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## Article

# The nexus between economic growth, financial development, trade openness, and CO2 emissions in European countries

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## GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

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# The nexus between economic growth, financial development, trade openness, and CO2 emissions in European countries

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the end of the article

**Abstract:** In this paper, we empirically investigate the causal nexus between economic growth (GDP), CO2 emissions (environmental degradation), financial development, and trade openness using the ordinary least squares technique for a yearly panel data of 40 European economies, during the period of study from 1985 to 2014. To examine this causal link, we utilize the Cobb–Douglas production function. The empirical findings point to a bidirectional Granger causal linkage among GDP and pollution, GDP and financial sector development, GDP and trade openness, financial sector development and trade openness, and trade openness and pollution in the case of European economies. From the causal link between GDP and environmental pollutants, we validate the existence/confirm the validity of the environmental Kuznets curve hypothesis. Also, we confirm/bear out the feedback suggestion of the bidirectional causality among trade openness and financial sector development. Besides, we find the neutrality hypothesis linking carbon emissions and financial sector development inflows. We find the presence of the bidirectional nexus between GDP and financial sector development and among GDP and trade openness in the European economies. Finally, panel causality verifies that bidirectional causal



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### PUBLIC INTEREST STATEMENT

This paper investigates empirically the causal nexus between economic growth, pollution, financial development, and trade openness in the European economies. The empirical findings point to a bidirectional Granger causal linkage among the four indicators GDP, pollution, financial sector development, and trade openness. We validate the existence of the environmental Kuznets curve hypothesis between GDP and environmental pollutants. We confirm out the feedback suggestion of the bidirectional causality among trade openness and financial sector development. We find the neutrality hypothesis linking pollution and financial development inflows. We find the presence of the bidirectional nexus between GDP and financial development and among GDP and trade openness.

connection is found between economic growth, environmental degradation (CO<sub>2</sub>), financial development, and trade openness.

**Subjects:** Energy; Macroeconomics; Development Economics

**Keywords:** economic growth; CO<sub>2</sub> emissions; financial development; trade openness; European economies

**JEL classifications:** C3; F1; G2; O4; Q4; Q5

## 1. Introduction

Over the past two decades, the topic of fundamental link between energy consumption and macroeconomics variables has been examined by many researchers (Fodha & Zaghdoud, 2010; Jamel & Derbali, 2016; Jaunky, 2010; Kahia, Ben Aïssa, & Charfeddine, 2016, 2017; Ozturk & Acaravci, 2010; Saboori, Sulaiman, & Mohd, 2012). Numerous studies have analyzed the causal relationship between energy consumption and several independent variables such as economic growth, financial development, employment, and population (Jamel & Derbali, 2016; Kahia et al., 2016, 2017). Then, energy is considered to be the life line of an economy, the most vital mechanism of socioeconomic development and renowned as one of the most important strategic commodities.

In this alignment, the link between GDP and energy consumption has been investigated empirically by different significant academic researches during the last few decades. Various researchers have been interested in yearly data for several countries by utilizing a diversity of econometric techniques and numerous proxy indicators which have been employed for the causal relationship between CO<sub>2</sub>, energy consumption, and GDP (Apergis & Payne, 2009; Baranzini, Weber, Bareit, & Mathys, 2013; Ghosh, 2010; Stern, 1993; Wolde-Rufael, 2005; Yuan, Zhao, Yu, & Hu, 2007). However, their main empirical conclusions are diverse and have not indicated unique results (Chen, Kuo, & Chen, 2007; Omri, 2014). Farhani, Shahbaz, Sbia, and Chaibi (2014) use the procedure of Granger causality test to empirically examine the link between energy consumption and GDP.

This problem has led some of which recent Granger causality-based studies investigating the causal relations among energy consumption and economic growth to incorporate capital and labor in the multivariate models. Recently, some other studies have incorporated trade openness in the production function in order to investigate the link between economic growth, capital, labor, and trade.

More recently, a few readings have studied the causal association between CO<sub>2</sub> emissions, energy consumption, and GDP. However, these empirical findings have demonstrated mixed results, which make an encouragement for supplementary study to clarify this causal linkage. Numerous recent studies confirm the presence of the relationship among GDP, CO<sub>2</sub> emissions, energy consumption, financial sector development, and trade openness by utilizing numerous econometric method as (1) the structural break unit root test; (2) the co-integration test for long-run linkage among the variables; (3) the ordinary least squares (OLS) technique and the error-correction model for long-run and short-run impacts; (4) the vector error-correction model (VECM) with Granger causality method for causal link; and (5) innovative accounting approach to study the robustness of causality analysis.

In this context, the main idea of this study is to examine empirically the causal relationship between GDP, CO<sub>2</sub> emissions, financial sector development, and trade openness. For the econometric method, we utilize the OLS technique to investigate this nexus for a yearly panel data of 40 European economies during the period of study from 1985 to 2014. The empirical findings indicate the existing of bidirectional causality among GDP and financial sector development, between GDP and environmental pollutants, between GDP and trade openness, between financial sector development and trade openness, and among trade openness and environmental pollutants. However, we remark the inexistence of the causal relation between the financial sector development and environmental

pollutants. Finally, panel causality verifies that bidirectional causal connection is found between economic growth, environmental degradation (CO<sub>2</sub>), financial development, and trade openness. These results are in conformity with the previous studies.

The rest of this study is organized as follow: in Section 2, we show a review of previous literature on the nexus between GDP, financial sector development, CO<sub>2</sub> emissions, and trade openness. In Section 3, we explore the econometric method utilized in our paper. In Section 4, we present the empirical results by studying the data description of all variables, the stationarity of variables, and providing the empirical findings analysis. Section 5 finds concluding remarks. The policy implications are showed in Section 6. Finally, Section 7 provides the Suggestions for future research.

## 2. Literature review

A host of researchers are concerned with the empirical examination of the presence of bidirectional causal nexus among GDP, energy consumption, environmental degradation, financial sector development, and trade openness.

The relationship between GDP and CO<sub>2</sub> emissions is investigated in various empirical studies. This link is focused on the EKC hypothesis. This hypothesis supposes that the causal nexus between GDP and environmental pollutants is significant with an extremely positive sign. Grossman and Krueger (1991) and Selden and Song (1994) confirm that the connection between GDP and pollution is positively significant with different threshold level. Their empirical conclusions prove that an increase in economic growth augment the environmental degradation as measured by the CO<sub>2</sub> emissions.

Additionally, Azomahou, Laisney, and Van (2006) corroborate the existence of a linear causal connection between GDP and CO<sub>2</sub> emissions. Lean and Smyth (2010) and Saboori et al. (2012) illustrate the existence of an inverted U-shaped liaison linking GDP and pollution.

The study developed by Friedl and Getzner (2003) indicates an N-shaped nexus between GDP per capita and CO<sub>2</sub> emissions. But, Richmond and Kaufmann (2006) show a non-causal link among GDP and CO<sub>2</sub> emissions.

The relationship connecting GDP and environmental pollutants can be examined by reference to the EKC hypothesis. The EKC can explain the causal linkage between GDP and pollution since the 1990s. Moreover, Grossman and Krueger (1991) and Selden and Song (1994) demonstrate that economic development as measured by the GDP per capita leads to a gradual pollution. This influence is acquired in the initial stages and after a certain threshold of economic growth. The EKC hypothesis maintains that the link between economic growth and pollution is nonlinear and takes the form of inverted-U shape. This empirical finding indicates that economic growth is correlated with an augment in environmental degradation initially and reduces it.

The EKC hypothesis is examined empirically by several researches which demonstrate contradictory empirical findings (Ekins, 1997; Fodha & Zaghoud, 2010; Heil & Selden, 1999; Jaunky, 2010; Managi & Jena, 2008; Ozturk & Acaravci, 2010; Saboori et al., 2012; Stern, Common, & Barbier, 1996).

