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Energizing Small and Medium-sized Enterprises for environmental sustainability in poor Europe: Do green finance and bureaucratic quality matter?

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Abstract

The sacrosanct role played by small and medium-sized enterprises (SMEs) in shaping economic realities in Europe resonates the accompanying impact of their activities on the environment. Furthermore, the unequal access to green finance across various sizes of small and medium enterprises alongside low level of bureaucratic quality in low-income nations in Europe further complicates the attainment of climatic targets by 2050. The study investigates the SME-environmental sustainability link amidst the moderating role of green finance and bureaucratic quality in selected low-income nations in Europe. Findings show that SMEs increased carbon emissions across all quantiles in the selected countries. The results from the interaction towed double-ends; interaction between SMEs and green finance reduced carbon emissions significantly from lower to upper quantiles. The interaction between SMEs and bureaucratic quality aggravates the level of carbon emission across all quantiles. Relevant policy recommendations were proffered to the sovereign governments and relevant EU agencies within the manuscript.

KEYWORDS

environmental sustainability, green finance and bureaucratic quality matter, SMEs

1 | INTRODUCTION

Past contributions across academic literature in Europe and other developing economies focus on small and medium-sized enterprise (SME)-economic growth link (Onyeiwu et al., 2021), barriers to accessing finance (Nizaeva & Coskun, 2019; Ur Rehman et al., 2019; Wagenvoort, 2003; Xheneti & Bartlett, 2012), SME-inclusive growth link (Okolo et al., 2023), and SME-environmental sustainability link (Okere et al., 2023; Okolo et al., 2023). The rationale behind the adoption of SMEs for Europe in this empirical adventure emanates from established facts: (a) SMEs account for 60%–70% environmental decimation in the case of EU; (b) SMEs account for over 90% of firms domiciled in the private sector in EU; (c) SME sector is one of the most important endogenous factors of regional development in underdeveloped Europe (see Constantinos et al., 2010; Lewandowska et al., 2014). However, the severity of the matter lies in the dependence on SMEs to drive regional growth in the case of Europe alongside its employment of over 70% of the entire European workforce (see De Wit & de Kok, 2013 for empirical verification).

The role of finance resonates stronger than pronounced in previous studies due to the geographical positioning of this study. In previous attempts such as Okolo et al. (2023), fears were raised concerning the finance-deficient regions within Europe and their inability to galvanize fund to execute environmental protection programs. SMEs situated in poorest areas of Europe erases the hope of eco-compliance due to paucity of funds, low financial performance, low adoption of renewable energy variants, presence of environmental technologies, inventions and innovations, and high technical knowhow. The European Union through the European Commission and its subbodies delved into the malaise by addressing the finance gap limiting the age-long expected growth of EU lagged countries. Furthermore, in the eve of the energy transition, the pool of EU developmental funds are channeled to aid low-growth regions cushion the socioeconomic effects of the transition through funding green-compliant startups and SMEs to create green jobs and increase overall productivity in the region (see Kyriacou & Roca-Sagalés, 2012; Sotiriou & Tsiapa, 2015).

A fresher perspective to the argument emanates from the study of Lewandowska et al. (2014) mirroring that the EU intervention funds efficiency is controversial from the perspective of public help. Statistically, there is ample empirical evidence showing that EU funds increase gross value added and regional per capita growth (see Maynou, et al. 2014). However, further insights shows that the EU funds is not accessible to everyone. Representatives of the 394 SMEs domiciled in Eastern Poland confirmed that EU structural funds were not considered the main source of financing for development. Rather, EU structural funds were indeed selective to bigger firms with a better financial situation (see Lewandowska et al., 2014). The above action limits the ability of SMEs to adopt sustainability innovations and engender environmental sanctity in Europe. Okolo et al. (2023) went further to add that firms who feel adopting sustainable practices deter financial progress or competitiveness especially SMEs would translate into rejection of more sustainable business models. Stakeholders call for components of the EU Green Deal to be SME-compatible is more germane in the low-growth regions in Europe. Joint research co-financed by the European Union and UNDP focused on scaling up green finance for private sector in Serbia post-pandemic reiterate that MSMEs continuously encounter barriers to green investments in Serbia. The barriers include lack of capital, insufficient skills, inadequate support from the regulatory environment, and information of green technologies and financial products. Furthermore, insights from the survey implicates commercial banks in their nonalignment to SMEs green projects evidenced by the demand of significant collateral and unfavorable loan terms, thereby favoring large firms only (see Ur Rehman et al., 2019). Furthermore, complexity of documentations necessary to access EU green funding sidelines SMEs with little or no financial history, accounting expertise, sound managerial team, and regulatory requirements reduces the engagement local SMEs has with the available EU funds. The authenticity of the green projects and the uniqueness are ignored due to their infancy of the green startup or SME.

The findings of Okolo et al. (2023) in the case of EU show that funding SMEs in the developed countries (inclusive part of EU) in the bloc enhances environmental sustainability. On the contrary, private sector and government funding of SMEs in the noninclusive part of EU aggravate environmental pollution. Muoneke et al. (2023), also decried the low level of bureaucratic quality in the underdeveloped part of Europe which to a greater extent contributes to the low internal capacity needed to settle technical requirements within the sovereign territories necessary to access the transition fund. The attention of past empirical inputs has been more focused on SME-growth link and SME-environmental sustainability in developed and developing countries within Europe with a GDP per capita threshold of above 30,000 USD (see Chatzistamoulou & Tyllianakis, 2022; Hessels & Parker, 2013; Okolo et al., 2023; Özbuğday et al., 2020); however, the impact of high bureaucratic quality and green finance on engendering environmental sustainability is ignored by authors. Countries below the 30,000 threshold are under-researched and largely deserted due to scarcity of data; nevertheless, empirical insights are needed more to expose grey areas to policymakers at the European Commission and governments of North Macedonia, Belarus, Serbia, Montenegro, Bulgaria, Bosnia, Albania, Ukraine, Moldova, Russia, Romania, and Croatia to accelerate the green transformation and technical capacity of the low-growth regions in Eastern and South-Eastern Europe. The contribution of this study to knowledge repository is two-folds: (a) Establish the state of the SMEs and environmental quality nexus in low-growth regions in Europe; (b) investigate the role of green finance and bureaucratic quality in mitigating the adverse effects of SME activities on the environment in low-growth regions in Europe. Therefore, the objective of this study is to investigate the SME-environment link amidst the role of green finance and bureaucratic quality in low-income European countries.

The present study adheres to a clearly defined structural framework. Section 1 presents a comprehensive review of many pertinent studies, while Section 2 furnishes an elaborate exposition of the dataset, accompanied by illustrated statistical measures. The empirical analysis is conducted in Section 3, where the results are presented. Section 4 finishes the study by discussing the policy implications.

1.1 | Literature review

The theoretical arguments for the relationship between SMEs and the environment sustainability have always anchored on institutional theory. This theory posits that external influences and prevailing norms shape the environmental sustainability practices of SMEs. Within the context of this framework, SMEs adopt environmentally friendly practices in order to conform to societal norms, industry standards, and regulatory obligations. In shaping the environmental sustainability plans of SMEs, institutional pressures exert a significant influence. These pressures encompass stakeholder expectations, industry standards, and governmental requirements.

These theoretical underpinning above offers narrow viewpoints that enable scholars and practitioners to comprehend the connection between SMEs and environmental sustainability (Khoja et al., 2022). It is imperative to acknowledge that the precise theoretical connection may differ based on the setting, industry, and distinct attributes of SMEs. Empirical investigations are required in order to enhance our comprehension of this association and its ramifications for SMEs and the environment.

1.2 | SMEs and environmental sustainability

On the empirical front, the contribution of SMEs to economic growth in the EU bloc is sacrosanct and the impact of increased economic activity on air quality across major cities in Europe resurrects the need for research on the SMEs and environmental sustainability nexus in Europe. The discussion takes a major geographical stance in the low-income countries in Europe, as growth-inducing activities are its a higher threshold evidenced by their endless quest for economic prosperity. Academic literature focused to the identified region are scarce; however, there are few studies focused on EU and developed areas of Europe. Neri et al. (2021) investigated the possible barriers to adopting industrial sustainability measures by European SMEs. Findings from an exploratory investigation on 26 SMEs operating in the chemical and metalworking manufacturing sectors across Germany and Italy depicted that the sampled firms are hindered by economic barriers. A similar evidence from China contained in the study by He et al. (2014) posited that strong economic ties between local county governments and chemical SMEs remain a barrier impeding the creation of stringent environmental degradation. Okere et al. (2023) and Okolo et al. (2023) provided insights on the contribution of SMEs to environmental degradation through the auspices of public and private sector financing. In the case of Africa, Okere et al. (2023) documents that credit from private sector counteract the adverse effect of SMEs on the environment, whereas credit from government increases the environmental footprint of SMEs in Africa. In the case of EU, Okolo et al. (2023) document that credit from the private sector to SMEs in both inclusive and noninclusive growth cohort in EU enhances environmental sustainability. On the contrary, credit from government sources only improves environmental sustainability in inclusive part of EU.

