“Relationship between sustainable development indicators and SMEs’ development indicators: Evidence from the EU countries”

AUTHORS	Bohdan Kovalov

ARTICLE INFO	Bohdan Kovalov (2024). Relationship between sustainable development indicators and SMEs’ development indicators: Evidence from the EU countries. *Problems and Perspectives in Management*, *22*(2), 71-92. doi:10.21511/ppm.22(2).2024.07
DOI	http://dx.doi.org/10.21511/ppm.22(2).2024.07
RELEASED ON	Tuesday, 16 April 2024
RECEIVED ON	Tuesday, 27 February 2024
ACCEPTED ON	Friday, 05 April 2024

JOURNAL	"Problems and Perspectives in Management"
ISSN PRINT	1727-7051
ISSN ONLINE	1810-5467
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
46	2	30

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine

www.businessperspectives.org

Bohdan Kovalov (Ukraine)

RELATIONSHIP BETWEEN SUSTAINABLE DEVELOPMENT INDICATORS AND SMES' DEVELOPMENT INDICATORS: EVIDENCE FROM THE EU COUNTRIES

Abstract

This study aims to identify whether achieving sustainable development goals influences SMEs' development and assess its degree. The dataset on SMEs' development indicators and SDGs 2, 8, 9, 12, and 13 for the panel of EU-27 countries in 2011–2020 was collected using Eurostat and OECD datasets. Breusch and Pagan Lagrangian multiplier test for pooled OLS/panel data random effects and Hausman test for fixed/random effects were utilized. The results were in favor of random effect GLS regression for SDG2 models, SDG9 models, and SDG12-13 (Model 1) and fixed effect GLS regression for SDG8 models and SDG12-13 (Model 2), respectively. Based on bibliometric analyses using VOSViewer 14 and a comprehensive literature review, 19 independent variables have been selected from the "Sustainable development indicators" catalog covering five sustainable development goals; SMEs' turnover and SMEs' employees employed are used as the dependent variables to reflect SMEs' development. The empirical evidence suggests a significant relationship between individual sustainable development and SMEs' development indicators. It was found that all seven sustainable development indicators of SDG 2 (Zero hunger) and SDG 12 (Responsible consumption and production) have a significant relationship with the indicators of SMEs' development. Instead, only a part (8 out of 13) of the sustainable development indicators of SDG 8 (Decent work and economic growth), SDG 9 (Industry, innovation and infrastructure), and SDG 13 (Climate action) have a significant relationship with two or one of the SMEs' development indicators. Therefore, achieving sustainability goals stimulates the development of SMEs itself.

Keywords SMEs, SDGs, regression analysis, panel data, EU, employment, turnover, indicators, sustainable development

JEL Classification L25, Q01

Received on: 27th of February, 2024
Accepted on: 5th of April, 2024
Published on: 16th of April, 2024

Bohdan Kovalov, Ph.D. in Economics, Associate Professor, Department of Economics, Entrepreneurship and Business Administration, Academic and Research Institute of Business, Economics and Management, Sumy State University, Ukraine.

Conflict of interest statement:
Author(s) reported no conflict of interest

INTRODUCTION

Today, considering sustainable development issues and the success of SMEs is becoming increasingly relevant. SMEs are catalysts for economic growth, providing employment and income distribution and facilitating innovation. Moreover, SMEs could participate in reducing the environmental impact, preserving biodiversity, and regenerating natural resources. In 2023, SMEs in the European Union employed around 84.75 million individuals (European Commission, 2023a). The collective contribution of SMEs to the European economy was estimated to be approximately 4.15 trillion euros in the same year, with micro-sized enterprises contributing roughly 1.5 trillion euros to this value (European Commission, 2023b).