For specific country studies, we present the studies elaborated by Ang (2008), Soytaş and Sari (2009) and Fodha and Zaghoud (2010) for the case of Malaysia, Turkey, and Tunisia, respectively, which find the existence of bidirectional causality linking GDP and environmental pollutants. However, Ang (2007), Jalil and Mahmud (2009), Nasir and Rehman (2011), and Saboori et al. (2012) for France, China, Pakistan, and Malaysia, respectively, demonstrate the presence of an inverted U-shaped curve amid GDP and environmental pollutants.

For multi-country study, Tsai (1994) for a panel of 62 economies, Apergis and Payne (2009) for a panel of 6 Central American economies, Pao and Tsai (2010) for a panel of 19 countries and Omri (2013) for a panel of 12 MENA economies show in their empirical outcomes an inverted U-shaped

curve with GDP and environmental degradation. Besides, the econometric method utilized in all cited studies is based on Granger causality tests.

In addition, the liaison among GDP and pollution is not concluded by Richmond and Kaufmann (2006) for the data of 36 countries, by Halicioglu (2009) and Ozturk and Acaravci (2010) for a data-set relative to Turkey, by Jaunky (2010) for a panel of 36 high-income economies, and by Menyah and Wolde-Rufael (2010) for South Africa.

The significance of CO<sub>2</sub> emissions in the environmental degradation and their implication in all economic and financial sectors motivated some researchers to incorporate some potential indicators to examine empirically the EKC hypothesis. Then, CO<sub>2</sub> emissions are associated with trade openness as developed by Halicioglu (2009), Nasir and Rehman (2011), Shahbaz, Hye, Tiwari, and Leitão (2013), Omri, Nguyen, and Rault (2014), and Omri, Daly, Rault, and Chaibi (2015), to urbanization rate as edited by Zhang and Cheng (2009), Hossain (2011), Sharma (2011), Omri et al. (2014, 2015), to financial sector development as studied by Tamazian, Piñeiro, and Vadlamannati (2009), Tamazian and Bhaskara Rao (2010), Yuxiang and Chen (2010), Ozturk and Acaravci (2013), Omri et al. (2014, 2015).

To observe the causal link among pollution and trade liberalization, Halicioglu (2009) studies how trade openness can influence the relation among GDP, environmental degradation and energy consumption in Turkey. His empirical results illustrate that trade liberalization is one of the most significant determinants of GDP, while income can amplify the threshold of pollution. For a panel of Chinese provinces, Chen (2009) concludes that the industrial sector growth is accompanied with an increase of the environmental pollutants due to energy consumption.

Also, by employing augmented Dickey–Fuller unit root test and cointegration test, Nasir and Rehman (2011) examine empirically the EKC hypothesis in Pakistan and conclude a positive impact of trade openness on environmental degradation. However, Shahbaz, Lean, and Shabbir (2012) prove that the increase in trade openness can reduce CO<sub>2</sub> emissions. Furthermore, Tiwari, Shahbaz, and Hye (2013) demonstrate that an augment in trade openness can increase environmental pollutants in India.

For the link between the environmental degradation and the economic and financial indicators, Tamazian et al. (2009) examine the influence of supplementary potential determinants on environmental pollutants such as economic, financial, and institutional indicators. Tamazian et al. (2009) investigate the influence of the financial sector development on environmental degradation in Brazil, Russia, India, China, the United States, and Japan. Also, Tamazian and Bhaskara Rao (2010) examine the effect of institutions indicators on environmental pollutants. Their findings indicate that GDP, trade liberalization, financial sector development, and institutions have a fundamental role in controlling gas emissions, while supporting the existence of the EKC hypothesis.

Yuxiang and Chen (2010) conclude that the financial sector in China facilitate the firms to employ advanced technology which reduce CO<sub>2</sub> emissions and increase GDP.

Moreover, in the case of the United States, Soytaş, Sari, and Ewing (2007) study the dynamic causal connection between environmental pollutants, national income, and energy consumption. Their findings prove that income and energy consumption contribute to pollution. A similar previous study conducted by Ang (2007, 2008) in France and Malaysia concludes that GDP per capita affects energy consumption and environmental pollutants in both countries. Also, a unidirectional causality is concluded running from GDP to energy consumption.

For data-set of Tunisia, Chebbi (2010) examines the causal linkage between energy consumption, national income, and environmental pollutants. Chebbi (2010) finds that the volatility of energy consumption affects GDP and CO<sub>2</sub> emissions.

By utilizing Indian data, Ghosh (2009) studies the causal liaison among GDP and environmental pollutants by incorporating the investment and employment factors as additional indicators of carbon emissions, even though his results show the nonexistence of causal nexus among income and pollution.

Additionally, Chang (2010) utilizes a multivariate Granger causality test for the case of China to study empirically the causal connection between GDP, energy consumption, and pollution. His results show that GDP affects energy consumption that leads to pollution.

Jamel and Derbali (2016) investigate empirically the impact of energy consumption and economic growth on the environmental degradation as measured by CO<sub>2</sub> emissions. They utilize the cointegration test, the fully modified OLS (FMOLS), and the panel causality to study the causality between environmental pollution and economic aggregates from a panel data of eight Asian countries during the period of study from 1991 to 2013. They find that the cointegration tests provide long-run relationship between environmental degradation and energy consumption and economic growth along with financial development, trade openness, capital stocks, and urbanization as control variables. In addition, FMOLS results provide that economic growth and energy consumption have a positive and significant impact on environmental degradation. Besides, panel causality through VECM confirms that bidirectional causal connection is found between energy consumption and economic growth and environmental degradation.

Charfeddine and Ben Khediri (2016) extend the recent study of Shahbaz, Khraief, Uddin, and Ozturk (2014) by implementing recent unit root tests with multiple structural breaks and regime-switching cointegration techniques considering for one and two unknown regime shifts to examine the relationship among CO<sub>2</sub>, electricity consumption, economic growth, financial development, trade openness, and urbanization for the UAE during the period of study from 1975 to 2011. Their empirical results confirm the presence of EKC. In addition, we show an inverted U-shaped relationship among financial development and CO<sub>2</sub> emissions. They also conclude that electricity consumption, urbanization, and trade openness contribute to improve environmental quality.

Kahia et al. (2016) explore the economic growth–energy consumption nexus for two samples of MENA Net Oil Exporting Countries (NOECs) over the period of study from 1980 to 2012. Using panel cointegration approach, they find strong evidence for the presence of a long-run linkage between real GDP, renewable and non-renewable energy consumption, real gross-fixed capital formation, and the labor force. In addition, the empirical findings from the estimation of the panel error correction model provide an evidence of a unidirectional causality running from economic growth to renewable energy consumption in the short run. In the long run, the empirical results confirm evidence of bidirectional causality for the entire group of MENA NOECs. For the five selected MENA NOECs sample, Kahia et al. (2016) find strong evidence for bidirectional causality among renewable energy and economic growth. Moreover, their findings confirm bidirectional causality among renewable and non-renewable energy consumption with negative and significant coefficient in the short run indicating substitutability between these two types of energy.

Magazzino (2016) examines the relationship between real GDP, CO<sub>2</sub> emissions, and energy use in the six Gulf Cooperation Council (GCC) countries. Using annual data for the years 1960–2013, stationarity, structural breaks, and cointegration tests have been conducted. The empirical results strongly support the existence of unit roots. Cointegration tests reveal the presence of a clear long-run linkage only for Oman. Granger causality analysis shows that for three GCC countries (Kuwait, Oman, and Qatar) the predominance of the “growth hypothesis” emerges, since energy use drives the real GDP. In addition, only for Saudi Arabia a clear long-run relation has not been discovered. Finally, the empirical findings of the variance decompositions and impulse response functions broadly confirm his previous empirical findings. His empirical results significantly reject the assumption that energy is neutral for growth. Notwithstanding, since the causality findings are different for the 6 GCC countries, unified energy policies would not be the good recipe for the whole area.

