How Does Institutional Quality Moderate the Influence of Financial Development on Environmental Pollution? Evidence From G20 Countries

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How does institutional quality moderate the influence of financial development on environmental pollution? Evidence from G20 countries

Abstract

Unlike previous studies that focused mainly on the relationship between financial development and CO2 emissions, the current study examined the moderating effect of institutional quality on the influence of financial development on environmental pollution in G20 countries over the period 2003-2015. The panel corrected standard errors (PCSE) is employed as an econometric technique. The findings are established as follows: First, the findings show that institutional quality appears to have a mixed (positive and negative) effect on environmental pollution. Second, the findings show that financial development has mixed (positive and negative) effect on environmental pollution. Third, the findings also show that the interaction between institutional quality and financial development has a negative and statistically significant on environmental pollution, meaning that institutional quality complements financial sector to reduce environmental pollution. Policy implications are discussed.

Keywords: Financial development, institutional quality, environmental pollution, G20 countries, PCSE

1. Introduction

Financial development has been identified as a significant cause of economic growth in both developed and developing countries (Acquah and Ibrahim 2020). In recent years, several studies have shown the positive contribution of financial development to economic growth (Alagidede et al. 2020). Moreover, Durusu-ciftci et al. (2016) argued that the positive effect of financial development can be observed on economic activity such as income inequality, foreign direct investment, trade, productivity and innovations and entrepreneurship. However, notwithstanding these positive effects, financial development is considered as a substantial contributor to the environmental pollution. As argued by Khoshnevis Yazdi and Ghorchi Beygi (2018), financial development can increase energy consumption and environmental pollution due to increase in the purchase of new industrial machines and equipments encouraged by lower financing costs and increased financing networks.

In recent years, the nexus between financial development and environmental pollution has received more attention among academic researchers, policymakers, and leaders

(Li et al. 2021; Odhiambo 2020). However, the findings of these studies remain mixed and inconclusive (Bui 2020). In the one hand, some studies conclude that financial development could contribute to exacerbating environmental pollution. Several channels have been identified through the positive influence of financial development on environmental pollution. Notable channels include: energy consumption and industrialization (Acheampong et al.2020). Recently, Odhiambo (2020) argued that household can easily have access to credit through financial development which can allow them to purchase motorcades and high-energy-demanding home appliances. Evidently, these motorcades and high-energy-demanding home appliances could increase energy consumption and CO₂ emissions, which in turn, could contribute to environmental pollution. Likewise, Odhiambo (2020) argued that providing financial assistance to domestic business might increase the number and size of manufacturing firms. A well-functioning of these manufacturing firms could increase energy consumption and CO₂ emissions which in turn could damage environmental quality.

In the other hand, other studies conclude that financial development contributes to reducing environmental pollution. As highlighted by Lv and Li (2021), in order to achieve the Sustainable Development Goals (SDGs), the United Nations have called for green finance initiative to combat climate change through providing financial support for low-carbon infrastructure and other solutions for climate change. According to Charfeddine and Kahia (2019), financial development can help to curb environmental pollution through enhancing technological advance in the energy sector. As argued by Zhao and Yang (2020), while financial development constitutes a key driver of foreign direct investment, foreign direct investment constitutes a primary source of technology transfer. Therefore, financial development can curb environmental pollution through foreign direct investment (Odhiambo 2020). In addition, Le et al (2020) indicate that affordable finance service and product can help to enhance the use of clean technology which will contribute to combat climate change. Recently, Odhiambo (2020) indicate that financial development can help to curb environmental pollution through investment in research and development (R&D) and innovation. As argued by Salahuddin et al. (2018), one of the channel of R&D is foreign direct investment.

The inconsistent of financial development on environment pollution call for further investigation especially by taking into consideration of the new factors that can

influence our economies. As argued by Acheampong et al. (2020), this inconsistency of financial development on environmental pollution can be ascribed to the estimation techniques, the period, the sample, and the variable. Analogous to this argument, the current study seeks to examine the moderating effect of institutional quality on the effect of financial development on environmental pollution. It is important to highlight that the finance-CO₂ emissions literature has failed to incorporate institutional quality during their analysis. During the transition of Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs), the United Nations has emphasized the role of good governance for the achievement of the Sustainable Development Goals (SDGs) by 2030 (Haldar and Sethi 2020). This call has followed by Paris Accord agreement which has received the contentment of 190 countries to fight against climate change. Recently, Le and Ozturk (2020) argued that institutional quality can promote environmental quality and economic growth through several ways, namely strong judicial system, providing effective mechanism for capital and information allocation and attracting foreign investment. Likewise, Asongu and Odhiambo (2019) indicated that a country with good governance can fight against environmental pollution through enforcing the rules and regulations for corporations. However, the literature on the influence of institutional quality on environmental pollution remains limited (Teng et al. 2021).

