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## Article

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## AN EMPIRICAL ASSESSMENT OF THE FINANCIAL DEVELOPMENT – ENVIRONMENTAL QUALITY NEXUS IN THE EUROPEAN UNION

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### Abstract

Our study examines the dynamic relationship between financial development and environmental degradation in the European Union (EU) in a panel VAR (Vector Autoregressive) methodological framework over the period 1996-2018. Panel causality tests and impulse response functions show that financial development contributes to higher carbon emissions, although this effect is stronger in the short run and weaker in the long run. At the same time, financial institutions development is the major contributor to fostering increased environmental degradation instead of financial markets, which points towards an engagement of financial institutions towards offering financial products that led to environmental degradation and/or lagging financial markets in terms of promoting environmentally-related securities and ESG principles. By providing new insights into the relationship between financial development and carbon emissions, we hope to assist EU policymakers and businesses in reconsidering the role of financial development as an effective means of decreasing environmental degradation in the region.

**Keywords:** Financial development, carbon emissions, financial markets, financial institutions, EU, panel VAR, impulse response.

**JEL Classification:** G20, O13, O44

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## Introduction

We have seen alarming changes in climate over the past century, with surface temperatures rising by more than 1.1 degrees Celsius and the amount of carbon dioxide in the atmosphere nearly doubling (UNEP, 2020; IPCC, 2021). This does not come cheaply, and the EU is paving the route to climate neutrality through the European Green Deal. The European Green Deal should be viewed as a road map to support sustainability and create opportunities for development related to environmental challenges. The European Green Deal intends to improve resource efficiency, prevent climate change, reverse biodiversity loss, and reduce pollution by addressing all sectors of the EU economy and creating a clean and circular economy. Equally important, the agreement outlines the necessary investments, as well as the available financing alternatives. As part of the agreement, all 27 EU members committed to being climate neutral by 2050, including a first step of reducing carbon emissions by at least 55% by 2030 (European Commission, 2021). Another key component of the vision of the EU reflected in the “Green agreement” is the decoupling of economic growth from the consumption of natural resources while leaving no one behind during the transition. In addition, the newer “NextGenerationEU” recovery and resilience program aimed at tackling post-pandemic recovery in the EU puts the green economy at its core, along with health and digitalization, and represents a major follow-up of the Green Deal. Furthermore, the recently announced “RePowerEU” strategy makes a strong case for a rapid clean energy transition in EU countries, by focusing on alternative clean energy sources, industry decarbonization, and investing in hydrogen accelerators (European Commission, 2022).

Because we traditionally assess economic growth by increases in actual output, we should expect environmental costs to climb as output and consumption increase. Increasing consumption of nonrenewable resources, increased pollution levels, and the probable loss of environmental ecosystems are only a few of the most evident environmental consequences of the world's economic progress over the last eight decades. The relationship between economic growth, as defined by post-WWII development models, and environmental degradation has been extensively researched in the literature since the early 1990s, with researchers concluding that human-caused climate change and greenhouse gas emissions are amplified when the economy expands. However, further developments of these studies suggested more nuanced approaches and conclusions, one of the most influential being the Environmental Kuznets curve (EKC), which states that pollution levels rise as incomes rise, but the trend reverses above a certain level of income per capital; thus, at high levels of income, economic growth leads to environmental improvement (Stern, 2004).

Subsequently, research covering the link between economic development and financial development has progressed and it showed that carbon emissions tend to be higher in countries with high levels of financial development due to the consumption generated by ever-expanding production lines, ultimately leading to an increased environmental deterioration (Shahbaz et al., 2016; Bui, 2020; Wang et al., 2020).

In this paper, our aim is to enrich the existing body of research exploring the dynamic relationship between environmental degradation and financial development by providing evidence from the EU. We contribute to the literature in the field in several ways. First, we consider financial development and environmental degradation (i.e., carbon dioxide emissions) to be endogenous, and we acknowledge this relationship in a panel vector autoregression (panel VAR) model rather than more traditional panel regressions, to gain insight into the potential bidirectional causality between the two. Second, the time course of

the relationship between financial development and carbon emissions is studied using impulse response functions, which indicate the time route of one variable (financial development and carbon emissions, respectively) as a result of a shock in another variable. As a result of examining the differences in their short-term versus long-term dynamics, we can gain a clearer understanding of the relationship between financial development and environmental degradation. Third, we believe that this is the first paper to assess the dynamic link between environmental degradation and financial development in the EU, using recently adopted IMF-promoted measures that address financial development in all its aspects. As a result, we gain a more detailed understanding of the relative importance of the two components of financial development (markets and institutions) for environmental degradation, which may serve as a starting point for developing policies related to the environment through more targeted financial strategies.

