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WHAT IS THE ROLE OF FINANCIAL DEVELOPMENT IN GREEN LOGISTICS? EVIDENCE FROM OECD COUNTRIES

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ABSTRACT

The aim of this study is to reveal the relationship between green logistics and financial development using data from OECD countries for the period of 2000-2020. The Panel ARDL approach is used in the study to display the relationship between non-stationary series of the same degree in both the short and long terms. The findings show that there is a significant and positive relationship between green logistics and financial development in the long run, while there is a negative relationship between green logistics and trade openness. On the other hand, there is no significant relationship between foreign direct investments and green logistics. Previous studies have usually highlighted the relationship between green logistics and economic indicators. However, this study investigates the relationship between financial development, a financial indicator, and green logistics. Thus, it is believed that this study will fill a gap in the literature.

Keywords: *Green Logistics, Financial Development, Trade Openness.*

JEL codes: *Q56, F40, F65.*

1. INTRODUCTION

Green logistics, also known as eco-logistics, is a set of sustainable policies and measures aimed at reducing the environmental impact of logistics activities throughout the entire life cycle of a product, from manufacturing to disposal (Abukhader and Jönson, 2004). Green logistics can also be defined as the process of minimizing pollution, decreasing the carbon footprint, and promoting sustainable practices of a product throughout its life cycle. It involves the integration of environmental, economic, and social dimensions to minimize environmental damage, operational costs, and energy usage, while also considering the well-being of communities and workers involved in logistics processes (Mohsin et al., 2022, Rad and Gülmez, 2017).

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Figure 1. Green Logistics as An Element of Sustainable Development

The three pillars of Sustainable Development can be applied to green logistics (Figure 1). The environmental pillar includes waste, land use, biodiversity, climate change, and air/noise pollution. The social pillar includes health, safety, equity, and access. The economic pillar includes choice, growth, efficiency, employment, and competitiveness. Green logistics is an important element of sustainable development, which can be achieved by applying these three pillars of sustainability (Kumar, 2015, Averkyna et al., 2019). Environmental sustainability in green logistics can be achieved by reducing energy usage and waste, as well as managing the treatment of waste (Seroka-Stolka, 2014; Sbihi and Eglese, 2009). Social sustainability in green logistics entails respecting human rights, promoting social responsibility, and considering the well-being of communities and workers involved in logistics processes (Seroka-Stolka, 2014). Economic sustainability can be achieved by the responsible management of economic resources, which implies environmental impact minimization, social and economic equity, and a more resilient and challenge-capable economy. Moreover, economic sustainability is crucial for ensuring that logistics activities are conducted in a financially viable manner while also considering their long-term impact on the economy and society (Seroka-Stolka, 2014; Rad and Gülmez, 2017). Therefore, green logistics can be defined as producing and distributing goods in a sustainable way, taking into account environmental and social factors (Lehtonen, 2004).

The financial development index (FDI) can significantly impact green logistics. According to Alshuribi (2017), financial development, including factors such as financial markets and economic growth, can influence the adoption of green logistics practices. In another recent study, Mohsin et al. (2022) stated that green logistics practices can be effective in reducing environmental damage and operational costs, thus influencing economic growth. Furthermore, the adoption of green logistics management practices was found to influence social welfare and health, indicating a connection between financial performance and green logistics management practices (Agyabeng-Mensah et al., 2020). While some studies have not found a significant impact of financial development and economic growth on green logistics, other studies have suggested that financial and economic factors can influence the adoption of green logistics practices (Mohsin et al., 2022; Barut et al., 2023). Thus, the relationship between financial development and green logistics is a topic of ongoing research, and current findings suggest that there is a complex interplay between these factors.