The motivation for choosing the G20 countries can be explained as follows: According to the United Nations-International Energy Agency (UN-IAE), the G20 countries produce almost 80% of CO₂ emissions.¹ Moreover, these countries are industrialized. Second, the G20 countries account for 64% of the world's population – 4.7 billion people. As argued by previous studies, the affluence is also able to drive environmental pollution. In addition, according to a report by International Monetary Fund, the G20 countries total GDP had reached nearly \$69 trillion in 2019. Also, according to the statistics prepared by International Monetary Fund, the G20 countries introduced trillions of dollars in fiscal stimulus packages worldwide, which saved or created millions of jobs that would otherwise have been destroyed. However, recent studies (Odhiambo 2020) argued that financial development can increase environmental pollution through poverty reduction.

¹ G20 nations, responsible for 80% global GHG emissions, need to ramp up their climate action targets, says a global report | India News - Times of India (indiatimes.com)

In this current study we seek to provide an answer two critical questions: First, does financial development increase or reduce environmental pollution in G20 countries? Second, does the level of institutional quality moderate the influence of financial development on environmental pollution? The outcome of the current study will be an important contribution for the achievement of the Sustainable Development Goals (SDGs). As highlighted by the United Nations, the quality of institutions remains an important role for the achievement of the Sustainable Development Goals (SDGs).

The contributions of this study are fourfold. First, this is the first study to examine the influence of financial development on environmental pollution in G20 countries. Second, unlike previous studies that exclusively focused on the influence of financial development on environmental pollution, the current study extended the inquiry by examining the moderating effect of institutional quality on the influence of financial development on environmental pollution in G20 countries. Third, our study differs from previous studies, since it uses various recently developed panel econometric techniques and applied them to both developed and developing countries. For example, we employ Pesaran (2004) cross-sectional dependence (CD) to examine the dependency among the variables. Moreover, based on the cross-sectional dependence outcomes, we employ Pesaran (2007) to examine the unit root properties among the variables. Lastly, unlike previous studies, the current study employs the panel corrected standard errors (PSCE) to examine the moderating effect of institutional quality on the influence of financial development on environmental pollution in G20 countries. It is important to note that the PCSE has been used in the recent environmental pollution literature. For example, Avom et al. (2020) used the panel corrected standard errors (PSCE) to examine the influence of information and communication technology on environmental quality. Unfortunately, there is no study that uses the panel corrected standard errors (PSCE) to examine these relationships.

The rest of this study is organised as follows. Section2 provides the relevant literature. Section 3 provides the model specification, data, and methodology. Section 4 focuses on the main results and discussion. Section 5 provides conclusion and policy implications.

2. Literature review

2.1.Environmental Kuznets Curve: an overview

Following the empirical work by Kuznets (1955), Grossman and Krueger (1991) have established an Inverted U-shaped relationship between environmental pollution and economic growth. Further, it has been used in several environmental studies (T. Le and Nguyen 2020). However, the findings of previous studies remain mixed and inconclusive (Ibrahim and Law 2016). For example, Le and Nguyen (2020) used the panel corrected standard errors (PSCE) to examine the influence of economic growth on environmental pollution for 95 countries and found the existence of the environmental Kuznets curve (EKC). Similarly, for 47 Emerging Markets and Developing Economies (EMDEs), Le and Ozturk (2020) used various estimations techniques, namely CCEMG, AMG, and DCCE to examine the effect of economic growth on CO₂ emissions. They confirmed the presence of the environmental Kuznets curve (EKC). In the same context, using 28 oil-producing countries, Elsalih et al. (2020) used two-step dynamic SYS-GMM estimator to investigate the influence of economic development on environmental degradation. Also, Godil et al. (2020) used a quantile autoregressive distributive lag technique (QARDL) to examine the relationship between economic growth and environmental pollution in Pakistan. The authors unveiled the presence of the environmental Kuznets curve (EKC). Similar results are found by Haldar and Sethi (2020) who examine the influence of economic growth on environmental pollution in 39 developing countries. In another study, for South Africa case, Sarkodie and Adams (2018) confirmed the presence of the environmental Kuznets curve (EKC). For 97 countries, Lv and Li (2021) used the spatial econometric model to investigate the influence of economic development on environmental pollution and found that there is a presence of the environmental Kuznets curve (EKC). Based on the case of Nigeria, Egbetokun et al. (2020) examined the influence of economic growth on CO₂ emissions and found the presence of the environmental Kuznets curve (EKC).

Unlike the abovementioned studies, other studies found no existence of the environmental Kuznets curve (EKC). For example Adams et al. (2020), for 19 Sub-Saharan African countries examined the influence of economic growth on environmental pollution. They found that the EKC is not valid. Similarly, Acheampong et al. (2020) examined the influence of economic growth on environmental pollution in 83 countries and found that there is no presence of the environmental Kuznets curve (EKC). As argued by the authors, the inconsistency

result of the environmental Kuznets curve (EKC) can be ascribed to the estimation techniques.

