Exploring the Role of Financial Development on Green Growth: An Empirical Analysis of Causal Factors in OECD Economies

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Abstract

Green growth promotes new investment opportunities and economic growth and creates a financially sound environment for international organizations and policymakers. One of the important factors is financial development, which supports green growth by providing the necessary funds to invest in environmentally sustainable technologies and practices. This study aims to investigate the effect of financial development and economic, technological, and environmental determinants on the green growth economy. This study covers an annual panel dataset in OECD countries from 1990 to 2020 by utilizing dynamic panel data models. Based on the empirical findings, we conclude that these factors produce a positive impact on green growth. Our findings have important implications for sustainable development since economies transition to more sustainable practices and financial institutions have a critical role to play in supporting and driving this transition. The findings of this study corroborate the growth-led finance theory and encourage policymakers to boost their green growth policy effort.

1 Introduction

Financial development has a significant role in the environmental process by influencing carbon emissions and promoting sustainable solutions. Through capital allocation and investment decisions, financial institutions can shape the direction of funds towards carbon-intensive industries or environmentally friendly sectors. By financing sustainable initiatives, such as renewable energy projects and energy-efficient technologies, financial development enables the decreasing of carbon emissions. It also supports the implementation of carbon pricing mechanisms, encourages emissions reporting and disclosure, and creates green finance opportunities that incentivize businesses to adopt low-carbon practices. While financial development alone is not a complete solution, it can be a powerful tool in driving the transition to a more sustainable and low-carbon economy.

A study by Acemoglu et al. (2012) explores the interaction with financial development, directed technical change, and environmental sustainability. The authors develop a theoretical model that highlights the role of financial institutions in shaping innovation and technology adoption, which have direct implications for green growth. On the other hand, financial development plays a crucial role in advancing green growth on the global agenda by mobilizing global capital, driving innovation and technology transfer, supporting policy alignment, promoting capacity building and knowledge sharing, and fostering public-private partnerships. For instance, Zhang et al. (2019) investigate the interaction between financial development and green growth in China by analyzing data from 30 provinces over the period 2004-2015. The study reveals a significant and favorable link between financial development and environmental-based growth.

Moreover, Dogan and Turkekul (2016) explore the impact of financial development on the energy-growth relationship in Turkey. The study concludes that financial development positively affected both energy consumption and economic performance. The authors argued that financial institutions played a critical role in providing the necessary capital for energy investments, including renewable energy projects, which contributed to both economic development and environmental sustainability. In addition, Tisdell (2018) provides a complete literature analysis on the relationship between financial development and economic development in a separate study, with implications for sustainable development. According to the analysis, green and sustainable industries, among others, benefited from the increased availability of finance made possible by progress in the financial sector. The study emphasized that a well-developed financial sector facilitates the allocation of funds towards environmentally friendly projects, supporting sustainable development. Another study by Lin et al. (2018) examines the relationship between financial development and green growth. They employed various econometric techniques to assess the impact of financial development on carbon emissions, energy intensity, and environmental performance.

However, the spread of environmentally friendly technologies is becoming increasingly central to international plans. To achieve sustainable development, green technology is essential because it mitigates the destructive effects of human activities on the environment while protecting precious natural resources. The term "green technology spread" is used to describe the global diffusion and adoption of environmentally friendly technologies. Technical progress is defined by Schumpeter (1942) that diffusion refers to the process of spreading and adopting innovation by different sectors and regions.

Financial development facilitates the environmental technologies, which, in turn, drives green growth. The resulting green growth reinforces the demand for and adoption of green technologies, further driving the need for financial development. This relationship creates an ecosystem where financial development, green technology diffusion, and environmental-based development collectively contribute to the transition to a more sustainable and low-carbon economy.

This paper also investigates several potential determinants of green growth. One of these is that green technology diffusion plays a crucial role in the establishment of green growth models and approaches. The proliferation of green technologies has facilitated the transition toward a more sustainable and environmentally friendly economy. Another important determinant is carbon emission levels. Growing awareness of environmental issues, such as carbon emissions, climate change, temperature, and resource depletion, acierates increased the demand for more sustainable products and services. On the other hand, social and economic factors such as population, urbanization, and changes in consumer behavior can also influence the development of green growth.

After this introductory section, the rest of the research consists of: The literature survey is presented in Section 2. Data visualization and methods are presented in Section 3. In addition, the empirical findings are presented in Section 4. The conclusion is briefly restated in Section 5.