The remainder of the work is organized as follows: The following section summarizes and examines the most important results in the literature; Section 2 presents our research methodology; and Section 3 shows the key results and compares them with other empirical evidence. The final section concludes and discusses the policy implications of our findings, as well as future research avenues.

### **1. Literature review**

The EU's strategy to decouple economic growth from the use (or abuse) of natural resources is evident in the Green Deal and, as outlined above, has been followed up by other measures in the EU encapsulated in "NextGenerationEU" and the newly announced "RePowerEU" programs. There is a growing body of research investigating the links between economic growth, including financial development, and environmental issues. When focusing on Europe, evidence suggesting financial development can, in fact, reduce environmental degradation by allocating significant resources to solutions that lower carbon emissions (Al-Mulali, Ozturk and Lean, 2015; Musa et al., 2015; Cheng et al., 2018; Musa et al., 2021). However, several articles do not find a credible link between the levels of financial development and environmental degradation (Çoban and Topcu, 2013; Bayar and Maxim, 2020).

Dogan and Seker (2016) and Horobeț et al. (2021) found a unidirectional link between economic growth and emissions in Europe, including the EU, which implies that economic growth need not come at the cost of environmental degradation. The latter paper also shows that, in the long term, foreign direct investment along with exports and imports has contributed to reductions in carbon dioxide emissions. This suggests that accelerating EU investments and trade integration are important avenues to improve environmental quality and support the goals expressed by the European Green Deal. In doing so, policymakers should pay close attention to the subsectors of the economy most vulnerable to transition risks. Bulai et al. (2021) show that the EU refining sector appears to be highly vulnerable, with Eastern EU member states particularly exposed to the energy and chemical sectors. However, the results regarding Europe remain mixed and no consensus was reached. For example, Antonakakis, Chatziantoniou, and Filis (2017) suggest the presence of a trade-off between environmental sustainability and economic growth based on their findings of a bidirectional link between the two variables. An explanation could be the Kuznetz curve, which hypothesizes that pollution levels tend to increase alongside income growth, but a

reversal in this trend can be observed beyond a certain level of income per capita, confirmed in numerous studies for countries and regions with different levels of development – see, for example, Charfeddine and Mrabet (2017) for 15 MENA countries, Neagu (2019) for 25 EU countries or Ulucak and Khan (2020) for BRICS economies.

Many research articles associate economic growth and financial development with a reduction in environmental degradation. Cheng et al. (2018) find that economic growth could lead to reductions in carbon dioxide emissions in the EU, both in the long-term and in the short term, suggesting that cooperation on carbon reduction policies and the promotion of green energy is vital. Al-Mulali, Ozturk, and Lean (2015) find that financial development, along with GDP growth and urbanization, increased carbon dioxide emissions in 23 selected European countries in the long run, while trade openness reduced them. Interestingly, Musa et al. (2021) found that financial development and renewable energy positively influence environmental performance in the EU, suggesting that both financial stability and a transition to renewable energy are required to improve environmental performance.

At the same time, the existing literature focusing mainly on countries outside Europe shows a negative relationship between financial development and carbon emissions. A possible explanation is that developed financial systems invest in new factories and production lines, which can result in increased levels of carbon emissions leading to a general deterioration of the environment (Bui, 2020). These findings are supported by Wang et al. (2020), which shows that financial development along with globalization could lead to a rise in carbon emissions in G7 countries. Furthermore, Shahbaz et al. (2016) found that the level of development of financial institutions can accentuate the degradation of Pakistan's environment, while the level of development of financial markets does not appear to have an impact on carbon emissions.

However, several articles did not find any relationship between financial development and carbon emissions. For example, the causal analysis of Bayar and Maxim (2020) in 11 post-transition European countries did not reveal a significant relationship between carbon emissions and the development of the financial sector. Furthermore, Çoban and Topcu (2013) assessed the relationship between financial development and energy consumption in the EU Member States and report mixed results depending on both how long countries have been EU members for and on the different measures used to quantify financial development. No significant relationship was reported when measured by the level of development of financial markets, but the newer EU members exhibited a negative relationship between financial institutions' development and energy consumption.

