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Article

# Influence of financial development on environmental quality—Evidence from countries of the European Union

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**Abstract:** This research paper aims to examine the association between financial development and environmental quality in 31 European Union (EU) countries from 2001 to 2020. This study proposed an estimation model for the study by combining regression models. The regression model has a dependent variable, carbon emissions, and five independent variables, including Urbanization (URB), Total population (POP), Gross domestic product (GDP), Credit to the private sector (FDB), and Foreign direct investment (FDI). This research used regression methods such as the Fixed Effects Model, Random Effects Model, and Feasible generalized least squaresThe findings reveal that URB, POP, and GDP positively impact carbon emissions in EU countries, whereas the FDB variable exhibits a contrary effect. The remaining variable, FDI, is not statistically significant. In response to these findings, we advocate for adopting transformative green solutions that aim to enhance the quality of health, society, and the environment, offering comprehensive strategies to address Europe's environmental challenges and pave the way for a sustainable future.

**Keywords:** financial development; carbon emission; economic growth

## 1. Introduction

Over the past two decades, the relationship between financial development and environmental quality has received attention from researchers and policymakers (Bayar et al., 2020). Although humanity has made progress in promoting economic growth, social and sustainable development issues such as poverty, inequality and environmental pollution have not been resolved satisfactorily, and the situation is even more complicated (Uzar, 2020). While the rapidly developing financial system has helped the world economy recover from the 2008 recession (Durusu-Ciftci et al., 2017), governments are starting to pay attention to the positive and negative effects of financial development towards sustainable development goals. If the growth of the financial system leads to a decline in environmental quality, policymakers will face achoice between promoting economic growth and protecting the environment.

Most empirical studies investigating the link between financial markets and environmental quality primarily utilize carbon emission variables as a measure of environmental impact. These studies have explored various aspects of this relationship. For instance, Farabi and Abdullah (2020) examined the effects of energy use, economic expansion, population increase, and foreign direct investment on $CO_2$ emissions in Indonesia and Malaysia. Uçak et al. (2015) analyzed the relationship between per capita income and $CO_2$ emissions in high-income nations. Hao et al. (2016) discovered a U-shaped pattern between financial development and carbon emissions. Levine et al. (2018) focused on the impact of financing restrictions on corporate pollution. Additionally, recent studies by Saud et al. (2019) and Ahmad et al. (2019)

have found nonlinear or weak relationships between financial development and environmental quality. It is important to note that these studies present mixed results across different countries.

In a report assessing the impact of the environment on human health, the European Environmental Agency (EEA) said that 13% of deaths in the "old continent" are due to environmental pollution, through which the EEA urge green solutions to this problem. The 8 September 2020, report emphasized that Europe's environmental quality plays a decisive role in the health of people on this continent. According to the above report, air pollution is the leading environmental factor, causing about 400,000 premature deaths yearly in the European Union (EU).

The EU's response to financial development and environmental quality involves significant initiatives, notably the 2019 European Green Deal (EGD). The EGD, introduced by the European Commission, aims to combat climate change until 2050 through comprehensive policies. Redirecting spending from polluting activities, as the Rousseau Institute advocates, funds projects aligning with a carbon-neutral economy transition. Additionally, state funding programs from France and Germany support EU transition efforts. The European Investment Fund facilitates financing for Small and Medium Enterprises (SMEs), prioritizing climate action and environmental policies showcasing the EU's commitment to sustainability. In 2023, the European Investment Bank (EIB) signed new financing contracts worth nearly €88 billion for high-impact projects prioritising EU policy areas such as climate action and the environment.

There are two opposing arguments about the impact of financial development on environmental quality. The first argument is that financial development reduces environmental quality because financial development encourages production and consumption activities. These activities consume energy input materials and emit emissions into the environment. The second argument analyzes the positive role of financial development on environmental quality through financial intermediaries promoting financing activities for environmentally friendly technologies and projects. Although many empirical studies have used different data and methods, there has not been a general and consistent conclusion on the relationship between financial development and environmental quality. This paper uses panel data regression models to test the relationship between financial development and environmental quality of 31 European Union countries from 2001 to 2020. The study results will be supplemented with empirical evidence on financial development factors that impact the environment in the European region. Thereby, we will have a more general overview of how financial development impacts environmental quality for each region. Based on the results of the, we proposes green solutions as a "cure" for Europe's environmental problems, such as solutions to improve the quality of all three factors: health, society and environment.