2 Literature Review

The literature on the role of financial development in environmental-based approaches has expanded significantly in recent years. Scholars and researchers have examined various aspects of this relationship, providing valuable insights into how financial development can promote and support sustainable economic growth.

A strand of the literature has concentrated on environmental-related growth and financial development. In their analysis of China's green growth from 2011 to 2018, Cao et al. (2022) focus on the geographical impact of financial and technological progress. According to the data, the scale of financial institution development has a negative impact on environmental-based growth there but a favorable impact on environmental-based growth in neighboring provinces. The level of CO2 emissions, GDP growth, population, green technologies, energy consumption, and employment rate are all examined by Yang et al. (2022) from 1980 to 2019. As a result of their research, the authors draw the conclusion that advancements in green technology and financial development have a substantial impact on environmental conservation. Ang and Zhang's (2020) research looks into the connection between China's monetary growth and its green development. The findings of the study suggest that financial development plays a positive role in promoting environmental-based growth. They find that measures of financial development, such as the ratio of bank assets to GDP and the number of bank branches per capita, are negatively associated with carbon emissions, indicating that greater financial development is associated with lower carbon emissions. Additionally, they find that financial development positively affects green productivity, which measures the efficiency of resource use in environmentally friendly sectors.

Furthermore, another study by Huang, Zhou, and Zhang (2020) examines the interaction between financial development and environmental-based development in China using a spatial econometric approach. They examine the impact of financial development, measured by indicators such as bank assets and insurance premium, on green growth indicators including carbon emissions intensity and energy efficiency. The results of the study suggest that financial development plays a crucial role in promoting green growth. They conclude that higher levels of financial development are interacted with lower carbon emissions intensity and higher energy efficiency. This indicates that a well-developed financial sector contributes to reducing the environmental effect of economic activities and enhancing energy efficiency.

The literature is also replete with studies on causal factors of environmental-based growth. Zaidi et al. (2019) show that financial development impacts environmental quality. From 1982-2014 throughout the sampled ASEAN-5 countries, Nasir et al. (2019) use the DOLS and FMOLS methods to examine the connection between environmental characteristics and GDP growth, financial development, and Foreign Direct Investment (FDI). Their study shows that financial development, economic performance, FDI, and deterioration of the environment are all interconnected in ways that are both positive and statistically significant over the long term. On the other hand, Aye and Edoja (2017) use a dynamic panel model to investigate the correlation between GDP growth and CO2 emissions in 31 developing countries. They draw the conclusion that the EKC hypothesis is not supported by the data since economic growth reduces CO2 emissions in the low regime but increases them in the high regime. The study also found that there are causal links between economic performance, energy expenditure, CO2 emissions and financial development.

In the context of environmental quality and environmental-based development in Latin American economies from 1990 to 2018, Ochoa-Moreno et al. (2021) examine the causal association between CO2 emissions and FDI. Based on their findings, it is clear that a short-term equilibrium cannot be assumed. Long-term investments in equilibrium, however, increase CO2 emissions, a source of environmental concern. This result is consistent with the conclusion reached by Frankel et al. (1991) that FDI has a negative effect on environmentally friendly development. However, this result is in contrast with the findings of (Dean et al., 2017). Their study shows that FDI contributes to green development in China.

As the investment stakes for this green transformation are too high, Jadoon et al. (2021) recently examine if the green economy will be effective in achieving its fundamental aim, namely stabilizing the global financial system. The current study concludes that green growth applications and strategies improved the country's financial stability in the short and long terms. However, Zhang (2023) digs deeper into the link between China's green growth, technical advancement, and the country's expanding financial sector. Long-term green growth in China is positively impacted by technology progress and both indicators of financial development.

The impact of economic expansion on carbon emissions must be investigated urgently. Fang et al. (2020) investigates the association with financial size, securities size, urbanization, economic development, trade openness, and carbon emission intensity in China. Their data shows that monetary size, economic growth, and the intensity of carbon emissions are positively related in both the short and long terms. In addition, Xu et al. (2022) analyze the effect of economic growth on ecological sustainability from the year 2000 to the year 2020. They discovered that CO2 emissions per capita, total CO2 levels, and transportation-related CO2 all have a negative correlation with interest rates. Total CO2 emissions and CO2 emissions from the power and transportation sectors were also shown to increase as a result of bank credit to the private sector. Finally, Liu et al. (2022) investigate the relationship between a country's ecological footprint and its level of economic growth, human capital, and quality of government. The findings demonstrated that expanding economies had a deleterious effect on environmental quality by rising their ecological footprint.