2.2.Financial development and environmental pollution

A vast literature has investigated the influence of financial development on environmental pollution (Aluko and Obalade 2020). However, the findings of these studies remain mixed and inconclusive (Odhiambo 2020). In the one hand, some studies found that financial development contributes to exacerbating environmental pollution. For example, Le and Ozturk (2020) used The domestic credit to the private sector to proxy financial development to examine the influence of financial development on environmental pollution in 47 developing countries. Using a various estimation technique, they unveiled that financial development contributes to exacerbating environmental pollution. In the same vein, Charfeddine and Kahia (2019) examined the relationship between financial development and environmental pollution in MENA over the period 1980-2014. The empirical evidence shows that financial development contributes to increasing CO₂ emissions. Also, Lv and Li (2021) examined the influence of financial development on environmental pollution in 97 countries and found that financial development could contribute to exacerbating CO₂ emissions. Similar results are found by Le et al. (2020) who examined the influence of financial inclusion on CO₂ emissions in 31 Asian countries over the period 2004–2014. In another study, Pata (2018) explored the linkage between financial development and environmental degradation in Turkey for 1974 to 2014. Using several econometric techniques, namely ARDL, FMOLS and CCR, the author shows that financial development contributes to environmental degradation. Also, similar results are revealed by Tamazian et al. (2010) who examined the influence of finance development on environmental pollution.

In the other hand, other studies conclude that financial development can help to reduce environmental pollution. For example, using real domestic credit to private sector per capita as a proxy of financial development, Shahbaz et al. (2013) used cointegration approach to examine the influence of financial development on environmental pollution in Malaysia over the period 1971–2011. They found that financial development can help to reduce CO₂ emissions through foreign direct investment and research and development. In the same vein, using the case of China,

known as the most polluter country, Zhao and Yang (2020) examined the influence of financial development on environmental pollution. Based on five financial development indicators, namely the ratio of total credit to provincial GDP, the ratio of credit to deposit, the ratio of FDI to provincial GDP, the ratio of stock market capitalization to provincial GDP, the ratio of stock traded value to provincial GDP, Zhao and Yang (2020) used the principal component analysis to build financial development index. They found that financial development can reduce CO₂ emissions by 4%. Similarly, the nexus between financial development, income inequality and CO₂ emissions in 39 Sub-Saharan African countries over the period 2004-2014 has been assessed by (Odhiambo 2020). Using the generalized method of moments (GMM), he revealed that financial development can help to combat climate change. The linkage among financial development and environmental degradation has been assessed by Shahbaz et al. (2013), who used ARDL bounds testing approach to explore this relationship. They found similar results with (Odhiambo 2020). Similar results are found by Salahuddin et al. (2018) who used DOLS techniques to examine the nexus between financial development and CO₂ emissions in Kuwait.

2.3. Institutional quality and environmental pollution

Recently, Teng et al. (2021) argued that the influence of institutional quality on environmental pollution has less attention among researchers, policymakers and leaders. Recent exceptions are (Danish and Ulucak 2020; Nair et al. 2021; Salman et al. 2019; Sarkodie and Adams 2018). For example, Sarkodie and Adams (2018) used several estimation techniques, namely CUSUM test, OLS, and ARDL approach to examine the effect of institutional quality on CO₂ emissions in South Africa over the period 1971-2017. They revealed that institutional quality can help to reduce CO₂ emissions. Similarly, from 18 Asia-Pacific countries, Danish and Ulucak (2020) used FMOLS, DOLS, and DK regression techniques to examine the relationship between institutional quality and environmental pollution. They unveiled that institutional quality can promote environmental quality.

The literature review exposed the fact that the findings of the influence of financial development on environmental pollution remains mixed and inconclusive. As argued by Odhiambo (2020), this inconsistency can be attributed to the estimations techniques, the region, or period. Moreover, most previous studies have failed to

incorporate the role of institutional quality. Additionally, Danish and Ulucak (2020) documented that the role of institutional quality remains an important for environmental quality. Therefore, the lack of empirical evidence on the moderating effect of institutional quality on the influence on financial development on environmental pollution encourages us to fill this gap for G20 nations.

3. Model specification, data, and methodology

3.1 Model specification

To unearth the influence of financial development on environmental pollution, we followed Le et al. (2020) who examined the relationship between financial development and CO2 emissions based on the “Stochastic Impacts by Regression on Population, Affluence and Technology” (“STIRPAT”) model developed by (Rosa, and Dietz 2003). Thus, the (“STIRPAT”) model can be written as follows:

$$I_{it} = \alpha_i P_{it}^{\beta_1} A_{it}^{\beta_2} T_{it}^{\beta_3} \varepsilon_{it} \quad (1)$$

Where: I denotes the environmental effects issued from human activities which is the function of population (P), affluence (A), and technology (T) for country i at time t . α represents the country specific effect. β_1 , β_2 , and β_3 are the elasticities of environmental effects (proxied by CO2 emissions) with respect to P , A and T , respectively. Furthermore, we converted the Eq. 1 into logarithmic form. Hence, Eq.2 can be written as follows:

$$\ln I_{it} = \alpha_{it} + \beta_1 \ln P_{it} + \beta_2 \ln A_{it} + \beta_3 \ln T_{it} + \varepsilon_{it} \quad (2)$$