Kahia et al. (2017) study the energy use–economic growth nexus by disaggregating energy use into two types of energy, renewable and non-renewable energy use. Their sample is composed of 11 MENA Net Oil Importing Countries (NOICs) over the period of study from 1980 to 2012. A multivariate panel framework was utilized to estimate the long-run link and the panel Granger causality tests was used to investigate the causality direction between variables. Their empirical findings provide evidence for long-term equilibrium linkage among real GDP, renewable and non-renewable energy use, real gross-fixed capital formation, and labor force. The empirical results show evidence also for positive and statistically significant elasticities. Besides, the results from panel error–correction model provide the presence of bidirectional causality among renewable energy use and economic growth, and between non-renewable energy use and economic growth, results that support the feedback hypothesis. In addition, their empirical results confirm evidence for two-way (bidirectional) causal relationship in both the short and long run between renewable and non-renewable energy use which proves the substitutability and interdependence between these two types of energy sources.

In Table 1, we present a review of existing empirical studies which examine the causal relation among GDP and environmental pollutants.

Based on the studies cited above, the empirical evidence of our paper is developed to examine the causal nexus between GDP, the financial sector development, trade openness, and pollution. Also, we utilize some indicators, such as Foreign Direct Investment, energy consumption, inflation, urbanization, and capital stocks, which prove highly significant in studying this causal connection. The empirical investigation is elaborated for an annually panel data of 40 European economies during the period of study from 1985 to 2014. The econometric method draws on/is founded on the utilization of the Cobb–Douglas production function which is estimated by the OLS technique.

**Table 1. Summary of previous empirical studies**

Author(s)	Purpose	Country(ies)	Methodology	Results and conclusions
<i>Panel A: Country-specific studies</i>				
Ang (2008)	Causal nexus between CO2 emissions and GDP	Malaysia	Granger causality based on VECM	Unidirectional causality between CO2 emissions and GDP. Only CO2 affect economic growth
Halicioglu (2009)	Causal nexus between CO2 emissions and GDP	Turkey	Granger causality based on VECM	Bidirectional causality between CO2 emissions and GDP
Soytas and Sari (2009)	Causal nexus between CO2 emissions and GDP	Turkey	Toda and Yamamoto (1995)	Bidirectional causality between CO2 emissions and GDP
Fodha and Zaghoud (2010)	Causal nexus between CO2 emissions and GDP	Tunisia	Granger causality based on ECM	Unidirectional causality between CO2 emissions and GDP. Only GDP affect CO2 emissions
Ghosh (2010)	Causal nexus between CO2 emissions and GDP	India	Granger causality based on VECM	Bidirectional causality between CO2 emissions and GDP
Saboori et al. (2012)	Causal nexus between CO2 emissions and GDP	Malaysia	EKC hypothesis	Unidirectional causality between CO2 emissions and GDP. Only CO2 affect economic growth and Inverted U-shape curve is presented
<i>Panel B: Multi-country studies</i>				
Richmond and Kaufmann (2006)	Causal nexus between CO2 emissions and GDP	36 countries	Panel cointegration	There is no relationship between CO2 emissions and GDP
Jaunky (2010)	Causal nexus between CO2 emissions and GDP	36 high-income economies	Panel unit root and cointegration tests	Unidirectional causality between CO2 emissions and GDP. Only GDP affect CO2 emissions
Omri et al. (2014)	Causal nexus between CO2 emissions and GDP	54 countries	Dynamic simultaneous-equation panel data models	Bidirectional causality between CO2 emissions and GDP
Omri et al. (2015)	Causal nexus between CO2 emissions and GDP	12 MENA countries	Dynamic simultaneous-equation panel data models	Bidirectional causality between CO2 emissions and GDP

Note: This table summarizes the previous empirical studies which examine the causal nexus among GDP (economic growth) and environmental pollutants (CO2 emissions).



### 3. Econometric methodology

To empirically examine the four-way causal link among GDP, CO2 emissions, the financial sector development, and trade openness in the European region, we utilize the Cobb–Douglas production function.

The Cobb–Douglas production function is widely used in economics to present the relationship between output and inputs (Kahia et al., 2016, 2017). The general production function is parameterized as follows:

$$Y = f(A, K, L) \Rightarrow Y = A K^\alpha L^\beta \quad (1)$$

where  $Y$  is the total production;  $A$  is the total factor productivity;  $K$  is the capital input;  $L$  is the labor input; and  $\alpha$  and  $\beta$  are the output elasticities of capital and labor, respectively. These values are constants determined by available technology.

Based on this function, we can explain the GDP by economic indicators as capital and labor force. Besides, the economic growth depends on the financial sector development, trade liberalization, foreign direct investment, environmental pollutants, urbanization, energy consumption, and capital stocks. In our study, we empirically estimate four equations, as follows:

$$\ln \text{GDP}_{it} = \alpha_0 + \alpha_{1i} \ln \text{CO2}_{it} + \alpha_{2i} \ln \text{FD}_{it} + \alpha_{3i} \ln \text{EC}_{it} + \alpha_{4i} \ln \text{FDI}_{it} + \alpha_{5i} \ln \text{INF}_{it} + \alpha_{6i} \ln \text{K}_{it} + \alpha_{7i} \ln \text{T}_{it} + \alpha_{8i} \ln \text{U}_{it} + \varepsilon_{it} \quad (2)$$

$$\ln \text{FD}_{it} = \alpha_0 + \alpha_{1i} \ln \text{GDP}_{it} + \alpha_{2i} \ln \text{CO}_{it} + \alpha_{3i} \ln \text{EC}_{it} + \alpha_{4i} \ln \text{FDI}_{it} + \alpha_{5i} \ln \text{INF}_{it} + \alpha_{6i} \ln \text{K}_{it} + \alpha_{7i} \ln \text{T}_{it} + \alpha_{8i} \ln \text{U}_{it} + \varepsilon_{it} \quad (3)$$

$$\ln \text{T}_{it} = \alpha_0 + \alpha_{1i} \ln \text{FD}_{it} + \alpha_{2i} \ln \text{GDP}_{it} + \alpha_{3i} \ln \text{CO}_{it} + \alpha_{4i} \ln \text{EC}_{it} + \alpha_{5i} \ln \text{FDI}_{it} + \alpha_{6i} \ln \text{INF}_{it} + \alpha_{7i} \ln \text{K}_{it} + \alpha_{8i} \ln \text{U}_{it} + \varepsilon_{it} \quad (4)$$

$$\ln \text{CO}_{it} = \alpha_0 + \alpha_{1i} \ln \text{T}_{it} + \alpha_{2i} \ln \text{FD}_{it} + \alpha_{3i} \ln \text{GDP}_{it} + \alpha_{4i} \ln \text{EC}_{it} + \alpha_{5i} \ln \text{FDI}_{it} + \alpha_{6i} \ln \text{INF}_{it} + \alpha_{7i} \ln \text{K}_{it} + \alpha_{8i} \ln \text{U}_{it} + \varepsilon_{it} \quad (5)$$

where  $\ln \text{GDP}$  measures the gross domestic product per capita for each country  $i$ ,  $\ln \text{FD}$  denotes the financial sector development,  $\ln \text{T}$  measures the trade liberalization,  $\ln \text{CO2}$  measures the CO2 emissions per capita,  $\ln \text{EC}$  denotes the energy consumptions,  $\ln \text{FDI}$  measures the foreign direct investment,  $\ln \text{INF}$  measures the inflation rate,  $\ln \text{K}$  measures the capital stock, and  $\ln \text{U}$  measures the urbanization rate.  $\alpha_0$  indicates the constant.  $\varepsilon_{it}$  measures the residual term.  $\alpha_{ji}$  measures the estimated coefficients of all explicative variables (where,  $j = 1, \dots, 8$ ). The subscript  $i = 1, \dots, 40$  measures the country. The subscript  $t = 1, \dots, 30$  is the time period. In Table 2, we define all variables utilized in our paper.