1.3 | Bureaucratic quality and environmental sustainability

Bureaucratic quality and its positive effects on environmental quality in advanced economies predominated with strong institutions and high technical capacity. Bureaucracy can increase environmental quality through the auspices of environmentally oriented bureaucrats with supreme expertise in environmental and climatic issues. Their expertise enables them to cut down any conflicting environmental regulations, eliminate bottlenecks, hasten the energy transition from coal to gas or direct to renewable energy, implement agreements, properly allocate EU funding to low-growth EU countries to wither climate change costs, and address ecological and environmental concerns. However, in underdeveloped EU nations, study conducted on EU countries in the Eastern Bloc deduced that bureaucratic quality aggravates environmental pollution (see Muoneke et al., 2023). A panacea was put forward by Alola et al. (2022) explicitly stating that promoting a sound bureaucratic system alongside the GDP per capita could be a viable solution to environmental challenges within the European Union. Therefore, high bureaucratic quality is a mundane support to governments in the low-growth EU countries to pursue growth and environmental protection parri-passu.

The next tranche of literature focuses on the ability of Central and Eastern European countries to manage EU cohesion funds effectively. Mendez and Bachtler (2021) anchored on the ability of government quality to improve the administrative performance of regions covered under the EU Cohesion Policy. The results confirm that government quality is a key determinant of administrative performance in terms of financial compliance, timely spending, and outcomes in the selected 173 European regions across seventeen member states. Rodríguez-Pose and Ketterer (2019) took a notch higher adopting 256 regions from 24 EU member states stressed that government quality improvements are essential for low-growth regions. The study reiterated that low government capacity is not the major barrier to future development, rather it is the absence of improvement in government quality that actually does the damage.

1.4 | Green finance and environmental sustainability

Theoretically, there are several pathways through which green finance can affect the environment namely: (a) the technological innovation/progress channel; (b) capital support channel; (c) resource allocation channel.

In the first two pathways share similarities, especially the external financial aid given to green-compliant firms, the former focuses on supporting firms engaging in green innovations in the area of research and development activities and firms making efforts to proffer feasible solutions capable of increasing energy efficiency usage. The latter mirrors financial support given to firms with a lower level of energy use and a lesser volume of carbon release. The action may influence other traditional energy intensive firms to refrain from their energy-intensive business activities to enjoy same financial support. Under the resource allocation channel, green finance through financial institutions allocates capital efficiently, that is, channeling financial flows from high carbon-emitting firms/industries to low carbon-emitting firms/industries. Financial institutions increase the interest rates charged on loans to high carbon-emitting firms to discourage engagement in business activities with dire consequences on the environment.

The inclusion of green finance in the foray emanates from the ability of green funding to promote environmental sanctity amidst strong institutional arrangements. Available empirical evidence from Bakry et al. (2023), Wang et al. (2023), and Jin et al. (2023) asserts that green finance exerts significant and inhibitory effects on CO_2 emission in developing and developed economies, respectively. Numan et al. (2023) also found that green finance and technological innovation reduce ecological footprint in the case of thirteen complex economies. Du (2023) also documented that the short- and long-run estimates of green finance reduces carbon intensity in Asian countries.

Furthermore, the intervention of government in the finance sector or supporting environmental innovation is indeed crucial to ensuring adoption of green technologies by SMEs. The risk associated with the finance sector engagement with sustainability issues persists necessitating nonparticipation from popular institutional investors and the onus falls on government to mitigate or downplay the risk (see Nykvist & Maltais, 2022; Polzin & Sanders, 2020). Flachenecker et al. (2022) supported accordingly stating that publicly supported environmental innovation increased firm employment, turnover, and market share. Nykvist and Maltais (2022) and Flachenecker et al. (2022) highlighted government intervention accelerates the finance sector participation in sustainability issues and public financial support for environmental innovations appears to be an effective instrument to facilitate the transition to a more sustainable economy. Geddes et al. (2018) recognizes the hesitant mood of the popular institutional investors due to the availing risk and proffers the State Investment Banks to close the gap, leverage additional finance, and provide sufficient guarantees for other financial institutions.

2 | MODEL, DATA, AND ESTIMATION TECHNIQUE

2.1 | Model building, framework, and empirical specification

Ehrlich and Holdren (1971) introduced the IPAT model as a valuable framework for understanding the economic factors that contribute to human impact on environmental resources and the ecosystem. This model expresses environmental consequences in a concise and systematic way, allowing for a deeper understanding of the complex interrelationships between human activities and their impact on the environment as thus:

$$I = PAT. \tag{1}$$

This model Equation (1) highlights the interplay of population size (*P*), affluence level (*A*), and technological advancement (*T*) in shaping environmental outcomes (York et al., 2003). However, to overcome limited empirical data, Dietz and Rosa (1994) introduced the STIRPAT model, which serves as a regression aid for statistical testing. By considering the impact of population, wealth, and technology, the STIRPAT[1] model provides a valuable approach to analyze and understand the complex relationship between human activities and their environmental repercussions.

$$I_t = \beta_0 . P_t^{\beta_1} . A_t^{\beta_2} . T_t^{\beta_3}. \tag{2}$$

Equation (2) encompasses essential parameters that are crucial in evaluating the impact of anthropogenic factors on the environment. The constant β_0 serves to scale the function, whereas β_1, β_2, and β_3 represent the elasticity of population (*P*), affluence (*A*), and technological advancement (*T*), respectively. The variable *t* accounts for the time element.

The correlation between SMEs and environmental sustainability is ascribed to the capacity of inventive and environmentally mindful company strategies to generate favorable ecological results (Ye et al., 2020). The concept of entrepreneurship SMEs, which is distinguished by its attributes of innovation, adaptability, and risk-taking, plays a crucial role in fostering the creation of sustainable solutions aimed at tackling environmental concerns

(Cooper-Ordoñez et al., 2019). Based on the provided context, our model extends its scope by incorporating additional factors, namely SMEs, green finance, and bureaucratic quality (refer to Okere et al., 2023). To fulfill the first objective, we define environmental impact as a linear function of population (Pop), economic growth (GDP), SMEs, green finance, bureaucratic quality, and control variables.

As a result, the augmented model is formulated as follows:

$$I_t = \beta_0 . P_t^{\beta_1} . A_t^{\beta_2} . \text{entrep}_t^{\beta_3} . \text{gfin}_t^{\beta_4} . \text{clrspct}_t^{\beta_5} . \varepsilon_t. \tag{3}$$

By applying the natural logarithm (ln) to Equation (3), this research establishes the subsequent functional relationship for guiding empirical analysis and achieving equilibrium in the equation through the inclusion of control variables.

$$\text{lnLCO}_2\text{gdp}_{it} = \beta_0 + \beta_1 \text{lnpop}_{it} + \beta_3 \text{lngdp}_{it} + \beta_3 + \text{lnentrep}_{it} + \beta_4 \text{lngfin}_{it} + \beta_5 \text{lnrenw}_{it} + \varepsilon_{it}, \tag{4}$$

$$\text{lnLCO}_2\text{gdp}_{it} = \beta_0 + \beta_1 \text{lnpop}_{it} + \beta_3 \text{lngdp}_{it} + \beta_3 + \text{lnentrep}_{it} + \text{lnclrpct}_{it} + \beta_5 \text{lnrenw}_{it} + \varepsilon_{it.} \tag{5}$$

Equation (4) showcases the variables in a logarithmic format (ln). CO_2gdp stands for the environmental effects resulting from CO_2 emissions, while Pop represents the total population. Affluence (A) corresponds to GDP per capita, and Technology is indicated by the proxy of Green Finance (gfin). SMEs as the Total business density is denoted as (entrep), Bureaucratic Quality is referred to as (clrspct), and control variable is renewable energy is expressed as (renw). β_1 to β_5 are the parameters slated for estimation. In this context, $i = 1, \ldots, N$ signifies the count of cross-sections, and t corresponds to the time frame. The term ε_t captures the overall error.