SMEs' development is pivotal to the implementation of sustainable development goals. Small businesses can address social, economic,

and environmental challenges, providing essential aspects of sustainable development. In particular, the creation of new jobs and the promotion of equal income distribution help achieve social stability and fight poverty (SDG 1). Small business is the basis for innovation and support of entrepreneurship, contributing to economic growth (SDG 8) and corresponding to sustainable development principles. In addition, a richer range of enterprises and their active participation in developing clean technologies and renewable energy sources (SDG 7) contribute to achieving environmental sustainability goals. Coordinated development of small businesses with sustainable development priorities helps significantly improve communities' quality of life (SDG 11), contributing to a balanced and sustainable development on the way to global sustainability.

Sustainable development indicators play a crucial role in determining and evaluating the progress of economic systems and the vector of development aimed at achieving sustainability in all spheres of life. For SMEs, these indicators are integral to strategies and actions aimed at balanced development. Indicators related to environmental sustainability can encourage enterprises to adopt environmentally friendly technologies and practices that help reduce environmental impact and promote sustainable production. Indicators of social responsibility can support enterprises in implementing social initiatives and creating a favorable work environment that promotes the attraction and retention of talented personnel. Indicators of economic stability determine the conditions for the financial strength of enterprises, in particular small and medium ones, creating prerequisites for their sustainable development.

In this context, it is essential to analyze how sustainable and SME development indicators interact and influence each other.

1. LITERATURE REVIEW, BIBLIOMETRIC ANALYSIS, AND HYPOTHESES

1.1. SMEs and sustainable development

SMEs are considered as a means of achieving various goals of sustainable development through the reduction of poverty by increasing quality of life and life satisfaction (SDG 1), new job generation and enhancing economic growth (SDG 8), cultivating sustainable consumption and production pattern (SDG 12), contributing to the industrial and innovational development (SDG 9), implementing sustainable and green practices for emissions reduction and climate action (SDG 13).

Abisuga-Oyekunle et al. (2020) emphasized the crucial role of SMEs in poverty reduction and employment generation in African countries. Lopes de Sousa Jabbour (2020) stated that SMEs play a vital role in generating employment and distributing income, and are essential for expanding Asian exports. Inegbedion et al. (2024) investigated the correlation between the competitiveness of SMEs and their role in generating employment. Their research sought to elucidate how the competitiveness of SMEs might bolster national income by fostering job creation, with SME growth serving as an intermediary factor. After conducting a cross-sectional survey involving 93 participants from SMEs, the study determined that product innovation and product differentiation exhibit notable associations with employment creation, as they can augment SME expansion. Jasińska-Biliczak (2023) and Horobchenko and Voronenko (2018) discovered that businesses acquainted with the principles of sustainable development and the sustainable development goals, integrated into their strategic plans, demonstrated a heightened likelihood of survival. Sonntag et al. (2022) explored implementing SDGs by SMEs in Germany and Poland. It was found that there is a national aspect (context) in the SDGs implementation by every country. The lack of financial funds is the primary barrier to implementing sustainable development goals in SMEs. Gomes and Pinho (2023) focus on the contribution of European SMEs to SDG 12 in terms of carbon neutrality. Their findings indicate that when SMEs implement resource-efficient practices at the individual company level, it positively affects their uptake of broader measures for

http://dx.doi.org/10.21511/ppm.22(2).2024.07

decarbonization at the macro level. Additionally, the adoption of these micro-level practices is positively influenced by internal business investments, while being negatively influenced by external funding sources and regulatory/administrative obligations.

1.2. Factors of SMEs' development

Tambunan (2009) states that economic development provides a supportive environment for the development and expansion of enterprises across all scales, encompassing micro, small, medium, and large entities. Sidik (2012) proposed a conceptual framework outlining the factors influencing the development of SMEs, focusing on innovative performance, capacity for innovation, organizational exploration, market focus, and entrepreneurial mindset. The author states that there is a positive correlation between entrepreneurial characteristics and the performance of SMEs. Thus, five secondary constructs are proposed to act as mediators between entrepreneur traits and firm performance, potentially elucidating this relationship. Bilan et al. (2018) investigated the relationship between the influence of tax factors on entrepreneurship development in Eastern European countries. The study found that absolute tax rates, the relative level of the tax burden and indicators of tax administration have a statistically significant impact on entrepreneurship development. Al-Mutawa and Saeed Al Mubarak (2024) examined how SMEs embrace cloud computing as a digital technology and evaluated its influence on the sustainability of these enterprises. The results indicate that cost reduction, user-friendliness, reliability, and collaboration significantly affect the sustainability of SMEs. However, the privacy and security factors do not show a statistically significant impact on the sustainability of SMEs. It is expected that disruptive technologies and additive economy specifically would reduce the energy intensity of products, promote dematerialization of both production/consumption links, and stimulate sustainability (Melnyk et al., 2022). Song and Ahn (2024) found that among diverse factors, such as innovative endeavors, government assistance, and external elements in the SME ecosystem, internal research and development (R&D) emerges as the most critical determinant for the success of SMEs.

