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Financial System Development and Environmental Quality: A System-GMM Dynamic Panel Analysis

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The connection between financial development and carbon emissions is intricate, considering both theoretical frameworks and empirical evidence. Consequently, this study seeks to reassess the relationship between these variables in Gulf Cooperation Council (GCC) countries from 2010 to 2020, employing a dynamic GMM approach. Findings affirm the presence of a nonlinear relationship between financial development and environmental pollution. They specifically indicate that banking industry and financial markets have a twofold influence on environmental quality, encompassing both detrimental and beneficial outcomes. Results indicate that a more developed financial system decreases pollution emissions in GCC countries. The results hold noteworthy policy implications for GCC countries as they work towards achieving their goals related to the establishment of a low-carbon economy.

Keywords: Carbon emission, Dynamic panel, Financial development, GCC countries, Non-linearity

Introduction

The topic of climate change has gained global recognition, with a prevalent belief that it arises from the excessive emission of greenhouse gases, especially carbon dioxide. One of the main aims of Millennium Development Goals (MDGs) is to provide clean environments to societies, utilizing modern and eco-friendly technologies.[1] Conversely, technologies that encourage pollution can threaten the environment, offering only temporary benefits to communities in terms of well-being. Following the signing of the Paris Agreement in November 2016, major emitting countries committed to mitigating the adverse effects of increasing carbon emissions. This agreement represents an effort to address the challenges of global warming and climate change, striving to limit greenhouse gas emissions to levels that prevent environmental issues through the adoption of advanced structures. Consequently, global warming has gained substantial attention, with numerous countries worldwide acknowledging environmental concerns.[2]

Similarly, the Middle East Green Initiative (MGI) represents a collective regional endeavour spearheaded by Saudi Arabia, aimed at alleviating the repercussions of climate change within the region and fostering collaboration to achieve worldwide climate objectives. Through enhancing regional cooperation and establishing the necessary infrastructure to curtail emissions and safeguard the environment, MGI has the potential to significantly enhance the global effort to combat climate change, simultaneously generating extensive economic prospects for the region. The Middle East Green Initiative has established ambitious goals that involve decisive measures to address climate change.

One of the strands in the environmental and economic literature has examined the correlation between financial development and environmental quality. A substantial body of research, particularly in the context of the Environmental Kuznets Curve (EKC), which has expanded significantly in recent decades, places significant emphasis on the influence of a country's economic and financial development level in enhancing water and air quality. In this regards, numerous scholars have posited that financial development plays a crucial role in influencing carbon emissions, with theoretical perspectives offering conflicting viewpoints on this impact. Several researchers[3–6] argue that the advancement of finance can play a role in decreasing carbon emissions for various reasons. One such reason is that in order to reduce production costs and improve competitiveness in the product market, businesses frequently require ongoing updates to their production technology and

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equipment, which often necessitates significant financial backing. A well-developed financial system can alleviate financing constraints for enterprises, facilitating these updates and indirectly decreasing energy costs, thereby reducing carbon emissions. Secondly, in response to environmental degradation, governments commonly initiate environmentally friendly projects, advocate for comprehensive industrial transformation, and promote the use of clean energy. With appropriate policy frameworks in place, financial institutions can provide the required funding for the execution of these projects or initiatives, assisting in the improvement of energy infrastructure and ultimately resulting in a decrease in carbon emissions. Conversely, other scholars[7–10] suggest that financial progress might lead to a rise in carbon emissions. They propose that a properly operating financial system effectively deals with the problem of information imbalance, broadens financing channels, and enables enterprises to access capital at lower costs, facilitating the expansion of production scales and consequently leading to a significant rise in carbon emissions. Additionally, the advancement of the financial sector could enhance the provision of consumption credit services, facilitating intertemporal consumption for individuals and encouraging the accumulation of additional goods like real estate, vehicles, and various electronic devices could significantly stimulate the growth of societal consumption and consequently increase carbon emissions.[11–17] As a result, current research has not produced a uniform conclusion on this matter.