## 2. Literature review

Finance is the movement of financial resources, monetary capital and the monetary funds of subjects in society (Gitman, 1997). Thereby, finance can be understood as a system of economic relationships in the distribution of total social product in the form of value among economic subjects through the creation and use of monetary funds. There are many different concepts and understandings of financial development in the world. First, one of the foundations of financial development is financial repression, which was first introduced by Shaw (1973) and McKinnon (1973). Financial repression assumes that the government will use policies on the financial system (through interest rates, required reserves, credit controls, etc.) to influence the economy. However, this may slow down financial development, and financial repression is often evident in developing countries. Second, Financial development implies improving the scale and efficiency of financial institutions (banks, finance companies, insurance companies, etc.) and financial markets (Zaman and associates, 2012). Third, financial development can be understood as part of private sector development to stimulate economic growth and reduce poverty. Financial development includes the development of financial institutions and financial markets to reduce transaction costs. Therefore, financial development is a combination of in-depth development, accessibility, and efficiency of financial institutions and financial markets (Svirydzenka, 2016).

Financial development can degrade environmental quality through different channels. The first channel exerts influence by providing financial resources to businesses, encouraging businesses to invest in factories, machinery and materials. This investment increases energy consumption and environmental emissions (Jiang and Ma, 2019). In addition, development finance encourages the establishment and operation of small businesses. These businesses rarely comply with environmental regulations while enjoying few benefits from applying environmentally friendly technologies (compared to large businesses), so the consequences of developing financial, environmental impact can be further increased (Yuxiang and Chen, 2011). The impact through this channel is called the capitalization effect.

The second channel promotes influence through technology (technology effect). For most businesses, investing in research, development and technology upgrades is costly, time-consuming and risky. Although the financial system can mitigate these problems through its basic functions, financing new technologies can create negative environmental impacts. According to Pata et al. (2021), technological development puts great pressure on natural resources and releases more emissions into the environment (rebound effect).

In the third channel, financial development promotes economic growth and increases people’s income. As income increases, people consume more and tend to save less energy, causing environmental quality to be negatively affected (Jiang and Ma, 2019). In addition, financial development tends to encourage people to borrow and consume more due to increased income. The impact through this channel is called the income effect and wealth effect.

On the other hand, financial development also positively affects environmental quality. First, when the financial market develops, businesses will be provided capital at more appropriate costs for projects and investment plans with more protective or environmentally friendly elements. When applying new environmentally friendly technologies, large-scale enterprises will achieve economies of scale (Shahbaz et al., 2018). In a country with a developed system of enterprises, the negative effects of capitalization effects can be minimized or reversed. As for technological impact, funding research and development activities and technology upgrades, financial development makes it easier for environmentally friendly projects and products to become a reality and bring them into real life (Zakarias and Bibi, 2019). Increased income and wealth can also positively impact environmental quality by raising people's environmental awareness, encouraging them to eliminate environmentally friendly products or contain ingredients that pollute the environment during production and consumption (Lahiani, 2020). Finally, developed financial markets can make government environmental regulations more easily implemented by applying government regulations to credit and investment practices ( Shahbaz et al., 2018).

Data on several national indicators related to the development transition for a sample of industrialized and developing nations from 1965 to 1987 were used by Parikh and Shukla (1995). The study focuses on the correlation between urbanization economic expansion rates and global carbon emissions. The author demonstrates that the urbanization and economic expansion rates favour overall $CO_2$ consumption by using a fixed effects regression model.

In Indonesia and Malaysia, Farabi and Abdullah (2020) examined the effects of energy use, economic expansion, population increase, and foreign direct investment (FDI) on $CO_2$ emissions. The most extensive and recent annual data from the years 1960 to 2018 were used in this analysis. The ordinary least square method is used, followed by the unit root test and the traditional assumption test. The findings indicate that all forms of energy use and other factors like real GDP, urbanization, population, and trade openness have a beneficial impact on $CO_2$ emissions.

