The Linkage between CO₂, FDI, Economic Growth and Value-Added: A European Perspective

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Research Article

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Abstract

This article aims to investigate the linkage among CO₂ emissions, Foreign Direct Investment (FDI), economic growth, Gross Value Added (GVA) of different sectors namely agriculture, service, manufacturing, and resource extensive industries including construction sectors in four European regions Eastern Europe (EE), Southern Europe (SE), Northern Europe (NE) and Western Europe (WE). To do, this article uses the 3SLS simultaneous equation estimation during the period of 2000 to 2018. This study is the extension of seeing the challenges in policy implication in reducing CO₂ emission in technologically rich economies. This article concluded that the causality among variables CO₂ emission, economic growth, FDI, and all four sectors GVA is varied according to the regions. However, the CO₂ emission has bidirectional causality with each industrial sector's GVA.

1 Introduction

Academic scholars and policymakers showed increasing interest how to reduce carbon emissions without sacrificing economic growth. The severity of this issue is described in the (UNIDO, 2019) report. Industrial energy is estimated to increase annually by 1.8% and 3.1% further in the next 25 years. This increasing energy demand creates worriedness between limited energy resources and economic growth. Growing industries always seek to improve the value addition with this limited resource and researchers argue that this goal can be achieved through development in technology and innovation.

Since the researchers argue that the establishment of innovations and implementation of new technology could positively affect the CO₂ emission in the short-run due to the increasing capacity of the production system but in the long-run, it will compensate and enhances the economic growth. Therefore, academic scholars tested the relationship of CO₂ with various variables in numerous researches with different countries or panel-groups samples. Samargandi, (2017) discusses the relation between sector (agriculture, services, and industrial) value-added, technology, and CO₂ emission in Saudi Arabia. Zhang et al., (2019) discussed the relationship between construction, manufacturing, and CO₂ emission in the sense of global scenario. Prastiyo et al., (2020) tested the relation between CO₂ emission, urbanization, and manufacturing in Indonesia. Rauf et al., (2018) discussed the relationship between carbon emission and industrial structural changes in China. H. Liu & Fan, (2017) discussed the CO₂ emission and value-added based accounting. They investigated the production-based accounting of CO₂ emissions, economic value-added based accounting of CO₂ emissions, and consumption-based accounting of CO₂ emissions in 77 high, middle, and low-income level economies. Jebli et al., (2020) discussed the relation between manufacturing value-added, services value-added, and CO₂ emission in four sub-groups of countries high-income countries, upper middle-income countries, lower middle income, and lower-income countries. Alam, (2015) investigated the relationship of service sector value added, manufacturing sector value added, agriculture value added, economic growth and CO₂ emission in South Asian countries. Murshed et al., (2020) analyzed the heterogeneous effect of service sector value-added and CO₂ emission in the Organization of the Petroleum Exporting Countries (OPEC) countries. Agboola & Bekun, (2019) tested how the agriculture value-added is associated with the environmental degradation in agrarian countries like Nigeria. Alamdarlo, (2016) discussed the relation between agriculture value-added, water consumption, and CO₂ emission in Iran. Therefore, the focus of this article is to contribute further to this literature by investigating the interaction among CO₂ emissions, Foreign Direct Investment (FDI), economic growth, Gross Value Added (GVA) of different sectors namely agriculture, service, manufacturing, and natural resources including construction in European regions. This research uses the four-GVA (GVAs) from World Development Indicators (WDI), first GVA related to agriculture, second GVA related to manufacturing industries, third GVA related to services industries (ex- transport, retail, and professional services) and we considered fourth GVA related to mining and construction industries (directly related to natural resources such as water, gas, oil including construction) separate then service sectors. Murshed et al., (2020) explained construction and mining industries have a different impact on CO₂ emission compare to core services sector industries such as tourism and restaurant services, etc.

Although the relationship of CO₂ with different variables is widely discussed in prior research, however, the simultaneous use of CO₂ emission, economic growth, FDI, and GVAs of all four sectors has never been carried out in earlier studies in European regions. To the best of the authors' knowledge, this is one of the first studies to simultaneously investigate GVAs in all four sectors. To do, this article uses the 3SLS simultaneous equation estimation from 2000 to 2018. We considered a panel of countries based on their similarity in basic economic structure and geographical proximity and bifurcate in four groups Eastern Europe (EE), Southern Europe (SE), Northern Europe (NE), and Western Europe (WE) such as (Singh & Gal, 2020).

The rest of the article is organized as follows: Sect. 2, provides a critical review of the existing literature. Section 3, data description and explanation of variables and, research methodology of empirical estimation and estimated equations. Section 4, presents the results and discussion. Finally, Sect. 5, discusses the concluding remarks, elaboration of policy implications, limitations, and future recommendations.

2 Literature

The relation between CO₂ emission, FDI, GDP per capita, and GVAs have been widely investigated in the last two decades through the various empirical and theoretical literature. But the sectoral relationship between CO₂ emission and GVAs have been a subject of debate and gained importance in the last decade. Some studies examine the individual countries (Agboola & Bekun, 2019; Alamdarlo, 2016; Asom & Ijirshar, 2016; Prastiyo et al., 2020; Rauf et al., 2018; Samargandi, 2017). Other research focused on income groups (Jebli et al., 2020; Zhang et al., 2019). While some other studies focused on geographic regions (Alam, 2015; Ceylan & Özkan, 2013; Kołodziejczak, 2020). Finally, some studies presented the overview (Friesenbichler, 2016; H. Liu & Fan, 2017; Murshed et al., 2020).

2.1 CO₂ and FDI

Demena & Afesorgbor, (2020) analyze the FDI and CO₂ relation through a meta-analysis of 65 primary literature. The effect of FDI on CO₂ emission depends on the FDI inflow origin so, developed and developing countries have a different effect. There is three-argument popularize through empirical evidence first, FDI invested in the host country have a positive effect on CO₂ emission on the other side second, argument argued that FDI accelerate the economic growth but it causes the negative spillover effect of carbon emission and third, it has no or zero effect, depending on the host country policy implications. Kiviyiro &