In Equation (2), we edit the influence of financial sector development, trade liberalization, environmental pollutants, energy uses, foreign direct investment, inflation rate, capital stock, and urbanization rate on GDP in the European economies (Ang, 2008; Anwar & Sun, 2011; Menyah & Wolde-Rufael, 2010; Omri et al., (2014, 2015).

In the third equation, we study the impact of GDP, trade liberalization, CO2 emissions, energy consumptions, foreign direct investment, inflation rate, capital stock, and urbanization rate on financial sector development (Ahlin & Pang, 2008; Omri et al., 2014, 2015; Ozturk & Acaravci, 2013).

In Equation (4), we examine the impact of trade liberalization on the financial sector development, GDP, CO2 emissions, energy consumptions, foreign direct investment, inflation, capital stock, and urbanization (Belloumi, 2014; Omri et al., 2014; Ozturk & Acaravci, 2013).

**Table 2. Variables definition and source**

Variable	Indicator name	Source
CO2	CO2 emissions (metric tons per capita)	Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States
EC	Energy Consumption (kg of oil equivalent per capita)	International Energy Agency (IEA) Statistics@OECD/IEA, <a href="http://www.iea.org/stats/index.asp">http://www.iea.org/stats/index.asp</a>
FDI	Foreign direct investment, net inflows (% of GDP)	International Monetary Fund, International Financial Statistics and Balance of Payments databases, World Bank, International Debt Statistics, and World Bank and OECD GDP estimates
GDP	GDP per capita (constant 2005 US\$)	World Bank national accounts data, and OECD National Accounts data files
INF	Inflation, consumer prices (annual %)	International Monetary Fund, International Financial Statistics and data files
K	Capital stock, total value (% of GDP)	Standard & Poor's, Global Stock Markets Factbook and supplemental S&P data
T	Trade (% of GDP)	World Bank national accounts data, and OECD National Accounts data files
U	Urban population growth (annual %)	World Bank Staff estimates based on United Nations, World Urbanization Prospects
FD	Domestic credit to private sector by banks (% of GDP)	International Monetary Fund, International Financial Statistics and data files, and World Bank and OECD GDP estimates

Finally, and with reference to Lotfalipour, Falahi, and Ashena (2010), Hossain (2011), Sharma (2011), Saboori et al. (2012), Lee (2013), Omri et al. (2014, 2015), we utilize Equation (5) to examine the consequence of trade liberalization, financial sector development, GDP, energy consumptions, foreign direct investment, inflation, capital stock, and urbanization on pollution.

To estimate the above equations, we choose the OLS as a preferred technique for an annually panel data-set in the European region.

#### 4. Empirical results

Following the standard panel data analysis procedure, we start to examine the data description of all variables used in our paper. Then, we study the stationarity of variables by employing a battery of panel unit root tests. Also, we employ OLS to investigate the causal link connecting four economic, environmental, and financial aggregates (economic growth (GDP), financial sector development, trade openness (liberalization), and CO2 emissions) in the European economies during the period of study through 1985–2014. Finally, we test the Granger causality.

##### 4.1. Data description







This study aims at empirically examining the causal link connecting four economic, environmental, and financial aggregates (economic growth (GDP), financial sector development, trade openness (liberalization), and CO2 emissions) in the European economies during the period of study through 1985–2014. We utilize an annually panel data for a sample of 40 European countries (Albania, Armenia, Iceland, Ireland, Italy, Latvia, Lithuania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Moldova, the Netherlands, Norway, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Luxembourg, the Republic of Macedonia, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom). Thus, we present in Table 3 the listing of all European countries utilized in our paper.

**Table 3. List of European countries used in this paper**

Rank	Name of country	Area (km <sup>2</sup> )	Population (2014)	Population density (per km <sup>2</sup> )	Capital
1	 Albania	28,748	3,020,209	105.1	Tirana
2	 Armenia	29,743	3,018,854	101.5	Yerevan
3	 Austria	83,879	8,504,850	101.4	Vienna
4	 Belarus	207,595	9,475,100	45.6	Minsk
5	 Belgium	30,528	11,198,638	366.8	Brussels
6	 Bosnia and Herzegovina	51,197	3,871,643	75.6	Sarajevo
7	 Bulgaria	110,994	7,364,570	66.4	Sofia
8	 Croatia	56,594	4,284,889	75.7	Zagreb
9	 Cyprus	9,251	1,117,000	120.7	Nicosia
10	 Czech Republic	78,866	10,513,209	133.3	Prague
11	 Denmark	42,916	5,655,750	131.8	Copenhagen
12	 Estonia	45,227	1,315,819	29.1	Tallinn
13	 Finland	338,424	5,470,820	16.2	Helsinki
14	 France	551,695	66,030,000	115.8	Paris
15	 Georgia	69,700	4,935,880	70.8	Tbilisi
16	 Germany	357,168	80,716,000	226.0	Berlin
17	 Greece	131,957	10,816,286	82.0	Athens
18	 Hungary	93,030	9,877,365	106.2	Budapest
19	 Iceland	103,001	325,671	3.2	Reykjavik
20	 Ireland	70,273	4,609,600	65.6	Dublin
21	 Italy	301,338	60,782,668	201.7	Rome
22	 Latvia	64,589	1,990,300	30.8	Riga
23	 Lithuania	65,300	2,944,459	45.1	Vilnius
24	 Luxembourg	2,586	549,680	212.6	Luxembourg
25	 Macedonia	25,713	2,058,539	80.1	Skopje
26	 Moldova	33,846	3,557,600	105.1	Chişinău
27	 Netherlands	41,543	16,856,620	405.8	Amsterdam
28	 Norway	385,178	5,136,700	13.3	Oslo
29	 Poland	312,679	38,483,957	123.1	Warsaw
30	 Portugal	92,212	10,427,301	113.1	Lisbon
31	 Romania	238,391	19,942,642	83.7	Bucharest
32	 Russia	17,075,400	143,700,000	8.3	Moscow
33	 Slovakia	49,035	5,415,949	110.5	Bratislava
34	 Slovenia	20,273	2,061,085	101.7	Ljubljana

(Continued)

**Table 3. (Continued)**

Rank	Name of country	Area (km <sup>2</sup> )	Population (2014)	Population density (per km <sup>2</sup> )	Capital
35	 Spain	504,645	46,704,314	92.6	Madrid
36	 Sweden	449,964	9,716,962	21.6	Stockholm
37	 Switzerland	41,285	8,183,800	198.2	Bern
38	 Turkey	783,562	76,667,864	97.8	Ankara
39	 Ukraine	603,628	44,291,413	73.4	Kiev
40	 United Kingdom	243,610	64,100,000	263.1	London

Notes: This table summarizes the list of 40 European countries (Albania, Armenia, the Republic of Macedonia, Moldova, the Netherlands, Norway, Poland, Austria, Belarus, Belgium, Iceland, Ireland, Italy, Latvia, Lithuania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Luxembourg, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom) employed in this study during the period of study from 1985 to 2014.