Our article aims to support policy makers in implementing the “European Green Deal” and enrich the existing body of research by analyzing the relationship between financial development and environmental deterioration, measured by the level of carbon dioxide emissions, in Europe. Many proxies for financial development have been used in the existing literature, usually a combination of banking sector and capital markets attributes, without a clear agreement on what might be the ideal choice (Mignamissi, 2021). To help solve this debate (Sahay et al., 2015), the International Monetary Fund (IMF) adopted a multidimensional approach to measuring financial development resulting in the development of several indexes (Svirydzenka, 2016). More specifically, the IMF proposed a combination of *efficiency*, or the ability of institutions to offer financial services at a low cost, while realizing sustainable revenues, *depth*, or the liquidity and overall size of financial markets and *access*, or the ability of both individuals and firms to easily access financial services.

These indicators have since been widely adopted by researchers (Islam et al., 2020). In this paper, we will focus on the Financial Development Index (FDI) and its two key components, the Financial Markets Index (FMI) and the Financial Institutions Index (FII).

Building on the results that the literature has reached so far, but also from the elements of originality that we propose in approaching the dynamic connection between financial development and environmental quality, we formulate the following three hypotheses to test in our research:

H1: The level of financial development has a significant and negative effect on environmental degradation (higher financial development increases carbon emissions).

H2: The level of development of financial markets has a significant and negative effect on environmental degradation (higher financial market development increases carbon emissions).

H3: The level of development of financial institutions has a significant and negative effect on environmental degradation (higher financial institution development increases carbon emissions).

## 2. Research Methods

We investigate the link between environmental degradation and financial development in the EU using an expanded framework that incorporates several key variables that moderate the relationship between the two primary variables of interest. The sample of the study spans all 28 EU member countries between 1996 and 2018. Data for all variables have an annual frequency and were gathered from various sources (see table no. 1).

**Table no. 1. Description of variables**

Variable	Acronym	Definition	Source
CO <sub>2</sub> emissions per capita	CO2CAP	Annual production-based carbon dioxide (CO <sub>2</sub> ) emissions, not accounting for emissions embedded in traded goods, in tonnes per person	Our World in Data
Financial development	FDEV	IMF Financial Development Index that measures the broad level of development of a country's financial markets, considering access, efficiency, and depth	IMF
Financial markets development	FMDEV	IMF Financial Markets Development Index	IMF
Development of financial institutions	FIDEV	IMF Financial Institutions Development Index	IMF
Gross Domestic Product per Capita	GDPC	Annual level of a country's gross domestic product per capita, in current US dollars	World Bank

*Source: Our World in Data, 2020.*

Variables have been selected based on existing contributions to the academic literature and their findings. Carbon emissions per capita is the variable that designates environmental degradation, although other possible variables were considered candidates. However, the existing literature has a clear preference for this variable in studies on environmental degradation and economic and financial issues; see, for example, Ozturk and Acaravci

(2013), Khan, Weili and Khan (2022), to mention only a few papers. The other variables in our model were also frequently employed in the literature that addresses carbon emissions and economic growth and development – see, for example, Deutch (2017), Sheldon (2019) – and the literature that focuses on the driving factors behind financial development – Boutabba (2014).

For what concerns financial development, the literature has advanced many proxies to capture the multiple facets of the phenomenon, typically preferring characteristics of countries’ banking systems, such as deposit size as share of GDP, banking market concentration, dimension of bank assets, bank performance metrics, etc., or focusing on various attributes of capital markets (Mignamissi, 2021). However, the recent publication by the International Monetary Fund of a consistent set of variables that recognizes the access, depth, and efficiency of financial systems as essential attributes of financial development has prompted scholars to use them (Islam et al., 2020; Ejemeyovwi, Osabuohien, and Bowale, 2021). Thus, we follow the same avenue and employ in our study the main three financial development indicators reported by the IMF, i.e., Financial development, Financial markets development, and Financial institutions development. To achieve consistent findings, all variables were translated into their logarithmic form before implementing the econometric model, allowing for an improvement of the model results brought about by transforming the distribution of the variables into one closer to the normal distribution.

The research methodology employed in this paper is a three-step panel Vector Autoregression (VAR) introduced by the works of Sims (1972, 1980) as follows: First, we verify the presence of unit roots in panel series; second, we evidence potential transmission mechanisms between variables with the help of Granger causality; third, we employ impulse response functions to observe the reaction of the variables to potential shocks in the system. We note that auto-regressive dynamic models and VAR, in particular, are among the most used investigation methodologies in economics and finance, due to their ability to seize interdependencies between time series and autocorrelation, which were further extended to panel data – see Brandt and Williams, 2006; Canova and Ciccarelli, 2013). The total number of observations included in our model is 644, resulting from 28 cross-sections (countries) and 23 observations (years) per each.