Uçak et al. (2015) research examines the per capita income and $CO_2$ emissions of 20 high-income nations from 1961 to 2004. It demonstrates a positive association between carbon dioxide ($CO_2$) emissions and gross domestic product (GDP). Except for Norway, it also seems that there is a positive relationship between GDP and $CO_2$.

Hao et al. (2016) demonstrate that the correlation between financial development and carbon emissions exhibits a U-shaped pattern. The study finds that as financial depth increases, so do carbon emissions, whereas improved financial efficiency is associated with a decrease in carbon emissions. These findings align with the research conducted by Charfeddine and Khediri (2016), who also confirm the existence of an inverted U-shaped relationship between financial development and carbon emissions. Levine et al. (2018) examined how financing restrictions on businesses affected their emissions of harmful air pollutants. The authors develop measures of the extent to which banks in non-shale counties, that is, counties where shale was not discovered, receive liquidity shocks through their branches in shale counties, and the extent to which a corporation in a non-shale county has a relationship lender that receives liquidity shocks through its branches, by taking advantage of cross-country. These cross-time shale discoveries produced liquidity windfalls at local bank branches. They find that favourable shocks to credit conditions lower corporate pollution at both the county and firm levels.

The novel strategy in Görg and Strobl's (2005) research was determining whether worker mobility results in spillovers. The authors compared firm-level productivity to data on whether or not a domestic company's owner had prior experience working for a multinational. According to the findings, domestic enterprises are less productive than owners who previously worked for international corporations in the same sector.

Based on extensive theoretical and empirical research, it is widely acknowledged that economic development can have both positive and negative implications for environmental quality. However, the specific nature of this relationship is contingent upon the level of economic development. Despite this subject's importance, few studies specifically explore financial development's impact on environmental quality. Thus, the primary objective of this study is to bridge this research gap by examining the relationship between these variables within a sample of 31 European countries for 20 years. Including this large and diverse sample of developed countries and the extended time period allows for more comprehensive and generalizable conclusions compared to previous studies.

## 3. Models

This study uses panel data from 31 European Union (EU) countries to ensure the sample is large enough and the regression is meaningful. The selection of these particular countries from the period of 2001 to 2020 for investigating the relationship between financial development and environmental quality is driven by compelling reasons. These countries have experienced significant economic growth, making them particularly relevant for studying the resulting environmental impacts. Gaining a deeper understanding of this connection provides policymakers with valuable insights that can inform the development of sustainable strategies. By studying this relationship, we can identify areas where intervention and policy formulation are needed, ensuring that economic growth aligns harmoniously with efforts to preserve the environment.

The author has inherited the background theories and fully inherited the Granda (2019) model, along with an expansion of the research model with several independent variables selected from the research by Acheampong (2019). The studies have analyzed the impacts of macro factors on environmental quality, which is completely consistent with the original research purposes set out by the author. To express the meaning of the research results by the estimation model and based on previous related studies, all variables will be converted to natural logarithms with base e. In logarithmic form, all variables are elastic. Therefore, the size of the influence of one variable on another variable will be known. The research model is presented as follows::

$$LnCO_{2\,i,t} = \beta_1 + \beta_2 LnURB_{i,t} + \beta_3 LnPOP_{i,t} + \beta_4 LnGDP_{i,t} + \beta_5 LnFDB_{i,t} + \beta_6 LnFDI_{i,t} + \mu_{i,t}$$

In which: $i = 1, 2, \ldots, n$ denotes the EU country included in the study; $t$ represents the study period in years; $\beta 1$ is the blocking coefficient; $\beta 2$ to $\beta 6$ are regression coefficients; $\mu i,t$ is the random error.

### Hypotheses

Urbanization – URB: Parikh and Shukla (1995) have argued that the expanding urbanization process brings more urban population and gives rise to more intensive urban economic activities due to residence, transportation and entertainment, leading to more Carbon emissions. Traffic jams and congestion often occur, increasing travel time and energy. This is consistent with the research of Farabi and Abdullah (2020), who found that when urbanization is high, people will move to cities to work, increasing travel demand for workers. Energy demand for cooling, heating, and powering buildings and public facilities increases. Urbanization can be accompanied by using fossil energy sources such as coal, oil and natural gas to power buildings and industrial activities, creating large carbon emissions (Cole and Neumayer, 2004). Therefore, this increases the need to use oil as the main fuel for transportation, thereby increasing Carbon emissions.