We tackle the study's pivotal second objective by enhancing Equations (4) and (5) with the incorporation of an interaction term $(\text{lnentrep}_t * \text{lngfin}_t)$ and $(\text{lnentrep}_t * \text{lnclrpct}_t)$. This augmentation allows us to assess how the interplay between these variables influences the environmental consequences stemming from CO_2 emissions.

$$\text{lnLCO}_2\text{gdp}_{it} = \beta_0 + \beta_1 \text{lnpop}_{it} + \beta_3 \text{lngdp}_{it} + \beta_3 \text{lnentrep}_{it} + \beta_4 (\text{lnentrep}_{it} * \text{lngfin}_{it}) + \beta_5 \text{lnrenw}_{it} + \varepsilon_{it}, \tag{6}$$

$$\text{lnLCO}_2\text{gdp}_{it} = \beta_0 + \beta_1 \text{lnpop}_{it} + \beta_3 \text{lngdp}_{it} + \beta_3 + \text{lnentrep}_{it} + \beta_4 (\text{lnentrep}_{it} * \text{lnclrpct}_{it}) + \beta_5 \text{lnrenw}_{it} + \varepsilon_{it}. \tag{7}$$

The potential of renewable energy (control variable) to mitigate CO_2 emissions is expected to foster a positive correlation with environmental sustainability (Nwani et al., 2023; Onuoha et al., 2023). The environmental impact of SMEs is dependent on their characteristics of innovation, adaptability, and propensity for risk-taking. These characteristics play a crucial role in enabling the creation of effective and long-lasting solutions designed to tackle environmental challenges. The influence of SMEs on CO_2-related GDP changes can be determined by examining the coefficient β_4 in Equations (6) and (7), which indicates whether the interaction between Clrspct and gfin strengthens or diminishes this relationship. Intuitively, a negative β_4 indicates that the impact of SMEs on environmental sustainability is enhanced by the combination of green funding and bureaucratic efficacy.

In order to achieve the third objective, we aim to examine the potential synergistic impacts of green finance and effective bureaucratic measures on the environmental sustainability outcomes of SMEs. Specifically, we seek to determine whether the existence of green finance and effective bureaucratic measures enhances the influence of SMEs on changes in CO_2-related GDP, taking into consideration the respective influence of both factors on the overall net outcome. Following Muoneke et al. (2022) and Alola et al. (2022), the total effect of SMEs is calculated by using the average values of green finance and bureaucratic quality indicators from Table 1. Therefore, taking into account the additional influence of green finance (lngfin) and bureaucratic quality (clrpct), the calculation of the total effect of lnentrp_{it} on lnCO_{2it} is as follows:

TABLE 1 Descriptive statistics.

Series	Definition	Sources	Mean	Std. Dev.	Skewness	Kurtosis	JB	Prob	Obs
lnCO_2gdp	CO_2 emissions (kg per 2015 US$ of GDP)	(WDI) Database	5.214	2.575	1.035	3.867	31.500	.000	150
lnpop	World Bank Doing Business Database	(WDI) Database	24,491,182	41,737,102	2.282	6.751	218.109	.000	150
lngdp	Gross Domestic Product Per Capita (Constant 2010 US$)	(WDI) Database	6216.283	3123.909	0.641	2.541	11.594	.003	150
lnrenw	Renewable energy consumption (% of overall final energy consumption)	(WDI) Database	17.785	11.000	0.266	2.186	5.909	.052	150
lnclrspct	Bureaucratic Quality indicate the rigorous and impartial administration. Scale: Interval, from low to high (0–1)	V-Dem: Varieties of Democracy	0.416	0.620	−0.444	2.644	5.730	.057	150
lngfin	Government and Public Sector Finance, Expenditure on Environmental Protection, Protection of Biodiversity and % of GDP (Green Finance)	(WDI) Database	0.347	0.299	1.254	4.032	45.997	.000	150
lnentrep	Total business density is calculated as the number of registered businesses as a % active population	World Bank Doing Business Database	37.821	24.472	0.629	2.454	11.742	.003	150

Note: World Development Database (WDI) available online at https://data.worldbank.org. World Bank Doing Business Database available online at https://www.worldbank.org/en/businessready. V-Dem: Varieties of Democracy available online at V-Dem

Source: Author's compilation.

$$\frac{\partial \mathrm{lnCO_2gdp}}{\partial \mathrm{lngfin}} = \beta_3 + \beta_4 \mathrm{lngfin}_t, \tag{8}$$

$$\frac{\partial \mathrm{lnCO_2gdp}}{\partial \mathrm{lnentrep}} = \beta_3 + \beta_4 \ln \mathrm{clrpct}_t. \tag{9}$$

Equations (8) and (9) shown above depict the partial derivative with respect of SMEs (entrep) to CO_2gdp. The symbol β is used to denote the instantaneous influence of SMEs on environmental sustainability, encompassing both positive and negative effects. By contrast, the coefficient β_4 represents the combined effect of green finance and bureaucratic quality on the aspect of environmental sustainability. The effect in question has the potential to manifest as either positive, negative, or neutral in nature. The presence of green funding and high bureaucratic quality has been found to minimize the harmful implications of SMEs on environmental sustainability, as evidenced by a negative cumulative impact. On the contrary, a positive cumulative effect suggests that the combination of green finance and bureaucratic quality enhances the positive results of SMEs in terms of environmental sustainability. A neutral interaction effect can be observed when the combination of green finance and bureaucratic quality does not have any significant influence on the relationship between SMEs and environmental sustainability.

2.2 | Estimation approach

Prior to commencing the econometric analyses, it is important to conduct preliminary examinations on the data. The three main components of the analysis encompass the following: (1) the examination of cross-sectional dependency (CSD), (2) the assessment of stationarity, and (3) the testing of cointegration. Failure to account for CSD may result in estimations that are biased, as a consequence of the significant interdependence observed among countries (Pesaran, 2015). The CSD test can be applied to datasets that are both balanced and unbalanced. According to Pesaran (2015), the null hypothesis assumes a weak level of CSD, whereas the alternative hypothesis proposes a significant level of cross-sectional reliance. In order to assess the consistency of slopes, we utilize the testing methodology introduced by Pesaran and Yamagata (2008). If there is evident CSD within the data, this analysis utilizes two panel unit root tests. There are two tests that can be used to examine unit root processes. The first test conducted by Im et al. (2003) evaluates individual unit root processes. The second test is conducted by applying the cross-sectionally augmented Dickey–Fuller (CADF). Furthermore, we utilize the Westerlund (2005) cointegration test designed specifically for panels that exhibit heterogeneity and CSD. The null hypothesis that there is no cointegration is rejected when the variables demonstrate cointegration in either all or part of the panels. If evidence of CSD in the data and the existence of cointegration among variables are detected, the fixed effects (FE-DK) estimators with Driscoll and Kraay (1998) standard errors, in conjunction with the augmented mean group (AMG) model introduced by Eberhardt and Teal (2010), are considered appropriate methodologies. The AMG estimator has been observed to exhibit reliability and robustness in addressing CSDs in panel data. As shown in the work of Eberhardt and Bond (2009), this approach is not bound by the stationarity properties of the variables, making unit root and cointegration tests redundant. Although FE-DK estimators provide robust parameter estimates for the model, its main emphasis lies in modelling the conditional mean of the dependent variable.

2.3 | MM-QR estimates

In order to address the problem of distributional variability, the utilization of a unique approach called method of moments quantile regression (MM-QR) is implemented. The method of moments fixed effects algorithm, as established by Machado and Silva (2019), is utilized to apply this technique. The methodology employed in this study effectively addresses the issue of fixed effects in panel quantile models, allowing for the estimate of several aspects of the conditional distribution, such as the 25th, 50th, and 75th quantiles of the dependent variable. The estimate methodology for the conditional quantile $Q_y(\tau|X_{it})$ of the location-scale variant model is derived by altering Equations (6 & 7) based on the approaches proposed by Machado and Silva (2019), and Okere et al. (2023). The broad specification is employed to alter the equations.

$$Q_y(\tau|X_{it}) = (\beta_i + \delta_i qi) + X'_{it}\beta + Z'_{it}\gamma q(\tau), \tag{10}$$

where $Q_y(\tau|X_{it})$ depict the quantile distribution of the dependent variable $\mathrm{lnLCO_2gdp}_{it}$, conditional on the location, and scale of explanatory variable (X'_{it}). X'_{it} it is a vector of explanatory variables (see Table 1). $\alpha_i(\tau) = \alpha_i + \delta_i q(\tau)$ represents the distributional effect at τ or the scalar coefficient of the quantile-τ fixed effect for individual i. $q(\tau)$ is the τ-th quantile estimated through optimization function:

$$\min_q \sum_i \sum_t \rho_\tau \left(\hat{R}_{it} - (\hat{\delta}_i + Z'_{it}\hat{\gamma})q\right). \tag{11}$$