The panel VAR model takes the form of

$$Y_{it} = \alpha_i + \sum_{j=1}^n \beta_j Y_{i,t-j} + \varepsilon_{it} \tag{1}$$

with  $\alpha_i$  the constant and  $\beta_1$  to  $\beta_k$  are the autoregressive coefficients in a  $N \times N$  dimension matrix.  $\varepsilon_i$  is the error term, normally distributed with a mean of zero and a covariance matrix  $\epsilon$ .  $Y_{it}$  is a multidimensional vector that contains the endogenous variables presented in table no. 1. The base line panel VAR model specifically addresses the main research question of the paper and includes LNCO2CAP, LNFDEV, and LNGDPC to capture the core interdependencies between environmental degradation and financial development, moderated the level of economic development. Following Berdiev and Saunoris (2016), we limit the baseline model to only three variables, given the significant decline in the degrees of freedom that each additional variable adds to the model; hence, the model includes, besides LNCO2CAP and LNFDEV, only LNGDPC, a variable that is a strong contributor to both, as evidenced by the literature and discussed in the previous section. Since the Choleski decomposition employed for impulse responses and variance decomposition requires ordering variables from least to most endogenous so that the first variables in the system have

an effect (contemporaneous and lagged) on the subsequent variables, while the variables that are last ordered have only a lag effect on the preceding ones (Love and Zicchino, 2006), we have imposed a causal ordering as follows: LNGDPC, LNCO2CAP, and LNFDEV.

We verified the series stationarity in the panel framework using Levin-Lin-Chu, Im-Pesaran-Shin, ADF-Fisher and PP-Fisher techniques (Bai and Ng, 2010). Stationarity is a prerequisite for implementing VAR models in their unrestricted form. We chose the Dumitrescu-Hurlin test (Dumitrescu and Hurlin, 2012) to test the Granger causality between variables because it considers differences between the regression coefficients in the bivariate regressions generated from conducting the test, which is a better approach than the classic Granger causality test, which assumes that coefficients are identical across all cross sections. The number of lags in the panel VAR models has been determined using the Schwartz Information Criterion (SIC), and the impulse response functions have been implemented using Choleski one-standard deviation innovations, adjusted to degrees of freedom and  $\pm 2$  standard errors estimated using 1000 Monte Carlo iterations. For impulse functions, we analyse the nature, size, and statistical significance of responses of carbon emissions to shocks in financial development, over the short and long run, but we pay attention to the other interdependencies between the variables included in the VAR system.

### 3. Results and discussion

Table no. 2 shows brief descriptive statistics of all variables. For EU countries, we note the great diversity of all variables for the analyzed period and the asymmetric and slightly leptokurtic distributions, indicated by non-zero skewness and kurtosis around 3 (with a value higher than 4.7 for LNFIDEV). Therefore, the Jarque-Bera normality test shows that the variables are not normally distributed, but normality is not required to implement the VAR model.

**Table no. 2. Descriptive statistics of variables**

	LNGDPC	LNCO2CAP	LNFDEV	LNFMDEV	LNFIDEV
Mean	9.898	1.968	-0.694	-1.168	-0.501
Median	10.046	1.989	-0.566	-0.804	-0.415
Maximum	11.724	3.245	-0.056	-0.048	-0.057
Minimum	7.216	1.074	-2.213	-4.081	-1.898
Std. Dev.	0.863	0.405	0.455	1.044	0.321
Skewness	-0.711	0.250	-0.925	-1.253	-1.175
Kurtosis	3.334	3.138	3.069	3.318	4.700
Jarque-Bera	57.111	7.181	91.731	170.740	225.161
Probability	0.000	0.028	0.000	0.000	0.000

Stationarity is a prerequisite for the implementation of VAR models in their unrestricted form, and we tested for its presence by performing panel unit root tests. The results of these tests are presented in table no. 3. They indicate that LNCO2CAP and LNGDPC are I(1), while the three variables describing financial development were indicated as I(0). Thus, LNCO2CAP and LNGDPC are nonstationary in level, but stationary in the first difference, while the variables that capture the financial development – LNFDEV, LNFMDEV and LNFIDEV are stationary in level. Therefore, we implemented the VAR model in the first differences of all variables.



**Table no. 3. Panel unit root tests results**

Variable	Levin, Lin, and Chu		Im, Pesaran, and Shin		ADF–Fisher		PP–Fisher		Level of integration
	Level	First Difference	Level	First Difference	Level	First Difference	Level	First Difference	
LNGDPC	-2.165*	-13.140*	2.847	-10.208*	20.400	200.56*	20.855	197.27*	I(1)
LNCO2CAP	1.384	-19.167*	3.091	-18.724*	38.924	381.17*	38.267	453.70*	I(1)
LNFDEV	-12.335*	-19.538*	-10.863*	-18.928*	237.12*	385.60*	307.51*	648.17*	I(0)
LMDEV	-21.637*	-25.258*	-16.828*	-22.972*	536.051*	533.24*	585.97*	793.88*	I(0)
LFIDEV	-4.892*	-17.830*	-2.090*	-16.702*	89.990*	337.41*	90.83*	371.89*	I(0)

Note: All tests included an intercept. \* denotes statistical significance at the 5% level. The null hypothesis for all tests is that the series have a unit root.