Arminen, (2014) shows carbon emission, economic growth and FDI are positively moving along in the same direction in Sub-Saharan Africa in long run. Similarly, Omri et al., (2014) find CO₂ emission may replicate the adverse effect on the host economy and have bidirectional causality between CO₂ emission and FDI. Chandran & Tang, (2013) found a heterogeneous linkage among FDI, economic growth, CO₂ emission in transport sectors in ASEAN five countries Malaysia, Singapore, Thailand, Indonesia, and the Philippines and suggested CO₂ emission can be minimized through selectivity in FDI except for Singapore. Results emphasize that policymakers should have to focus on FDI related to technology transfer and provide an incentive to high-tech sectors. Similarly, Al-mulali & Foon Tang, (2013) presented no relation between CO₂ emission and FDI inflow while GDP growth rate finds the positive causal relationship between economic growth and CO₂ emission in Gulf Cooperation Council (GCC) countries. The GCC countries have to promote FDI inflow since it is directly related to economic growth but should have encouraged FDI in technology-intensive industries. Omri et al., (2017) examine the causality among CO₂, FDI, and economic growth global panel of 54 countries and three regional sub-panels Latin America and the Caribbean, Europe and Central Asia, and the Middle East, North Africa, and sub-Saharan Africa throughout 1990-2011. They find that bidirectional causality between economic growth, CO₂, and FDI inflow in all panels and has bidirectionality causality except North Asia and Europe. Mert et al., (2019) examine the relation between CO₂ emission and FDI in the European region and, find the long-run causality between CO₂ emission and FDI in overall Europe. It implies the FDI inflow deteriorates the CO₂ emission in Europe so, the European region should have to tighten the regulation and environmental law. Bengochea-morancho et al., (2001) find in the European region there is a disparity between rest and advanced industrialized country. This disparity depends on the economic situation and industrial structure of each EU member state.

Therefore, there is heterogeneity in the literature to make uniform consciousness about the CO₂ and FDI relations. Adaptation of better policy, management, and advanced technology may play a critical role to curve CO₂ emission. Hence, in that case through FDI we can achieve zero or negative effect on CO₂ emission.

2.2 CO₂ and economic growth

The relation between CO₂ emission and economic growth draws the attention of academic researchers, especially in the last two decades. Zakarya et al., (2015) examine the relation among CO₂ emission, economic growth, and FDI in BRICS (Brazil, Russia, India, China, and South-Africa) nations using Granger causality and co-integration test from 1990 to 2012. They find that GDP and FDI inflow are important factors to increase the CO₂ emission and have positive unidirectional relations in long run. The BRICS nation has to increase the energy efficiency to increase productivity without harming the environment.

Niu et al., (2011) analyzed the relation between CO₂ emission, economic growth, and energy conservation in eight Asia Pacific countries using Vector Error Correlation Model (VECM), unit root and cointegration tests, result, shows the long-run equilibrium relationship among GDP and CO₂ emission in developed countries while no such causality in developing countries. Further, the result argues that the CO₂ emission per capita energy is lower in the Asia Pacific region compared to the developed nation however, the CO₂ emission per unit energy consumption is higher.

Jardón et al., (2017) investigated the cross-section dependency between CO₂ per capita and economic growth in Latin American and Caribbean countries through cointegration and unit root test. They find the mixed results of cross-dependency, exist inverse U-shaped curve, and rejected the Environmental Kuznets Curve (EKC) hypothesis.

Acaravci & Ozturk, (2010) used the autoregressive distributed lag (ARDL) method to find the causal relationship between CO₂ emission, economic growth, and energy consumption in the European region. The results show the long-run relation between GDP per capita and CO₂ emission in Switzerland, Portugal, Italy, Iceland, Greece, Germany, and Denmark. However no long-run relation in Sweden, Norway, Luxemburg, Motherland, UK, France, Belgium, Finland Austria. Manta et al., (2020) estimated the nexus among CO₂ emission, economic growth, energy use, and financial development in Central and Eastern European Countries (CEEC) using VECM and Granger causality over the period of 2000 to 2017. The result shows that in the long run energy emission and CO₂ emission have no impact on economic growth while in the short-run increasing in financial development increases the CO₂ emission and leads to enhanced economic growth. So, the European Union has to promote financial development which will help the countries to reduce the CO₂ emission, focus on the implementation of renewable and lower emission options. Kasperowicz, (2015) examines the relation between CO₂ emission and economic growth in 18 European member countries using Error Correction Model (ECM) estimation and find the negative long-run relation because technological advancement for the production facility, in the long run, reducing the CO₂ emission in Europe. However, for short period increasing economic growth increases the CO₂ emission because the fast production system extensively needs energy.

The relationship between CO₂ and economic growth not showing uniform results in empirical literature review even within the European region this relation have a heterogeneous characteristic, which means it depends on the national characteristic (Choi et al., 2010)

2.3 CO₂ and value-added in different sectors

Jebli et al., (2020) investigate the relationship between services value-added, industrial value-added, renewable energy consumption, economic growth, and CO₂ emission worldwide in four-panel groups of countries lower income, lower middle income, upper middle income, and high-income countries using GMM and Granger Causality test. Their results indicated that industries value-added and economic growth has a positive and significant impact on CO₂ emission in the lower middle income countries while economic growth has a negative impact, similarly upper middle income countries economic growth have a negative impact while industries have a positive impact on CO₂ emission and finally upper middle income countries economic growth have positive and significant while services value-added have a negative impact on CO₂ emission. Further, they suggested that eco-friendly project uses of natural resources like wind, water, solar, hydrogen, and nuclear energy countries have to promote and raise the productivity to minimize the carbon emission, another solution is carbon taxation and subsidizing the ecofriendly project investment rely investors on efficient energy sources.

H. Liu & Fan, (2017) presented value-added accounting (production based and consumption based) system based on CO₂ emission, Main objective of the study investigated the accountability of CO₂ emission originating through human activity, within the boundary of economic benefits principle. The study was

based on bilateral trade of industrial production and variables of CO₂ emission such as CO₂ emission from transport, CO₂ emission from the manufacturing industry and construction, CO₂ emission from electricity and heat production and, CO₂ emission from other sectors. Further, they used these variables to analyze the 3 panel groups based on income level; high income, low income, and middle-income group countries. They promote the CO₂ emission-based accounting system based on "consumption" high consumption of good more responsibility and to reduced CO₂ emission advanced country should have to help developing nation by technology transfer to achieve a reduction of CO₂ emission target.

Alam, (2015) examines the value-added influence on GDP in the service sector, agriculture sector, and manufacturing sectors in South Asian countries. Results show that value addition in the agriculture sector negatively influences the CO₂ emission while the service and manufacturing sector positively contributing to CO₂ emission. Therefore, the research suggested dependency on the services sector is not the solution to reduce CO₂ emission.

Similarly, Samargandi, (2017) analyses the KEC curve on Saudi-Arabia by considering the technology, sectors value addition in GDP, and volume of production, through the ARDL method. The result shows that the economic growth nurture the CO₂ emission and, value-added growth in industrial and service sector foster the CO₂ emission. However, the value addition in the agriculture sector reduces the CO₂ emission, also, technological advancement help to reduces the CO₂ emission without sacrificing the economic growth.