Table 4 summarizes the descriptive statistics of all variables utilized in our paper. From the empirical results in this table, we can observe that on average, the highest levels of CO<sub>2</sub> is equal to 27.42196, EC is equal to 18774.97, FDI is equal to 430.6407, CO<sub>2</sub> is equal to 86127.24, INF is equal to 4734.914, K is equal to 372.3756, T is equal to 371.4397, U is equal to 5.657103, and FD is equal to 311.0630. Then, we can remark that the highest level of risk (standard deviation) is for GDP (18263.42), followed by EC (2180.304) and INF (532.3235), respectively.

Moreover, Table 5 conducts the estimation coefficients of the Pearson correlation matrix between all indicators used in this paper. The empirical results shown in this table find that all estimating coefficients are inferior to the tolerance limit of Pearson (0.7), which doesn't cause problems in estimating the four equations.

#### 4.2. Panel unit root test

We apply the unit root test for panel data in Table 6. Then, we utilize two econometric tests as Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS). The null hypothesis (H<sub>0</sub>) relative to these tests supposes that all variables are non-stationary and the alternative hypothesis (H<sub>1</sub>) assumes all variables are stationary.

To accept or refuse the null hypothesis, we can refer to the p-value of unit root test which is compared to 10%. If p-value is inferior to 10%, then we refuse the null hypothesis and if it is superior to 10%, while we admit the null hypothesis. In Table 6, we summarize the results of the unit root tests of all indicators. Based on this table, we can assume that all indicators are statistically stationary in the level and in the first difference based on the two tests of LLC and IPS. Consequently, we can reveal that all indicators are non-integrated. Accordingly, we can find that all indicators utilized in this paper are stationary.

#### 4.3. Results discussion

In this section, we identify the nature of estimation for all used equations, which is a regression on panel data. Then, the choice of the panel regression is determined by the presence of the double dimensions in the data employed, the first dimension is time using a period of 30 years and the second is specific by the sample utilized which is composed of 40 European countries.

**Table 4. Descriptive statistics**

	ln CO2	ln EC	ln FDI	ln GDP	ln INF	ln K	ln T	ln U	ln FD
Mean	7.397460	3,398.665	4,098018	19,937.06	108.6164	22.65638	89.18206	0.510334	65.94835
Median	7.004315	3,021.391	2.104713	12,779.06	4.026683	3.741646	82.38176	0.463411	54.63906
Maximum	27.42196	1,8774.97	430.6407	86,127.24	4,734.914	372.3756	371.4397	5.657103	311.0630
Minimum	0.486455	384.5950	-57.42970	565.1557	-4.479938	0.000000	26.25670	-6.547706	1.383941
Std. Dev.	3.935124	2,180.304	13.76219	18,263.42	532.3235	42.57108	42.70703	1.114888	51.51523
Skewness	1.292063	2.542899	25.22483	0.944021	7.059702	3.241657	2.270208	-0.498009	1.327324
Kurtosis	7.191020	15.25300	775.6845	3.201342	55.39772	16.69964	12.69614	7.374851	5.171778
Jarque-Bera	1,206.057	8,756.071	29,829.425	179.3606	14,6507.7	11,428.25	5,702.868	1,001.536	585.2480
Probability	0.000000*	0.000000*	0.000000*	0.000000*	0.000000*	0.000000*	0.000000*	0.000000*	0.000000*
Observations	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194

Notes: This table reports the descriptive statistics of all indicators utilized in this paper. We employ annually panel data of 40 European countries (Albania, Armenia, Austria, Belarus, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Bosnia and Herzegovina, Bulgaria, Croatia, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Republic of Macedonia, Moldova, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom) throughout the period from 1985 to 2014.

\*Statistical implication at the threshold level of 1 %.

**Table 5. Matrix of Pearson correlation**

	In CO2	In EC	In FDI	In GDP	In INF	In K	In T	In U	In FD
In CO2	1.000000								
In EC	0.6202(0.0000)*	1.000000							
In FDI	-0.0286(0.3231)	-0.0230(0.4263)	1.000000						
In GDP	0.6245(0.0000)*	0.6879(0.0000)*	0.0978(0.0007)*	1.000000					
In INF	-0.1731(0.0000)*	-0.1647(0.0000)*	-0.3692(0.0000)*	-0.4931(0.0000)*	1.000000				
In K	0.4591(0.0000)*	0.4831(0.0000)*	0.2249(0.0000)*	0.7119(0.0000)*	-0.4802(0.0000)*	1.000000			
In T	0.1361(0.0000)*	0.1672(0.0000)*	0.4318(0.0000)*	0.0496(0.0858)**	-0.1808(0.0000)*	-0.0804(0.0053)*	1.000000		
In U	-0.1559(0.0000)*	-0.1143(0.0001)*	0.0286(0.3231)	-0.0782(0.0067)*	0.1091(0.0002)*	-0.0861(0.0028)*	0.0921(0.0014)*	1.000000	
In FD	0.3746(0.0000)*	0.3944(0.0000)*	0.0935(0.0012)*	0.6836(0.0000)*	-0.5115(0.0000)*	0.5306(0.0000)*	0.1300(0.0000)*	-0.0127(0.6609)	1.000000

Notes: This table recapitulates the estimated coefficients of correlation among all indicators. We utilize annually panel data of 40 European countries (Albania, Armenia, Austria, Belarus, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Republic of Macedonia, Moldova, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Bosnia and Herzegovina, Bulgaria, Croatia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom) during the period of study through 1985-2014.

\*Statistical significance at 1%.

\*\*Statistical significance at 10%.

**Table 6. Unit root tests**

Variables	Levin–Lin–Chu (LLC)				Im–Pesaran–Shin (IPS)			
	Level		First difference		Level		First difference	
	t-statistic	p-value	t-statistic	p-value	t-statistic	p-value	t-statistic	p-value
ln CO2	-27.8613	0.0000*	-38.6790	0.0000*	-20.4508	0.0000*	-29.4184	0.0000*
ln EC	-25.9521	0.0000*	-36.4681	0.0000*	-21.1006	0.0000*	-27.9519	0.0000*
ln FDI	-16.2314	0.0000*	-21.1148	0.0000*	-21.3708	0.0000*	-18.7527	0.0000*
ln GDP	-24.3884	0.0000*	-25.0094	0.0000*	-21.4157	0.0000*	-26.5651	0.0000*
ln INF	-13.8674	0.0000*	-16.0891	0.0000*	-20.4920	0.0000*	-17.0321	0.0000*
ln K	-6.1144	0.0000*	-8.4216	0.0000*	-14.5658	0.0000*	-11.0766	0.0000*
ln T	-9.0501	0.0000*	-10.9903	0.0000*	-18.3855	0.0000*	-12.0632	0.0000*
ln U	-19.8526	0.0000*	-20.5643	0.0000*	-20.7354	0.0000*	-22.4053	0.0000*
ln FD	-24.0630	0.0000*	-26.3711	0.0000*	-23.0861	0.0000*	-28.5783	0.0000*

Notes: This table recapitulates the results of stationary test. In this test the calculate  $p$ -value is compared to 10%. If the calculate  $p$ -value < 10% therefore, we refuse the hypothesis  $H_0$  and if the calculate  $p$ -value > 10%, then we accept the hypothesis  $H_0$ . With the hypothesis  $H_0$ : all variables are non-stationary.

\*Statistical meaning at 1%.

We can observe that the panel structure is homogeneous. Then, we can apply the method of OLS which allows a better fit by reducing the summation of squared error terms. But, the problem that arises when estimating the model is the selection of the estimation technique, as to the estimation with fixed or random effects models. So, to resolve this problem, the Hausman test is utilized to choose either the estimation with fixed effects or the estimation with random effects.