Green logistics and the financial development index calculated by the IMF may seem independent of each other, but they are actually interconnected concepts. Green logistics aims to optimize logistics and supply chain processes based on environmental sustainability principles. These practices not only raise awareness about environmental responsibility among businesses but also help reduce costs and increase efficiency. The financial development index calculated by the IMF, on the other hand, measures the level of development of a country's financial markets and institutions. This index assesses the financial system in terms of depth, accessibility, efficiency, and stability, supporting economic growth and improving the investment environment. Thus, a relationship between green logistics and the financial development index can be identified. In financially developed economies, greater access to capital plays a crucial role in investments in green logistics technologies (Jinru, et. al, 2021 such as energy-efficient vehicles and renewable energy sources for storage (Rad and Gülmez, 2017 and Xu and Li, 2024). Moreover, developed financial markets offer innovative financial products, such as green bonds and green insurance, to finance environmentally friendly projects, making it easier to secure funding for green logistics initiatives (Jinru, et. al, 2021). Financially developed systems also provide better access to finance for small and medium-sized enterprises (SMEs). This facilitates the adoption of green logistics practices, which might otherwise be costly for businesses. Furthermore, broader access to financial services encourages businesses of all sizes to invest in green logistics (Barut et al., 2023). In strong financial systems, the cost of capital tends to be lower, enabling businesses to invest in high-cost, long-term green logistics projects. Efficient financial markets can also offer risk management products, such as green insurance, to mitigate risks associated with investments in green technologies. In financially developed countries, there is generally higher sensitivity to environmental sustainability issues. This can help companies that adopt green logistics practices increase their market share and gain a competitive advantage. In summary, the relationship between financial development and green logistics can be mutually reinforcing. While the development of financial systems encourages the widespread adoption of green logistics practices, these practices, in turn, support economic and environmental sustainability in the long term. In this context, the aim of the study is to investigate the relationship between green logistics and the financial development index in OECD countries for the period from 2000 to 2020. One of the study's limitations is that green logistics data will not be available over 2020. The rest of this paper is organized as follows: Section 2 presents the review of the relevant literature and hypotheses on financial development and green logistics; Section 3 explains the econometric methodology, econometric model, variable definitions, and data sources used; Section 4 reports the estimation results; Section 5 discusses the similarities and differences between this paper and the existing literature in terms of the methodology and conclusions of this study, and Section 6 summarizes the main findings of this paper and recommends some policy implications for OECD countries at present.

2. LITERATURE REVIEW

To increase the efficiency of logistics operations, governments are developing new logistics methods to strengthen competition in the supply chains of businesses, particularly through infrastructure investments. This has led to the investigation of the relationship between logistics and economic development (Kuhlmann and Klumpp, 2017). While the relationship between logistics performance and growth is a frequently researched topic in the literature, there are few studies examining the relationship between green logistics and economic and financial indicators. Some studies focusing on green logistics and financial indicators. Zaman and Shamsuddin (2017) investigated the relationship between the logistics performance index and energy use for the period of 2007-2014. European countries were examined in the study, and it was determined that the logistics performance index increased per capita energy use. Wang et al. (2018) investigated the relationship between green logistics and exports for 113 countries using data covering the period of 2007-2014. In the study, a significant relationship was found between green logistics and exports. Aldakhil et al. (2018) examined the relationships of socio-economic factors, GDP per capita, FDI, and trade with the logistics performance index. A two-way relationship was found between per capita income of countries and logistics indices, and a one-way relationship was found from carbon-fossil emissions to logistics indices. In the study conducted by Agyabeng-Mensah and Tang (2021), where a survey was applied, it was determined that green logistics practices significantly increased social performance, financial performance, and green competitiveness. Guo, Li, and Lin (2021) found that innovation and FDI have a significant impact on environmental efficiency, while they do not significantly affect the environmental efficiency of the Belt and Road logistics industry. Nguyen (2021) investigated the relationship between the logistics performance index (LPI) and GDP growth, CO_2 emissions, health expenditures, FDI, and trade openness within the scope of the 2007-2018 period. In the study examining Southeast Asian countries, it was determined that LPI had a significant impact on GDP growth, CO_2 emissions, and current health expenditures. Agyabeng-Mensah and Tang (2021) investigated into the impact of green logistics on the financial and social performance of 152 Ghanaian businesses. The study's findings showed a considerable improvement in social performance, financial performance, green competitiveness, and green logistics methods. In the study performed by Fan et al. (2022), the relationships between the green logistics performance index values of ASEAN countries and GDP, population, and economic openness were examined. In the study covering the period of 2012-2018, it was determined that green logistics performance significantly increased China's exports trade. Du, Cheng and Ali (2023) examined the relationship between financial innovation and green logistics for the BRICS-T countries between 2000 and 2018. Green innovation, logistics, and renewable resources have been found to impact environmental sustainability in the BRICS-T countries favorably. Zhu et al. (2023) investigated how transportation emissions were affected by green financing and green logistics from 2000/Q1 to 2019/Q4. According to research findings, green financing and green logistics have a negative impact on transportation emissions in all segments. In their study, Ali, Jianguo and Kirikkaleli (2024) evaluated the impact of financial innovation and green logistics on China's ability to sustain growth within the 2000/Q1-2018/Q4 period. The study results revealed that every component was integrated with each other. Sezer (2023) investigated the relationships between green logistics and economic growth, FDI, trade openness, portfolio investments, RandD investments, and financial development for BRICS-T and G7 countries. In the study, a significant relationship was found between green logistics and all variables for the two country groups. Based on the review of the relevant literature, three hypotheses were developed to investigate the impact of GL on FDI, FD, and TO with the help of relevant tests.