Rauf et al., (2018) use the ARDL method to find the linkage between industrial value-added, agriculture value-added, service value-added, economic growth, urbanization, financial development, and CO₂ emission in China from 1968 to 2016 and, their result shows in the long run and short run industrial, agriculture and services sector value-added have a negative relation with CO₂ emission in China. They recommended that increases carbon taxes, strong law, and a greenhouse-based economy can is the solution to reduce CO₂ emission. While Xiaoqing & Jianlan, (2011) find positive relation for the period of 2000 to 2005 and long-term negative relation, between CO₂ emission and industrial value-added from 2006 to 2009. They used the cointegration test to investigate the linkage between CO₂ emission and industrial value-added and, recommended that reform in industrial structure can help to curve down the CO₂ emission.

Through the empirical literature, we observed the relation of CO₂ emission with FDI, economic growth and, service value-added, agriculture value-added, and manufacturing value-added in different regions. In the primary outlook of investigation, empirical literature verified the association among CO₂ emission, FDI, economic growth, and different sectors value-added in different regions of the world economies. This relation varies for a short-run and long-run period. In the essence of observed literature, we find the literature gap for the European region. This study constitutes a debate on CO₂ emission, FDI, and GVA in the service sector, manufacturing sector, construction and natural resources and, agriculture sectors in four-panel of European regions EE, SE, NE, and WE. This study is the extension of seeing the challenges in policy implication in reducing CO₂ emission in technologically rich economies. This study involves the GVA of all sectors including wholesale, retail, trade transport, government, financial, professional and personal services, education, health care real estate services, hotels and restaurants, agriculture, services, construction, mining and natural resources and, sub-grouped these sectors into four categories of GVA in technologically advanced economies.

Table 1
summary of the literature review of CO2 emission and value added

Author	Region	Methodology	Period	Scope
(Zhang et al., 2019)	Global/income level classification	Environmental Kuznets curve and various	1960–2014	CO2 is directly related to income level, higher income higher EKC curve, significant relation between manufacturing and construction directly related to CO2 emission
(Jebli et al., 2020)	Global/income level classification	GMM and Granger causality	1990–2015	Negative relation between CO2 emission and, manufacturing and service sector industries value added in higher income countries, this relation is positive in low-income industries
(Asom & Ijirshar, 2016)	Nigeria	Augmented Dickey-Fuller, Johansen co-integration, unit root, error correction	1981–2015	agriculture value added have positive and insignificant effect on economic growth in short and long run
(Rauf et al., 2018)	China	ARDL	1968–2016	Agriculture, services and manufacturing value added have significant and positive relation with CO2 emission
(Kołodziejczak, 2020)	Europe	Comparative analysis	2000–2008	Positive association between employment and value added of different sectors
(H. Liu & Fan, 2017)	Multi country	Comparative analysis	2000–2010	Positive promotion of value-added based accounting of CO2
(Alam, 2015)	South Asia	Environmental Kuznets curve and various	1972–2010	Negative and significant association between agriculture value added and CO2 emission, positive and significant association between services sectors value added and CO2 emission
(Ceylan & Ozkan, 2013)	Europe	Comparative analysis	1995–2007 and 2002–2007	positive relation between agriculture value added and economic growth
(Murshed et al., 2020)	OPEC	Environmental Kuznets curve and various	1992–2015	Positive association between CO2 emission and construction and services value added
(Agboola & Bekun, 2019)	Nigeria	Environmental Kuznets curve and various	1981–2014	Positive association between CO2 emission and FDI and agriculture value added
(Prastiyo et al., 2020)	Indonesia	Environmental Kuznets curve and various	1970–2015	Bidirectional causality between CO2 emission and, manufacturing, agriculture and urbanization
(Samargandi, 2017)	Saudi Arabia	Environmental Kuznets curve, ARDL	1970–2014	Value addition in services and manufacturing sectors positively causes CO2 emission, technology and innovation help to reduce CO2 emission with enhancement of economic growth
(Alamdaro, 2016)	Iran	Environmental Kuznets curve and various	2001–2013	Direct relation among water consumption, agriculture value added and CO2 emission
(Friesenbichler, 2016)	Eastern Europe and Central Asia	3SLS	2010–2013	Positive and direct association between labor value added and innovation in manufacturing and services industry
Source: author.				

3 Methodology And Data Description

Factors like urbanization, inflation, labor, tax, and advancement in technology have a significant effect on CO2 emission. Such as according to L. Liu et al., (2011) increases population expanded urbanization and contribute to an increase in CO2 emission. Al-mulali et al., (2012) hold that in a world overview study, 84% of the countries have a positive correlation between urbanization and CO2 emission. Another aspect of determinants labor participation has an important effect on CO2 emission. Wei et al., (2018) find labor supply is proportional to the population size and overestimate the CO2 emission in key aging region Europe, Russia, United States, and Japan while it underestimates in India. Further Ghazouani et al., (2020) noticed that important factors like an increase in tax influence the CO2 emission, therefore, in Northern European nations government policies on taxation have a significant impact on CO2 emission. European nations after 1991 started to implement the taxation policy related to curve CO2 emission. However, the influx of CO2 pollutant is still persistent and need more innovative reforms and advanced technologies. According to Niu et al., (2011) technology significantly contribute to conduct the clean production development mechanism and reduce CO2 emission. So, in essence, to investigate the relationships that exist between CO2 emission, FDI, labor (L), tax (TA), inflation (I), urbanization (U), information and commination technology (ICT), GDPPC (Gross Domestic Product Per Capita) and GVAs in different sectors this paper expressed through following equations:

$$CO2_i = f(FDI_i, U_i, GDPPC_i, L_i, TA_i, I_i, ICT_i, GVAs_i) \text{ ----- (1)}$$

Where i = 1.....N, country, and GVAs (GVA-A, GVA-CN, GVA-M, GVA-S) is gross value added from the different sectors, see Table-1 variable description.

Test our objectives research model includes a system of simultaneous equations and decomposes CO2, FDI, L, TA, TE, U, I, GDPPC and GVAs in following econometric models can be presented as:

$$(CO2)_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 (U)_{it} + \beta_3 (GDPPC)_{it} + \beta_4 (L)_{it} + \beta_5 (TA)_{it} + \beta_6 (I)_{it} + \beta_7 (ICT)_{it} + \beta_8 (GVAs)_{it} + \varepsilon_{it} \quad (2)$$

Equation (1) is common for all models where the value of GVAs is A-GVA, ISCI-GVA, M-GVA, and S-GVA, the subscript $i=1, \dots, N$ denotes the country, and $t = 1, \dots, T$ time period.