Beside our interest variables, namely financial development (FD) and institutional quality (INST), the current study uses a number of additional control variable that seems to have a significant effect on environmental pollution. For example, previous studies pointed out trade openness, industrialization, FDI as a major determinants of environmental pollution (Appiah-otoo and Acheampong 2021; Paramati, Alam, and Chen 2017). Therefore, the Eq.3 can be written as follows:

$$\ln CO2_{it} = \beta_0 + \beta_1 \ln FD_{it} + \beta_2 \ln INST_{it} + \beta_3 \ln GDPpc_{it} + \beta_4 \ln Pop_{it} + \beta_5 \ln energy_{it} + \beta_6 \ln industry_{it} + \beta_7 \ln Top_{it} + \beta_8 \ln FDI_{it} + \varepsilon_{it}$$

(3)

Where: environmental pollution is proxied by CO2 emissions, the explanatory variable, FD, INST, GDPpc, Pop, energy, industry, Top, and FDI denotes financial development, institutional quality, gross domestic product per capita, energy consumption, and foreign direct investment inflows, respectively.

In accordance with previous studies (Acheampong et al. 2020; Adams et al. 2020; Opoku, Adams, and Aluko 2021) that tested the environmental Kuznets curve hypothesis, we incorporated the square of gross domestic product per capita in the equation 3. Thus, the Eq.3 can be extended as follows:

$$\ln CO2_{it} = \beta_0 + \beta_1 \ln FD_{it} + \beta_2 \ln INST_{it} + \beta_3 \ln GDPpc_{it} + \beta_4 \ln GDPpc_{it}^2 + \beta_5 \ln Pop_{it} + \beta_6 \ln energy_{it} + \beta_7 \ln industry_{it} + \beta_8 Top_{it} + \beta_9 FDI_{it} + \varepsilon_{it}$$

(4)

Finally, we examined the moderating effect of institutional quality on the influence of financial development on environmental pollution by incorporating the interaction effect of financial development and institutional quality in equation 4. Therefore, our final equation can be written as follows:

$$\ln CO2_{it} = \beta_0 + \beta_1 \ln FD_{it} + \beta_2 \ln INST_{it} + \beta_3 FD_{it} * INST_{it} + \beta_4 \ln GDPpc_{it} + \beta_5 \ln GDPpc_{it}^2 + \beta_6 \ln Pop_{it} + \beta_7 \ln energy_{it} + \beta_8 \ln industry_{it} + \beta_9 Top_{it} + \beta_{10} FDI_{it} + \varepsilon_{it}$$

(5)

3.2. Variable definition

Following previous studies (Acheampong et al. 2020; Le et al. 2020), we use CO2 emissions per capita which is measured in metric tons to proxy environmental pollution (CO2). In accordance with Phuc Canh and Trung Thong (2020), most of the previous studies have used credit supply as financial development measures. However, the findings of these studies remain mixed and inclusive. Therefore, following Phuc Canh and Trung Thong (2020), we use nine financial indicators, namely financial development Index (FI), Financial Institutions Index (FI), Financial Markets Index (FM), Financial Institutions Depth index (FID), Financial Institutions Access index (FIA), Financial Institutions Efficiency index (FIE), Financial Markets Depth index (FMD), Financial Markets Access index (FMA), and Financial Markets Efficiency

index (FME) to proxy financial development. Through globalisation, Phuc Nguyen et al. (2020) and Le and Nguyen (2020) documented that trade and foreign direct investment play a significant role on environmental pollution. Therefore, we use trade openness (%GDP) and foreign direct investment inflows (%GDP) to proxy trade liberalization (Top) and foreign direct investment (FDI). In addition, Le et al. (2020) argued that energy efficiency and economic development appear to have a significant role on environmental pollution. Therefore, we use energy use (kg of oil equivalent per capita) and gross domestic per capita to proxy energy and the level of economic development. Moreover, we use the ratio of industrial valued added to GDP as a proxy of the level of industrialization. Additionally, we use total of population to see the effect of human activity on environmental pollution. Following Adedoyin et al. (2021), six governance indicators, namely governance effectiveness, regulatory quality, control of corruption, political stability, voice accountability, and rule of law has been used in this study. However, to avoid multicollinearity problem, we use principal component analysis to construct institutional quality index (INST) (Table 1).

3.3. Data

The current study uses G20 countries² as a case study over the period 2003-2015. Due to the available data. The required data on Institutional quality was sourced from the World Governance Indicators of the World Bank, while the data on trade openness, foreign direct investment inflows, total of population, energy use, CO2 emissions (kt), the ratio of industry value added to GDP, and gross domestic product per capita were collected from the World Development Indicators (WDIs) of the World Bank. The financial development was obtained from the International Monetary Fund. While the data on governance effectiveness, regulatory quality, control of corruption, political stability, voice accountability, and rule of law are collected from the World Governance Indicators (WGIs) of the World Bank.

Table 1. Principal component analysis for institutional quality index (INST).

Component	PCA1	PCA2	PCA3	PCA4	PCA5	PCA6
Eigenvalue	5.217	0.370	0.269	0.075	0.040	0.026

² These countries are: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, South Korea, Spain, Mexico, Russia, Saudi Arabia, South Africa, Turkey, United Kingdom, United States.