Hypothesis H1: Urbanization rate has a positive impact on carbon emissions.

Total population—POP: Farabi and Abdullah (2020) have argued that high population growth increases Carbon emissions directly and indirectly. Presently, a high population stimulates an increase in carbon emissions through the burning of fossil fuels in the transportation sector and household demand, in addition to the higher demand for transportation to support the movement of people. Indirectly, the population increases carbon emissions through the demand for electrical energy, where power plants use fossil energy as the main fuel. Population growth increases carbon emissions through electricity demand and housing. High population growth is predicted to boost carbon emissions produced by the household sector, particularly in emerging nations like India, China, and Indonesia (Zhang et al., 2016).

Hypothesis H2: Total population has a positive impact on carbon emissions.

Economic growth rate—GDP: Uçak et al. (2015) argue that when the economy grows, companies also promote business activities. As a result, they emit more CO2 emissions and increase domestic production. Manufacturing is one of the industries that Fauzel (2017) claims contributes to increased environmental harm in emerging nations. Additionally, this leads enterprises and firms to construct additional factories, which results in emissions and an increase in carbon emissions.

Hypothesis H3: Economic growth has a positive impact on carbon emissions.

Credit to the private sector—FDB: Levine et al. (2018) believe that financial institutions can reduce carbon emissions in the economy through domestic credits provided to the private sector. Chen et al. (2019) also supported this view, stating that financial institutions have begun to show interest in environmental protection by transferring a significant proportion of their credits to companies that demonstrate higher environmental protection or to companies that comply with environmental protection condition standards using a postal questionnaire survey, Thompson and Cowton (2004) looked at the connection between bank lending and the requirement for environmental disclosure. The research's findings support banks' interest in environmental conservation, but they are still limited.

Hypothesis H4: Credit to the private sector has a negative impact on Carbon emissions.

Foreign direct investment—FDI: Görg and Strobl (2005) argue that large multinational companies have more advanced and environmentally friendly technologies, and when they invest, they will deploy them. These technologies in the host country make environmental quality more positive. This research result is consistent with Granda's (2019) study, which found that the foreign direct investment (FDI) factor has a positive and significant relationship with carbon emissions.

However, multinational corporations tend to invest in nations with lax environmental standards, which is bad for the environment. Cole and Elliott (2005) contend that this will make it simpler for people to employ the least expensive technology and fuel without having to think about how it would affect the environment, which will have a detrimental effect on environmental quality. Evidence that international multinational corporations are moving their industries from rich nations with rigorous environmental protection legislation to developing countries has been supported by Copeland and Taylor (2004). Environmental protection laws are lax in developing nations.

Hypothesis H5: Foreign direct investment has a positive impact on carbon emissions.

**Table 1** provides a descriptive overview of some of the key variables related to economic and environmental factors used to analyze the research data.

**Table 1.** Description of variables.

| Variable | Formula | Unit |
|---|---|---|
| $CO_2$ | Carbon emissions per capita | Tons/person |
| URB | Urbanization | %POP |
| POP | Total population | Person |
| GDP | Gross domestic product per capita | USD/person |
| FDB | Credit to the private sector by banks | %GDP |
| FDI | Foreign Direct Investment | %GDP |

Source: Worldbank.com.

## 4. Results and discussion

**Table 2** shows an overview of the sample data, specifically the carbon emissions data of the EU countries and the factors that are believed to have an impact on their carbon emissions from 2001 to 2020. The number of observations between variables is equal, and the observations of the data are uniform, this makes the research results more reliable.

**Table 2.** Descriptive statistics.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $LnCO_2$ | 620 | 1.8891 | 0.5085 | 0.0553 | 3.2430 |
| LnURB | 620 | 4.2530 | 0.2066 | 3.7480 | 4.5858 |
| LnPOP | 620 | 16.2455 | 1.5038 | 12.5601 | 19.6192 |
| LnGDP | 620 | 9.8297 | 1.1498 | 6.2293 | 11.7254 |
| LnFDB | 620 | 4.1567 | 0.6529 | 1.8247 | 5.7189 |
| LnFDI | 620 | 1.1100 | 1.2267 | −6.5237 | 5.4573 |

Source: Extracted from Stata results.