The theoretical framework posits that Financial Development (FD) can result in both positive and negative outcomes for the environment, as suggested by the current literature.[18–20] Consequently, the connection between FD and climate change remains unclear, lacking a definitive consensus. Part of the literature contends that FD contributes to improvements in environmental quality. Consistent with Levine's viewpoint (2005), the evolution of financial systems, including elements such as banks, capital markets, banking regulations, and capital market regulations, is devised to alleviate obstacles related to funding, oversight, and access to financial information. This, in turn, facilitates initiatives in the environmental sector by mitigating associated costs. Likewise, it is hypothesized that FD improves environmental health by reducing carbon emissions. Indeed, the introduction of a carbon tax on projects having a carbon footprint and the provision of financial assistance for the development of low-carbon technologies have led to the replacement of conventional financing with green finance.[4] According to many authors, the growth of stock markets causes industrialized nations' CO_2 emissions to decrease.[3] This is explained by the fact that investors now have more financing choices at their disposal, which incentivizes them to invest more in clean energy projects rather than those utilizing conventional energy sources.

Through the provision of green finance choices that support carbon-neutral and environmentally beneficial activities, the financial industry plays a crucial role in supporting environmental preservation. Moreover, FD actively works to reduce carbon emissions through providing funding for research and development projects, offering techno-financial support to businesses, and encouraging the adoption of innovative and environmentally friendly technologies.[5–7] Furthermore, the belief that a country's FD can result in lower environmental emissions is based on the notion that advances in technology are correlated with growth in the financial and economic spheres. As a result, companies must invest in technology advancements in order to stay competitive and improve operational effectiveness.[21] Similar to this, FD improves the environment by facilitating flexible planning schedules and utilizing economies of scale.[22] There is also the argument that by providing incentives for businesses to follow environmental regulations, the market may efficiently reduce carbon emissions.[23–26]

A different stand of the literature highlights how FD makes environmental deterioration worse.[9] It is stated that FD has a negative impact on environmental quality, mainly because domestic loans to the private sector are directed toward projects that have a detrimental environmental impact.[8] There is also the argument that when loans are given to the manufacturing sector, FD causes environmental degradation by encouraging widespread use of traditional, energy-intensive technology. In addition, the promotion of consumer car purchases via credit facilities results in a notable increase in carbon emissions. Leverage financing makes it easier to purchase equipment and automobiles, which increases carbon emissions.[11] As such, the large-scale manufacturing activities increase environmental hazards, supported by the financial sector.[7,10,27] Furthermore, an increase in carbon emissions from higher energy usage has been linked to the growth in

private borrowing. Industrial output is accelerated in an economy by easier access to financial resources. Under these conditions, countries with loose laws are more likely to put economic growth ahead of environmental concerns, which makes them more dependent on environmentally harmful technology like coal, natural gas, and fossil fuels. Lastly, some academics have suggested that while FD can help improve the environment by enabling flexible planning schedules and utilizing economies of scale, it may also have negative long-term effects on the environment. This may happen if inexpensive funding is made available to encourage new players to enter businesses that produce pollution.[22]

Furthermore, empirical studies showcase mixed results regarding the effects of FD on carbon emissions. For instance, Some authors[28] utilized an extensive panel dataset spanning 83 countries from 1980 to 2015. They discovered that in advanced economies, enhanced depth and efficiency in financial markets correlate with a decrease in carbon emissions intensity. Likewise, another study[29] examined the effects of FD on the establishment of a low carbon economy, taking into account innovation's influence within Saudi Arabia between 1981 and 2016. It illustrated that finance serves as a pivotal factor in achieving a low carbon economy by fostering innovation. In contrast, utilizing Autoregressive Distributive Lag (ARDL) and Vector Error Correction Methods (VECM), other authors[30] analyzed both the long-term dynamics and causal relationships of FD on environmental degradation from 1971 to 2016. Empirical findings suggested that FD contributes to increased CO_2 emissions and a decline in environmental quality. Similarly, a comparable study[31] investigated the impact of FD on carbon dioxide emissions from 1970 to 2016, with a focus on the technological dimension. The results from the empirical analysis indicated that the technology associated with FD might have adverse effects on environmental quality. Considering the aforementioned arguments, we predict the following hypothesis: *There is a nonlinear relationship between financial system development and carbon emissions in GCC countries.*