$$\ln(CO2)_{it} = \beta_0 + \beta_1 \ln FDI_{it} + \beta_2 \ln (U)_{it} + \beta_3 \ln (GDPPC)_{it} + \beta_4 \ln (L)_{it} + \beta_5 \ln (TA)_{it} + \beta_6 \ln (I)_{it} + \beta_7 \ln (ICT)_{it} + \beta_8 \ln (GVAs)_{it} + \varepsilon_{it} \quad (3)$$

$$\ln(FDI)_{it} = \beta_0 + \beta_1 \ln CO2_{it} + \beta_2 \ln (U)_{it} + \beta_3 \ln (GDPPC)_{it} + \beta_4 \ln (L)_{it} + \beta_5 \ln (TA)_{it} + \beta_6 \ln (I)_{it} + \beta_7 \ln (ICT)_{it} + \beta_8 \ln (GVAs)_{it} + \varepsilon_{it} \quad (4)$$

$$\ln(GDPPC)_{it} = \beta_0 + \beta_1 \ln FDI_{it} + \beta_2 \ln (U)_{it} + \beta_3 \ln (CO2)_{it} + \beta_4 \ln (L)_{it} + \beta_5 \ln (TA)_{it} + \beta_6 \ln (I)_{it} + \beta_7 \ln (ICT)_{it} + \beta_8 \ln (GVAs)_{it} + \varepsilon_{it} \quad (5)$$

$$\ln(GVAs)_{it} = \beta_0 + \beta_1 \ln FDI_{it} + \beta_2 \ln (U)_{it} + \beta_3 \ln (GDPPC)_{it} + \beta_4 \ln (L)_{it} + \beta_5 \ln (TA)_{it} + \beta_6 \ln (I)_{it} + \beta_7 \ln (ICT)_{it} + \beta_8 \ln (CO2)_{it} + \varepsilon_{it} \quad (6)$$

Equations 3 to 6 presenting the common equations for all sectors GVA, the value of GVA in the system of equation is altered to i) GVA-A, ii) GVA-C, iii) GVA-M and iv) GVA-S one by one. This research uses annual data of the period 2000 to 2018 for 21 European countries, converted into panel form and grouped into four groups, EE, SE, NE, WE. The data is extracted from World Development Indicators (WDI) and take a log to make analysis and results in interpretation more viable. Sampling of regions and bifurcation in four panel-group of countries are mentioned in Table 2 and variable description is presented in Table 4. Further, descriptive statics is presented in Table 4. The log equations (3)(4) (5) and (6) are derived from a simultaneous system of equation approach. We use four GVA; A-GVA-A, GVA-C, GVA-M, and GVA-S industry involved in each sector, and details of the variables are presented in Table-3. The simultaneous equation approach is used for the econometric estimation and the 3SLS estimation is used for the empirical estimation. Analyze the relationships among the variable is problematic due to the error correlation between variables. Testing the relation through 3SLS is fulfill our objective requirement, it estimates all parameters in the equation at once and allows correlation between the error terms across the various equations in the number of included equations to be analyzed. The 3SLS method is more robust because it addresses the correlation between error and endogeneity, this method is time tested and used by various researchers (Adewuyi & Awodumi, 2017; Bakhsh et al., 2017; Bui, 2020; Kahouli, 2018; Mahmoudian et al., 2020). The endogeneity problem is resolved by using a set of instrumental variables. It could be obvious that the endogeneity between the GVAs could occur so, while we considered one GVA for a single sector the other three GVA considered as an endogenous variable. All other right-hand side variables are considered as explanatory instrumental and exogenous to the system. The LLC unit root test is used in this article to test the stationarity of the variables, shown in Table 5. All variables reject the null hypothesis and accept the alternate hypothesis of the unit root test, which implies all variables used in this article are stationary at the first difference.

Table 2
panel bifurcations

Panel	Countries
Northern Europe	Denmark, Finland, Ireland, Norway, Sweden, United Kingdom
Southern Europe	Greece, Italy, Portugal, Slovenia, Spain,
Western Europe	Austria, Belgium, France, Germany, Netherlands
Eastern Europe	Czech Republic, Hungary, Poland, Romania, Ukraine

Table 3
variable description

Variable	Definition	Unit of measurement	Source
CO2 emission	damage of environment due to CO2 emission	current US dollar in million	WDI
Foreign direct investment, (FDI)	net inflows	current US\$ in million	WDI
Economic growth	GDP per capita	current US\$ in million	WDI
Inflation	consumer prices	annual %	WDI
Labor	labor force participation rate	% of total population ages 15-64	WDI
Urbanization	urban population growth	annual %	WDI
Tax	taxes on income, profits and capital gains	% of total taxes	WDI
Gross Value Added Agriculture sectors (GVA-A)	Representing the agriculture, industry and services sectors	current US\$ in million	WDI
Technology (ICT)	Individuals using the Internet	% of population	WDI
Gross value added of Industry (GVA-C)	industry including construction, mining, electricity, water, and gas (resource extractive industry)	current US\$ in million	WDI
Gross Value Added Manufacturing (GVA-M)	manufacturing industries	current US\$ in million	WDI
Gros Value Added Service sectors (GVA-S)	industry including Wholesale, retail, trade transport, government, financial, professional and personal services (education, health care real estate services, hotels and restaurants	current US\$ in million	WDI
Source: author			

Table 4
descriptive statics

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Obs	Mean	Std
(1) logCO2	1.000												399	7.834	1.0
(2) log FDI	0.282*	1.000											399	6.937	.06
(3) log GDPPC	-0.078	0.218*	1.000										399	10.119	.88
(4) log ICT	-0.006	0.149*	0.784*	1.000									399	3.952	.71
(5) log Inflation	-0.019	-0.107*	-0.627*	-0.608*	1.000								399	2.526	.23
(6) log Labor	-0.136*	0.158*	0.616*	0.523*	-0.340*	1.000							399	4.268	.07
(7) log Urban	-0.152*	0.203*	0.658*	0.405*	-0.340*	0.439*	1.000						399	1.714	.13
(8) log Taxes	0.218*	0.245*	0.434*	0.131*	-0.193*	0.031	0.353*	1.000					399	3.651	.31
(9) log GVA-C	0.769*	0.350*	0.520*	0.404*	-0.353*	0.228*	0.261*	0.438*	1.000				399	11.443	1.1
(10) log GVA-A	0.771*	0.360*	0.533*	0.420*	-0.376*	0.227*	0.282*	0.445*	0.985*	1.000			399	12.721	1.1
(11) log GVA-M	0.769*	0.356*	0.480*	0.386*	-0.363*	0.167*	0.205*	0.394*	0.972*	0.963*	1.000		399	10.924	1.1
(12) log GVA-S	0.752*	0.365*	0.552*	0.434*	-0.398*	0.233*	0.302*	0.451*	0.972*	0.997*	0.953*	1.000	399	12.329	1.2
All significant correlation coefficients at the 5% level are marked with two stars.															
Source: author															

Table 5
results of panel unit root test

LLC test		
Variables	t-stat	P value
log CO2	-3.019*	0.0013
log GDPPC	-9.332*	0.000
log FDI	-3.478*	0.001
log Labor	-9.485*	0.000
log Inflation	-7.436*	0.000
log Urban	-5.845*	0.000
log ITC	-19.81*	0.000
log Taxes	-2.383*	0.009
log GVA-C	-7.678*	0.000
log GVA-A	-9.261*	0.000
log GVA-M	-7.606*	0.000
log GVA-S	-11.525*	0.000
* Significant at the 1% level.		
Source: author.		