When using more than one independent variable in a regression model can lead to multicollinearity problems between variables, the author believes the possibility of multicollinearity problems between variables must be overcome before checking to see if the independent variables contribute to the model. Therefore, analyze the correlation matrix to check the correlation between variables and analyze the Variance inflation factor (VIF) coefficient to consider whether the multicollinearity problem appears in the study's regression model.

The results of the correlation matrix show the two-way relationship between independent and dependent variables and between pairs of independent variables. The larger the correlation coefficient, the stronger the relationship between two variables and vice versa, in which a positive coefficient represents a positive relationship between pairs of variables, and a negative coefficient represents an inverse relationship. **Table 3** shows that all independent variables LnURB, LnPOP, LnGDP, LnFDB and LnFDI have a positive correlation with the dependent variable ($LnCO_2$). The results of **Table 3** also show that the variables LnURB and $LnCO_2$ have the strongest correlation with a correlation coefficient of 0.5768. All correlation coefficients are less than 0.8, indicating that multicollinearity does not exist between variables in the model (Farrar and Glauber, 1967).

**Table 3.** Correlation matrix.

| | **$LnCO_2$** | **LnURB** | **LnPOP** | **LnGDP** | **LnFDB** | **LnFDI** |
|---|---|---|---|---|---|---|
| $LnCO_2$ | 1.0000 | | | | | |
| LnURB | 0.5768 | 1.0000 | | | | |
| LnPOP | 0.2241 | 0.1223 | 1.0000 | | | |
| LnGDP | 0.5757 | 0.6854 | 0.0205 | 1.0000 | | |
| LnFDB | 0.3375 | 0.5290 | −0.0139 | 0.7865 | 1.0000 | |
| LnFDI | 0.0433 | −0.0218 | −0.2497 | −0.0211 | −0.0515 | 1.0000 |

Source: Extracted from Stata results.

The author takes an additional step of testing multicollinearity using the variance inflation factor VIF to more accurately check whether or not the model has multicollinearity in the variables.

**Table 4** results show no variables with a VIF coefficient greater than 10, and the average value of VIF is 2.06 < 10. Therefore, it can be concluded that no multicollinearity phenomenon appears in the regression model (Neter et al., 1985).

**Table 4.** Testing for multicollinearity.

| **Variable** | **VIF** | **1/VIF** |
|---|---|---|
| LnGDP | 3.57 | 0.2802 |
| LnFDB | 2.64 | 0.3786 |
| LnURB | 1.93 | 0.5180 |
| LnPOP | 1.1 | 0.9125 |
| LnFDI | 1.07 | 0.9320 |
| Mean VIF | 2.06 | |

Source: Extracted from Stata results.

Next, the author conducts panel data regression using three models: Generalized Least Squares Model (Pooled OLS), Fixed Effects Model (FEM) and Random Effects Model (REM). The regression results of the models retrieved through Stata 16.0 software.

**Table 5** presents the regression results of three different models: Ordinary Least Squares (OLS), Fixed Effects Model (FEM), and Random Effects Model (REM). Here's a breakdown of what each model represents:

**Table 5.** Regression results of OLS, FEM, REM models.

| | **Pooled OLS** | | **FEM** | | **REM** | |
|---|---|---|---|---|---|---|
| | **Coef** | ***P*-value** | **Coef** | ***P*-value** | **Coef** | ***P*-value** |
| LnURB | 0.738*** | [7.31] | −0.837*** | [−4.98] | −0.485** | [−2.50] |
| LnPOP | 0.0663*** | [6.34] | −2.059*** | [−18.18] | −0.178*** | [−3.51] |
| LnGDP | 0.257*** | [10.41] | −0.0442** | [−2.41] | −0.0542** | [−2.37] |
| LnFDB | −0.210*** | [−5.63] | 0.0543*** | [2.65] | 0.0869*** | [3.39] |
| LnFDI | 0.0403*** | [3.18] | 0.0179*** | [3.73] | 0.0218*** | [3.60] |
| _cons | −4.021*** | [−11.37] | 39.09*** | [20.37] | 6.993*** | [6.46] |
| N | 620 | | 620 | | 620 | |
| R-sq | 0.464 | | 0.423 | | 0.215 | |

Note: *, **, *** correspond to statistical significance levels of 10%, 5% and 1%.
Source: Extracted from Stata results.