1.3. Co-occurrence analysis

As a part of the literature review, co-occurrence analysis was performed to identify the linkage between sustainable development and SMEs' development concepts. The dataset includes 606 journal articles in English in the Scopus database and is searched by topic "sustainable development" and "SMEs." The document outcomes were filtered by the Social Sciences, Business Management and Accounting subject areas from 2014 to 2024. The co-occurrence network was visualized using VOSviewer, while a thesaurus was employed to eliminate 93 irrelevant keywords, including country names, method and model names, and commonly used article keywords (e.g., "article" or "questionnaire"). Additionally, 44 keywords were substituted (e.g., plural to singular or synonyms). A minimum threshold of five occurrences per keyword was set. Out of 2,982 keywords, only 133 met this criterion (Figure 1).

The study identified eight keyword clusters with from nine to 25 items in each.

The first cluster (highlighted in red) includes 22 items with the main keyword "sustainable development." The group focuses on sustainable development, manufacture and supply chains (i.e., sustainable production, lean production, green manufacturing, sustainable business, and food supply), investments (i.e., in energy efficiency, renewable energy resources, and electric energy storage), and environmental sustainability and environmental impact (i.e., carbon dioxide).

The second cluster (highlighted in green) contains 21 items with the main keyword "competition." The set focuses on enhancing competition through competitive advantage (i.e., eco-innovations, technological innovation, and open innovation), environmental technology in sustainable manufacturing and cleaner production, life cycle analysis and assessment, and climate change.

The third cluster (highlighted in blue) unites 19 elements with the central keyword "SMEs." The group of keywords covers research on SMEs and business development (i.e., through leadership, human resource management, and sustainability management); sustainability (i.e., corporate

Source: Compiled using VOSViewer based on Scopus publications.

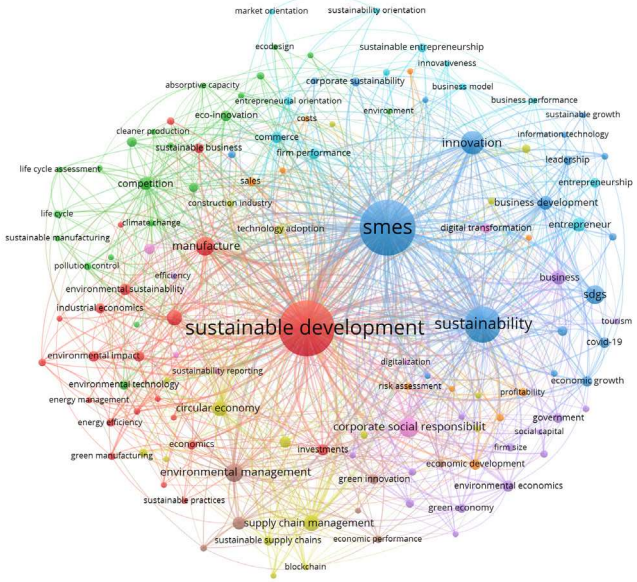

Figure 1. The "Sustainable development – SMEs' development" network visualization

sustainability), sustainable growth and SDGs; innovation, technological development, and information technology; and economic growth (i.e., through competitiveness and industrial development) in the condition of COVID-19.