H1: There is a relationship between GL and FDI.

H2: There is a relationship between GL and FD.

H3: There is a relationship between GL and TO.

3. ECONOMETRICS METHODS

3.1. Research Design

The relationship between green logistics and financial development was investigated for OECD countries in the 2000-2020 period. For this purpose, in the study, the dependence of the cross-section (countries) between the series that make up the panel was examined before investigating the cointegration relationship. Since the time dimension was 10 years, and the cross-section dimension was 7, the cross-sectional dependence (N>T) was tested with the Pesaran CD test (2004). In the panel data analysis method, it is necessary to determine whether all the cross-sectional units in the panel data are already affected at the same level when the series is shocked (Güriş, 2018: 88). Accordingly, the cross-sectional dependence test is performed to understand the effect of a shock influencing a country or business on other countries or enterprises in the panel. Additionally, the examination of cross-sectional dependence provides guidance on which unit root tests should be used in the study. If there is no cross-sectional dependence between the series, first-generation unit root tests are used. If there is cross-sectional dependence, second-generation unit root tests should be preferred. In the study, the PANIC test, which is one of the second-generation unit root tests and was developed by Bai and Ng (2004), was used due to the cross-sectional dependence between the series. According to the results of the PANIC unit root test, it was determined that not all series were stationary to the same degree. Therefore, the Autoregressive Distributed Lag (ARDL) model, which allows series to be stationary at different levels, was used in the study.

The ARDL model, which is preferred over the single cointegration approach for a number of reasons, is used to determine whether the provided time series data demonstrates along-and short-run equilibrium (Pesaran, et. al., 2001; Zhang, et. al., 2019). Panel ARDL model concurrently gives long- and short-term coefficients (Sheng and Guo, 2016; Vieira and da Silva, 2019). In light of these benefits, we used the ARDL panel approach to validate potential long- and short-term relationships between green innovation EPU and FD. The long-run and short-run models are based on the panel ARDL and are represented in Equations (1) and (2) below, respectively (Topaloğlu and Bayrakdaroğlu, 2024):

$$Y_{it} = \sum_{j=1}^{p} \lambda_{ij} Y_{i,t-j} + \sum_{j=0}^{p} \delta'_{ij} X_{i,t-j} + \varepsilon_{it} \quad (1)$$

$$\Delta Y_{it} = \phi_i (Y_{it-1} - \Theta'_t X_{it}) + \sum_{j=1}^{p-1} \lambda^*_{ij} + \Delta Y_{it-j} + \sum_{j=0}^{p-1} \delta^*_{ij} + \Delta X_{it-j} + \varepsilon_{it} \quad (2)$$

In Equations 9 and 10 i, N denotes the cross-sectional dimension, $t = 1,2,3 \ldots \ldots$ T denotes the time dimension, $k\,x1$ denotes the vector of explanatory variables, $\delta_{it}, kx1$ denotes the vectors of coefficients, λ_{ij}, denotes the scales, ϕ_i denotes the error correction mechanism and ε_{it} denotes the error term.

3.2. Baseline Model

The relationship between green logistics and financial development was examined using the Panel ARDL model. This model was based on the studies conducted by Sezer (2023) and Barut et al. (2023).

$$GL_{i,t} = \beta_0 + \beta_1 FD_{i,t} + \beta_2 controlvariables_{i,t} + \varepsilon_{i,t}$$

GL in the above equation shows green logistics, FD is the financial development index, and as the control variables, TO is Trade Openness, FDI is foreign direct investments, and the error term is given by ε.

3.3. Sample and Data

The variables used in the study are shown in Table 2. The list of OECD countries is shown in Table 3.