The regression results from the Pooled OLS model show that all 5 independent variables impact Carbon emissions at the 1% statistical significance level. The variables LnURB, LnPOP, LnGDP, LnFDI affect in the same direction, and the variable LnFDB affects the dependent variable $LnCO_2$ in the opposite direction.

The regression results from the FEM model show that the variables LnURB and LnPOP have opposite effects on the variable $LnCO_2$ at the 1% statistical significance level. The LnGDP variable has a negative impact on the $LnCO_2$ variable at the 5% statistical significance level. The variables LnFDB and LnFDI have the same impact on the dependent variable at the 1% statistical significance level.

The regression results from the REM model show that the LnURB and LnGDP variables have a negative impact on the $LnCO_2$ variable at the 5% statistical significance level. The LnPOP variable has a negative impact on the $LnCO_2$ variable at the 1% statistical significance level. The variables LnFDB and LnFDI have the same impact on the dependent variable at the 1% statistical significance level.

However, estimating the model using the Pooled OLS method does not reflect the separate, country-specific impacts. The author continues to perform the Hausman test to be able to decide to choose between the two models FEM and REM based on the following pair of data hypotheses:

Hypothesis H0: The REM model is more effective for research.

Hypothesis H1: The REM model is more effective for research.

**Table 6** presents the results of a Hausman test, which is a statistical test used to choose between a fixed effects model (FEM) and a random effects model (REM) in panel data analysis:

**Table 6.** Hausman test.

| **Test: Ho: difference in coefficients not systematic** |
|---|
| Chi2(5) = (b-B)’[(V_bV_B)^(-1)](b-B) |
| = 316.62 |
| Prob > chi2 = 0.0000 |

Source: Extracted from Stata results.

Through the Hausman test results, we get the value *P*-Value = 0.0000 < $\alpha$ = 0.05. This means there is a basis to reject hypothesis H0 and accept hypothesis H1 at the 1% significance level. Therefore, the FEM model is a suitable model for the study.

Each model may have its own defects, which greatly reduce the model's reliability. For that reason, after deciding that the FEM model is a suitable model to explain the influence of factors affecting Carbon emissions, the study will conduct a test of the model's defects. FEM regression includes heteroskedasticity and autocorrelation to ensure that the resulting estimates are robust and robust. The author will use the Wald test to determine heteroskedasticity and the Wooldridge test to determine autocorrelation.

**Table 7** presents the results of a Wald test, which is a statistical test used to assess the overall significance of a set of coefficients in a regression model:

**Table 7.** Wald test.

| **Modified Wald test for groupwise heteroskedasticity in fixed effect regression model** |
|---|
| H0: sigma(i)$^2$ = sigma$^2$ for all i |
| chi2 (31) = 6256.42 |
| Prob > chi2 = 0.0000 |

Source: Extracted from Stata results.

*P*-Value = 0.0000 < 0.05 means rejecting hypothesis H0 (H0: The model has uniform error variance) and accepting hypothesis H1 (H1: The model has uniform variance). Therefore, rejecting H0 means that the FEM regression model has heteroskedasticity.

**Table 8** presents the results of a Wooldridge test, which is a statistical test used to detect the presence of serial correlation in the residuals of a regression model. Serial correlation occurs when the error terms in a regression model are correlated across observations:

**Table 8.** Wooldridge test.

| **Wooldridge test for autocorrelation in panel data** |
|---|
| H0: no first-order autocorrelation |
| F(1, 30) = 102.971 |
| Prob > F = 0.0000 |

Source: Extracted from Stata results.

Similar to the Wald test, the Wooldridge test results in *P* value = 0.0000 < 0.05. Therefore, meeting the conditions to reject hypothesis H0 (H0: no first-order autocorrelation) means that the regression model shows autocorrelation.