The fourth cluster (highlighted in yellow) includes 17 items with the main keyword "supply chain management" and focuses on supply chain and sustainable supply chain management (i.e., agroindustry and agriculture), circular economy, waste management and recycling (i.e., construction industry), sustainable performance, social sustainability, and technology adoption issues.

The fifth cluster (highlighted in violet) includes 15 items with the main keyword "business." The group investigates business within environmental economics and green economy concepts (i.e., environmental policy) and business sustainability and efficiency (i.e., benchmarking, human capital, finance).

The sixth cluster (highlighted in cyan) contains 12 items with the main keyword "entrepreneur." The set is focused on entrepreneurship and commerce, including entrepreneurial orientation (i.e., sustainability orientation and market orientation), firm (business) performance, and business model (i.e., sustainable entrepreneurship, sustainable innovation, and innovativeness).

The seventh cluster (highlighted in orange) unites ten elements with the main keyword "economic development." The keywords cover research on sales, profitability, corporate strategy, and risk assessment issues of SMEs' development.

The eighth cluster (highlighted in brown) includes seven items with the central keyword "environmental management." It focuses on environmental and green supply chain management, and environmental, industrial, economic, and social performance of SMEs.

The last ninth cluster (highlighted in pink) includes only six items with the main keyword "corporate social responsibility." The group focuses on corporate social responsibility (i.e., sustainability reporting), and SMEs' development within digital transformation and digitalization trends (i.e., Industry 4.0).

Research focusing on SDGs includes the following keywords (Figure 2):

- sustainable development, supply chain, carbon dioxide;
- sustainability, innovation, economic growth, leadership, COVID-19, business development;
- supply chain management, circular economy, agroindustry;

http://dx.doi.org/10.21511/ppm.22(2).2024.07

Source: Compiled using VOSViewer based on Scopus publications.

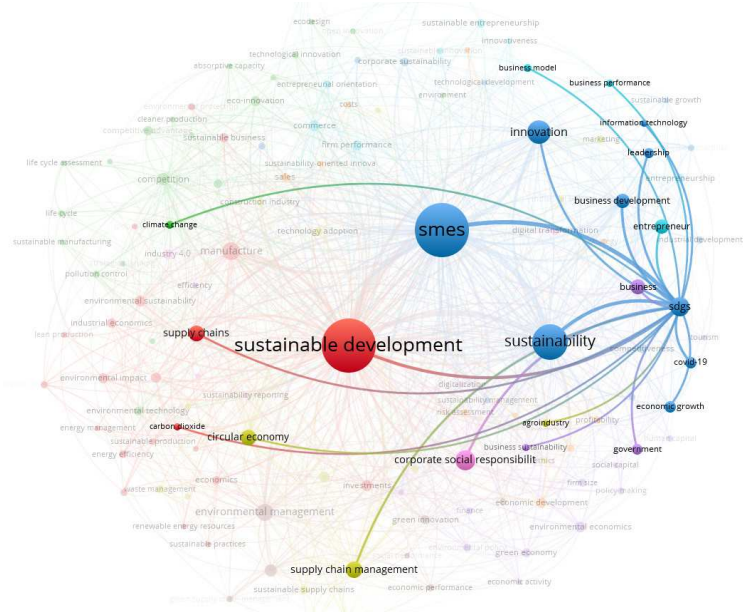

Figure 2. The "Sustainable development goals" keywords network visualization

- entrepreneur, business performance, business model, information technology;
- business, government, business sustainability;
- climate change;
- corporate social responsibility.

These listed keywords correspond to the following SDGs: SDG 2 (Zero hunger), SDG 8 (Decent work and economic growth), SDG 9 (Industry, innovation and infrastructure), SDG 12 (Responsible consumption and production), and SDG 13 (Climate action).