We start our empirical analysis by the presentation of the estimation findings and coefficients of Equation (1). In this equation, we study the influence of financial sector development, trade liberalization, environment pollutants, energy consumptions, foreign direct investment, inflation rate, capital stock, and urbanization on economic growth. The estimation findings of Equation (1) are reported in Table 7. Moreover, the Hausman test support evidence for the fixed effects models,  $p$ -value = 0.000. Next, we employ supplementary statistic tests to validate the estimated models and to defend the significance of the estimations.

We test the correlation among the explicative variables and the residual terms. This type of test is based on the value ( $\text{Prob} > \chi^2$ ). If the  $p$ -value is inferior to 5%, then we refuse the null hypothesis for the presence of the correlation between explicative variables and residual terms. And, if it is superior to 10%, we admit the null hypothesis. In Equation (1), the probability ( $\text{Prob} > \chi^2$ ) is inferior to 5%. Consequently, we can assume the nonexistence of problems of dependence among the explicative variables and residual terms.

To test the implication of the estimated equation, we base our analysis on the probability of Fisher. Thus, we remark that the probability ( $\text{Prob} > F$ ) is inferior to 5% in Equation (1). Therefore, we can remark that the estimated model is globally significant. In consequence, we find that the coefficient of  $R^2$  is larger than 0.91, then the Equation (1) is characterized by a good linear fit.

From the estimated coefficients in Table 7, we can observe that pollution (ln CO2) has a positive effect on ln GDP. Then, a 5% increase in pollution augments the economic growth with 0.12%.

Additionally, the financial sector development has a positive and significant impact on ln GDP. So, the augment of the financial sector development by 1% can increase the ln GDP with 0.41%.

**Table 7. Estimation results of OLS**

**Dependent variable: ln GDP**

Independent variables	Fixed effects			Random effects				
	Coef.	Std. err.	t-statistic	p-value	Coef.	Std. err.	t-statistic	p-value
ln CO2	0.1186958	0.0487767	2.43	0.015**	0.1420525	0.0488323	2.91	0.004*
ln FD	0.4091634	0.0264496	15.47	0.000*	0.3913427	0.0243529	16.07	0.000*
ln EC	0.7364884	0.0533456	13.81	0.000*	0.7619257	0.0530863	14.35	0.000*
ln FDI	0.0094266	0.015697	0.60	0.548	-0.007584	0.0150958	-0.50	0.615
ln INF	-0.1132431	0.0123947	-9.14	0.000*	-0.099471	0.011678	-8.52	0.000*
ln K	0.1355512	0.0104439	12.98	0.000*	0.1254517	0.0099242	12.64	0.000*
ln T	-0.1421228	0.0556689	-2.55	0.011*	-0.204454	0.0534739	-3.82	0.000*
ln U	0.0414276	0.0206529	2.01	0.045**	0.0362993	0.0204926	1.77	0.077***
Cons	2.378503	0.3812851	6.24	0.000*	2.469117	0.3781798	6.53	0.000*
Obs.	1,200							
R <sup>2</sup>	0.9055							
Prob > F	0.0000							
Prob > $\chi^2$	0.0000							
Prob Hausman test	0.0000							
Estimation chosen								

Model with fixed effects

Notes: This table recapitulates the estimated coefficients from OLS of GDP (Economic growth) as a dependent variable. To examine empirically this model, we utilize annually data panel of 40 European countries (Albania, Armenia, Austria, Belarus, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Republic of Macedonia, Moldova, the Netherlands, Norway, Poland, Bosnia and Herzegovina, Bulgaria, Croatia, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom) throughout the period starting 1985 to 2014.

\*Statistical significance at 1% level.

\*\*Statistical significance at 5% level.

\*\*\*Statistical significance at 10% level.



Also, we can stipulate that energy use has a positive consequence on the ln GDP. So, we can assume that an augment of 1% in the energy use increases the economic growth with 0.74%.

The coefficient of inflation is negative and significant in threshold of 1%. Thus, an augment of 1% in inflation can reduce the GDP by 0.11%.

The capital stocks have a positive and significant impact on ln GDP in threshold of 1%. This result shows that an increase of 1% in capital stocks augments the economic growth with a level of 0.13%.

Then, the trade liberalization influences negatively the ln GDP. This finding implies that an augment of 5% in the trade liberalization reduces the ln GDP with 0.14%.

Finally, we observe that urbanization has a positive and significant consequence on ln GDP with threshold of 5%. So, this finding implies that a supplement of 5% in the urbanization involves an augment of 0.04% in GDP. However, foreign direct investment doesn't have an impact on GDP in the European region.

In the Equation (2), we examine the impact of the GDP, trade liberalization, CO2 emissions, energy use, FDI, inflation, capital stock, and urbanization on the financial sector development. The estimation findings of the Equation (2) are presented in Table 8. We choose the fixed effects model as a preferred estimation method because the p-value of the Hausman test is less than 1% (0.0000).

Additionally, we test the correlation among the explicative variables and the residual terms. As the probability ( $\text{Prob} > \chi^2$ ) is less than 5%, then there are no problems of connection among the explicative variables and residual terms.

Next, we apply the test of significance of the model based on the value of the probability of Fisher. We observe that the p-value ( $\text{Prob} > F$ ) is inferior to 5%. Therefore, we can assume that the model is globally significant. Also, we mentioned that the coefficient of  $R^2$  is equal to 0.67 in Equation (2); consequently, the model has a good linear fit.

The main empirical conclusions of Table 8 indicate that ln GDP has a positive and crucial effect on the financial sector development. Then, 1% increases in GDP raises the financial sector development with 0.42%. In addition, the energy use has a negative influence on financial sector development in the European economies. Thus, we can find that an increase of 1% in energy use reduces the financial sector development with 0.19%.

The coefficient of ln FDI is negative and significant in a threshold of 1%. This result verifies that an augment of 1% in ln FDI reduces the financial development sector by 0.08%. Inflation, in turn, has a 1% negative influence on the financial sector development. Thus, a raise of 1% in inflation rate decreases the financial sector development with (-0.09%). The capital stocks positively influence the level of financial sector development in the European region. This finding implies that a 1% raise in capital stocks augments financial development by 0.05%.

Trade liberalization has a positive consequence on the financial sector development. Then, the 1% increase in trade openness can elevate the financial sector development by 0.21%.

Finally, we observe that urbanization has a positive impact on the financial sector development. This empirical finding implies that the raise of a threshold level of 5% in urbanization involves an increase of 0.04% in the financial sector development.

However, CO2 emissions don't have an influence on financial sector development in Europe.

**Table 8. Estimation results of OLS**

Dependent variable: ln FD	Fixed effects				Random effects			
	Coef.	Std. err.	t-statistic	p-value	Coef.	Std. err.	t-statistic	p-value
ln GDP	0.4173739	0.0269804	15.47	0.000*	0.4420743	0.0278041	15.90	0.000*
ln CO2	0.0484607	0.0493686	0.98	0.326	0.0197546	0.0515641	0.38	0.702
ln EC	-0.1959674	0.0578443	-3.39	0.001*	-0.204249	0.060281	-3.39	0.001*
ln FDI	-0.0871192	0.0156488	-5.57	0.000*	-0.087493	0.0158716	-5.51	0.000*
ln INF	-0.0917273	0.0126779	-7.24	0.000*	-0.100534	0.012575	-7.99	0.000*
ln K	0.0452491	0.0112085	4.04	0.000*	0.0429098	0.011228	3.82	0.000*
ln T	0.2145157	0.0560298	3.83	0.000*	0.3055958	0.0565071	5.41	0.000*
ln U	0.0444171	0.0208545	2.13	0.033**	0.045418	0.0216328	2.10	0.036**
cons	0.6406899	0.3910353	1.64	0.102	0.1474694	0.4064127	0.36	0.717
Obs.	1,200							
R <sup>2</sup>	0.6650							
Prob > F	0.0000							
Prob > $\chi^2$	0.0000							
Prob Hausman test	0.0000							
Estimation chosen								

Model with fixed effects

Notes: This table recapitulates the estimated coefficients from OLS of financial sector development as a dependent variable. To examine empirically this model, we utilize annually data panel of 40 European countries (Albania, Armenia, Austria, Belarus, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Republic of Macedonia, Moldova, the Netherlands, Norway, Poland, Bosnia and Herzegovina, Bulgaria, Croatia, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom) throughout the period starting 1985–2014.