4 Results And Discussion

The four-panel group we use in this article are characterized by a similar economic structure, similar transformation of external factors, and similar economic development. In this article, there are four models created for each GVA for each region EE, SE, NE, and WE. The models estimated through the coefficient of equations 3 to 6 are presented in Table 6, 7, 8, and 9. We empirically tested the relation among CO2, FDI, GDP per capita, and GVAs of four industrial sectors. The variable description is shown in Table 3. Descriptive statics of variables used in this study and Pearson correlation coefficient test are reported in Table 4. We created the four models for each GVA in EE, NE, SE, and WE regions, summary of models is presented in Table 6, 7, 8, and 9. All linkage among CO2 emission, FDI inflow, GDPPC, and GVAs are significant and their R2, Chi2, and RMSE value are reported in model's summary Table 6, 7, 8, and 9 where R² values indicating the model fitted along the regression line and Root Mean Square Value (RMSE) indicating the accuracy of the model and explaining the occurrence of error and absolute measure of fit. The Chi2 value indicating the significance of relationships among the four dependent variables here the null hypothesis is no relation between the dependent variables. In model summary tables all models are significant with p < 0.5, so the null hypothesis is rejected and accept the alternate hypothesis. It implies the relation among the variables CO2 emission, FDI inflow, GDPPC, and GVAs is significant, we can proceed with models and further discuss in detail.

Table 6
GVA-C model equation summary statistics.

	Eastern Europe				South Europe				Norther Europe				Western Europe	
	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2
CO2	0.26	0.87	1065.55	0.00	.37	0.90	966.28	0.00	.20	0.94	3469.51	0.00	.29	0.89
FDI	.01	0.14	20.89	0.007	.01	0.54	169.01	0.00	.03	0.48	148.36	0.00	.01	0.08
GDPPC	.19	0.94	2271.38	0.00	.14	0.77	382.60	0.00	.14	0.80	545.69	0.00	.10	0.82
GVA-C	14326.93	0.87	1233.99	0.00	61966.14	0.86	764.76	0.00	35267.91	0.94	3544.61	0.00	89135.33	0.91
<i>Source: author, * p<0.05, ** p<0.01, *** p<0.001.</i>														

Table 7
GVA-A model equation summary statistics.

	Eastern Europe				South Europe				Norther Europe				Western Europe	
	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2
CO2	.16	0.94	2811.73	0.00	.12	0.90	12411.79	0.00	.17	0.96	5084.60	0.00	.18	0.95
FDI	.01	0.14	2811.73	0.003	.01	0.52	12411.79	0.00	.03	0.46	133.04	0.00	.09	0.08
GDPPC	.14	0.97	3990.98	0.00	.11	0.87	862.94	0.00	.12	0.83	795.75	0.00	.08	0.87
GVA-A	.12	0.96	3991.38	0.00	.11	0.90	17694.01	0.00	.18	0.95	4694.05	0.00	.17	0.96
<i>Source: author, * p<0.05, ** p<0.01, *** p<0.001.</i>														

Table 8
GVA-M model equation summary statistics.

	Eastern Europe				South Europe				Norther Europe				Western Europe	
	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2
CO2	.22	0.90	1423.45	0.00	.28	0.94	1783.85	0.00	.32	0.87	1270.03	0.00	.17	0.96
FDI	.01	0.14	21.38	0.006	.01	0.55	148.29	0.00	.03	0.51	159.07	0.00	.10	0.07
GDPPC	.14	0.97	4158.75	0.00	.14	0.78	366.24	0.00	.14	0.80	520.84	0.00	.10	0.86
GVA-M	.15	0.95	2797.99	0.00	.29	0.95	2315.99	0.00	.27	0.87	1371.89	0.00	.17	0.96
<i>Source: author, * p<0.05, ** p<0.01, *** p<0.001.</i>														

Table 9
GVA-S model equation summary statistics.

	Eastern Europe				South Europe				Norther Europe				Western Europe			
	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P	RMSE	R2	Chai2	P
CO2	.17	0.94	2492.16	0.00	.12	0.95	11289.97	0.00	.19	0.95	4102.69	0.00	.19	0.95	342	
FDI	.01	0.15	18.66	0.016	.01	0.50	117.99	0.00	.03	0.45	119.42	0.00	.10	0.09	12.5	
GDPPC	.14	0.95	3869.97	0.00	.11	0.87	867.99	0.00	.13	0.81	628.47	0.00	.08	0.87	849	
GVA-S	.13	0.96	3884.47	0.00	.12	0.95	15540.88	0.00	.21	0.95	3843.10	0.00	.19	0.95	356	
<i>Source: author, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.</i>																

Addressing the relation between CO2 emission and value-added in agriculture and its condition regional differences noticeable factor. Therefore, Table 9, presents the empirical estimation of the agriculture sector in EE, NE, and WE European regions where we find the four-way linkage while in the SE region relationship of CO2 with others variable is insignificant so, the three-way linkage is noticed. The significance of GVA-A models in Table 9 is in line with the (Ceylan & Özkan, 2013; Kulyk & Augustowski, 2020). It is well known that the energy sector plays important role in economic development. The FDI investment can contribute an important role to reduce CO2 emissions and enhances the agriculture related industries' production by technology transfer and positively increases the country's economic growth. Long et al., (2018) revealed that technology advancement and innovation negatively affect CO2 emission and FDI brings the new technology and innovation. So, it is possible to reduce the greenhouse emission and increase production through technology advancement and structural changes in the production system and, grow in a sustainable development way. It is also the condition that in long run the opposite relation could be expected, where enhancement in production will not be associate with greenhouse emission. Optimal changes in policy at the individual country level are beneficial not economically but also socially such as the association between academia and agriculture. Labor is the most important factor that contributes to the four-way linkage of GVA-A. The positive approach of labor training a necessary condition for adaptation and implementation of new technology. Similar to the argument Pishgar-Komleh et al., (2012); Mobtaker et al., (2013) reported that advanced machinery and trained labor increase production and save the energy consumption in the production system which reduces the CO2 emission. The rationalization of employment in agriculture in Europe supports sustainability and economic development.

The relation between FDI and CO2 emission is positive in EE and WE region, negative in the NE region, and has no significance in the SE region. The results of the negative and positive association between FDI and CO2 emission are in line with the (Huang et al., 2019; Shao, 2018). According to Pazienza, (2015) suggestion, the sign between FDI on CO2 emission is dependent on the productivity specialization of the country and the country's competitive advantage. The insignificance of FDI and CO2 emission in the SE region is understood by the isolated phenomena, it implies other sectors have a greater impact compared to agriculture, which means these phenomena influenced by the other factors (Atici, 2012; Demena & Afesorgbor, 2020; Wang et al., 2020). Further, the increase of FDI inflow by 1% tends to raise the CO2 emission 3.23% in EE and 5% increase tends to 0.43% in WE, while in NE this association is negative so the increase of FDI inflow by 0.1% decrease the CO2 emission - 1.37%. Therefore, in the NE region, FDI inflow sufficiently brings the technological advancement and innovation to reduce CO2 emission.