1.4. Designing research hypotheses

The SDG 2 indicators, focusing on food production, nutrition, and agricultural sustainability, align closely with SMEs' activities and impact areas, particularly those engaged in agriculture. In turn, SMEs play a crucial role in contributing to SDG 2, which aims to end hunger. SMEs, particularly in the agricultural sector, enhance food security by fostering sustainable and inclusive practices (Mota et al., 2023). Through innovation and technology adoption (da Silva et al., 2023; Hrytsenko et al., 2021), SMEs in agriculture enhance productivity and promote sustainable farming practices (Bucci et al., 2018), aligning to achieve food security. Furthermore, SMEs create employment opportunities in rural areas (Farja et al., 2017), supporting local communities and ensuring a more equitable distribution of resources. By empowering smallholder farmers, promoting resilient agricultural systems, and enhancing the efficiency of food supply chains, SMEs significantly contribute to the broader efforts to eliminate hunger.

SDG 12 centers on promoting sustainable consumption and production practices, prioritizing the efficient utilization of resources, minimizing waste, and ensuring responsible business operations. For SMEs, aligning with these indicators involves adopting environmentally conscious practices, optimizing resource utilization, and integrating circular economy principles into their production processes (Kafel & Nowicki, 2023; Dey et al., 2022; Mishenin et al., 2015). In addition, SMEs prioritizing responsible consumption and production contribute to waste reduction, energy efficiency (Wang et al., 2023), and a lower ecological footprint.

SDG 13 emphasizes the urgency of tackling climate change by taking significant action to diminish greenhouse gas emissions and expand resilience. To comply with climate indicators, SMEs implement ecological practices, minimize their carbon footprint, and implement strategies for the sustainable use of resources.

SDG 8 focuses on creating decent jobs, economic productivity, and fair economic opportunities. Thus, SMEs must encourage fair labor practices, ensure decent working conditions, and promote inclusive employment. Moreover, SMEs can improve workforce satisfaction and productivity by prioritizing decent work, including fair wages, safe working conditions, and employee well-being. A motivated and satisfied workforce promotes efficiency and innovation, directly influencing SMEs' overall turnover and competitiveness.

SDG 9 emphasizes the importance of inclusive and sustainable industrialization, innovation, and infrastructure. Embracing innovation and advanced technologies enhances the capacity of SMEs to adapt, improve productivity, and remain competitive (Koblianska & Kalachevska, 2019). The focus on infrastructure development, including efficient logistics, connectivity, and employment accessibility, facilitates the growth of SMEs, enabling them to expand their market reach and operational capabilities.

Based on the literature review and the co-occurrence analysis, the study aims to investigate the relationship between sustainable development indicators and SMEs' development in EU countries. Specifically, this paper explores the influence of SDGs 2, 8, 9, 12, and 13 indicators on SMEs' development indicators. The following research hypotheses were designed:

H1: Indicators measuring sustainable agriculture relate positively to SMEs' development indicators.

H2: Indicators measuring sustainable sourcing, reduced CO2 and greenhouse gas emissions, and responsible manufacturing relate positively to SMEs' development indicators.

H3: Promoting inclusive employment and safe working conditions positively affects both turnover and employment of SMEs.

H4: Responsible industrial practices, innovation and transport infrastructure positively affect turnover and employment of SMEs.

2. METHODOLOGY

Based on the literature review and results of co-occurrence analysis, 19 statistical indicators assessing progress toward sustainable development were selected, covering SDG 2 (four indicators), SDG 8 (five indicators), SDG 9 (five indicators), SDG 12 (three indicators), and SDG 13 (two indicators). Some of the indicators are involved in several SDGs (Table 1). Indicators of SMEs' turnover and SMEs' persons employed were chosen to reflect SMEs' development better.

Panel data for listed 19 sustainable development indicators and two SMEs' development indicators were collected for EU-27 countries from Eurostat and OECD databases in 2011–2020. SMEs' turnover and SMEs' persons employed were selected as the dependent variables, and 19 sustainable development indicators were chosen as independent variables.

All variables were also logarithmized, which were used in regression models. This procedure reduces data variability and helps increase the stability of model parameter estimates.

Before performing the regression analysis, checking for multicollinearity between the variables was important. Pearson's correlation coefficients and VIF (variance inflation factor) were used. The multicollinearity assessment was carried out to identify and exclude redundant variables from the regression models.