Table 2. Variables

Symbol	Variables	Definition	Source
GL	Green Logistics	Green logistics performance as a total GDP ratio of CO_2 emissions from the transportation sector	Climate watch
FD	Financial Development	Financial Development Index	International Financial Statistics (IFS)
FDI	Foreign Direct Investments	Foreign direct investments, net inflows (% of GDP)	World Bank
TO	Trade Openness	The ratio of total international trade to GDP	World Bank

Table 3. OECD Countries

Symbol	Country	Symbol	Country	Symbol	Country
USA	United States	CHL	Chile	TUR	Türkiye
JPN	Japan	AUT	Austria	ESP	Spain
CAN	Canada	BEL	Belgium	POL	Poland
DEU	Germany	CZE	Czech Republic	NLD	Netherlands
FRA	France	ISR	Israel	SVN	Slovenia
MEX	Mexico	SWE	Sweden	LVA	Latvia
KOR	South Korea	GRC	Greece	EST	Estonia
GBR	United Kingdom	CHE	Switzerland	ISL	Iceland
AUS	Australia	PRT	Portugal	NOR	Norway
ITA	Italy	NZL	New Zealand	DNK	Denmark
IRL	Ireland	HUN	Hungary	FIN	Finland
SVK	Slovakia	LUX	Luxembourg		

4. RESULTS AND DISCUSSION

The descriptive statistics of the variables that were used in this study are presented in Table 4.

Table 4. Descriptive statistics

	LNGL	FDI	FD	TO
Mean	3.301391	5.187125	0.622571	0.940495
Median	2.998229	2.681294	0.652494	0.771209
Maximum	7.499822	234.4663	0.996816	3.778430
Minimum	-0.462035	-117.3747	0.170899	0.195596
SD	1.499641	15.00992	0.194750	0.551604
Skewness	0.226765	5.531552	-0.279193	2.041959
Kurtosis	3.423216	89.38131	2.155974	8.826238
Jarque-Bera	11.78453	231631.7	31.36537	1550.343
Probability	0.002761	0.000000	0.000000	0.000000
Observations	735	733	735	735

As seen in Table 4, the mean value of logarithmic transformed Green Logistics (LNGL) was 3.301, while the mean values of Foreign Direct Investments, Financial Development, and Trade Openness, which were included in the model as independent variables, were 5.18, 0.62, and 0.94, respectively. Additionally, while green logistics, foreign direct investments, and trade openness were skewed to the right, financial development was skewed to the left. It is observed that the Jarque-Bera probability value of all variables was smaller than 0.05. In this case, the hypothesis *"Ho: The series are normally distributed"* was rejected. Since the series in the model did not have a normal distribution, the Spearman Correlation Matrix was created. According to this method, a high level of correlation (r>0.90) between the variables creates a multicollinearity problem (Çokluk et al., 2010).

Table 5. Correlation Matrix

	FDI	FD	TO	RESID01	LNGL
FDI	1.000000				
FD	-0.122469	1.000000			
TO	0.334249	-0.247110	1.000000		
RESID01	0.648300	-0.028462	-0.318368	1.000000	
LNGL	-0.232540	0.443127	-0.650477	0.212623	1.000000

As seen in the correlation matrix shown in Table 5, there were weak and moderate correlations between the variables. Additionally, a weak correlation (0.21) was found between the error term (RESID1) and the variables added to determine whether there was an internality problem in the model. This shows that there was no internality problem between the series. Finally, a Variance Inflation Factor (VIF) analysis was performed for the presence of a multicollinearity problem, and the results are given in Table 6.

Table 6. Multicollinearity Testing Results

Variable	Coefficient Variance	Centered VIF
FDI	1.00E-05	1.111421
FD	0.057442	1.074760
TO	0.008140	1.190110
C	0.037201	NA

If the critical value calculated according to VIF is greater than 10, there may be a problem of multicollinearity (Çokluk et al., 2010). According to the results shown in Table 6, the calculated critical value of the variables in the model was not greater than 10. The Pesaran CD test was used to determine the method to be used for testing the stationarity of the series. These results are shown in Table 7.

Table 7. Cross-Sectional Dependence Test

Variables	Test	Statistic	Prob.
lnGL	Pesaran CD	24.12034	0.0000
FD	Pesaran CD	37.24764	0.0000
TO	Pesaran CD	49.58001	0.0000
FDI	Pesaran CD	14.38072	0.0000
Panel	Pesaran CD	23.82814	0.0000

***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

As seen in Table 7, cross-sectional dependence was determined based on both the model and the variables. Since the probability values calculated on based on both the variables and the model were smaller than the critical value of 0.05, the hypothesis *"H_0: There is no Cross-Sectional Dependence"* was rejected. In other words, there was cross-sectional dependence. In this case, the stationarity of the series was tested with the PANIC test, which is a second-generation unit root test that takes into account cross-sectional dependence. The PANIC unit root test results are shown in Table 8.