Accordingly, this threshold $\rho_\tau(A) = (\tau-1)AI\{A \le 0\} + \tau AI\{A > 0\}$ offers a check function. Drawing from the Equation (10), we present the final modified baseline model stated in Equations (4), (5), and (6) for panel quantile calculation as thus

$$Q_{\mathrm{lnLCO_2gdp}_{it}}(\tau|\beta_i, \varepsilon_{it}, X_{it}) = \beta_0 + \beta_1 \mathrm{lnpop}_{it} + \beta_3 \mathrm{lngdp}_{it} + \beta_3 + \mathrm{lnentrep}_{it} + \beta_4 \mathrm{lngfin}_{it} + \beta_5 \mathrm{lnrenw}_{it} + \varepsilon_{it}, \tag{12}$$

$$Q_{\mathrm{lnLCO_2gdp}_{it}}(\tau|\beta_{ii}, \varepsilon_{it}, X_{it}) = \beta_0 + \beta_1 \mathrm{lnpop}_{it} + \beta_3 \mathrm{lngdp}_{it} + \beta_3 + \mathrm{lnentrep}_{it} + \mathrm{lnclrpct}_{it} + \beta_5 \mathrm{lnrenw}_{it} + \varepsilon_{it}, \tag{13}$$

$$Q_{\mathrm{lnLCO_2gdp}_{it}}(\tau|\beta_{ii}, \varepsilon_{it}, X_{it}) = \beta_0 + \beta_1 \mathrm{lnpop}_{it} + \beta_3 \mathrm{lngdp}_{it} + \beta_3 \mathrm{lnentrep}_{it} + \beta_4 (\mathrm{lnentrep}_{it} * \mathrm{lngfin}_{it}) + \beta_5 \mathrm{lnrenw}_{it} + \varepsilon_{it}, \tag{14}$$

$$Q_{\mathrm{lnLCO_2gdp}_{it}}(\tau|\beta_{ii}, \varepsilon_{it}, X_{it}) = \beta_0 + \beta_1 \mathrm{lnpop}_{it} + \beta_3 \mathrm{lngdp}_{it} + \beta_3 + \mathrm{lnentrep}_{it} + \beta_4 (\mathrm{lnentrep}_{it} * \mathrm{lnclrpct}_{it}) + \beta_5 \mathrm{lnrenw}_{it} + \varepsilon_{it}. \tag{15}$$

2.4 | Data and statistical description of variables

The accessible data have an impact on the data choice. In order to carry out this study, a carefully selected group of ten (10) countries[2] is collected, encompassing the period from 2006 to 2020, resulting in a total duration of 15 years and a dataset comprising 150 observations. Drawing upon the empirical specifications and preceding descriptions of the variables, we have incorporated Table 1 to provide a succinct summary of the conceptual definitions and fundamental statistical characteristics of these variables. The Jarque–Bera statistical test is employed to assess the adherence of a series to a normality distribution by utilizing measurements of skewness and kurtosis from the distribution. The outcomes of the Jarque–Bera test indicate that none of the variables conform to a normal distribution. The distribution of the variables is visually depicted in Appendix A through the utilization of histograms and Kernel density plots. The presented plots provide evident indications of a substantial skewness in the distribution of the series, as well as a noticeable deviation from a normal distribution characterized by symmetry. The non-normality of the probability distribution of the series implies that estimates obtained using FE-DK and AMG estimators, which rely on the conditional mean distribution of the dependent variable, may provide limited support for policy analysis. Therefore, the present study relies on the dependability of the MM-QR algorithm in order to investigate the effects of composite, de facto, and de jure conditions on the process of information globalization.

The investigation is carried out across several conditional distributions of carbon dioxide (CO_2) emissions within the sampled geographical area.

3 | EMPIRICAL RESULTS AND DISCUSSION

3.1 | Preamble

This section commences with a series of preliminary tests designed to investigate CSD, as presented in Table 2. Additionally, it aims to ascertain the unit root characteristics of the variables, as reported in Table 3. Furthermore, it seeks to explore the presence of cointegration among the variables, as suggested by the results detailed in Table 4. Lastly, it aims to assess the existence of fixed effects in the model setup, as demonstrated by the results outlined in Table 5. Following this, the study explores the fundamental model that utilizes the fixed effects regression with Driscoll–Kraay standard errors D–K and augmented mean group (AMG) approach (with the results presented in Table 6), and it performs distributional impact analyses using the MM-QR panel quantile regression method (as shown in the results presented in Table 7). Table 7 is subdivided into three distinct sections based on quantiles. The first portion encompasses the lower quantile, which encompasses values such as qtile_10th and qtile_25th. The second section represents the median quantile, specifically qtile_50th. Lastly, the higher quantile is composed of qtile_75th and qtile_90th.

3.2 | Preliminary tests

The first stage of this investigation entails evaluating the descriptive nature of the data series (see Figure A1) and the presence of multicollinearity among the variables by the utilization of a statistical test known as the variance inflation factors (VIF) test, which was first established by Belsley (1980). The results provided in Table A1, for the four model specifications, demonstrate that the computed VIF values and their mean values are both below the commonly recognized thresholds of 10 and 6, respectively. Based on the results obtained, it can be asserted with confidence that there are no issues of multicollinearity observed among the variables in the specified model parameters. Next, we determine the results of the CSD test introduced by Pesaran (2015), as presented in Table 2, offer significant empirical support for the presence of CSD in all variables at a significance level of 1%. The findings of the slope

TABLE 2 Cross-section dependence test.

Variable	CD test	*p*-value	Average joint T	Mean p	Mean abs(ρ)
lnCO_2gdp	5.628	.000	15	.22	0.45
Lnpop	7.441	.000	15	.29	0.89
lngdp	16.41	.000	15	.63	0.7
lnrenew	11.417	.000	15	.44	0.54
lnclrspct	1.723	.000	15	.01	0.42
lngfin	16.448	.000	15	.63	0.77
lnentrep	−0.953	.000	15	−.04	0.43
lninter1	1.634	.000	15	.06	0.36
lninter2	−1.054	.000	15	−.04	0.42

Note: Under the null hypothesis of cross-section independence, CD ~ N(0,1);
****p* < .01; ***p* < .05; **p* < .1.

TABLE 3 Panel Unit Root Tests.

	Panel A				Panel B				
	First generation: Im, Pesaran, and Shin (IPS) unit root test				Second generation: CADF (Pesaran, 2007) unit root test				
	Level I(0)		1st difference I(1)		Level I(0)		1st difference I(1)		
Variables	Without trend	With trend	Without trend	With trend	Without trend	With trend	Without trend	With trend	Decision
lnCO_2gdp	−0.756	−1.824	−5.519***	−5.699***	−1.679	−1.529	−3.057***	−3.374***	I(1)
lnpop	−0.897	−0.725	−5.148***	−5.922***	−1.812	−2.607	−3.146***	−3.708 ***	I(1)
lngdp	−1.340	−0.713	−3.704***	−4.053***	−1.034	−1.283	−2.174***	−2.989***	I(1)
lnrenew	−0.392	−1.698	−5.575***	−6.126***	−1.448	−1.998	−3.126***	−3.322***	I(1)
lnclrspct	−0.9762	−0.422	−3.751***	−3.932***	−1.119	−1.405	−2.608**	−2.978**	I(1)
lngfin	−1.963	−1.284	−4.693***	−4.771***	−1.105	−2.257	−3.121***	−3.173***	I(1)
lnentrep	−1.002	−1.585	−4.659***	−5.188***	−1.430	−1.551	−2.871***	−3.015***	I(1)
lninter1	−0.274	−1.689	−5.755***	−6.144***	−2.203	−2.414	−2.964***	−3.790***	I(1)
lninter2	0.658	1.100	−2.873**	−3.402**	−0.868	−1.135	−2.591***	−3.019***	I(1)

Note: CADF is for the cross-sectionally augmented Dickey-Fuller test.
***$p < .01$; **$p < .05$; *$p < .1$.

TABLE 4 Pesaran and Yamagata (2008) slope heterogeneity test.

Model specifications	Delta tilde	*p*-value	Adjusted delta tilde	*p*-value
1. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lngfin	5.393	.000	7.384	.000
2. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lnclrspct	5.191	.000	7.108	.000
3. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lninter1	5.352	.000	7.329	.000
4. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lninter2	5.14	.000	7.038	.000

Note: Statistically significant indicates a rejection of the null hypothesis.
***$p < .01$; **$p < .05$; *$p < .1$.

TABLE 5 Westerlund (2007) bootstrap test.