\*Statistical significance at 1% level.

\*\*Statistical significance at 5% level.

**Table 9. Estimation results of OLS**

Independent variables	Fixed effects			Random effects				
	Coef.	Std. err.	t-statistic	p-value	Coef.	Std. err.	t-statistic	p-value
In FD	0.0580725	0.0151681	3.83	0.000*	0.0853593	0.0142553	5.99	0.000*
In GDP	-0.0392467	0.0153728	-2.55	0.011**	-0.05930	0.0155113	-3.82	0.000*
In CO2	0.0778764	0.0255955	3.04	0.002*	0.0639533	0.0263284	2.43	0.015**
In EC	0.2339443	0.0294559	7.94	0.000*	0.2297742	0.0302412	7.60	0.000*
In FDI	0.1155892	0.0075209	15.37	0.000*	0.1358809	0.0071143	19.10	0.000*
In INF	-0.0118243	0.0067343	-1.76	0.079***	-0.027599	0.0064288	-4.29	0.000*
In K	-0.0733263	0.0054644	-13.42	0.000*	-0.067610	0.0053445	-12.65	0.000*
In U	0.0485669	0.0107781	4.51	0.000*	0.0456258	0.0109722	4.16	0.000*
cons	0.577594	0.1891361	13.63	0.000*	0.728854	0.1916209	14.24	0.000*
Obs.	1,200							
R <sup>2</sup>	0.6659							
Prob > F	0.0000							
Prob > $\chi^2$	0.0000							
Prob Hausman test	0.0000							
Estimation chosen								

Model with fixed effects

Notes: This table recapitulates the estimated coefficients from OLS of Trade openness as a dependent variable. To examine empirically this model, we utilize annually data panel of 40 European countries (Albania, Armenia, Austria, Belarus, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Republic of Macedonia, Moldova, the Netherlands, Norway, Poland, Bosnia and Herzegovina, Bulgaria, Croatia, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom) throughout the period starting 1985–2014.

\*Statistical significance at 1% level.

\*\*Statistical significance at 5% level.

\*\*\*Statistical significance at 10% level.

In Equation (3), we estimate the influence of the financial sector development, ln GDP, pollution (ln CO<sub>2</sub>), energy use (ln EC), ln FDI, inflation, capital stocks, and urbanization on trade liberalization (ln TO). The estimation results of Equation (3) are shown in Table 9. From the main findings of this table, we choose the fixed effects model as a suitable estimation method because the p-value of Hausman test is less than 10% (0.0000).

We find that the probability (Prob > chi<sup>2</sup>) is less than 5%. Then, there are no problems of correspondence among explicative variables and error term.

Afterward, we prove that the probability (Prob > F) is inferior to 5% in Equation (3). Therefore, the estimated model is globally significant. Consequently, the coefficient of determination R<sup>2</sup> is equal to 0.67, and then the model (Equation 3) is characterized by a good linear fit.

The results of Table 9 prove that the financial sector development has a positive impact on trade liberalization. Therefore, 1% increase in the financial development sector can increase trade liberalization with 0.06%.

ln GDP has a negative effect on trade liberalization. So, 5% increase in the GDP diminishes trade liberalization by 0.04%. So, the high level of the economic growth can reduce the dependence to the trade openness.

Furthermore, gas emissions have a positive impact on trade liberalization. Thus, an increase of 1% in pollution can reduce the trade liberalization by 0.08%.

In addition, energy use has a positive influence on trade liberalization in Europe. So, an augment of 1% in energy use can diminish trade liberalization by 0.23%. Besides, the coefficient of ln FDI is of a positive effect on trade liberalization. This result means that a raise of 1% in FDI has a decrease in trade liberalization with 0.12%.

Inflation has a negative effect on trade liberalization. Consequently, an augment of 10% in the inflation reduces the trade liberalization by 0.01%. The capital stocks negatively influence trade liberalization in Europe. This implies that an increase of 1% in the capital stocks can decrease the trade liberalization with 0.07%.

Finally, we illustrate that urbanization has a positive effect on trade liberalization. This indicates that the supplement of 1% in urbanization implies an augment of 0.05% in trade liberalization.

In Equation (4), we summarize the effect of trade liberalization, the financial sector development, the GDP, energy use, the FDI, inflation, the capital stock, and urbanization on the environment degradation. The estimation findings of Equation (4) are concluded in Table 10. We choose the random effects model as a preferred estimation method because the probability of the Hausman test is equal to 0.30 (more than 10%).

We test the correlation between the explicative variables and the residual terms. In Equation (4), the p-value (Prob > chi<sup>2</sup>) is less than 5%. Thus, there are no problems of dependence between the explicative variables and error terms.

The probability of Fisher is used to examine the significance of the model. We notice that the p-value (Prob > F) is less than 5% in Equation (4). Consequently, the model is globally significant. Thus, we observe that R<sup>2</sup> is bigger than 0.68, therefore, the estimated equation has a good linear fit.

The main results of Table 10 prove that trade liberalization has a positive consequence on the environmental pollutants with a significant threshold level of 5%. So, an increase of 5% in trade liberalization augments the environmental pollutants (CO<sub>2</sub> emissions) with 0.08%.

**Table 10. Estimation results of OLS**

Dependent variable: ln CO2	Fixed effects			Random effects				
	Coef.	Std. err.	t-statistic	p-value	Coef.	Std. err.	t-statistic	p-value
ln T	0.1014909	0.0333568	3.04	0.002*	0.0770824	0.0317334	2.43	0.015**
ln FD	0.0170971	0.0174174	0.98	0.326	0.0022682	0.015884	0.14	0.886
ln GDP	0.0427166	0.0175539	2.43	0.015**	0.0496647	0.0170729	2.91	0.004*
ln EC	0.7344532	0.0269798	27.22	0.000*	0.7444134	0.0262759	28.33	0.000*
ln FDI	-0.0169603	0.009405	-1.80	0.072***	-0.020876	0.0089064	-2.34	0.019**
ln INF	0.0029364	0.0076976	0.38	0.703	0.0076503	0.0071088	1.08	0.282
ln K	0.0184807	0.0066821	2.77	0.006*	0.0164313	0.0062312	2.64	0.008*
ln U	-0.0512633	0.0123197	-4.16	0.000*	-0.048879	0.0120501	-4.06	0.000*
Cons	-0.946018	0.1817104	-27.22	0.000*	-0.929481	0.1771715	-27.82	0.000*
Obs.	1,200							
R <sup>2</sup>	0.6870							
Prob > F	0.0000							
Prob > $\chi^2$	0.0000							
Prob Hausman test	0.3027							
Estimation chosen								

Model with random effects

Notes: This table recapitulates the estimated coefficients from OLS of CO2 emissions as a dependent variable. To examine empirically this model, we utilize annually data panel of 40 European countries (Albania, Armenia, Austria, Belarus, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Republic of Macedonia, Moldova, the Netherlands, Norway, Poland, Bosnia and Herzegovina, Bulgaria, Croatia, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom) throughout the period starting 1985–2014.

\*Statistical significance at 1% level.

\*\*Statistical significance at 5% level.