Proportion	0.869	0.061	0.044	0.012	0.006	0.004
Cumulative	0.869	0.931	0.976	0.988	0.995	1.000
Variable	Vector1	Vector2	Vector3	Vector4	Vector5	Vector6
CC	0.427	-0.187	-0.128	-0.352	-0.251	-0.760
GE	0.424	-0.199	-0.215	-0.312	0.767	0.215
PS	0.384	0.004	0.921	0.000	0.033	0.048
RQ	0.420	-0.196	-0.171	0.861	0.048	-0.101
RL	0.426	-0.20	-0.187	-0.187	-0.586	0.602
VA	0.361	0.919	-0.154	0.002	-0.003	0.001

Note: CC: control of corruption; GE: governance effectiveness; PS: political stability; RQ: regulatory quality; RL: rule of law; VA: voice accountability; PCA: principal component analysis.

3.4. Methodology

Consistent with previous studies, the estimation techniques start with panel unit root test to check the order of integration and the stationary property of the series to avoid spurious regressions. We first recruit Pesaran (2004) cross-sectional dependence (CD) to check the dependency among the variables. The estimation results revealed the existence of CD among the variables (see, Table 2). Moreover, we use Pesaran (2007) to examine the stationary property which help us to avoid spurious regressions. The estimation results unveiled that all variables are stationary at first difference (see Table 3). Recently, Nguyen et al. (2020) argued that the presence of cross-sectional dependence requires strong estimation techniques such as the panel corrected standard errors (PCSE). As documented by Le and Nguyen (2020), the use of traditional econometric may produce a spurious outcomes. To get more details about the panel corrected standard errors (PCSE), please refer to (Jönsson 2005). It is important to note that the use of the panel corrected standard errors (PCSE) in environmental literature remains sparse. Recent exception is Avom et al. (2020) who used the panel corrected standard errors (PCSE) to examine the influence of information and communication technology on environmental quality in Sub-Saharan Africa. A robust, ordinary least square (OLS), pool ordinary least square (POLS), and feasible generalized least square are also used in the current study to examine the mechanism of the impact.

363 Table 2. Pesaran (2004) cross-sectional dependence test.

Variable	Statistic	p-value
lnCO2	14.512***	0.00
lnFD	22.014***	0.00
lnFI	23.105***	0.00
lnFM	15.444***	0.00
lnFID	21.496***	0.00
lnFIA	9.833***	0.00
lnFIE	13.166***	0.00
lnFMD	7.479***	0.00
lnFMA	5.601***	0.00
lnFME	8.222***	0.00
ln INST	2.666***	0.00
lnPop	7.496***	0.00
lninergy	17.345***	0.00
lnindustry	15.531***	0.00
lnGDPpc	13.128***	0.00
lnFDI	7.404***	0.00
lnTop	12.044***	0.00

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365 Table 3. Pesaran's cross-sectional augmented Dickey–Fuller.

Variables	Intercept	Intercept and trend
	t bar	t bar
Level		
lnCO2	-5.117***	-0.762
lnFD	-8.355***	-1.304**
lnFI	-5.868**	-2.355***
lnFM	-8.378***	-1.293**
lnFID	-3.772***	2.625
lnFIA	-9.084***	-1.47**
lnFIE	-1.880***	4.226
lnFMD	-3.385***	-8.439***

lnFMA	-1.723**	-7.805***
lnFME	-9.395***	-6.720***
ln INST	-7.356***	-9.502***
lnPop	-1.527***	-4.417***
lnenergy	-4.316***	-4.676***
lnindustry	-0.765	-5.199***
lnGDPpc	3.264	-8.591***
lnFDI	-5.751***	-9.267***
lnTop	0.143	-6.777***
First difference		
lnCO2	-12.206***	-10.046***
lnFD	-12.166***	-9.459***
lnFI	-13.053***	-12.585***
lnFM	-11.661***	-7.473***
lnFID	-12.353***	-10.072***
lnFIA	-9.451***	-6.758***
lnFIE	-13.370***	-12.238***
lnFMD	-13.065***	-10.157***
lnFMA	-11.946***	-7.509***
lnFME	-11.546***	-6.662***
ln INST	-13.831***	-13.982***
lnPop	-6.434***	1.180***
lnenergy	-12.943***	-11.100***
lnindustry	-11.791***	-9.108***
lnGDPpc	-8.291***	-4.210***
lnFDI	-12.838***	-10.468***
lnTop	-12.148***	-9.775***

*** indicate significant levels at 5%.

4. Main findings and discussions

The result of the panel corrected standard errors (PCSE) by Jönsson (2005) between financial development, institutional quality and environment pollution (baseline) are

reported in Table 4. The study suggests that gross domestic per capita and its square term have respectively a positive and negative and statistically significant effect on environmental pollution. This implies that economic growth increases as well as environmental pollution until the threshold (maximum point) and then contributes to environmental quality. Similar results have been found by Le and Nguyen (2020) who examined the relationship between economic growth and CO₂ emissions in 95 countries over the period 1998–2014. It should be noted that their study has been examined based on STIRPAT model combined with the EKC. Likewise, our result is consistent with the findings of Le et al. (2020) who examined the influence financial inclusion on environmental pollution under environmental Kuznets curve (EKC) for 31 Asian countries over the period 2004–2014. However, our result contradicts the findings of Acheampong et al. (2020) and Adams et al. (2020) who examined the influence of economic development on environmental pollution in 83 countries and 19 Sub-Saharan African countries, respectively.