3 Data and Methodology

Concerns about the environment, accelerating economic growth and financial development are all topics that have been the subject of extensive discussion. However, emerging and established countries are likely to approach green growth in very different ways due to disparities in historical backdrop, economic progress, and environmental deterioration. The main purpose is to provide an overview of the role of financial development, economic growth, green technology diffusion, and environmental issues in the green growth process in OECD economies. Table 1 shows the data gathered by the analysis from 1990 to 2020 using the World Development Index (WDI), the World Intellectual Property Organization (WIPO) database, and the OECD patent database.

Variable	Description	Data source
GG	Green Growth Index	OECD
GDP	Gross domestic product per capita	WDI
FD	Financial Development	WDI
CO2	Carbon Emissions per capita	WDI
GTD	Green Technology Diffusion	WIPO
URB	Urbanization index	WDI

***Table 1**. Variable specifcation and data source*

The dynamic panel model is formulated with the assumption that the following form is true if the connection between the dependent and independent variables is linear:

$$ln(ggi)_{i,t} = \alpha_0 + \sum_{j=1}^{p} \rho_i \, lnggi_{i,t-j} + \alpha_1 lngdp_{i,t} + \alpha_2 lnfd_{i,t} + \alpha_3 lnco2_{i,t} + \alpha_4 lngtd_{i,t} + \alpha_5 lnurb_{i,t} + \ +\eta_{i,t} + \varepsilon_{i,t}$$

$$\varepsilon_{i,t} = \eta_i + v_{i,t} \ , \ E(\eta_i) = 0, \ \ E(v_{i,t}) = E(\upsilon_{i,t}\eta_i) = 0$$

In natural logarithm form, the error term $\varepsilon_{i,t}$ in the autocorrelation order q equation consists of two orthogonal components, namely fixed effects η_i and idiosyncratic shocks $v_{i,t}$. The current research suggested the following equations for the dynamic panel model to determine the effect of green growth on economic growth.

There are two main challenges when using the GMM technique: the need for more instruments and the serial correlation of error terms, according to (Roodman, 2009). These challenges become more difficult when the panel has a small number of individuals and a large period. Increasing the number of instruments means using more advanced instruments. The model becomes overidentified by creating instrumental variables in levels and differences. The Sargan and Hansen tests provide an opportunity to determine whether the sample size is sufficient and if the number of instruments used may lead to overidentification (Sargan, 1958). The description statistics for all of the variables is summarized in Table 2. The number of observations includes 1,178 individual data points. The first column of the panel lists the variable names for the logarithmic levels.

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
lgg	1,178	3.89468	0.58242	1.904035	5.508782
lgdp	1,178	4.35564	0.299532	3.238685	5.08265
lgtd	1,178	1.680253	0.963926	0	3.906389
lfd	1,178	0.5555413	0.224618	0	1
lco2	1,178	0.8515033	0.255599	-0.041565	1.482327
lurb	1,178	1.872053	0.067145	1.680471	1.991408

***Table 2.** Descriptive Statistics*

Table 3 displays the estimated Pearson correlation coefficients across all parameters. Multicollinearity in a model may be better understood by calculating correlation estimates to see whether there is a high degree of association between the model's variables (Sarafidis et. al, 2009). It is revealed that the correlation coefficients between carbon emissions and green growth are negative. Green growth index is positively associated with several other characteristics. In addition, several sets of data have a high degree of positive association with one another. Some examples of such combinations include green technology diffusion and green growth index, financial development and green growth index, financial development and GDP per capita, financial development and green technology diffusion.

Variables	lgg	lgdp	lgtd	lfd	lco	lurb
lgg	1.0000					
lgdp	0.3075	1.0000				
lgtd	0.7064*	0.5530*	1.0000			
lfd	0.6039*	0.7078*	0.6491*	1.0000		
lco2	-0.0402	-0.2650	-0.2572	-0.2715	1.0000	
lurb	0.0144	-0.1036	-0.0806	-0.2173	0.2565	1.0000

Table 3. *Pair-wise Correlation Estimates* ***Note:*** *Levels of significance of 5%, 10%, and 1% are represented by the symbols ***, **, and *.*

4 Empirical Findings

This study analyzes the role of financial development, economic performance, carbon emissions, green technology diffusion, and green growth using panel data analysis. The cross-sectional dependence (CD) test created by Pesaran (2004), provides the examination of cross-sectional dependence and diverse slopes as a starting point. Table 4 displays the outcomes of cross-sectional dependence testing, and the null hypothesis of no cross-sectional dependence is rejected for all nations in all models at all significant levels. Table 5 represents the slope homogeneity by using two different tests. These results from Tables 4 and 5 indicate that cross-sectional dependence exists in the panel and that slope homogeneity must be considered in the next phases. After continuing to present the series for all variables comprising unit root tests of the second generation, the analysis moved on to an analysis of the system-GMM two-step model employing dynamic panel estimation.