Based on the results of defect testing, the model has heteroskedasticity and autocorrelation between variables. The author uses the Feasible Generalized Least Squares (FGLS) method to overcome these phenomena, thereby obtaining consistent and highly reliable research results.

The results of **Table 9** show that the P-Value of the FGLS model is 0.0000, less than the 1% significance level, which is the basis for the author to reject hypothesis H0 and accept hypothesis H1. This means that using the FGLS method has overcome the violations of the autocorrelation and heteroskedasticity assumptions for the regression estimation model of the study. The regression results have proven the correlation between the dependent and independent variables. With the dependent variable $LnCO_2$, the results provide evidence that four variables are statistically significant and explain the level of impact on Carbon emissions in EU countries, including LnURB, LnPOP, LnGDP and LnFDB. In particular, the variables LnURB, LnPOP, LnGDP have an impact at the 1% significance level, and the LnFDB variable has statistical significance at the 5% level. In addition, the variable that is not statistically significant is the LnFDI variable.

**Table 9.** FGLS regression.

| **Dependent variable: $LnCO_2$** | | | | | | |
|---|---|---|---|---|---|---|
| **Number of Obs: 620** | | | **Number of groups: 31** | | **Periods: 20 years** | |
| $CO_2$ | Coef. | Std. Err. | z | P > z | [95% Conf. | Interval] |
| URB | 0.4965 | 0.1536 | 3.2300 | 0.0010 | 0.1955 | 0.7975 |
| POP | 0.0994 | 0.0210 | 4.7300 | 0.0000 | 0.0582 | 0.1406 |
| GDP | 0.1062 | 0.0167 | 6.3500 | 0.0000 | 0.0734 | 0.1389 |
| FDB | −0.0381 | 0.0202 | −1.8900 | 0.0590 | −0.0778 | 0.0015 |
| FDI | 0.0007 | 0.0021 | 0.3400 | 0.7310 | −0.0034 | 0.0048 |
| _cons | −2.7395 | 0.6311 | −4.3400 | 0.0000 | −3.9764 | −1.5027 |
| Wald chi2(5) = 112.86 | | | | | | |
| Prob > chi2 = 0.0000 | | | | | | |

Source: Extracted from Stata results.

The coefficient of 0.496 demonstrates a substantial positive correlation between urbanization (URB) and $CO_2$ emissions. Additionally, the coefficient of 0.0994 for the total population (POP) further supports this association in the same direction as urbanization. These findings collectively indicate that the consequences of overpopulation resulting from urbanization can negatively impact environmental quality, ultimately leading to a decline in overall sustainability. Additionally, rapid population growth can cause deforestation, changes in land use and burning of wood for fuel. The findings of this study align with the author's initial expectations and are consistent with the research conducted by Farabi and Abdullah (2020). Notably, coal-based $CO_2$ emissions are primarily influenced by population dynamics due to the significant electricity demand from households, which is fulfilled by coal-based power generation. While population growth is essential for stimulating economic development, it also leads to increased demands for energy, housing, and transportation.Moreover, the urbanization process can give rise to more economic and financial activities, with a large-scale movement of the labour force from rural to urban areas because many jobs are created here. This has increased Carbon emissions due to more oil-consuming vehicles moving around. Urban economic activities such as industrialization can distinctly affect environmental quality. Urbanization allows for economies of scale in production but still requires transportation. Furthermore, the urbanization process also causes businesses to focus on helping reduce the costs of enforcing environmental laws. It may also encourage public transport instead of motor vehicles (Farabi and Abdullah, 2020).

The coefficient of 0.1062 for Gross Domestic Product (GDP) suggests that an increase in GDP is associated with higher $CO_2$ levels, potentially leading to increased pollution. This finding aligns with previous research by Smith et al. (2019), which highlights that as companies and businesses expand their production and scale in response to economic growth, there is a greater likelihood of environmental consequences.According to Uçak et al. (2015), the manufacturing sector is believed to increase environmental damage in developing countries. In addition, this causes companies and businesses to build more factories, emitting emissions and increasing carbon emissions.