Further GDP per capita has a significant relation with all variables FDI, CO2, and GVA-A, except, FDI inflow and economic growth in the SE region. This insignificant result is consistent with the (Alvarado et al., 2017). Another side, the relation between GDP per capita and CO2 emission has a negative association in all region because in the long-run development of new technology to reduce CO2 emission production system produces the same product with a lower level of carbon emission while, in the short-run GDP and CO2 emission is positive because the rapid increase in production can be achieved due to large intensive energy used compared to previous consumption of energy with lower production, capacity increase CO2 emission increase (Kasperowicz, 2015).

The empirical estimation for GVA-S sector industries is shown in Table 10. The EE region countries' service sector are more positively contribute to CO2 emission compare to the other three European panel-groups, which have an almost similar effect on carbon emission because according to Kołodziejczak, (2020) less affluent countries in Europe, a greater number of workforces related to the agriculture while in high affluent countries a smaller number of workforces related to the agriculture sector, so the high GVA is generated through the secondary sectors (industry) and tertiary sectors (service).

Table 10
result of 3SLS using GVA-A

Table 1: GDPs using GVA-A													
		Eastern Europe				Southern Europe		Europe		Northern Europe		Europe	
		Model 1				Model 2				Model 3			
logCO21		0.0252**	-0.881***	0.769***		0.00	-0.834***	0.976***		-0.0734***	-0.617***	1	
		-2.89	(-26.68)	-39.00		-0.17	(-12.29)	-47.63		(-3.78)	(-12.93)	-5	
logFDI	3.213**		2.447*	-1.70	0.16		-1.21	0.94	-1.375***		-0.809**	2	
		-2.89		-2.45	(-1.94)	-0.17		(-1.30)	-1.03	(-3.78)		(-2.83)	-5
logGDPPC	-1.119***	0.0243*		0.867***	-0.878***	-0.01		0.919***	-1.169***	-0.0817**		1	
		(-26.68)	-2.45		-30.11	(-12.29)	(-1.30)		-14.96	(-12.93)	(-2.83)	-1	
logGVA-A	1.286***	-0.02	1.141***		1.004***	0.01	0.898***		0.966***	0.105***	0.569***		
		-39.00	(-1.94)	-30.11		-47.63	-1.03	-14.96		-54.08	-5.75	-11.11	
logICT	0.01	0.00	0.02	-0.01	0.245***	0.01	0.323***	-0.268***	0.657***	0.02	0.609***	-0	
		-0.45	(-0.13)	-0.68	(-0.47)	-5.01	-1.23	-8.95	(-5.75)	-7.70	-0.99	-13.95	(-
logInflation	-0.09	0.01	-0.08	0.07	-0.07	0.0240*	0.03	0.03	0.24	-0.02	0.13	-0	
		(-1.59)	-0.98	(-1.64)	-1.52	(-0.68)	-2.31	-0.32	-0.30	-1.78	(-0.63)	-1.24	(-
logLabor	4.314***	-0.157***	3.789***	-3.280***	-1.604***	0.05*	-1.683***	1.596***	-3.800***	-0.608***	-2.044***	4	
		-14.29	(-3.55)	-12.95	(-13.17)	(-5.49)	-1.38	(-6.43)	-5.57	(-7.22)	(-4.38)	(-4.63)	-7
logUrban	1.250***	-0.01	1.123***	-0.985***	0.07	0.02	0.26	-0.13	0.507*	0.03	0.811***	-0	
		-6.47	(-0.45)	-6.71	(-6.77)	-0.47	-1.06	-1.74	(-0.80)	-2.09	-0.47	-5.33	(-
logTaxes	-0.04	0.0248*	0.00	0.00	-0.398***	-0.01	-0.442***	0.411***	0.353***	0.0361**	0.275***	-0	
		(-0.32)	-1.98	(-0.04)	-0.05	(-4.26)	(-0.60)	(-4.46)	-4.83	-7.71	-3.01	-8.91	(-
Const.	-39.15***	7.335***	-31.91***	24.82***	10.07	6.629***	20.47***	-17.75**	27.99***	9.42***	17.13***	-3	
		(-4.94)	-38.46	(-4.47)	-3.96	-1.60	-37.31	-3.35	(-2.91)	-7.56	15.92	-5.75	(-

Source: author, Note: *t* statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The GVA-S sector industries have a 0.1% significance level and positive relation with CO2 emission in all four regions of Europe, this result is similar to the (Jebli et al., 2020; Murshed et al., 2020). The relation between CO2 emission and FDI inflow has 0.1% significant relation in SE region it implies 0.1% increase in FDI inflow CO2 emission rise 4.01%, significant and negative relation in NE region 1% increase in FDI inflow CO2 emission decreases 1.059% and insignificant relation in EE and WE region. While GDP per capita has 0.1% significant and negative association with CO2 emission in all four European regions this result is similar to the (Kasperowicz, 2015). Because adaptation of low carbon technologies takes time to reach the same production level with lesser CO2 emission. Further GVA-S and CO2 emission results are highly significant, thus every 0.1% rise in service sectors GVA tends to 1.276% rise of CO2 emission in EE region while in SE, NE, and WE regions it increases approximately 0.9% (one point decimal place).

Regarding the GVA-M panel, estimation results Table 11 indicating that in all four European regions manufacturing sectors are the highly significant and positive contributor of CO2 emission. It is also noticeable that comparing to all four European regions EE has a high coefficient value for every 0.1% rise of GVA of manufacturing sectors, CO2 value increases 1.42%. This result is similar to the (Jebli et al., 2020). Although it is admissible that the manufacturing value-added is the most impactful driver of CO2 emission, up-gradation of technology through innovations, industries can improve the efficiency of the production system and reduces the carbon emission (Li et al., 2019). Although CO2 emission increases rapidly due to cheaper polluting resources Central and Eastern European (CEE) countries have high CO2 emission per capita since 1980 this carbon emission is continuously decreasing. However, compared to other technologically advanced European regions such as WE countries CO2 emission per capita is still high in CEE countries (Atici, 2009). Thus, the CEE regions need FDI which brings innovation and technology advancement therefore, FDI inflow can play an important role to address this issue, based on previous empirical literature. In this research results, a 1% rise of FDI inflow tends to increases the 4.04% of CO2 emission in EE regions. Another step of reducing the CO2 emission can be to increase the GDP per capita, the results show the significant and negative association between GDP per capita and CO2 emission in EE, WE, and NE region increase in per capita income decreases the carbon emission this significant result is supported by the (Alvarado et al., 2017; Kasperowicz, 2015). Therefore every 0.1% increase of GDP per capita reduces the CO2 emission 1.56%, 1.12%, and 1.62% in EE, NE, and WE regions respectively. Further GVA-M has a significant relation with all variables FDI, CO2, and GDP per capita except, FDI inflow and GVA-M in EE regions.