Variables	CD Test	*p*-value
lgg	128.57***	0.000
lgdp	143.35***	0.000
lgtd	68.29***	0.000
lfd	133.09***	0.000
lco2	33.32***	0.000
lurb	54.29***	0.000

Table 4*. Cross-section Dependency Test Results* ***Note:*** **** denotes statistically at 1% the significance level.*

Test	LM statistics	*p*-value
$\tilde{\Delta}_{HAC}$	24.481	0.452
$\tilde{\Delta}_{adj,\ HAC}$	27.959	0.243

Table 5. *Homogeneity of Slope Test Result*

The unit root test is a statistical procedure used to test whether a time series is stationary or non-stationary. Due to the cross-sectional nature of the data in this study, second-generation unit root tests are employed. Table 6 shows that, for both the constant and constant plus trend specifications, all tests reject the null hypothesis of the existence of a unit root.

Variables	Tests with a constant			Tests with a constant and trend		
	CIPS	PANIC-$Z_{\hat{e}}$	PANIC-$Z_{\hat{e}}^{+}$	CIPS	PANIC-$Z_{\hat{e}}$	PANIC-$Z_{\hat{e}}^{+}$
lgg	-3.352***	-4.112***	-6.539***	-3.719***	-9.739***	-9.423***
lgdp	-2.270***	-3.933***	-4.098***	-2.819**	-8.157***	-7.349***
lgtd	-3.225***	-4.841***	-9.148***	-3.414***	-5.344***	-8.661***
lfd	-2.433***	-4.120***	-7.062**	-2.965***	-6.418***	-10.121***
lco2	-1.969	-2.229**	-3.017***	-2.387***	-2.183***	-3.919***
lurb	-1.857	-2.175**	-2.406**	-1.801	-2.114***	-2.466***

Table 6. *Panel Unit Root Tests Results* ***Note:*** *The significance levels indicated by ** and * are 5% and 1%, respectively.*

Due to the nature of the panel data framework, we are unable to include all potentially relevant variables in each model. This is because of issues like overfitting, multicollinearity, autocorrelation, and endogeneity. Several permutations of the variables are shown in Table 7. As seen in Table 6, AR(1) specification is accurate and significant at the 1% level. However, there is no significant relation at the 5% and 1% levels for AR(2) specification, rendering the AR(2) specification invalid. In all model specifications, we employ a single lag of the dependent variable. The data presented in this section confirms the validity of the offered instrumental variables and suggests that an AR(1) dynamic specification is adequate for capturing autocorrelation. Because the Sargan test does not reject the null hypothesis of valid over-identification constraints at any significance level, we can also conclude that the instruments used in all estimated models are valid.

The GMM estimator is capable of reducing cross-sectional dependence while maintaining consistency in accordance with the definitions established by Sarafidis and Wansbeek in 2009 and 2012, respectively. Similarly, it is possible to create a trustworthy GMM estimator by employing a subset of parameters that depend on exogenous instruments. Table 7 displays the results of the SYR-CD test on the cross-sectional dependence of the residuals of the system GMM estimations. The SYR-CD test verifies that the system GMM estimator is capable of managing all cross-sectional dependencies in the data, and that the conclusions derived from GMM estimations are still accurate.

This study examines to influence of financial development, economic performance, green technology diffusion, carbon emissions, and urbanization on green growth index. Table 7 presents the results of the dynamic panel estimations conducted for three different model specifications. The initial model in this study assesses how economic performance and financial development factors impact on green growth. All factors have a positive and significant effect on environmental-based development process. Strong economic performance, characterized by high GDP growth rates and increased productivity, provides a foundation for investing in sustainable technologies and supporting the development of green industries. Meanwhile, financial development, including access to capital, efficient financial markets, and supportive policies, facilitates the mobilization of funds for green investments, green technologies, and the adoption of sustainable business practices. Empirical studies demonstrate that countries with stronger economic performance and well-developed financial systems tend to exhibit higher levels of green growth, highlighting the importance of these factors in promoting sustainable economic development. However, it is crucial to couple economic and financial factors with effective environmental policies and sustainable practices to ensure long-term environmental sustainability.