Gulf Cooperation Council (GCC) countries are expanding their financial markets as part of a diversification policy. Consequently, assessing the environmental impacts of financial system development is crucial to validate its overall environmental effects in the region. The GCC region stands out as a significant hub for oil production, further boosting and advancing the regional financial sector. This advancement brings about favorable impacts on consumer lending and investment within the industrial domain, contributing to the escalating environmental degradation in the region. The growth of the financial sector in the GCC has streamlined the process of increasing investments across various sectors. As noted by many scholars[11,12] financial market development enhances the efficiency of stock markets, thereby assisting businesses in reducing their production costs. In the Gulf Cooperation Council, there is a limited body of literature exploring the factors, especially the development of the financial sector, influencing pollution emissions in the region. For example, some authors[13,14] explored the link between electricity and pollution in the GCC area. Others[15,16] investigated the relationship between foreign direct investment and pollution in the GCC region and Kuwait, respectively. Additionally[16], assessed the influence of financial market development on pollution in Kuwait, while[17] examined this association in Saudi Arabia using a nonlinear cointegration method. Despite these individual studies, there remains a notable absence of a comprehensive examination of the nexus between financial market development and CO2 emissions across the entire GCC panel. Consequently, the present study aims to explore the impact of financial system development on carbon emissions in the GCC countries. We specifically investigate the nonlinear relationship between financial development and CO2 emissions in the GCC panel throughout the period from 2010 to 2020.

Data and Methodology

Data and Sample

This research aims to explore the effect of financial system development on carbon emissions. The data for all the variables is sourced from the World Bank World Development Indicators (2023) over the period from 2010 to 2020. The choice of the time frame is constrained by the availability of data. Specifically, data on carbon emissions is not accessible beyond the year 2020.The sample consists of six GCC countries with are Kuwait, Oman, Saudi Arabia, Qatar, United Arab Emirates and Bahrain.

Variables

The Dependent Variable

The dependent variable is carbon emissions (CO_2). It is measured by carbon emissions (metric tons per

capita). The selection of this variable as a proxy of environmental quality is justified by the fact that it is considered as a major anthropogenic greenhouse gas, accounting for approximately 73% of the total greenhouse gas emissions.[32] Data is sourced from the World Development Indicators (2023).

The Explanatory Variable

The variable of interest is the financial system development. Financial system development is measured by both by the development of the banking sector as well as the development of financial markets. We particularly employ the ratio of domestic credit to private sector to GDP as a measure of Bank Sector Development (BSD) and the ratio of market capitalization of listed domestic companies to GDP (MCAP) as an indicator of the financial markets development.

According to the preceding review of literature, it is anticipated that the factor of financial development will have a favorable impact on carbon emissions[33,34], whereas the variable financial development squared is expected to have a negative effect on environmental pollution.[18,33] Data on financial development is obtained from the World Development Indicators (2023).

The Control Variables

Following the previous literature[35] we control for the effect of additional variables such as economic growth, measured by GDP per capita growth (annual %), trade openness measured by exports and imports in percentage of GDP, urban population measured by people living in urban areas. These variables are sources from the World Development Indicators (2023).

The Empirical Model

The EKC hypothesis is often used to analyze drivers of carbon emission especially the relationship between growth and environment sustainability. Besides, following the previous literature[35], we estimate the following model:

$$Y_{it} = \alpha_{it} + \beta_1 Y_{it-1} + \beta_2 FD_{it} + \beta_3 FD_{it}^2 + \beta_3 Z_{it} + \varepsilon_{it} \quad \dots (1)$$

where, i denotes the country and t represents time. Y_{it} is the carbon emission dependent variable, Y_{it-1} is the lagged dependent variable, FD_{it} is the financial development explanatory variable, Z_{it} is the vector of control variables and ε_{it} is the error term.