The Bresch and Pagan Lagrangian multiplier test was performed for panel data. This test helped determine between the OLS (ordinary least squares) and GLS (generalized least squares) methods, which better accounts for heteroskedasticity in the data. Next, a Hausman test was performed to select between fixed and random effects in panel models. The STATA 18 software was used to run the regression analysis.

2.1. Equations for the theoretical concepts

The theoretical concepts for the SMEs' and SDG 2 indicators could be presented as follows:

http://dx.doi.org/10.21511/ppm.22(2).2024.07

$$SMEturnperCa_t = f\begin{pmatrix} AgFaIn_t, AgriRnD_t, \\ OrgFarmArea_t, AmmonEmis_t \end{pmatrix}, \quad (1)$$

$$SMEpersperCa_t = f\begin{pmatrix} AgFaIn_t, AgriRnD_t, \\ OrgFarmArea_t, AmmonEmis_t \end{pmatrix}. \quad (2)$$

A similar approach has been utilized for the SDG 8 (equations 3 and 4), the SDG 9 (equations 5 and 6), and the SDGs 12-13 indicators (equations 7 and 8).

$$SMEturnperCa_t = f\begin{pmatrix} InvInGDP_t, UnempYouth_t, \\ EmpltmntRt_t, LngTrmNmpl_t, \\ FatAccid_t \end{pmatrix}, \quad (3)$$

$$SMEpersperCa_t = f\begin{pmatrix} InvInGDP_t, UnempYouth_t, \\ EmpltmntRt_t, LngTrmNmpl_t, \\ FatAccid_t \end{pmatrix}, \quad (4)$$

$$SMEturnperCa_t = f\begin{pmatrix} RDinGDP_t, Patent\_Inv_t, \\ ShrBssNTrn_t, ShrRlNWtrWs_t, \\ AirEmis_t \end{pmatrix}, \quad (5)$$

$$SMEpersperCa_t = f\begin{pmatrix} RDinGDP_t, Patent\_Inv_t, \\ ShrBssNTrn_t, ShrRlNWtrWs_t, \\ AirEmis_t \end{pmatrix}, \quad (6)$$

$$SMEturnperCa_t = f\begin{pmatrix} CrclrMtrlSR_t, NewCarEmis_t, \\ RwMtrlCnsmptn_t, NtGrnhsGsEms_t, \\ PopCovMayAgr_t \end{pmatrix}, \quad (7)$$

$$SMEpersperCa_t = f\begin{pmatrix} CrclrMtrlSR_t, NewCarEmis_t, \\ RwMtrlCnsmptn_t, NtGrnhsGsEms_t, \\ PopCovMayAgr_t \end{pmatrix}, \quad (8)$$

where: *SMEturnperCa* – SMEs' turnover per capita; *SMEpersperCa* – SMEs` persons employed per capita; *AgFaIn* – agricultural factor income per annual work unit; *AgriRnD* – government support for agricultural research and development; *OrgFarmArea* – an area under organic farming; *AmmonEmis* – ammonia emissions from agriculture; *InvInGDP* – the investment share of GDP; *UnempYouth* – young people who are neither employed nor in education and training; *EmpltmntRt* – the employment rate; *LngTrmNmpl* – the long-term unemployment rate; *FatAccid* – fatal accidents at work per 100,000 workers; *RDinGDP* – gross domestic expenditure on R&D; *Patent_Inv* – patent applications to the European Patent Office by inventors; *ShrBssNTrn* – the share of buses and trains in inland passenger transport; *ShrRlNWtrWs* – the share of rail and inland waterways in inland freight transport; *AirEmis* – air emission intensity from the industry; *CrclrMtrlSRt* – the circular material use rate; *NewCarEmis* – the average CO2 emissions per km from new passenger cars; *RwMtrlCnsmptn* – raw material consumption; *NtGrnhsGsEms* – net greenhouse gas emissions; *PopCovMayAgr* – a population covered by the Covenant of Mayors for Climate & Energy signatories.