The Dumitrescu–Hurlin causality test shows that the variables in our panel are connected through unidirectional and bidirectional links (table no. 4). Of particular interest is the bidirectional Granger causation between carbon emissions and financial development, which suggests a mutual reinforcement between the two, especially through the financial institutions channel, which motivates our research. The Granger causality between financial development and carbon emissions has been advanced by other scholars; see, for example, Boutabba (2014), Cetin, Ecevit and Yucl (2018). Moreover, the results confirm the bidirectional causality between GDP per capita and financial development, in all forms of the latter. The strong position of the institutional channel confirms previous findings in the literature that show the importance of sound institutions for financial development (Demetriades and Law, 2006; Huang, 2010). These results demonstrate the robust links between our variables in the EU framework and validate the research questions and our panel models.

**Table no. 4. Results of the panel causality test**

	LNGDPC	LNCO2CAP	LNFDEV	LNFMDEV	LNFIDEV
LNGDPC	--	8.834*	5.648*	2.133**	14.471*
LNCO2CAP	2.817*	--	4.636*	0.240	7.663*
LNFDEV	1.735	6.050*	--	--	--
LNFMDEV	1.338	3.248*	--	--	--
LNFIDEV	4.324*	6.319*	--	--	--
LNTRADEOP	-1.214	4.324*	3.665*	0.584	3.094*
LNINFRS	11.820*	4.173*	5.939*	4.108*	13.295*

Note: The table reports the values of the Z-bar statistic for the Dumitrescu–Hurlin causality panel test. Null Hypothesis: Variable on the line does not cause variable on the column in Granger sense. \* and \*\* denote statistical significance at 1% and 5%, respectively, and indicate the presence of Granger causality between the two variables.

Table no. 5 shows the results of the panel VAR estimation for the baseline model. Also, figure no. 1 presents the impulse response functions for the baseline model. In the figure, the solid line shows the impulse response of each variable (one at a time) to a shock of one standard deviation in another variable in the system. The dashed lines indicate the 95% confidence intervals calculated using 1000 Monte Carlo simulations. Since our variables of interest are carbon emissions and financial development, we first address the results in their case. The response of carbon emissions to shocks in financial development is positive and significant. Explicitly, a one standard deviation shock in financial development increases carbon emissions by about 5.5% in the first year, although this decline in rather quickly

corrected until year six. This supports our hypothesis that financial development leads to higher carbon emissions, but we note that the connection between the two variables is important in the first three years and diminishes over time toward zero, albeit it remains statistically significant. It is worth mentioning that the adjusted R-square values are quite low (the highest value is recorded in the case of LNGDPC as a dependent variable, 0.242), which leads to the idea that the variation of a given variable is not largely explained by the variation of the other variables included in the model. However, our interest was to observe the impact of variations (shocks) in the three variables on the shocks of the other variables in the VAR model – especially in the case of financial development and carbon emissions – and to check their statistical significance. Or, our results show that there is a statistically positive and significant carbon emissions response to financial development shocks, but also a similar GDP per capita response to financial development shocks. These findings match other contributions in the literature that observed the increased impact on environmental degradation that financial development had in the case of emerging economies (Sadorsky, 2010), China (Zhang, 2011), Greece (Işık, Kasımatı, and Ongan, 2017) or South-East Asia (Tahir et al., 2021).

**Table no. 5. Results of baseline model**

	LNGDPC	LNCO2CAP	LNDFDEV
LNGDPC (t-1)	0.286*	-0.064*	0.038
LNGDPC (t-2)	-0.092*	0.001	0.128*
LNCO2CAP (t-1)	0.418*	-0.026	0.097
LNCO2CAP (t-2)	0.072	0.004	0.001
LNDFDEV (t-1)	0.255*	0.102*	-0.029
LNDFDEV (t-2)	-0.099	-0.028	-0.088*
Adjusted R-squared	0.242	0.020	0.066
F-statistic	26.442	2.622	6.643
S.E. of equation	0.090	0.059	0.065

