - | - | - | - | -0.129** | - | - | - | - | - | - | - | - | - | - | - | - |
| V&A * DCPS | - | - | - | - | - | - | -0.086*** | - | - | - | - | - | - | - | - | - | - | - |
| PS * DCPS | - | - | - | - | - | - | - | -0.092** | - | - | - | - | - | - | - | - | - | - |
| GE * DCPS | - | - | - | - | - | - | - | - | -0.077 | - | - | - | - | - | - | - | - | - |
| RQ * DCPS | - | - | - | - | - | - | - | - | - | -0.023 | - | - | - | - | - | - | - | - |
| RL * DCPS | - | - | - | - | - | - | - | - | - | - | -0.169* | - | - | - | - | - | - | - |
| CC * DCPS | - | - | - | - | - | - | - | - | - | - | - | -0.140* | - | - | - | - | - | - |
| V&A * PCFI | - | - | - | - | - | - | - | - | - | - | - | - | -0.093** | - | - | - | - | - |
| PS * PCFI | - | - | - | - | - | - | - | - | - | - | - | - | - | -0.111* | - | - | - | - |
| GE * PCFI | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.017 | - | - | - |
| RQ * PCFI | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | -0.004 | - | - |
| RL * PCFI | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | -0.133** | - |
| CC * PCFI | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | -0.083*** |
| GDP | 0.369* | 0.404* | 0.299* | 0.306* | 0.429* | 0.396* | 0.180** | 0.199* | 0.277* | 0.290* | 0.355* | 0.295* | 0.312* | 0.378* | 0.209* | 0.251* | 0.188** | 0.205* |
| EC | 0.536* | 0.491* | 0.462* | 0.552* | 0.388* | 0.389* | 0.611* | 0.592* | 0.413* | 0.360* | 0.503* | 0.271* | 0.360* | 0.447* | 0.660* | 0.505* | 0.331* | 0.406* |
| T | 0.191** | 0.186* | 0.122 | 0.101 | 0.271* | 0.256* | 0.092*** | -0.118 | 0.134*** | -0.102 | 0.273* | 0.199** | 0.169*** | -0.177** | 0.196*** | 0.219** | 0.188* | 0.163** |
| Constant | 1.067 | -2.873* | 9.142* | 18.250* | 4.798* | 0.926 | 34.250* | -5.367* | -3.145** | -2.226*** | 14.267* | 21.035* | 5.562** | 12.278* | 10.002* | -8.344* | 16.221* | 9.266* |

**Note**: * and ** indicate the rejection of the null hypothesis at 1% and 5% level of significance, respectively.

## 4. Conclusion and policy implications

The main purpose of the current study is to examine the relationship between financial sector development and carbon emissions in the presence of good governance for Saudi Arabia during the period 1996-2016. Three indicators of financial development (financial development index, domestic credit to private sector, and private credit by deposit money banks and other financial institutions) and three categories of governance quality (political governance, economic governance, and institutional governance) are included in the analysis. Necessary econometric approaches, such as unit root test, Johansen's cointegration test, and the DOLS estimator to extract the long-run coefficients, are employed.

The empirical findings show that, as expected, (i) there is an unconditional impact of the three indicators of financial development on increasing $CO_2$ emissions in the most models; (ii) the conditional impact of the indicators of governance quality increases CO2 emissions in the most models; (iii) the interactions between the indicators of governance quality and the indicators of financial development are negative and statistically significant only in the models pertaining to political and institutional governance, meaning that the development of financial sector improves environmental quality if it is accompanied by good political and institutional governance, such as voice and accountability, political stability, the rule of law, and control of corruption.

Based on these results, an important contribution will be made to the pace of financial growth by improving the governance quality through the strengthening of the legal or institutional system, implementation of standards and empowerment of supervision agencies as well as the creation of an effective regulatory environment to promote financial inclusion. Regarding the environmental side, policymakers should improve their governance institutions and then enable them to work efficiently to improve environmental quality. The efficient operation of these institutions would allow for adequate legislation, rights of property and means of fighting corruption, that, if is controlled regularly, will decrease emissions and enhance environmental conditions. Moreover, continuing to improve governance would further reduce pollution, because good governance signifies increased political independence and access to information that reinforces citizens' wish to create a cleaner environment and sensitizes the public to environmental laws (Omri and Ben Mabrouk, 2020). Accordingly, public desire for improved environmental standards thus leads to the implementation of environmental legislation, reduction of environmental damage and the potential for damage to human health. Besides, ensuring environmental protection, for instance, by incorporating environmental concerns into development plans and implementing applicable environmental laws is recommended. Overall, environmental awareness and knowledge should cover all age groups and all professions such as justice systems, senators, executives and other citizens

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**Compliance with ethical standards**

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