3. RESULTS

3.1. Checking multicollinearity

No multicollinearity issues were found for the SDG2, the SDG12-13, and the SMEs' development variables. The analysis found multicollinearity for SDG8 models: a high negative correlation between *EmpltmntRt* and *UnempYouth* (coefficient equals –0.82), as well as *EmpltmntRt* and *LngTrmNmpl* (coefficient equals –0.77) were observed. Moreover, VIF values for *EmpltmntRt* (4.42-4.53) indicated moderate multicollinearity. Also, *EmpltmntRt* as an independent variable in the model resulted in lower significance and changing sign of the regression coefficients for *UnempYouth* and *LngTrmNmpl*. Thus, *EmpltmntRt* was excluded from the SDG8 regression models.

Next, a multicollinearity issue was found for the SDG9 models. Pearson correlation coefficient values were 0.81 and 0.86 between *Patent_Inv*

and *SMEturnperCa*, as well as *Patent_I*nv and *RDinGDP*, respectively. VIF values for *Patent_Inv* (4.99-5.16) indicated moderate multicollinearity. Also, *Patent_Inv* as an independent variable in the model resulted in lower significance and changing sign of the regression coefficients for *RDinGDP*. Thus, the *Patent_Inv* variable was excluded from SDG9 regression models. Detailed results of calculations are presented in Appendix A (Tables A1-A12).

3.2. Selecting the regression method and the estimated results

The results favored random effect GLS regression for SDG2 models, SDG9 models, and SDG12-13 (Model 1). However, fixed effect GLS regression was fitted better for SDG8 models and SDG12-13 (Model 2). Detailed results of calculations are presented in Appendix B (Tables C1-C8) and Appendix C (Tables C1-C8).

The estimated results of GLS FE and RE for examining the relationship between the SDG 2, SDG 12-13 indicators, and the SMEs' development are presented in Table 1.

For both SDG2 models, all regression coefficients have statistically significant values at the 1% or 5% significance level, indicating the statistical importance of the relationship between dependent and independent variables. Specifically, the coefficients for the "Agricultural factor income per annual work unit," the "Government support to agricultural research and development," and the "Area under organic farming" indicators in both models are statistically significant at the 1% or 5% level. Additionally, it is worth noting that the coefficients for the "Ammonia emissions from agriculture" indicator in Model 2 are statistically significant at the 1% significance level. The positive signs of all regression coefficients indicate a direct relationship between both dependent and inde-

Table 1. The estimated results of GLS FE and RE for the SDG 2, SDG 12-13 indicators, and the SMEs' development

Variables	Model 1 SDG2 SMEs' persons employed (RE)	Model 2 SDG2SMEs' turnover (RE)	Model 1 SDG12-13 SMEs' persons employed (RE)	Model 2 SDG12-13 SMEs' turnover (FE)
Agricultural factor income per annual work unit	0.0476**	0.138***		
	(0.0498)	(0.00514)		
Government support to agricultural research and development	0.0340***	0.0509**		
	(0.00172)	(0.0187)		
Area under organic farming	0.0537***	0.119***		
	(7.55e–05)	(1.19e–05)		
Ammonia emissions from agriculture	0.0710	0.359***		
	(0.111)	(0.000164)		
Circular material use rate			0.0484***	0.0892***
			(0.000352)	(0.000866)
Average CO2 emissions per km from new passenger cars			–0.206***	–0.429***
			(0.000912)	(0.000458)
Raw material consumption			0.198***	0.516***
			(3.11e–10)	(0)
Net greenhouse gas emissions			0.0677	0.0182
			(0.115)	(0.836)
Population covered by the Covenant of Mayors for Climate & Energy signatories			0.0232***	0.00981
			(0.00534)	(0.536)
Constant	–2.423***	–6.245***	–1.496***	–3.198***
	(0)	(0)	(1.33e–06)	(1.66e–07)
Observations	268	260	268	260
Number of id	27	27	27	27
R–squared				0.329

Note: pval in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

http://dx.doi.org/10.21511/ppm.22(2).2024.07

pendent variables. The constant values are –2.423 and –6.245 for Model 1 and Model 2, respectively, at the 1% significance level.