We also note that financial development is a contributor to economic development – a one standard deviation shock in financial development leads to a 1.6% growth in GDP per capita after the second year, but the reverse relationship between the two is also observable (a one standard deviation in LNDFDEV leads to a 1% increase in GDP per capita in the first year before diminishing over time). Hence, the bidirectional link between financial development and economic development evidenced in the existing literature is supported by our findings. These results are a natural reflection of the economic development of the EU in the past decades that has been strongly propelled by market integration, including financial market integration, which led to the progress of all financial markets and institutions for member countries. Moreover, they are in line with substantial contributions in the literature that argues the role of financial development as a trigger of economic development particularly in the early stages of development – see, for example, Levine (1997), Ferreira (2017) – through increased opportunities for borrowing and investing, higher efficiency in capital allocation or reduced cost of capital, but also through institutional development, improved governance, and fostering macroeconomic discipline. This view of the financial development – economic development relationship, or the “supply-leading hypothesis” is accompanied in the literature by the opposite approach, of the “demand-leading hypothesis”, which argues that economic growth acts as a promoter of financial development, fostered by the increased demand for financial products and instruments (Demetriades and Hussein, 1996; Shan, 2005).

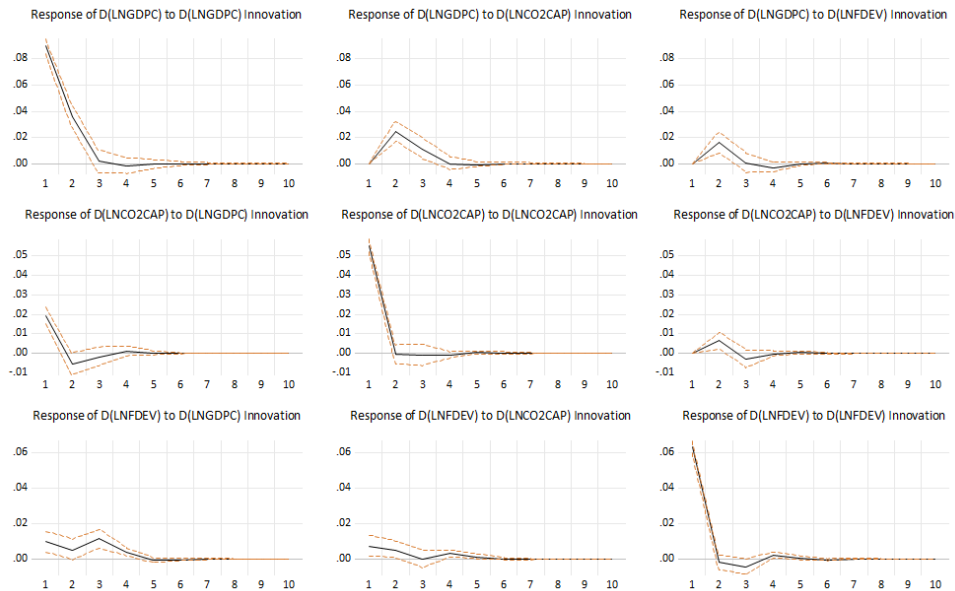
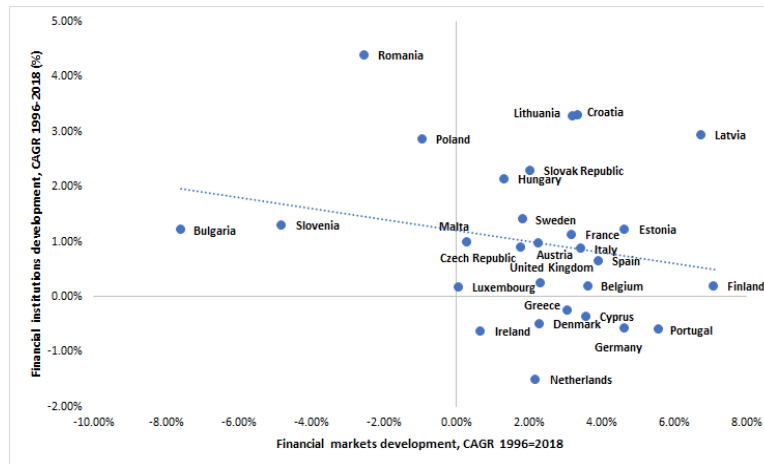


Figure no. 1. Impulse response functions – Model 1

Interestingly, shocks in carbon emissions do not lead to significant changes in financial development, but they do have an impact on GDP per capita: GDP per capita increases by 2% after two years after one standard deviation shock in carbon emissions. The reverse is also true: Standard deviation shocks in GDP per capita lead to a 2% increase in carbon emissions in the first year, but further shocks in GDP per capita negatively impact environmental degradation. Our findings confirm the studies of Jorgenson and Clark (2012) and Muhammad (2019), but also that CO2 emissions and economic growth were mutually reinforcing, given the intensive use of fossil fuels in the growth model after WWII.