Table 11
result of 3SLS using GVA-S

	Eastern Europe			Southern Europe			Northern Europe		
	Model 1			Model 2			Model 3		
logCO21	0.013	-0.844***	0.773***	0.04***	-0.798***	1.013***	-0.048**	-0.504***	1.059***
	-1.550	(-25.83)	-36.680	-4.210	(-12.26)	-45.230	(-2.64)	(-9.40)	-48.710
logFDI	1.848	1.129	-0.483	4.010***	1.787	-3.010**	-1.059**	-0.439	1.999***
	-1.550	-1.110	(-0.52)	-4.210	-1.900	(-3.00)	(-2.64)	(-1.41)	-4.780
logGDPPC	-1.164***	0.011	0.908***	-0.928***	0.021	1.009***	-0.991***	-0.039	0.938***
	(-25.83)	-1.110	-29.610	(-12.26)	-1.900	-15.050	(-9.40)	(-1.41)	-7.650
logGVA-S	1.276***	-0.006	1.087***	0.967***	-0.029**	0.828***	0.906***	0.0770***	0.408***
	-36.680	(-0.52)	-29.610	-45.230	(-3.00)	-15.050	-48.710	-4.780	-7.650
logICT	0.031	-0.001	0.033	-0.025	0.297***	-0.003	0.357***	-0.334***	0.556***
	-0.980	(-0.20)	-1.270	(-1.02)	-5.760	(-0.52)	-10.190	(-6.57)	-5.740
logInflation	-0.030	0.004	-0.027	0.019	0.031	0.0211*	0.121	-0.071	0.307*
	(-0.50)	-0.800	(-0.53)	-0.420	-0.290	-2.030	-1.250	(-0.66)	-2.040
logLabor	4.914***	-0.109*	4.140***	-3.76***	-2.179***	0.112**	-2.092***	2.259***	-3.884***
	-15.380	(-2.31)	-13.780	(-14.17)	(-7.09)	-3.270	(-7.98)	-7.230	(-6.69)
logUrban	0.830***	0.009	0.723***	-0.67***	0.337*	0.007	0.479**	-0.403*	0.501
	-4.110	-0.520	-4.290	(-4.30)	-2.010	-0.400	-3.250	(-2.38)	-1.830
logTaxes	0.146	0.025	0.161	-0.148	-0.484***	0.015	-0.483***	0.514***	0.335***
	-1.100	-1.950	-1.430	(-1.44)	(-4.91)	-1.170	(-4.87)	-5.540	-6.580
Const.	-31.25***	7.128***	-23.50**	17.70**	-13.41*	6.178***	1.779	5.892	25.72***
	(-3.70)	-36.150	(-3.23)	-2.650	(-2.10)	-33.960	-0.290	-0.880	-6.300

Source: author, Note: t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Results related to the GVA-C are shown in Table 12, representing the resource extensive industries including construction, mining, electricity, water, and gas. The Table 12 results demonstrate that GVA-C has a 0.1% significant and positive impact on CO2 emission in all four panel-group EE, SE, NE, and WE regions. This result is similar to the (Murshed et al., 2020). However, the impact of GVA-C on CO2 emission is very less in all European countries possibly because the European region is a group of advanced developed countries where construction and mining are very rare compare to developing nations where construction is at peak. Further FDI has a significant and positive impact on CO2 in EE, SE, and WE region and a negative impact in the NE region concerning GVA-C. Every 5% rise of FDI inflow tends to increase CO2 emission 4.44%, 1% rise in FDI inflow tends to increase CO2 emission 10.04% in SE and 0.85 % in WE. The significance of the model of GVA-C is supported by (Alcántara & Padilla, 2006; Murshed et al., 2020; Zhang et al., 2019). We observed the four-way linkage in terms of GVA-C which is significant with variables CO2, FDI inflow, and GDP per capita in all regions except the relation between FDI inflow in EE regions. Furthermore, we observed the heterogeneity in the relation between the GDP per capita and FDI inflow; insignificant relation in EE regions, significant but negative relation in SE regions, insignificant relation in NE regions, and a significant and positive association in WE regions. This result is similar to the (Bačić et al., 2004; Jorge & Werner, 2018; Simionescu, 2016). The insignificant effect of economic growth on FDI inflow strives to be positive by developing a strong domestic financial system- FDI is more beneficial to advanced economies (Hermes & Lensink, 2003).

Table 12
result of 3SLS using GVA-M

Result of SSEs using GVA-M													
		Eastern		Europe		Southern		Europe		Northern		Europe	
		Model 1				Model 2				Model 3			
logCO21		0.017**	-0.621***	0.664***		-0.003	0.044	0.833***		-0.029**	-0.221***	0.772***	
		-2.620	(-22.93)	-27.170		(-0.72)	-0.850	-14.120		(-2.88)	(-5.99)	-25.990	
logFDI	4.035**		1.766	-1.335	-1.808		-3.030*	12.47***	-2.061**		-0.076	3.908***	
		-2.620		-1.790	(-1.26)	(-0.72)		(-2.26)	-5.500	(-2.88)		(-0.22)	-7.290
logGDPPC	-1.565***	0.018		1.065***	0.163	-0.0172*		0.560**	-1.123***	-0.005		0.513**	
		(-22.93)	-1.790		-30.770	-0.850	(-2.26)		-3.040	(-5.99)	(-0.22)		-3.060
logGVA-M	1.462***	-0.012	0.929***		0.846***	0.019***	0.152**		1.103***	0.078***	0.144**		
		-27.170	(-1.26)	-30.770		-14.120	-5.500	-3.040		-25.990	-7.290	-3.060	
logICT	0.155***	-0.002	0.105***	-0.108***	-0.389**	0.000	0.434***	0.125	0.889***	-0.009	0.732***	-0.396**	
		-3.720	(-0.51)	-4.520	(-3.95)	(-2.89)	-0.060	-8.200	-0.960	-5.330	(-0.41)	-15.100	(-2.68)
logInflation	-0.141	0.005	-0.088	0.089	-0.749**	0.013	0.208	0.401	0.643*	-0.004	0.051	-0.479*	
		(-1.80)	-0.960	(-1.80)	-1.690	(-2.99)	-1.320	-1.560	-1.590	-2.520	(-0.12)	-0.440	(-2.23)
logLabor	3.647***	-0.115***	2.225***	-2.344***	1.787*	0.0891**	-1.216**	-1.855*	2.638**	-0.005	0.890*	-1.753*	
		-8.710	(-3.39)	-7.960	(-7.79)	-2.240	-2.930	(-3.09)	(-2.43)	-2.700	(-0.04)	-2.030	(-2.15)
logUrban	1.990***	-0.004	1.288***	-1.387***	-1.364***	0.001	0.633**	0.820*	0.834	-0.011	1.495***	-0.055	
		-7.220	(-0.17)	-7.810	(-7.91)	(-3.39)	-0.060	-3.060	-2.030	-1.760	(-0.19)	-9.530	(-0.14)
logTaxes	-0.395*	0.0283*	-0.195	0.210	0.349	-0.019	-0.248	0.155	0.812***	0.0479***	0.290***	-0.641***	
		(-2.38)	-2.250	(-1.75)	-1.780	-1.480	(-1.74)	(-1.74)	-0.670	-9.340	-3.960	-6.900	(-8.60)
Const.	-38.16***	7.128***	-18.67**	16.09*	6.382	6.564***	31.83***	-83.26***	0.382	6.268***	0.488	-14.45**	
		(-3.47)	-52.050	(-2.65)	-2.130	-0.380	-44.830	-3.660	(-5.51)	-0.060	-12.050	-0.160	(-2.66)