Model specifications	Gt value	Ga value	Pt value	Pa value
1. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lngfin	−2.454***	−11.010***	−15.580***	−7.338***
2. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lnclrspct	−2.468***	−7.541***	−11.397**	−11.150***
3. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lninter1	−2.422***	−9.013***	−13.728***	−9.335***
4. lnCO_2gdp, lnpop, lngdp, lnrenw, lnentrep, lninter2	−2.345***	−8.571***	−16.225***	−10.320**

Note: Statistically significant indicates a rejection of the null hypothesis of no cointegration; robust *p*-value are from Bootstrap replications of the critical values.
***$p < .01$; **$p < .05$; *$p < .1$.

heterogeneity test conducted by Pesaran and Yamagata (2008) are presented in Table 3. The estimates provide evidence against the null hypothesis of slope homogeneity, suggesting the presence of slope heterogeneity in the panel data. In order to determine the stationarity properties of the variables, taking into consideration the presence of CSD, we utilize the Im, Pesaran, and Shin (IPS) unit root test and second generation panel unit root test (CADF) developed by Pesaran (2007). In Table 3, it is observed that all the variables exhibit stationarity only after being differenced once. Based on the provided information, it may be inferred that all the variables exhibit an integrated order of one, denoted as I(1). Further, we undertake an examination of cointegration among the variables by employing the error correction-based test proposed by Westerlund (2007). As indicated in Table 4, the p-values associated with the panel test statistics (Pt and Pa) do not surpass the threshold of 5% (i.e., 0.05). This suggests that the null hypothesis of no cointegration is rejected for the entire panel. The null hypothesis is rejected for the cross-sectional units, as evidenced by the p-values associated with the Gt and Ga statistics.

3.3 | Empirical results and discussion

In this section, we present empirical findings to fill crucial knowledge gaps concerning the topic of empowering SMEs for environmental sustainability in economically disadvantaged European regions. Our analysis leverages fixed effects regression with Driscoll–Kraay standard errors (D–K) and augmented mean group (AMG) techniques, and the results are summarized in Table 6. Our study seeks to elucidate the specific roles of SMEs, green finance, and bureaucratic quality in either promoting or impeding environmental sustainability in these regions. Furthermore, we investigate how the interplay between these variables either facilitates or obstructs the impact of SMEs on environmental sustainability. Beginning with the findings displayed in Table 6, it is evident that both the FE-DK and AMG estimations validate the positive and statistically significant relationship of the population coefficients. Therefore, the findings suggest that population size plays a significant role in exacerbating carbon emissions, thereby contributing to environmental problems. This finding suggests that a one unit increase in population size is associated with an

TABLE 6 Fixed effects regression with Driscoll–Kraay standard errors D–K and augmented mean group (AMG).

	Dependent variable CO_2gdp							
Variables	**DK-1**	**DK-2**	**DK-3**	**DK-4**	**AMG-5**	**AMG-6**	**AMG-7**	**AMG-8**
lnpop	0.570*	0.929**	0.693**	0.823*	−0.580**	−0.870**	−0.511**	−0.694**
	(0.307)	(0.423)	(0.284)	(2.400)	(2.263)	(1.408)	(2.278)	(1.615)
lngdp	0.568***	0.564***	0.561***	0.555***	0.628***	0.692***	0.622***	0.684***
	(0.057)	(0.064)	(0.061)	(0.055)	(0.159)	(0.196)	(0.185)	(0.201)
lnrenw	−0.111***	−0.129***	−0.115***	−0.130***	−0.225***	−0.273***	−0.226***	−0.276***
	(0.034)	(0.031)	(0.035)	(0.032)	(0.065)	(0.077)	(0.066)	(0.076)
lnentrep	0.236***	0.225***	0.224***	0.211***	0.114***	0.128***	0.107***	0.119***
	(0.025)	(0.024)	(0.024)	(0.022)	(0.061)	(0.083)	(0.060)	(0.085)
lngfin	−0.01***				−0.0138**			
	(0.014)				(0.086)			
lnclrspct		0.0282***				0.0405***		
		(0.015)				(0.012)		
lninter1			−0.001 ***				−0.016***	
			(0.012)				(0.079)	
lninter2				0.015***				0.031***
				(0.011)				(0.011)
Net effect			0.224	0.217			0.101	0.132
Constant	−4.953**	−7.429**	−5.803**	−6.674**	2.376	5.752	1.898	4.042
	(2.247)	(3.101)	(2.048)	(2.919)	(16.280)	(15.460)	(16.490)	(17.620)
Observations	150	150	150	150	150	150	150	150
Number of groups	10	10	10	10	10	10	10	10

Note: Standard errors in parentheses.
***$p < .01$; **$p < .05$; *$p < .1$.

TABLE 7 MM-QR estimates.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Variables	location	scale	qtile_10	qtile_25	qtile_50	qtile_75	qtile_90	location	scale	qtile_10	qtile_25	qtile_50	qtile_75	qtile_90
lnpop	0.693**	0.017**	0.668**	0.677**	0.694**	0.709**	0.717**	0.823**	0.406**	0.194**	0.449**	0.826**	1.236**	1.426**
	(0.615)	(0.344)	(0.804)	(0.699)	(0.615)	(0.689)	(0.784)	(0.516)	(0.288)	(0.719)	(0.608)	(0.519)	(0.563)	(0.628)
lngdp	0.561***	−0.022 ***	0.594***	0.582***	0.560***	0.540***	0.529***	0.555***	−0.039*	0.615***	0.591***	0.555***	0.516***	0.498***
	(0.091)	(0.051)	(0.118)	(0.103)	(0.091)	(0.101)	(0.116)	(0.084)	(0.047)	(0.118)	(0.100)	(0.085)	(0.092)	(0.103)
lnrenw	−0.115***	−0.011***	−0.130***	−0.125***	−0.114***	−0.105***	−0.0996***	−0.130***	0.010**	−0.145***	−0.139***	−0.130***	−0.120***	−0.116***
	(0.029)	(0.016)	(0.038)	(0.033)	(0.029)	(0.033)	(0.037)	(0.027)	(0.015)	(0.038)	(0.032)	(0.028)	(0.030)	(0.034)
lnentrep	0.224***	0.016***	0.200***	0.209***	0.224***	0.238***	0.246***	0.211***	0.007	0.223***	0.218***	0.211***	0.204***	0.200***
	(0.038)	(0.021)	(0.050)	(0.043)	(0.038)	(0.043)	(0.049)	(0.029)	(0.016)	(0.040)	(0.034)	(0.029)	(0.031)	(0.035)
lninter1	−0.001**	−0.014***	0.022 ***	0.014 ***	0.001*	−0.012 **	−0.019***							
	(0.014)	(0.008)	(0.018)	(0.016)	(0.214)	(0.015)	(0.018)							
lninter2								0.015 ***	0.001***	0.017***	0.016 ***	0.015***	0.015***	0.014***
								(0.007)	(0.004)	(0.010)	(0.009)	(0.007)	(0.008)	(0.009)
Constant	−5.803	0.009	−5.817	−5.812	−5.803	−5.794	−5.790	−6.674*	−2.684*	−2.520	−4.203	−6.696*	−9.403**	−10.66**
	(4.459)	(2.495)	(5.831)	(5.070)	(4.459)	(4.996)	(5.688)	(3.794)	(2.123)	(5.293)	(4.472)	(3.812)	(4.140)	(4.624)
Net effect			0.191	0.203	0.224	0.233	0.238			0.229	0.224	0.216	0.209	0.205
Observations	150	150	150	150	150	150	150	150	150	150	150	150	150	150

Note: Standard errors in parentheses.
***$p < .01$; **$p < .05$; *$p < .1$.

average rise of around 0.570% and 0.929% in CO_2 emissions, respectively. Nevertheless, the estimations provided by the AMG exhibit negative results and do not demonstrate statistical significance. Based on the estimates provided by FE-DK, it can be observed that there exists a positive correlation between population size and the rate of CO_2 emissions, indicating that an increase in population size leads to an acceleration in CO_2 emissions. The findings indicate that the coefficients associated with FE-DK and AMG with respect to income per capita exhibit a statistically significant positive relationship with CO_2 emissions at 1%. This implies that the pursuit of environmental sustainability through carbon emissions reduction may be unattainable in the presence of rising income levels or economic expansion in economically challenged European nations. The impact of renewable energy is clearly observable, as it demonstrates a statistically significant and adverse effect in both estimate methods. The coefficient elasticity ranges from −0.111% to −0.276%. This suggests that by promoting the use of renewable energy, it is possible to alleviate the adverse effects of CO_2 emissions in economically susceptible European nations.

The first objective of the study is on the examination of coefficients pertaining to SMEs, which demonstrate a notable pattern in both methods. SMEs exhibit positive or unfavorable associations with CO_2 emissions at 1% level, indicating that the activities of SMEs contribute to elevated levels of carbon emissions. From the estimates in Colum 1, a unit increase in the number of SMEs increases emissions by 0.236% in the selected countries. Consequently, this could potentially lead to adverse environmental repercussions. The study suggests that the operations and activities of SMEs have a role in the release of carbon dioxide (CO_2), a prominent greenhouse gas that substantially contributes to the persistent problem of climate change. One plausible rationale for this observed positive correlation could be attributed to the inherent difficulty faced by most countries included in the study in obtaining access to financial resources. Furthermore, it seems that the available funds exhibit a bias towards larger corporations that possess strong financial stability. As a result, this circumstance impedes the capacity of small enterprises to embrace ecologically sustainable methods. This discovery is consistent with the conclusions made by Okolo et al. (2023), who similarly contend that SMEs might exert a negative influence on environmental sustainability, particularly when European Union (EU) policies fail to encompass all countries equally.