When exploring the characteristics of financial development in the EU, several observations are worth considering. First, at the group level (i.e., all EU countries), financial development was increasing at a CAGR of 1.37%, as indicated by the median FDEV between 1996 and 2018, which means that EU countries have improved their financial component of the economy during this time frame. Second, despite a growth in the median FDEV, three EU countries (Bulgaria, Ireland, and Slovenia) have seen their overall financial development declining at CAGR between -0.04% (Ireland) and -0.67% (Bulgaria). Third, financial development in EU countries was triggered, in most of the cases (19 countries), by financial markets development (FMDEV had a higher CAGR than FIDEV between 1996 and 2018), while the development of financial institutions was the main catalyst behind financial development (FIDEV had a higher CAGR than FMDEV) in the case of ten countries. Fourth, Central and Eastern European countries have made more progress in terms of financial development between 1996 and 2018 than the more developed EU countries (median FDEV increased by 1.91% in the former case against 1.20% for the latter), but due to the more rapid improvement in financial institutions than in financial markets (median FIDEV increased by 2.57% for CEE countries and only by 0.18% for the more developed EU countries, while median FMDEV went up by 1.69% for CEE countries against 2.71% for western EU countries) – see figure no. 2. This increased improvement in financial institutions in the CEE

region can be easily explained by the need for these economies engaged in a development process to consolidate first their institutions that will further support the expansion and growth of financial instruments and markets.



**Figure no. 2. Development of financial institutions and financial markets in the EU, 1996-2018**

*Data sources: International Monetary Fund*

To capture the potentially divergent impact of the two components of financial development on carbon emissions in EU countries, as indicated by Zhang (2011), we implement two supplementary VAR models in which LNFDEV is replaced by LNFMDEV and LNFIDEV, respectively. The results are reported in table no. 6 and the cumulative impulse response functions are presented in figure no. 3.

**Table no. 6. Results of Models 2 and 3**

	Model 2			Model 3		
	LNGDPC	LNCO2CAP	LNFMDEV	LNGDPC	LNCO2CAP	LNFIDEV
LNGDPC (t-1)	0.292*	-0.061*	-0.088	0.273*	-0.063*	0.072*
LNGDPC (t-2)	-0.077	0.008	0.074	-0.137*	-0.013	0.103*
LNCO2CAP (t-1)	0.437*	-0.016	0.322*	0.402*	-0.024	0.036
LNCO2CAP (t-2)	0.071	0.003	0.173	0.402*	-0.025*	0.036
LNFMDEV (t-1)	0.044*	0.021	-0.227*			
LNFMDEV (t-2)	-0.033	-0.010	-0.249*			
LNFIDEV (t-1)				0.481*	0.187*	0.052
LNFIDEV (t-2)				-0.021	-0.043	0.032
Adjusted R-squared	0.226	0.014	0.095	0.264	0.031	0.200
F-statistic	24.217	2.113	9.389	29.540	3.547	20.933
S.E. of equation	0.091	0.059	0.211	0.089	0.058	0.045