Source: author, Note: t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 13
result of 3SLS using GVA-C

	Eastern Europe			South Europe			Norther Europe		
	Model 1			Model 2			Model 3		
logCO21	0.0136*	-0.712***	53586.2***	0.00875**	0.147***	68769.6***	-0.0674***	-0.3	
	-2.45	(-17.93)	-23.05	-3.08	-3.90	-4.76	(-4.21)	(-6.6)	
logFDI	4.339*	2.12	-83088.90	10.04**	-3.833**	2884903.8***	-1.836***	-0.3	
	-2.45	-1.60	(-0.84)	-3.08	(-2.85)	-5.90	(-4.21)	(-1.0)	
logGDPPC	-1.314***	0.01	73106.5***	0.954***	-0.0216**	135107.6***	-0.783***	-0.03	
	(-17.93)	-1.60	-21.77	-3.90	(-2.85)	-3.40	(-6.62)	(-1.07)	
logGVA-C	1.78e-5***	-8.67e-8	1.32e-5***	2.65e-6***	9.69e-8***	8.03e-7***	5.65e-6***	5.83e-7***	1.68e-6***
	-23.05	(-0.84)	-21.77	-4.76	-5.90	-3.40	-45.10	-6.73	-4.8
logICT	0.322***	0.00	0.259***	-18298.1***	-0.580**	0.00	0.387***	46777.90	0.687***
	-6.51	(-0.62)	-9.29	(-7.04)	(-3.22)	(-0.39)	-6.93	-1.67	-6.55
logInflation	-0.288**	0.01	-0.218***	15287.6**	-1.278***	0.01	0.18	131934.3*	-0.10
	(-3.23)	-1.05	(-3.39)	-3.10	(-3.81)	-0.85	-1.31	-2.43	(-0.60)
logLabor	4.065***	-0.108**	2.869***	-209956.1***	2.08	0.137***	-0.64	-858836.3***	-2.481***
	-8.48	(-3.21)	-7.57	(-7.46)	-1.78	-4.19	(-1.44)	(-5.26)	(-4.02)
logUrban	1.762***	0.00	1.354***	-101952.7***	-1.926***	0.00	0.620**	172378.0*	0.29
	-5.63	-0.22	-6.10	(-6.24)	(-3.61)	-0.14	-2.98	-1.99	-0.96
logTaxes	0.02	0.0256*	0.14	-9035.30	1.834***	-0.0217*	-0.316*	-23326.80	0.08
	-0.12	-2.02	-0.95	(-0.82)	-7.19	(-2.13)	(-2.34)	(-0.43)	-1.52
Const.	-31.53*	7.052***	-15.70	643763.40	-78.54***	6.538***	36.20***	-18777466.8***	34.90***
	(-2.49)	-58.68	(-1.66)	-0.91	(-3.68)	-44.77	-4.17	(-5.76)	-7.86
Source: author, Note: t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.									

Conclusion

This study analyses the four-way linkage among CO2 emission, FDI inflow, GDP per capita, and value-added in four sectors GVA-A, GVA-S, GVA-M, and GVA-C in four European regions EE, WE, SE, and NE over the period of 2000 to 2018 and data have been used from the WDI database. To do this simultaneous equation approach has been used with the 3SLS estimation technique.

The result of sub-panel group EE, NE, SE, and WE regions shows that the CO2 emission has bidirectional causality with each industrial sector GVA-A, GVA-S, GVA-M, and GVA-C. Therefore, this article finds homogeneity in the relation between CO2 and industrial sectors.

There is a bidirectional relation between CO2 emission and economic growth in EE, SE, NE, and WE regions for industrial sector GVA-A, GVA-S, and GVA-C, while there is no association between CO2 emission and economic growth when we considered the manufacturing GVA in SE region.

The relation between CO2 emission and FDI we find the heterogeneous results. In the scenario of the GVA agriculture sector EE, NE, and WE region countries have bidirectional causality while SE region result shows no relation. For the case of the services sector, GVA bidirectional causality in NE and SE regions while no relation in EE and WE regions. Further manufacturing sector GVA there is bidirectional relation in EE, NE, and WE regions and no relation for SE region. Furthermore, with consideration of GVA-C sectors, we find bidirectional relation in all sub-group EE, SE, NE, and WE regions.

The result of the relation between FDI inflow and economic growth is also heterogeneous. There is no relation between FDI and economic growth in EE, SE, NE, and WE region for the case of sector GVA. In the case of GVA of agriculture sector EE, NE, and WE bidirectional relation while no causality in SE region.

The results of this article help the policymakers to understand and grasp the complexity of the relation among the CO2 emission, FDI inflow, economic growth, and GVA of different sectors in the European region. Therefore, the findings of this study have potential importance for policymaking to tackle the CO2 emission in different industrial sectors. This article concluded that the causality among this research variable depends on the regions, indicating that it is impossible to give universal policy recommendations. Therefore, to make pollution free economic development decision-maker (such as European Union) have to draft the policies which should have to consider regional factors and coherent with industrial sectors which will help to reduce the CO2 emission

without sacrificing the economic growth because in our results factors like labor, urbanization, taxes, and internet and telecommunication variable influence CO2 emission heterogeneously according to the region and industry-specific in Europe. Along with its merits, this article has some limitations. This article panel-groups limited to the group of countries and didn't focus on country-specific; it leads the future research. Finally, it will be interesting to find out these relations at the country level.

Declarations

Discloser statement

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Figures

Figure 1

Relation summary of GVA-A and GVA-S.

Figure 2

relation summary of GVA-M and GVA-C.