The negative coefficient of −0.0381 for Credit to the private sector (FDB) confirms that an increase in credit provided to private firms can lead to a reduction in $CO_2$ levels. This finding supports the research conducted by Levine et al. (2018), which suggests that financial institutions play a crucial role in mitigating a nation's carbon emissions by offering domestic credits to the private sector. By facilitating access to financing, these institutions can encourage adopting sustainable practices and investments that contribute to lower carbon emissions. This finding was also supported by Chen et al. (2019), who noted that financial institutions have started to show interest in environmental protection by allocating a sizable portion of their credit to businesses that exhibit higher environmental protection or adhere to environmental protection conditions standards.

## 5. Conclusion

This study has achieved, specifically: (1) the study has shown factors affecting Carbon emissions in EU countries in the 20 years from 2001 to 2020 including Urbanization (LnURB), Total Population (LnPOP), Economic Growth (GDP), Domestic Credit to the Private Sector by Banks (LnFDB); (2) the study analyzed the influence of these factors on Carbon emissions in EU countries; (3) propose some recommendations based on research results to provide valuable empirical evidence.

For urbanization to have a constructive role in energy conservation and carbon emission reduction, countries must enact market-oriented policies. Governments at the national level may pursue initiatives to impose environmental levies on fossil fuel pricing regulations, advance green technologies, encourage the use of renewable energy sources, and strengthen industrial structures. Countries must implement market-oriented policies for urbanization to contribute positively to energy conservation and reduce carbon emissions.

National governments must regulate population increase to maintain financial and economic growth and reduce environmental harm by cutting emissions. Increase community and individual awareness to support environmental protection legislation. This will boost public demand for environmental quality improvement and protection since raising public knowledge of environmental quality is crucial.

National governments may explore initiatives to enact environmental fees on rules governing the cost of fossil fuels, advance green technologies, promote renewable energy sources, and bolster the industrial structure. Instead of merely emphasizing technology that supports economic expansion, policymakers should concentrate on upgrading production technologies that generate minimal carbon emissions. In addition, it's critical for poor nations to refrain from bringing cutting-edge technologies from wealthy nations in the name of reducing climate change when doing so would instead encourage economic growth and raise carbon emissions. Focus should be placed on economic policy initiatives that encourage investment in new, more energy-efficient technologies that enable the same economic activity while consuming less energy and emitting fewer greenhouse gases.

Banks and other financial institutions should take policy measures to support the inclusion of environmental protection rules or requirements in proposals for loans, investments, risk management, green finance, and limitations on investments in environmentally destructive technologies. Banks and financial institutions may think about offering credit with preferential interest rates to customers buying low-carbon consumer goods like solar-powered equipment or new technologies that help improve the structure of energy consumption, i.e., transition to cleaner energy sources. Customers of financial institutions and banks that employ polluting technology, such as gasoline-powered automobiles, may also be subject to exorbitant interest rates or even be denied credit altogether. Additionally, banks and financial institutions must create policies and plans to be sustainable and fit local and national economic situations. This will raise the bar for environmental protection in credit-related operations. Encourage industries or enterprises to engage in environmentally friendly projects and give credit to those who agree to invest in projects with long-term environmental sustainability at lower interest rates. This might promote economical energy efficiency and sustainable usage.

These findings suggest some recommendations that are helpful for further research and policy experts to decrease environmental degradation. The government should analyze the role of governance structures and policy frameworks in promoting sustainable urbanization practices. Policymakers must develop strategies to manage population growth sustainably. Further research should focus on understanding the relationship between population growth and environmental degradation and identifying effective policy interventions. The government should consider trade-offs between economic development and environmental conservation. Furtheremore, future research investigates the effectiveness of green growth policies, including investment in renewable energy, sustainable infrastructure, and eco-friendly industries. Governors should encourage banks to adopt sustainable financing practices regarding credit to the private sector. This can include providing preferential interest rates for loans related to renewable energy projects, energy-efficient technologies, and environmentally friendly initiatives.

The effect of sustainable funding methods on lowering environmental degradation should be the main topic of future study. These suggestions can direct future investigations and help shape legislative choices to reduce environmental deterioration. Policymakers and scholars can collaborate towards sustainable development and environmental protection by tackling the variables of urbanization, total population, economic growth, and domestic credit.

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