Variables	Model 1	Model 2	Model 3
l..lgg	0.8891***	0.8821***	0.7908***
	(0.002)	(0.004)	(0.009)
lgdp	0.0694***	0.0336***	0.0246***
	(0.004)	(0.004)	(0.007)
lgtd			0.07942***
			(0.005)
lfd	0.0689***	0.1023***	0.0771***
	(0.005)	(0.004)	(0.008)
lco2		-0.1082***	-0.0338***
		(0.007)	(0.004)
lurb	0.7178***	0.5457***	-0.2963***
	(0.054)	(0.034)	(0.072)
Constant	1.443***	-1.374***	-1.0679***
	(0.098)	(0.054)	(0.1183)
N	1102	1102	1102
$\hat{\sigma}^2$	0.167	0.112	0.058
χ^2	23462.21***	29335.46***	42229.28***
AR(1)	-2.842**	-3.840***	-3.883***
AR(2)	1.1754	1.1661	1.1512
J-stat.	37.85637	37.52365	37.4961
SYR-CD	1.821	1.015	1.249

Table 7. *System GMM (two-step) Model* ***Note:*** *Levels of significance of 5%, 10%, and 1% are represented by the symbols ***, **, and *.*

Model 2 investigates the impact of financial development, economic performance, carbon emissions, and urbanization on environmental-based growth process. The findings show a positive interaction between financial development, economic progress and green growth. However, there is negative interaction between CO2 emissions and green growth process. The environmental-based growth involves promoting sustainable economic development while actively reducing carbon emissions and environmental degradation. Moreover, Model 3 includes the green technology diffusion on environmental-based development. The results reveal a positive association between green technology diffusion and environmental-based growth. Green technology diffusion plays a critical role in driving the environmental-based growth. As green technologies are adopted and integrated into production processes, they contribute to improved resource efficiency, reduced environmental impacts, and enhanced sustainability. On the other hand, while there is positive interaction between financial development, economic growth and green growth, a negative links between carbon emissions and green growth index.

5 Conclusion

This study aims to explore the role the financial development with causal factors on the green growth process in OECD countries from 1990 to 2020. Our empirical findings indicate that financial development has a substantial impact on green growth development. On the other, economic growth, green technology diffusion, and urbanization have a positive impact on the green growth index. In contrast, carbon emission levels in OECD economies have a detrimental impact on environmental-based growth. On the other hand, our findings indicate that high carbon emission levels in OECD economies pose a significant obstacle to the development of green growth. These emissions contribute to climate change, causing environmental degradation and hindering sustainable development. Misaligned policies, market barriers, and competitive disadvantages further impede the transition to a low-carbon economy. To foster green growth, it is crucial for OECD economies to prioritize emission reduction, invest in clean technologies, and promote international cooperation, ensuring a more sustainable and prosperous future for all.

According to our empirical results, environmental circumstances at the global level improve the environmental-based growth. This implies that when environmental conditions, such as reduced pollution and improved resource management, are favorable on a global scale, it has a beneficial effect on the growth of environmentally sustainable sectors. These findings highlight the importance of international cooperation and coordinated efforts to address global environmental challenges and create an enabling environment for green growth. By prioritizing global environmental sustainability, countries can enhance their own environmental-based growth and contribute to a more sustainable and resilient global economy. Results from Yang et al. (2022) and Cao et al. (2019) are in agreement with the findings in this paper.

In summary, the results of empirical findings confirm to promote green growth, OECD economies need to prioritize emission reduction targets, invest in clean technologies, incentivize sustainable practices, and align policies with environmental goals. International collaboration and knowledge-sharing can facilitate the adoption of best practices and ensure a more sustainable and inclusive global economy. Policy recommendations to leverage financial development for green growth include the promotion of green financial instruments such as green bonds and investment funds, the establishment of a robust regulatory framework that mandates disclosure of climate-related risks and encourages sustainable investments, the provision of financial incentives such as tax breaks and subsidies for green projects, capacity building in sustainable finance, collaboration and information sharing among stakeholders, ensuring long-term policy stability to attract investments, and integrating environmental risk assessment into banking practices. Together, these measures are meant to facilitate the transition to a low-carbon economy and promote green development by directing investment toward ecologically responsible initiatives, inspiring innovative approaches to problems, and creating a welcoming environment.

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