Both the variables lngfin and lnclrspct exhibit statistical significance across various model assumptions for CO_2 emissions. The variable lngfin has a negative coefficient, whereas the variable lnclrspct demonstrates a positive coefficient. This indicates that there are substantial variations in the environmental implications resulting from green finance and bureaucratic quality. An increase of one unit in the value adds of lngfin leads to a reduction in CO_2 emissions by around −0.0138% and −0.01%. Bakry et al. (2023) and Jin et al. (2023) have reported on evidence that highlight the substantial and inhibitory impacts of lngfin on CO_2 emissions. Conversely, every incremental rise in lnclrspct leads to a corresponding increase in CO_2 emissions between 0.0282% and 0.0405%. This aligns with the findings of Rodríguez-Pose and Ketterer (2019), who discovered that the lack of progress in government quality hinders the achievement of environmental sustainability.

In pursuit of the study's second objective, we turn our attention to the coefficients of $(\text{lnentrep}_{it} * \text{lngfin}_{it})$ and $(\text{lnentrep}_{it} * \text{lnclrpct}_{it})$ within Equations (6) and (7). These coefficients reveal a statistically significant interaction effect at the 1% significance level. Interestingly, the observed impact is a blend of outcomes: negative in relation to green finance, but positive in relation to bureaucratic quality. Examining the negative impact, an increase in green finance magnifies the SMEs' ability to counteract CO_2 emissions. Conversely, the positive interaction effects imply that an enhancement in bureaucratic quality intensifies SMEs' contribution to environmental degradation. This finding appears counter-intuitive, as existing evidence demonstrates that both green finance and bureaucratic quality, considered independently (as seen in columns 1 and 5, as well as 2 and 6), have both negative and positive associations with CO_2 emissions. Furthermore, the interplay between these two variables highlights a positive overall impact from SMEs when computed at the mean values[3] of both green finance and bureaucratic quality. This alignment with our third objective underscores the interconnected nature of these factors.

Our research demonstrates that the integration of green finance and (SMEs) operations serves as a crucial avenue for enhancing environmental sustainability in economically vulnerable European countries. The presence of bureaucratic quality in (SMEs) has the potential to induce economic changes that can maintain the trajectory of carbon dioxide (CO_2) emissions in the economy. Based on the equations (8 and 9), the inclusion of green financing and bureaucratic quality in the analysis reveals that the net impact of (SMEs) is 0.224% and 0.217% for FE-DK, and 0.101% and 0.132% for AMG. The explicit calculations are as follows:

$$\frac{\partial \ln CO_2gdp}{\partial \ln entrep} = 0.224 - 0.001 * (0.347) = 0.223 \ldots FE - DK3, \tag{16}$$

$$\frac{\partial \ln CO_2gdp}{\partial \ln entrep} = 0.211 + 0.0154 * (0.416) = 0.217 \ldots FE - DK4, \tag{17}$$

$$\frac{\partial \ln CO_2gdp}{\partial \ln entrep} = 0.107 - 0.0161 * (0.347) = 0.101 \ldots AMG7, \tag{18}$$

$$\frac{\partial \ln CO_2gdp}{\partial \ln entrep} = 0.119 + 0.0314 * (0.416) = 0.132 \ldots AMG8. \tag{19}$$

In the set of Equations (16)–(19), it is constantly seen that each of the interacting variables exerts a positive overall influence. The results of our study indicate that lnentrep (SMEs) situated in economically disadvantaged areas in Europe may face challenges in attaining eco-compliance. These challenges arise from various constraints, including limited financial resources, decreased financial performance, insufficient adoption of renewable energy alternatives, a scarcity of environmental technologies, restricted opportunities for inventions and innovations, bureaucratic bottle neck, and a lack of advanced technical expertise (see, Lewandowska et al., 2014; Muoneke et al., 2023; Okolo et al., 2023; Ur Rehman et al., 2019).

Given that the offered estimates indicate the average impacts of their respective variables within specific circumstances, it is crucial to acknowledge that the results shown in Table 6 may be influenced by a distributional bias. This bias is a consequence of the failure to consider potential changes in impact along the entire conditional distribution of per capita CO_2 emissions. In order to address this particular concern, our focus is redirected towards the panel quantile regression estimates, utilizing the MM-QR methodology proposed by Machado and Silva (2019). This methodology is specifically developed to successfully address distributional heterogeneity and offers enhanced resilience. This is presented in the analysis below.

3.4 | Sensitivity analysis, MM-QR estimates

The estimates suggest that both the lnpop and lngdp have positive coefficients across different quantile distributions. Furthermore, statistical significance is found at a significance level of 1%. The estimations combined reinforce the relevance of the IPAT identity in understanding the determinants behind environmental pressure. Furthermore, the findings are consistent with prior studies conducted by Dietz and Rosa (1994) and Dietz et al. (2007). For population, its impact exhibits variation in different estimations. The estimations obtained from the FE-DK model demonstrate positive and statistically significant impacts, particularly exhibiting a more significant impact at the top quantile (qtile_90th) (see Figure A2). On the contrary, an analysis of the coefficient of lngdp reveals that the environmental consequences of economic expansion are more noticeable inside the lower quantile (qtile_10th). This observation implies that nations positioned at the lower end of the spectrum exhibit higher levels of carbon-intensive carbon dioxide emissions. Moreover, when considering the inclusion of renewable energy, the negative coefficient of this variable continues to maintain statistical significance throughout all the quantile distribution. This implies that an increase in one unit of renewable energy is associated with a reduction in CO_2 emissions of approximately 0.130%, 0.114%, and 0.099% for nations located in the lower, middle, and upper quantiles, respectively.

The coefficient of SMEs (lnentrep) consistently exhibits a positive and statistically significant association across all quantiles (see Figure A2). On the contrary, the coefficient of lninter1 demonstrates a statistically significant negative trend, which decreases when quantiles migrate from lower to upper levels. This observed pattern provides support for the current body of literature that posits green financing as a crucial factor in advancing environmental sustainability. Likewise, the findings pertaining to lninter2 exhibit consistent patterns, demonstrating statistical significance across multiple quantiles and consistently indicating a positive coefficient. The above findings collectively underscore significant disparities in the environmental outcomes resulting from the impacts of green funding and bureaucratic quality. In the analysis of the collective influence of green financing and bureaucratic quality via the net effect, it is observed that the overall outcome of SMEs is favorable when the average values of both variables are utilized for computation. The aforementioned results not only corroborate previous research findings but also substantiate our third objective, highlighting the complex interrelationship among these components.

4 | CONCLUSION AND POLICY REMARKS

This study delves into the dynamic relationship between green finance, bureaucratic quality, and SMEs concerning environmental sustainability in economically disadvantaged regions of Europe. Drawing data from ten European nations spanning the years 2006–2020, the research centers on environmental sustainability as the focal outcome. The measurement of CO_2 emissions is employed to gauge the ecological strains stemming from human activities, while the roles of green finance and bureaucratic quality are investigated as factors driving SMEs toward eco-friendly practices. To establish a balanced framework, the STIRPAT model incorporates renewable energy. Recent econometric techniques are leveraged to examine both the conditional mean and distributional impacts. The findings are as follows:

- The research outcomes corroborate the validity of the adverse environmental impacts of population and affluence within economically vulnerable Europe.
- The coefficient of SMEs consistently leads to an increase in CO_2 emissions across all quantiles.
- The interaction between green finance and SMEs results in a decrease in CO_2 emissions as quantiles transition from lower to upper levels.
- Conversely, the interaction between bureaucratic quality and SMEs yields an increase in CO_2 emissions across various quantiles.
- Substantial disparities in environmental outcomes emerge from the influences of green funding and bureaucratic quality.
- In totality, the combined effects of green finance, bureaucratic quality, and SMEs contribute unfavorably to environmental sustainability.

4.1 | Policy options

Following the empirical results, green finance interaction term with entrepreneurship reduces environmental pollution in low-growth regions in Europe. Governments, national development banks, central banks, state investment guarantee agencies, and SMEs agencies should create a pre-credit on-boarding programs for small-scale business in their early years of existence, which allows them properly structure their businesses, learn about the industry and its business environment, develop rudimentary accounting skills, create a sound organizational structure, devise feasible business plans, construct proper cashflow forecasts, construct a risk management strategy, and adopt eco-compliant line of businesses to increase their eligibility for green financing at national and EU level.