Following the previous literature, we estimate Eq. (1) using the Dynamic Generalized Method of Moments (GMM) estimation model. Eq. (1) will be estimated using the GMM estimator. The rationale for employing a dynamic specification lies in incorporating the dependent variable as a lagged explanatory factor. The statistical inference relying on Ordinary Least Squares (OLS) regression estimation is questioned due to the inclusion of the lagged dependent variable. This inclusion leads to correlation between the autoregressive term and individual-specific effects, consequently causing residual auto correlation. The justification for employing the GMM estimator stems from another potential source of endogeneity, wherein the dependent variable might impact certain explanatory variables within the model. This endogeneity bias, particularly pertinent to the financial system development variable, as noted in previous research, could be influenced by environmental quality, creating a situation of double causality. Additionally, the likelihood of double causality cannot be discounted for certain control variables, notably the economic growth variable.

The GMM estimator, aside from rectifying these two forms of endogeneity, offers a distinct advantage compared to the instrumental variables estimator by internally producing instruments. It instruments the presumed endogenous variables with their lagged values. Moreover, the system-GMM estimator integrates the equations in both first differences and levels for each period, employing instruments based on their first differences. Through Monte Carlo simulations, it was demonstrated that the system GMM estimator, estimated simultaneously from the derived equations, outperforms the GMM estimator in differences. The latter solely utilizes the moment conditions of the equation in first differences. To assess the reliability of the lagged variables employed as instruments, Hansen's overidentification test and the second-order autocorrelation test are recommended.

Finally, different signs of the coefficients associated to the financial development variable in eq. (1) might indicate various functional forms. Indeed, if $\beta_2 > 0$ and $\beta_3 = 0$, this indicates a monotonically increasing relationship between financial development and carbon emission. If $\beta_2 > 0, \beta_3 < 0$, then it will indicate an inverted U-shaped relationship, thus the EKC hypothesis. If $\beta_2 < 0, \beta_3 > 0$, then it will indicate a U-shaped relationship between pollution and financial development.

Results

Descriptive Statistics

Descriptive statistics are presented in Table 1. As shown in Table (1), the average value for the variable of interest which is the banking sector development is 68.870 whereas the mean value of the variable market capitalization is 69.330. These values are relatively high compared to the minim and maximum values of the same variables. This indicates a relatively developed financial sector of the GCC countries. The mean value of carbon emissions is 160826.8, indicating that GCC countries exhibit a moderately average level of carbon emissions when compared to the minimum and maximum values. The standard deviations as well as maximum and minimum values are also shown the table below.

Correlation Matrix and VIF Results

The correlation matrix and the Variance Inflation Factor (VIF) results are displayed in Table 2. First, results demonstrate that the main variable of interest, i.e.the financial system development, measured both by the development of the banking sector and the development of financial markets are negatively correlated with the dependent variable. Besides, table 2 shows that all the variables are weakly correlated between them. This fact is also corroborates by the VIF results where all values are below the threshold value of 10. Therefore, these results justify the inclusion of all the variables within the same model.

Estimation Results

Estimation results are presented in Table 3. Model 1 includes banking sector development variable as well as its square, without any control variables. In model 2, we add control variables. Model 3 includes stock market development variable as a measure of financial system development as well as its square, without any control variables. Control variables are introduced in model 4. First, results in Table 3 show that coefficients associated with the lagged dependent

Table 1 — Descriptive statistics

Variables	Obs	Mean	Std. dev	Min	Max
CO_2	66	160826.8	168145.8	25965.7	565190.1
BSD	60	68.870	24.451	33.828	138.857
MCAP	53	69.330	52.897	19.440	330.818
GDP	78	0.337	4.035	−0.531	12.3875
TO	70	111.777	36.777	49.713	191.872
Urb	78	7738413	9320282	1075052	$3.08e^{+07}$

Table 3 — Estimation results

VARIABLES	(1)	(2)	(3)	(4)
$L.CO_2$	1.017***	0.867***	1.015***	0.861***
	(0.002)	(0.073)	(0.001)	(0.069)
BSD	0.532*	0.378***	—	—
	(0.273)	(0.142)		
BSD^2	−0.268*	−0.214*	—	—
	(0.157)	(0.110)		
GDP	—	0.502**	—	0.113*
		(0.236)		(0.578)
TO	—	−0.102	—	−25.07
		(0.245)		(0.308)
Urb	—	0.002**	—	0.0026**
		(0.001)		(0.001)
MCAP	—		0.474*	0.133**
			(0.255)	(0.606)
$MCAP^2$	—		−0.047*	−0.562***
			(0.068)	(0.167)
Constant	0.232**	0.199***	0.379***	0.272
	(0.109)	(0.273)	(1,187)	(1,531)
Observations	47	46	49	48
Number of counties	6	6	6	6
AR(1) (p-value)[a]	0.100	0.051	0.187	0.105
AR(2) (p-value)[b]	0.119	0.226	0.259	0.937
Hansen's (p-value)[c]	0.324	0.322	0.216	0.220
Number of instruments	10	10	11	11