The coefficient depicting trade openness, proxied by the ratio of trade to gross domestic product, was positive and statistically significant at 1% level in all models. This implies that as the level of trade increases, the level of environmental pollution also increases. Results in the current study can be inferred from the investigation conducted by Appiah-otoo and Acheampong (2021) which examined the influence of trade liberalization on environmental pollution in BRICS countries and held that trade openness can observe a positive effect on environmental pollution. This is contrary to findings in extant literature that trade openness could contribute to reducing environmental pollution (Lv and Xu 2019). Similarly, our finding is in line with Ren et al. (2014) who note that trade openness could contribute to environmental quality through several ways such as scale effect, structure effect and technology effect.

The coefficient of population was positive and statistically significant at 1%, implying that as the level of population increases, the level of environmental pollution also increases. As argued by Appiah-otoo and Acheampong (2021), the rapid growth in terms of population seems to increase energy consumption which in turns contribute to increasing CO₂ emissions in G20 countries. Our finding is consistent with Bai et al. (2019), Zhu et al. (2017) for China, Acheampong et al. (2019) for 46 Sub-Saharan African countries, Adams et al. (2020) for 19 African countries, and Appiah-otoo and Acheampong (2021) for BRICS countries.

The estimated coefficient of the ratio of export and import to gross domestic product (trade openness) has a positive and statistically significant effect on environmental pollution. This means that trade liberalization contributes to increasing CO₂ emissions in G20 nations. This corroborates the findings of previous studies (Aluko and Obalade 2020; Appiah-otoo and Acheampong 2021) that conclude that trade could contribute to increasing CO₂ emissions, but contradicts other studies Lv and Xu (2019) that support the view that trade could contribute to reducing environmental pollution through several channels such as technology transfer and foreign direct investment.

The result further suggests that energy consumption appears to have a positive and statistically effect on environmental pollution. Our result is similar with Appiah-otoo and Acheampong (2021) who found energy consumption as a major determinant of CO₂ emissions in BRICS countries.

Industry representing the ratio of industrial valued added to GDP, has a positive and statistically significant effect on environmental pollution. This implies that industrialization contributes to increasing the volume of CO₂ emissions in G20 countries. Our finding is in line with Le and Nguyen (2020) who documented that industrialization seems to increases CO₂ emissions in 95 countries.

Foreign direct investment representing the ratio of foreign direct investment inflows to gross domestic product, has a negative and statistically significant effect on environmental pollution. This means that foreign direct investment can help to reduce CO₂ emissions through research and development, technology transfer, and know-how. This finding is consistent with Acheampong et al. (2019) who conclude that foreign direct investment contributes to carbon emission mitigation.

Table 4. Financial development, Institutional quality, and Environmental pollution

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
lnGDPpc	0.101** (0.049)	0.154*** (0.051)	0.0949 (0.049)	0.154*** (0.058)	0.0130 (0.045)	0.0925* (0.055)	0.0961* (0.049)	0.142*** (0.052)	0.120 (0.05)
lnGDPpc ²	-0.0105*** (0.003)	-0.0142*** (0.003)	-0.0100** (0.003)	-0.0141*** (0.004)	-0.00381 (0.003)	-0.00961** (0.003)	-0.0102*** (0.003)	-0.0132*** (0.003)	-0.0117 (0.00)
lnINST	0.00603* (0.003)	0.00830* (0.004)	-0.000131 (0.004)	0.00122 (0.002)	-0.00354 (0.002)	-0.0115* (0.006)	0.00278 (0.003)	-0.00239 (0.002)	-0.001 (0.00)
lnTop	0.124*** (0.032)	0.117*** (0.026)	0.125*** (0.010)	0.118*** (0.028)	0.0987*** (0.024)	0.113*** (0.033)	0.137*** (0.011)	0.116*** (0.020)	0.124 (0.00)
lninergy	1.120***	1.119***	1.109***	1.106***	1.109***	1.102***	1.117***	1.102***	1.100