Governments in these low-growth EU countries must create an independent bureau to assess green finance loan applications in accordance with a set criteria, thereby limiting the favoritism to large firms only and increasing the speed at which final decisions are reached before forwarding to the state investment guarantee agencies to liaise with deposit money banks and development banks to issue credit to chosen eco-compliant firms. Furthermore, governments of the selected EU nations should invest in training and development programs for state bureaucrats to increase their technical capacity to handle varying technicalities associated with the requirements of EU transition fund. In the case of low-income countries in Europe, the inability of state bureaucrats to understand the complexities attached to achieving environmental sustainability and economic growth (twin-objective) reduces their ability to produce sound policies, enact simpler regulations, and quicker procedures to aid the growth of green-compliant SMEs. Several complaints has been made on the issue of multiple regulations and increased regulatory complexity within EU member states epitomizes the level of inefficiency among state bureaucrats and administrators. Governments of the affected European countries (North Macedonia, Belarus, Serbia, Montenegro, Bulgaria, Bosnia, Albania, Ukraine, Moldova, Russia, Romania, and Croatia) should develop periodic continuing development programs for state bureaucrats on crafting sound policies and processes that upholds environmental protection whilst the pursuit of economic prosperity.

CONFLICT OF INTEREST STATEMENT

The authors have no competing interests to declare that are relevant to the content of this article.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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ENDNOTES

[1]Stochastic Impacts by Regression on Population, Affluence, and Technology.

[2]Albania, Belarus, Bulgaria, Croatia, North Macedonia, Moldova, Romania, the Russian Federation, Serbia, and Ukraine.

[3]Mean values of Lngfin 0.347 and Lnclrspct 0.416, respectively (extract on Table 1).

REFERENCES

Alola, A. A., Okere, K. I., Muoneke, O. B., & Dike, G. C. (2022). Do bureaucratic policy and socioeconomic factors moderate energy utilization effect of net zero target in the EU? *Journal of Environmental Management.*, *317*, 115386.

Bakry, W., Mallik, G., Nghiem, X., Sinha, A., & Vo, X. V. (2023). Is green finance really "green"? Examining the long-run relationship between green finance, renewable energy and environmental performance in developing countries. *Renewable Energy*, *208*(2023), 341–355.

Belsley, D. A. (1980). On the efficient computation of the nonlinear full-information maximum-likelihood estimator. *Journal of Econometrics*, *14*(2), 203–225.

Chatzistamoulou, N., & Tyllianakis, E. (2022). Green growth & sustainability transition through information. Are the greener better informed? Evidence from European SMEs. *Journal of Environmental Management.*, *306*, 114457. https://doi.org/10.1016/j.jenvman.2022.114457

Constantinos, C., Sørensen, S. Y., Larsen, P. B., & Alexopoulou, S. (2010). SMEs and the environment in the European Union, PLANET SA and Danish Technological Institute, Published by European Commission, DG Enterprise and Industry.

Cooper-Ordoñez, R. E., Altimiras-Martin, A., & Leal Filho, W. (2019). Environmental friendly products and sustainable development. *Encyclopedia of Sustainability in Higher Education*, 575–588.

De Wit, G., & de Kok, J. (2013). Do small businesses create more jobs? New evidence for Europe. *Small Business Economics*, *42*(2), 283–295. https://doi.org/10.1007/s11187-013-9480-1

Dietz, T., & Rosa, E. A. (1994). Rethinking the environmental impacts of population, affluence and technology. *Human Ecology Review*, *1*(2), 277–300.

Dietz, T., Rosa, E. A., & York, R. (2007). Driving the human ecological footprint. *Frontiers in Ecology and the Environment*, *5*(1), 13–18.
Driscoll, J. C., & Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics*, *80*(4), 549–560.
Du, G. (2023). Nexus between green finance, renewable energy, and carbon intensity in selected Asian countries. *Journal of Cleaner Production*, *405*, 136822.
Eberhardt, M., & Bond, S. (2009). Cross-section dependence in nonstationary panel models: A novel estimator.
Eberhardt, M., & Teal, F. (2010). *Productivity analysis in global manufacturing production*. Department of Economics, University of Oxford; Discussion Paper 515, http://www.economics.ox.ac.uk/research/WP/pdf/paper515.pdf
Ehrlich, P. R., & Holdren, J. P. (1971). Impact of Population Growth: Complacency concerning this component of man's predicament is unjustified and counterproductive. *Science*, *171*(3977), 1212–1217.
Flachenecker, F., Kornejew, M., & Janiri, M. L. (2022). The effects of publicly supported environmental innovations on firm growth in the European Union. *Journal of Cleaner Production*, *372*, 133429.
Geddes, A., Schmidt, T. S., & Steffen, B. (2018). The multiple roles of state investment banks in low-carbon energy finance: An analysis of Australia, the UK and Germany. *Energy Policy*, *115*, 158–170.
He, G., Zhang, L., Mol, A. P. J., Wang, T., & Lu, Y. (2014). Why small and medium chemical companies continue to pose severe environmental risks in rural China. *Environmental Pollution*, *185*, 158–167.
Hessels, J., & Parker, S. C. (2013). Constraints, internationalization and growth: A cross-country analysis of European SMEs. *Journal of World Business*, *48*(1), 137–148. https://doi.org/10.1016/j.jwb.2012.06.014
Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115*(1), 53–74.
Jin, C., Lv, Z., Li, Z., & Sun, K. (2023). Green finance, renewable energy and carbon neutrality in OECD countries. *Renewable Energy*, *211*(2023), 279–284.
Khoja, F., Adams, J., Kauffman, R., & Yegiyan, M. (2022). How SMEs benefit from environmental sustainability strategies and practices. *Supply Chain Forum: An International Journal*, *23*(2), 97–112.
Kyriacou, A. P., & Roca-Sagalés, O. (2012). The impact of EU structural funds on regional disparities within member states. *Environment and Planning C: Government and Policy*, *30*(2), 267–281. https://doi.org/10.1068/c11140r
Lewandowska, A., Stopa, M., & Humenny, G. (2014). The European Union structural funds and regional development. The perspective of small and medium enterprises in Eastern Poland. *European Planning Studies*, *23*(4), 785–797. https://doi.org/10.1080/09654313.2014.970132
Machado, J. A., & Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics*, *213*(1), 145–173.
Maynou, L., Saez, M., Kyriacou, A., & Bacaria, J. (2014). The impact of structural and cohesion funds on eurozone convergence, 1990–2010. *Regional Studies*, *50*(7), 1127–1139. https://doi.org/10.1080/00343404.2014.965137, accessed on 11th March 2019.
Mendez, C., & Bachtler, J. (2021). The quality of government and administrative performance: Explaining cohesion policy compliance, absorption and achievements across EU regions. *Regional Studies*, 1–14. https://doi.org/10.1080/00343404.2022.2083593
Muoneke, O. B., Okere, K. I., & Nwaeze, C. N. (2022). Agriculture, globalization, and ecological footprint: the role of agriculture beyond the tipping point in the Philippines. *Environmental Science and Pollution Research*, *29*(36), 54652–54676.
Muoneke, O. B., Egbo, O. P., & Okere, K. I. (2023). Coal–environmental quality nexus in EU-part of the Eastern Bloc: Do socioeconomic factors and bureaucracy play a substantial role? *Energy and Environment*. https://doi.org/10.1177/0958305X221149503
Neri, A., Cagno, E., & Trianni, A. (2021). Barriers and drivers for the adoption of industrial sustainability measure in European SMEs: Empirical evidence from chemical and metalworking sectors. *Sustainable Production and Consumption*, *28*, 1433–1464.
Nizaeva, M., & Coskun, A. (2019). Investigating the relationship between financial constraint and growth of SMEs in South Eastern Europe. *SAGE Open*, *9*(3), 215824401987626. https://doi.org/10.1177/2158244019876269
Numan, U., Ma, B., Sadiq, M., Bedru, H. D., & Jiang, C. (2023). The role of green finance in mitigating environmental degradation: Empirical evidence and policy implications from complex economies. *Journal of Cleaner Production*, *400*, 136693.
Nwani, C., Usman, O., Okere, K. I., & Bekun, F. V. (2023). Technological pathways to decarbonisation and the role of renewable energy: A study of European countries using consumption-based metrics. *Resources Policy*, *83*, 103738.
Nykvist, B., & Maltais, A. (2022). Too risky – The role of finance as a driver of sustainability transitions. *Environmental Innovation and Societal Transitions*, *42*(2022), 219–231.
Okere, K. I., Ibe, G. I., Muoneke, O. B., & Nwaeze, N. C. (2023). Environmental sustainability, small and medium enterprises, and finance in Africa: A triplicate relationship. *Environmental Science and Pollution Research*, *30*, 41359–41378.
Okolo, V. O., Ohanagorom, M. I., Okocha, R. E., Muoneke, O. B., & Okere, K. I. (2023). Does financing SMEs guarantee inclusive growth and environmental sustainability in the European Union? *Heliyon*, *9*(4), 15095. https://doi.org/10.1016/j.heliyon.2023.e15095

Onuoha, F. C., Dimnwobi, S. K., Okere, K. I., & Ekesiobi, C. (2023). Funding the green transition: Governance quality, public debt, and renewable energy consumption in Sub-Saharan Africa. *Utilities Policy*, *82*, 101574.