Table 8. PANIC Unit Root Test

Variables		Constant		Constant +Trend	
		Level	1st difference	Level	1st difference
LNGL	PCe_Choi	-1.1610	6.6231***	-0.1473	3.1902***
	PCe_MW	56.2631	148.3659***	68.2571	107.7467***
FDI	PCe_Choi	4.2028***	-	4.4288***	-
	PCe_MW	119.7284***	-	122.4023***	-
FD	PCe_Choi	-0.8002	9.6328***	1.1802	5.6582***
	PCe_MW	60.5321	183.9766***	83.9645	136.9490***
TO	PCe_Choi	-0.7088	5.5649***	-0.7377	3.8318***
	PCe_MW	61.6139	135.8443***	61.2713	115.3379***

Note: *PCe_MW:* Maddal and Wu (1999); *PCe_Choi:* Represents statistics proposed by Choi (2001). The maximum number of common factors for the PANIC unit root test is 2, and the delay lengths are 4. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

According to the values seen in Table 8, the probability values calculated for all other series except foreign direct investments (FDI) from both the constant and the constant + trend series at level were greater than the critical value of 0.05. In other words, the hypothesis *"Ho: There is a unit root in the series"* could not be rejected. When the first-order differences of the series were taken, it was determined that the series did not contain unit roots. In the examination of the short- and long-term relationships between the series, the Panel ARDL method, which takes into account different degrees of stationarity in the series, was utilized. The Panel ARDL results are shown in Table 9.

Table 9. Panel ARDL Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long Run Equation				
FDI	0.002214	0.001817	1.218850	0.2239
FD	4.757323	0.282865	16.81833	0.0000
TO	-0.440554	0.042721	-10.31225	0.0000
Short Run Equation				
COINTEQ01	-0.074212	0.071744	-1.034408	0.3019
D(FDI)	0.006032	0.004659	1.294790	0.1965
D(FD)	-0.208354	0.246642	-0.844762	0.3990
D(TO)	0.230610	0.108708	2.121375	0.0348
C	-0.162294	0.202397	-0.801861	0.4233

The results in Table 9 show a statistically significant and positive relationship between green logistics and financial development in the long run, while a negative relationship was found between green logistics and trade openness. On the other hand, no statistically significant relationship was found between foreign direct investments and green logistics. While a one-unit increase in financial development led to an increase of 4.75 units in green logistics, an increase of one unit in trade openness corresponded to a decrease of 0.44 units in green logistics. These results were similar to those reported by Sezer (2023) and Barut et al. (2023). Furthermore, it was determined that green logistics is positively affected by trade openness in the short term compared to the long term.

5. CONCLUSION

Green logistics is a crucial issue due to the increase in environmental problems caused by transportation activities. In this study, the relationship between green logistics and financial development was examined using data from OECD countries covering the period of 2000-2020. In the study, first, the cross-sectional dependence test was performed to determine the method to be used to test the stationarity of the series. According to the results of the cross-sectional dependence test, a second-generation unit root test was applied, and it was determined that the series were not stationary at the same degree. The panel ARDL test was applied for the short- and long-term relationships between the non-stationary series of the same order. According to the panel ARDL test results, while there was a statistically significant and positive long-term relationship between green logistics and financial development, a negative relationship was found between green logistics and trade openness. However, no statistically significant relationship was found between foreign direct investments and green logistics. These results were compatible with the reports of Alshuribi (2017), Agyabeng-Mensah et al., (2020), Mohsin et al. (2022), Sezer (2023) and Barut et al. (2023). The negative relationship between trade openness and green logistics can be interpreted as countries trying to increase their productivity for export products, where this increase causes environmental degradation. Additionally, it can be stated that the increase in trade will increase transportation activities and thus trigger environmental deterioration in transportation channels. Some examples of this issue are fossil fuel-based logistics activities, the technological equipment of the vehicles used in transportation, and the general preference of land transportation in logistics activities. The positive relationship between financial development and green logistics can be interpreted as low credit costs and substantial funds in financing environmentally friendly investment projects on local, national, or regional scales. It is recommended that policymakers direct businesses to produce and use vehicles that operate on clean energy resources rather than fossil fuels and provide financial support for this transformation. Furthermore, it is recommended to pay importance to logistics infrastructure developments, especially to make infrastructure investments by targeting low emissions. Future researchers interested in this topic can evaluate the relationship between financial development and green logistics by examining different country groups, such as developed, developing, and underdeveloped countries. Additionally, researchers can make comparisons between these groups. Comparing different country groups can be helpful in better understanding the impact of financial development on green logistics. This comparison can reveal in which countries green logistics practices are more prevalent and how these are related to financial development. Advanced econometric analyses can be used to explore various dimensions of the relationship between green logistics and financial development. Finally, other macroeconomic or sectoral variables that may influence this relationship can be included in the analysis.

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