\*\*\*Statistical significance at 10% level.

ln GDP has a positive effect on environmental pollutants. Then, a raise of 1% in the GDP diminishes the environmental pollutants within 0.05%.

Moreover, energy use (ln EC) has an effect (positive) on the gas emissions (ln CO<sub>2</sub>) in the European region. Thus, an augment of 1% in energy use (consumption) decreases the environmental pollutants by 0.74%.

In addition, the coefficient of ln FDI is negative. This result implies that a raise of 5% in FDI can result in a 0.02% decline in CO<sub>2</sub> emissions.

The capital stocks have a positive consequence on the CO<sub>2</sub> emissions. Thus, an increase of 1% in capital stocks can decrease gas emissions by 0.02%.

Finally, we notice that urbanization has a negative impact on CO<sub>2</sub> emissions with a threshold level of 1%. This result denotes that the increase of 1% in urbanization implies a decrease of 0.05% in trade openness.

However, the financial sector development and consumer price index (inflation rate) does not affect CO<sub>2</sub> in Europe.

#### **4.4. Causality test**

In order to study the causal link between the economic variables of the model, we used a causality test initiated by Granger in 1969, which over time has become a reflective framework as interesting as that relating to the identification of econometric links.

In general, from this test, we can show whether it is a close link to environmental degradation and energy consumption, environmental degradation and economic growth, environmental degradation and financial development, CO<sub>2</sub> emissions and trade openness, environmental degradation and capital stock, and environmental degradation and urbanization rate.

The results reported in Table 11 indicates short run dynamics that there exists bidirectional causal relationship between environmental degradation and energy consumption, environmental degradation and economic growth, environmental degradation and financial development, CO<sub>2</sub> emissions and trade openness, environmental degradation and capital stock, and environmental degradation and urbanization rate. Additionally, the error-correction term results show adjustment speed and it is significant at the level of 1% that also confirms long-run relationship between GDP, CO<sub>2</sub> emissions, the financial sector development, and trade liberalization.

#### **5. Conclusion**

In this study, we have empirically investigated the causal connection among GDP, CO<sub>2</sub> emissions, the financial sector development, and trade liberalization. For that goal, we have utilized the OLS as an econometric methodology for yearly panel data composed of 40 European economies through the period from 1985 to 2014. The main objective of this manuscript is to empirically inspect the four-way connection among GDP, financial sector development, trade liberalization, and CO<sub>2</sub> emissions by employing four models to examine the consequence of (1) CO<sub>2</sub>, financial sector development, trade liberalization, and other explicative variables on GDP; (2) GDP, CO<sub>2</sub>, trade liberalization (openness), and other control variables on the financial sector development; (3) financial sector development, GDP, CO<sub>2</sub>, and other explicative variables on trade openness; and (4) trade liberalization, the financial sector development, GDP, and other explicative variables on environmental pollutants.

The main empirical conclusions of our manuscript prove an evidence of bidirectional rapport among GDP and gas emissions, GDP and financial sector development, GDP and trade openness, the financial sector development and trade liberalization, and trade openness and carbon emissions.

**Table 11. Panel causality**

Short run									Long run
Dependent Variable	$\Delta LEC$	$\Delta LCO_2$	$\Delta LFD$	$\Delta LT$	$\Delta LK$	$\Delta LFDI$	$\Delta LINF$	$\Delta LU$	$\Delta LECT$
$\Delta LGDP$	3.027*	1.812***	2.425**	3.928*	5.001*	6.748*	4.290*	3.827*	3.192*
Short run									Long run
Dependent Variable	$\Delta LEC$	$\Delta LGDP$	$\Delta LCO_2$	$\Delta LT$	$\Delta LK$	$\Delta LFDI$	$\Delta LINF$	$\Delta LU$	$\Delta LECT$
$\Delta LFD$	4.920*	4.384*	3.001*	6.379*	7.290*	3.039*	7.230*	5.829*	4.578*
Short run									Long run
Dependent Variable	$\Delta LEC$	$\Delta LGDP$	$\Delta LFD$	$\Delta LCO_2$	$\Delta LK$	$\Delta LFDI$	$\Delta LINF$	$\Delta LU$	$\Delta LECT$
$\Delta LT$	6.021*	2.928*	1.991**	4.018*	7.273*	5.389*	5.190	5.111*	5.019*
Short run									Long run
Dependent Variable	$\Delta LEC$	$\Delta LGDP$	$\Delta LFD$	$\Delta LT$	$\Delta LK$	$\Delta LFDI$	$\Delta LINF$	$\Delta LU$	$\Delta LECT$
$\Delta LCO_2$	2.09**	1.772***	2.224**	5.378*	6.278*	8.495*	5.485*	4.112*	5.902*

Note: ECT represents error correction term.

\*Significant at 10%.

\*\*Significant at 5%.

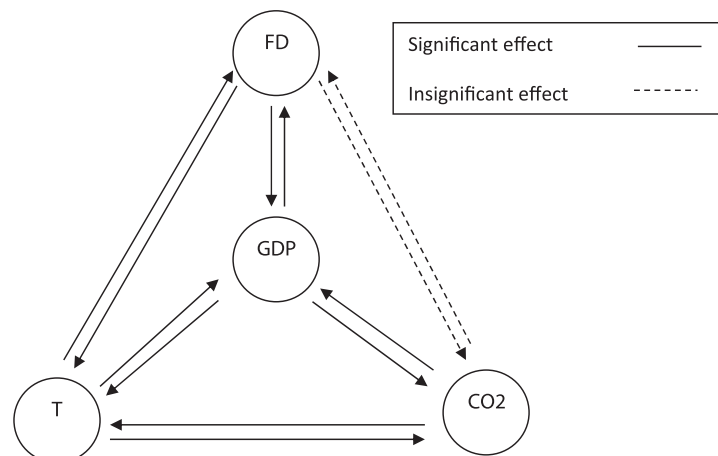
\*\*\*Significant at 10%.

But, we indicate a nonexistence of the significant link among the financial sector development and gas emissions in Europe. Figure 1 recapitulates the existing link between the four fundamental economic indicators in Europe.

The main empirical findings of our paper find that GDP and the environmental degradations are positively and extremely associated. The GDP per capita predicts a positive linkage with gas (CO<sub>2</sub>) emissions. Furthermore, GDP per capita promotes the financial sector development. However, GDP can prevent trade openness. The increase in financial development can increase trade openness. We, also, find a positive connection between CO<sub>2</sub> and trade liberalization. Finally, we can watch the nonexistence of causal nexus between financial development and CO<sub>2</sub> emissions.

Our manuscript is on conformity with the previous literature on the relationship between financial development and trade openness, financial development and GDP, GDP and trade openness, GDP and CO<sub>2</sub>, and trade openness and CO<sub>2</sub>. However, we find a different result for the nexus between financial development and CO<sub>2</sub>.

**Figure 1. The causal relationship between CO<sub>2</sub> emissions, GDP, the financial sector development, and trade openness.**



Finally, panel causality verifies that bidirectional causal connection is found between economic growth, environmental degradation (CO<sub>2</sub>), financial development, and trade openness.

## 6. Policy implications

In our case, the economy is called energy using policies may be implemented with adverse influences on real economic growth. Therefore, if energy consumption affects economic growth, then energy preservation policies aiming at protecting the environment are expected to deteriorate the current phase of economic growth. Also, energy production and preservation policies, financial development, trade openness, and economic growth would be the fine method for the whole area. Even though there may be political will to construct the common objects and purposes, different strategy, and plan design for subgroups of member states ought to probably be considered.

## 7. Suggestions for future research

For the possible future works, we can decompose our sample into developing and emerging countries. Also, we can use the analysis by the cross-section methodologies.

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