	(0.022)	(0.021)	(0.021)	(0.022)	(0.020)	(0.021)	(0.021)	(0.021)	(0.021)
lnPop	1.026***	1.019***	1.023***	1.014***	1.006***	1.010***	1.030***	1.011***	1.017***
	(0.014)	(0.017)	(0.014)	(0.013)	(0.016)	(0.014)	(0.013)	(0.013)	(0.013)
lnindustry	0.175***	0.166***	0.198***	0.203***	0.115***	0.205***	0.190***	0.208***	0.208***
	(0.004)	(0.003)	(0.004)	(0.006)	(0.004)	(0.003)	(0.005)	(0.004)	(0.004)
lnFDI	-0.0222	-0.0321*	-0.0205**	-0.0204*	-0.0225*	-0.0215**	-0.0221**	-0.0306**	-0.015**
	(0.006)	(0.003)	(0.005)	(0.005)	(0.006)	(0.007)	(0.005)	(0.006)	(0.006)
lnFD	-0.116***								
	(0.024)								
lnFI		-0.0915***							
		(0.022)							
lnFM			-0.0606**						
			(0.004)						
lnFID				-0.0124					
				(0.023)					
lnFIA					-				
					0.0955***				
					(0.032)				
lnFIE						0.0654**			
						(0.021)			
lnFMD							-0.0525***		
							(0.024)		
lnFMA								-0.00648	
								(0.021)	
lnFME									-0.011**
									(0.021)
_cons	-15.46***	-15.42***	-15.36***	-15.32***	-14.52***	-14.99***	-15.58***	-15.20***	-15.25***
	(0.256)	(0.298)	(0.271)	(0.244)	(0.274)	(0.289)	(0.254)	(0.307)	(0.261)
Observation	250	250	250	250	250	250	250	250	250
R-squared	0.959	0.959	0.959	0.959	0.960	0.959	0.959	0.959	0.959
No. of countries	20	20	20	20	20	20	20	20	20

Note: The results are estimated based on the PCSE model. Standard errors are in brackets. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Table 5. Financial development, Institutional quality, and Environmental pollution

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
lnGDPpc	-0.0282	0.0169	0.0308	0.106*	-0.310***	0.0191	0.0589	0.246***	-0.031**
	(0.052)	(0.055)	(0.065)	(0.058)	(0.056)	(0.063)	(0.057)	(0.060)	(0.060)
lnGDPpc ²	-0.00273	-0.00643	-0.00624	-0.0123***	0.0180***	-0.00526	-0.00845**	-0.0189***	-0.0064**
	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
lnINST	-0.0501***	-0.0533***	-0.0404***	-0.0524***	-	-0.0691***	-0.0364***	0.0664***	-0.021**
					0.0521***				
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.010)	(0.004)	(0.014)	(0.006)
lnTop	0.102***	0.124***	0.0932***	0.142***	0.0687**	0.156***	0.104***	0.126***	0.104***
	(0.040)	(0.061)	(0.024)	(0.018)	(0.072)	(0.054)	(0.010)	(0.017)	(0.017)
lnenergy	1.141***	1.173***	1.113***	1.188***	1.101***	1.111***	1.150***	1.142***	1.081***
	(0.015)	(0.019)	(0.012)	(0.006)	(0.020)	(0.018)	(0.006)	(0.025)	(0.015)
lnPop	1.049***	1.053***	1.033***	1.042***	1.053***	0.998***	1.042***	0.951***	1.034***
	(0.026)	(0.025)	(0.027)	(0.022)	(0.012)	(0.030)	(0.026)	(0.028)	(0.026)

lnindustry	0.188*** (0.019)	0.151*** (0.025)	0.209*** (0.015)	0.149*** (0.023)	0.110*** (0.028)	0.184*** (0.020)	0.161*** (0.018)	0.00210 (0.020)	0.19
lnFDI	-0.0145 (0.005)	-0.0214* (0.005)	-0.0105 (0.005)	-0.0146* (0.004)	-0.0202 (0.016)	-0.0170 (0.006)	-0.0121 (0.004)	-0.0282** (0.011)	-0.01
lnFD	-0.322*** (0.031)								
lnFD*lnI NST	-0.145*** (0.009)								
lnFI		-0.426*** (0.033)							
lnFI*lnIN ST		-0.176*** (0.011)							
lnFM			-0.153*** (0.029)						
lnFM*lnI NST			-0.0907*** (0.009)						
lnFID				-0.145*** (0.027)					
lnFID*lnI NST				-0.0777*** (0.008)					
lnFIA					-0.404*** (0.006)				
lnFIA*lnI NST					-0.126*** (0.039)				
lnFIE						-0.0589 (0.030)			
lnFIE*IN ST						-0.106*** (0.011)			
lnFMD							-0.137*** (0.030)		
lnFMD*ln INST							-0.0695*** (0.009)		
lnFMA								-0.0116 (0.047)	
lnFMA*ln INST								0.133*** (0.011)	
lnFME									-0.15
lnFME*ln INST									(0.0
_cons	-15.52*** (0.319)	-15.90*** (0.385)	-15.22*** (0.290)	-16.11*** (0.384)	-14.21*** (0.275)	-14.66*** (0.427)	-15.64*** (0.298)	-14.28*** (0.294)	-14.9
Observati on	242	242	242	242	242	242	242	242	24
R-squared	0.965	0.967	0.963	0.965	0.968	0.962	0.965	0.966	0.9

Note: The results are estimated based on the PCSE model. Standard errors are in brackets. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