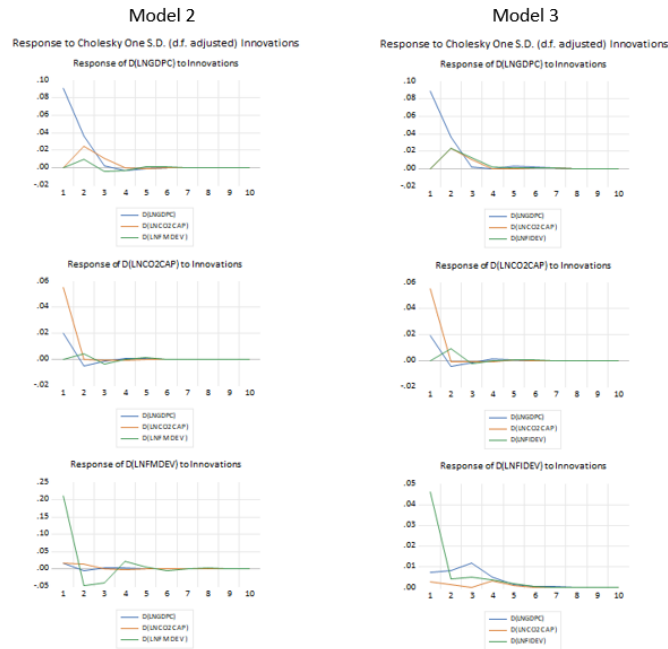


Figure no. 3. Impulse response functions for Models 2 and 3

Our results show that financial institutions, as opposed to financial markets, are the factor that significantly impacts carbon emissions in EU – a one standard deviation shock in EU – a one standard deviation shock in LNFIDEV leads to a 1% increase in CO2 emissions per capita after 2 years, although the effect vanishes after year four – while financial markets development has no significant impact on carbon emissions. On the other hand, the impact of LNFIDEV is positive, indicating that more developed institutions have not led to declines in carbon emissions, as expected, but in the contrary. This could be explained by a majority of bank-based financial systems in the EU when linked to the findings of Shahbaz et al. (2016), who find that only these types of systems lead to higher carbon emissions. However, the previous links between financial development and economic growth are confirmed by Models 2 and 3, as both financial development components positively impact economic growth, although the impact is greater in the case of financial institutions. Similar to the results reported in table no. 5, we find fairly low adjusted R-square values – also with higher values in the case of LNGDPC as a dependent variable –, which confirms that the variation of variables is not largely explained by the variation of the other two variables. However, our interest was in studying the impact of changes over time on each other, and the results show that there is a positive and statistically significant impact on the development of financial markets and financial institutions on both per capita GDP and carbon emissions.

Finally, as a robustness test, we estimated supplemental VAR models with the same variables but different ordering to ensure that the ordering of the variables employed in all three models had no effect on our results. The findings reveal that, similar to Models 1-3, financial development has increased carbon emissions in the EU while also promoting economic

growth. Furthermore, the development of financial institutions, rather than the expansion of financial markets, remains the primary source of growing carbon emissions in the EU. Hence, our results are not sensitive to the ordering constraints we imposed on the VAR system.

## **Conclusions**

Our study employs panel data for the 28 EU member countries between 1996 and 2018 to examine the dynamic relationship between financial development and environmental quality (the latter included in the model as carbon emissions), using an approach that treats the variables, alongside Gross Domestic Product per capita, as endogenous and allows for an investigation of the changes in this relationship over time.

The panel causality tests, panel VAR, and impulse response functions clearly show that financial development contributes to higher carbon emissions in the EU, although this effect is stronger in the short run and weaker in the long run. Furthermore, the most interesting outcome of our research refers to the greater importance of financial institutions development in fostering increased environmental degradation instead of financial markets. This may point, on the one hand, on the flourishing of institutions that engaged in offering financial products and instruments that led to environmental degradation both for households and the business sector, such as loans for purchasing polluting cars and nonenvironmentally friendly homes, and for investments in polluting industries. But, on the other hand, this may also suggest that financial markets in the EU are lagging in terms of promoting securities related to environmental issues, such as green bonds, and principles that are potential transformers of business models, such as ESG (Environmental, Social, and Governance).

The results we have reached are limited by the data set used and the econometric model implemented. The period selected for the study, 1996-2018, is long enough to generate statistically significant results, but was also marked by the global economic and financial crisis of 2007-2010, followed by the sovereign debt crisis in the European Union (2012-2014), which could influence the results. However, we consider that the VAR model manages to capture well the particularities of these subperiods, through the dynamic analysis of the links between carbon emissions and financial development, mediated by the level of GDP per capita. A future direction of research could be, in context, the use of a structural VAR to take into account possible structural breaks in the data series. Future research directions may also consider studying the effects of globalization, including financial globalization, on carbon emissions, but also investigating the connection between financial development and environmental quality by using different tools to assess the latter, such as the degree of use of renewable energy or the intensity of carbon emissions.

We expect that by providing new insights into the relationship between financial development and carbon emissions, we may assist EU policymakers and businesses in reconsidering the role of financial development as an effective means of decreasing environmental degradation. Several measures, in our opinion, could be carried out to enable this strategy. First, we support the creation of innovative financial instruments that can aid mitigate the environmental impact of polluting industries and behaviours with financial markets serving as the proper route to achieve environmental sustainability. Second, policymakers should better regulate (and even tax) the operations of financial institutions in order to prevent the financing of environmentally damaging activities while also encouraging investments in green initiatives and businesses and the development of non-fossil alternative

energy sources. Third, EU countries must recognize that their goal of becoming the first climate-neutral region by 2050 will necessitate significant effort from all economic agents and countries, but this effort can be eased by understanding the nexus of relationships between environmental degradation, economic growth, energy types used, financial development, economic integration, and so on. In this framework, we want to continue this research to obtain insight into the influence that financial development and its features have on the environment in various regions and continents, as well as to better understand its connections with other environmental channels.

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