Note: Robust standard errors in parentheses. a: Test for first-order serial correlation. b: Test for second-order serial correlation. Given these values, the null hypothesis that "there is no second-order autocorrelation in the residuals of the differenced model" cannot be dismissed. c: Examine the null hypothesis concerning the suitability of the instruments. With reference to these values, the null hypothesis of the validity of instruments at the standard significance levels is accepted.***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 2 — Correlation and VIF results

	CO_2	BSD	MCAP	GDP	TO	Urb	VIF
CO_2	1	—	—	—	—	—	—
BSD	−0.303	1	—	—	—	—	0.039
MCAP	−0.020	0.531	1	—	—	—	0.338
GDP	0.342	−0.270	−0.197	1	—	—	0.725
TO	−0.375	0.197	0.022	0.161	1	—	0.662
Urb	0.995	−0.324	−0.044	0.344	−0.384	1	0.009

variable L.CO_2 are positive and highly significant through all the specifications, which justifies the use of the dynamic specification.

Furthermore, findings in Table 3 demonstrate that BSD variable has a positive and significant effect on carbon emission, ranging from 0.378 to 0.532 percentage term, whereas its squared term has a negative and significant coefficient, ranging from −0.214 to −0.268 percentage term. Likewise, the coefficient associated to MCAP variable is positive and significant whereas the variable square is negative and significant. These results corroborate previous studies that supported the anticipated negative impact of squared financial development on CO_2 emissions.[18,33] The decline in carbon dioxide emissions, attributed to the negative coefficient of squared financial development, supports the existence of the inverted U-shaped Environmental Kuznets Curve. This negative influence of squared financial development on carbon dioxide emissions contributes positively to the long-term environmental sustainability. This correlation, where squared financial development inversely affects carbon dioxide emissions, is consistent with the inverted U-shaped hypothesis of the EKC. Studies conducted by[18,33] respectively in China, Indonesia, and the UAE provide evidence for this non-linear adverse impact, further corroborating the validity of the inverted U-shaped Environmental Kuznets Curve hypothesis. Thus, our results indicate a nonlinear relationship between financial system development and environmental pollution in GCC region. Our findings might be explained by the fact that investors have more financing choices at their disposal, which incentivizes them to invest more in clean energy projects rather than those utilizing conventional energy sources.[3] Additionally, the argument that advances in technology are correlated with growth in the financial and economic spheres might explain our results. Indeed, companies will invest in technology advancements in order to stay competitive and improve operational effectiveness with positive effects on environment.[21] Similar to this, financial development improves the environment by facilitating flexible planning schedules and utilizing economies of scale.[22]

Finally, the outcomes concerning the various control variables are aligned with the previous literature. Specifically, GDP growth consistently demonstrates a positive and significant impact on carbon emissions in all specifications. Urbanization similarly exhibits a positive and significant effect, while the variable trade openness does not show a significant effect on carbon emissions.

Conclusion

The aim of this research is to explore the connection between FD and carbon emissions in GCC nations. Findings affirm the presence of a nonlinear relationship between financial development and environmental pollution. Results indicate that banking industry and financial markets have a twofold influence on environmental quality. These findings have important policy implications. One effective policy involves expanding the availability of green credit. Financial institutions should actively support research, development, and innovation in the green industry. Banks are also encouraged to promote the concept of green development and play a leading role in directing private capital toward environmentally responsible initiatives. Moreover, it is recommended that banks provide financial assistance to enterprises focused on environmental protection and energy conservation. Additionally, banks are expected to contribute to these efforts by advancing green finance, participating in policy development, and enhancing their capacity-building initiatives. Finally, future research could include a wider range of environmental pollution indicators, encompassing variables like water and land pollution.

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