For the variable of interest, institutional quality, a proxy for principal component analysis of six governance indicators, namely political stability, governance effectiveness, rule of law, voice accountability, control of corruption, regulatory quality has mixed signs, indicating that the level of institutional quality in this bloc countries is not similar and its effects on environmental pollution also is not similar. As an example, developed countries, namely the United States of America, Australia, the United Kingdom, and other seem to have a better institution. While, developing countries such as South Africa, Mexico, Brazil and other still are struggling to provide a better institution. It is important to note that the findings of previous studies on the influence of institutional quality on environmental pollution still remain mixed and inconclusive. For example, Teng et al. (2021) used a sample of 10 countries to examined the influence of institutional quality on environmental pollution. Using a pooled mean group (PMG) estimator, the findings revealed that institutional quality seems to increase environmental degradation. Conversely, Sarkodie and Adams (2018) used a various econometric techniques, namely ordinary least square (OLS) and autoregressive distributed lag (ARDL) to examine the influence of institutional quality on environmental pollution in South Africa over the period 1971-2017. They unveiled that institutional quality could contributes to environmental quality. According to Danish and Ulucak (2020), this disagreement among previous studies can be attributed to their estimation techniques, sample, variable, period.

The first contribution of this article refers to our results suggesting that different finance sector can differently affect environmental pollution. Indeed, our article is one of the first empirical study showing that finance can have diversified effects on environmental pollution as our estimation results.

The estimation coefficient of financial development in terms of financial development Index (FI), Financial Institutions Index (FI), Financial Markets Index (FM), Financial Institutions Access index (FIA), Financial Markets Depth index (FMD), Financial Markets Access index (FMA), and Financial Markets Efficiency index (FME) appear to have a negative and statistically significant effect on environmental pollution. Moreover, the findings suggest that Financial Institutions Depth index (FID) has no effect on environmental pollution. While Financial Institutions Efficiency index (FIE)

has a positive and statistically significant on environmental pollution. This results can be explained as follows: as our sample contains both developed and developing countries, financial development is developed in developed countries while it is underdeveloped in developing countries. It should be noted that the findings of previous studies still remain mixed and inconclusive. For example, considering 39 Sub-Saharan African countries, Odhiambo (2020) used the system generalized method of moments to examine the influence of financial development on environmental pollution and found that financial development contributes to reducing environmental pollution. contrary, the linkage between financial development and environmental in 97 countries has been assessed by Lv and Li (2021) who found that financial development could contribute to exacerbating CO2 emissions. As outlined above, the lack of consensus among existing empirical studies can be ascribed to their model specifications, data sources, sample periods, and constructed variables.

According to the main purpose of this study, we, further, examine the moderating effect of institutional quality on the influence of financial development on environmental pollution (Table 5). From the results, the interaction between financial development and institutional quality has a negative and statistically significant effect on environmental on pollution. This implies that good institution is expected to exert a pressure on financial sector to finance in green energy and technology which can help to reduce environmental pollution.

Finally, we performed a sensitivity analysis. First, we use another method, namely pool ordinary least square (OLS), robust pool ordinary least square (OLS) and feasible generalized least squares (FGLS) to check the robustness. The findings are very similar to the ones reported earlier. For brevity, these results are not reported but are available on request.

5. Conclusions

The current study examines the moderating effect of institutional quality on the influence of financial development on environmental pollution in G20 countries over the period 2003-2015. The panel corrected standard errors is used to examines these relationships. The results show that financial development and institutional quality have mixed signs, while the interaction between financial development and institutional quality has a negative and statistically significant effect environmental pollution. In addition, the findings also show that energy consumption, trade openness, industrialization, and population appear to have a positive and statistically significant

on environmental pollution. However, the findings show that foreign direct investment seems to have a negative and statistically significant effect on environmental pollution.

5.1 Theoretical contribution

In recent years, a vast literature has investigated the relationship between financial development and environmental pollution in both development and developing countries (Odhiambo 2020). Unfortunately, the findings of these studies remains mixed and inconclusive. For example, focusing on 39 Sub-Saharan African countries (developing countries), Odhiambo (2020) examined the influence of financial development on environmental pollution and found that financial development could contribute to reducing environmental pollution. While Lv and Li (2021) examined the relationship between financial development and environmental pollution in 97 countries (developed and developing countries) and found that financial development seems to exacerbate environmental pollution.

Those mixed results call for further investigation especially by taking into consideration of the new factors that can influence our economies. Therefore, the study has extended the literature by examining the moderating effect of institutional quality on the influence of financial development on environmental pollution. The findings suggest that institutional quality complements financial development to reduce environmental pollution.

5.2. Practical contribution

The findings of this study identify important policy implications. Given that institutional quality complement financial development to reduce environmental pollution. Therefore, omitting institutional quality from carbon emissions model can lead to the underestimation of actual environmental pollution and can provide policies and strategies for reducing environmental pollution in G20 countries to be off track. In September 2015, during the transition of Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs), the United Nations have emphasized the important role of good governance on the achievement of 17 goals by 2030. Following this line, the policymakers and governments should strengthen their institutions which will exert a pressure on financial sector to provide a minimum

green finance for research and development on technology. As argued by Afrifa et al. (2020), good governance can promote innovation (technology) which can help to fight against climate change.

Author's contributions DTAM and ENK conceived the idea and wrote all the sections of the manuscript. Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Availability of data and materials The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Ethics approval and consent to participate Not applicable.

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