Onyeiwu, C. I., Muoneke, O. B., & Nkoyo, U. (2021). Financing of small and medium scale enterprises and its growth impact in Nigeria. *The Journal of Entrepreneurial Finance*, *22*(2), 30–49.

Özbuğday, F. C., Findik, D., Özcan, K. M., & Başçi, S. (2020). Resource efficiency investments and firm performance: Evidence from European SMEs. *Journal of Cleaner Production*, *252*, 119824. https://doi.org/10.1016/j.jclepro.2019.119824

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265–312.

Pesaran, M. H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric Reviews*, *34*(6–10), 1089–1117.

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50–93.

Polzin, F., & Sanders, M. (2020). How to finance the transition to low-carbon energy in Europe? *Energy Policy*, *147*, 111863.

Rodríguez-Pose, A., & Ketterer, T. (2019). Institutional change and the development of lagging regions in Europe. *Regional Studies*, *1–13*, 974–986. https://doi.org/10.1080/00343404.2019.1608356

Sotiriou, A., & Tsiapa, M. (2015). The asymmetric influence of structural funds on regional growth in Greece. *Environment and Planning C: Government and Policy*, *33*(4), 863–881. https://doi.org/10.1177/0263774X15603905

Ur Rehman, N., Çela, A., Morina, F., & Sulçaj Gura, K. (2019). Barriers to growth of SMEs in Western Balkan countries. *Journal of Management Development*, *38*(1), 2–24. https://doi.org/10.1108/JMD-09-2018-0273

Wagenvoort, R. (2003). Are finance constraints hindering the growth of SMEs in Europe? EIB Papers, ISSN 0257-7755, European Investment Bank (EIB). *Luxembourg*, *8*(2), 23–50.

Wang, T., Umar, M., Li, M., & Shan, S. (2023). Green finance and clean taxes are the ways to curb carbon emissions: An OECD experience. *Energy Economics*, *124*, 106842.

Westerlund, J. (2005). New simple tests for panel cointegration. *Econometric Reviews*, *24*(3), 297–316.

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and statistics*, *69*(6), 709–748.

Xheneti, M., & Bartlett, W. (2012). Institutional constraints and SME growth in post-communist Albania. *Journal of Small Business and Enterprise Development*, *19*(4), 607–626. https://doi.org/10.1108/14626001211277424

Ye, Q., Zhou, R., Anwar, M. A., Siddiquei, A. N., & Asmi, F. (2020). Entrepreneurs and environmental sustainability in the digital era: Regional and institutional perspectives. *International Journal of Environmental Research and Public Health*, *17*(4), 1355.

York, R., Rosa, E. A., & Dietz, T. (2003). STIRPAT, IPAT and ImPACT: analytic tools for unpacking the driving forces of environmental impacts. *Ecological Economics*, *46*(3), 351–365.

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APPENDIX A

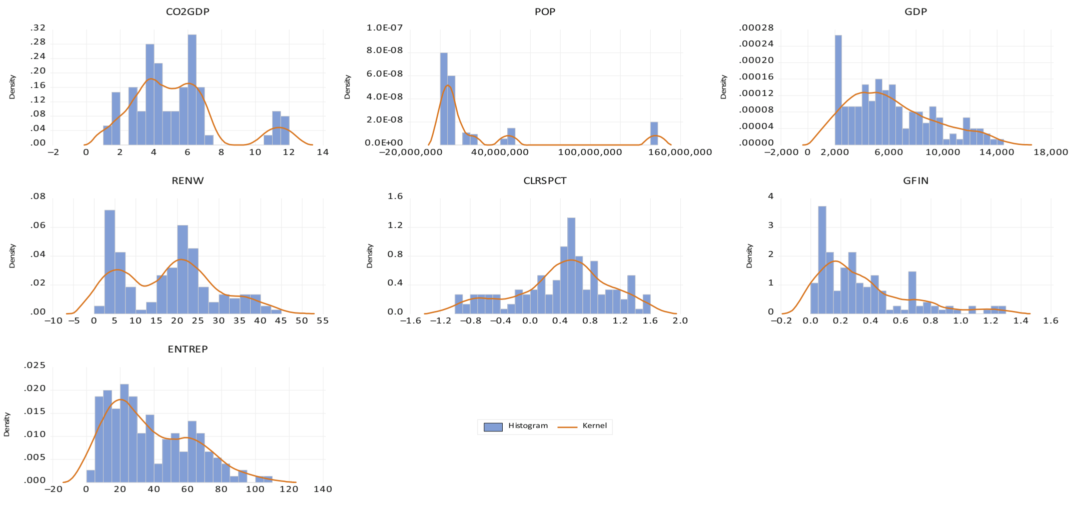

FIGURE A1 Graphical representation data series.

TABLE A1 Test for multicollinearity.

Dependent variable CO_2gdp								
	1		2		3		4	
Variable	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF
lnrenw	3.6	0.277	3.54	0.282	3.72	0.268	3.51	0.284
lnpop	3.3	0.303	4.22	0.236	3.4	0.294	4.27	0.234
lngdp	1.49	0.670	1.65	0.607	1.52	0.659	1.62	0.618
lnentrep	1.34	0.748	1.49	0.668	1.43	0.700	1.35	0.742
lngfin	1.04	0.961						
lnclrspct			2.24	0.446				
lninter1					1.20	0.833		
lninter2							2.24	0.446
Mean VIF	2.15		2.63		2.25		2.6	

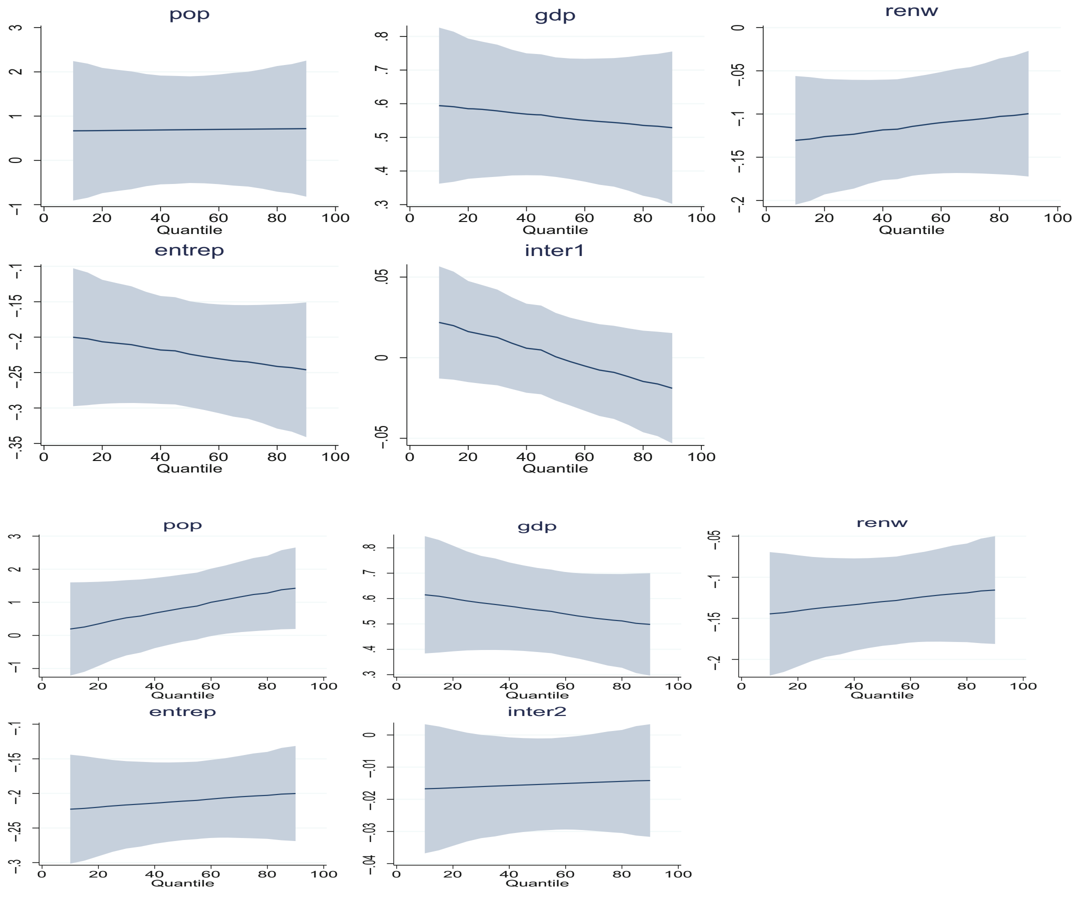

FIGURE A2 Graphical representation of MM-QR.