For both SDG12-13 models, results show that the regression coefficients for the "Circular material use rate," the "Average CO2 emissions per km from new passenger cars," and the "Raw material consumption" indicators have statistically significant values at the 1% significance level. The coefficient for the "Population covered by the Covenant of Mayors for Climate & Energy signatories" indicator is statistically significant at the 1% level for Model 1 and not statistically significant for Model 2. The coefficients for the "Net greenhouse gas emissions" indicator are not statistically significant for either model. The positive signs of the regression coefficients for the "Circular material use rate," the "Raw material consumption," and the "Population covered by the Covenant of Mayors for Climate & Energy signatories" indicators display a direct relationship between dependent and independent variables. The negative signs of the coefficients for the "Average CO2 emissions per km from new passenger cars" indicator reflect an inverse relationship between variables. The constant values are –1.496 and –3.198 for Model 1 and Model 2, respectively, at the 1% significance level. The *R*-squared value of 0.329 suggests that approximately 32.9% of the variability in the dependent variable (SMEs' turnover) is explained by the independent variables in the Model 2.

Table 2 presents the regression models' results for the SDG 8, SDG 9, and the SMEs' development indicators.

For both SDG8 models, the regression coefficients for the "Young people neither in employment nor in education and training" and the "Long-term unemployment rate" indicators have statistically significant values at the 1% significance level. The coefficients for the "Investment share of GDP" and the "Fatal accidents at work per 100,000 workers" indicators are not statistically significant for either model. The negative signs of the coefficients for the "Young people neither in employment nor in education and training" and the "Long-term unemployment rate" indicators reflect an inverse relationship between dependent and indepen-

Table 2. The estimated results of GLS FE and RE for the SDG 8, SDG 9 indicators, and the SMEs' development indicators

Variables	Model 1 SDG8 SMEs' persons employed (FE)	Model 2 SDG8 SMEs' turnover (FE)	Model 1 SDG9 SMEs' persons employed (RE)	Model 2 SDG9 SMEs' turnover (RE)
Investment share of GDP	–0.00288	–0.0408		
	(0.917)	(0.474)		
Young people neither in employment nor in education and training	–0.152***	–0.188***		
	(3.83e–06)	(0.00621)		
Long-term unemployment rate	–0.0591***	–0.124***		
	(4.51e–09)	(4.17e–09)		
Fatal accidents at work per 100,000 workers	0.000616	–0.0252		
	(0.948)	(0.204)		
Gross domestic expenditure on R&D			–0.0104	0.0853
			(0.722)	(0.149)
Share of buses and trains in inland passenger transport			–0.0919***	–0.0547
			(0.00195)	(0.351)
Share of rail and inland waterways in inland freight transport			0.00330	–0.0949
			(0.903)	(0.115)
Air emission intensity from industry			–0.0760***	–0.177***
			(2.99e–06)	(1.25e–07)
Constant	–1.148***	–2.803***	–1.546***	–3.567***
	(0)	(0)	(0)	(0)
Observations	267	259	250	242
Number of id	27	27	25	25
R–squared	0.552	0.476		

Note: pval in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

dent variables. The constant values are –1.148 and –2.803 for Models 1 and 2, respectively, at the 1% significance level. The *R*-squared values of 0.552 and 0.476 suggest that approximately 55.2% and 47.6% of the variability in the dependent variable (SMEs' persons employed and SMEs' turnover) is explained by the independent variables in Model 1 and Model 2, respectively.

For both SDG9 models, the regression coefficients for the "Air emission intensity from industry" indicator have statistically significant values at the 1% significance level. Also, the coefficient for the "Share of buses and trains in inland passenger transport" indicator is statistically significant at the 1% level for Model 1, and it is not statistically significant for Model 2. The negative signs of the coefficients for the "Air emission intensity from industry" and the "Share of buses and trains in inland passenger transport" indicators display an inverse relationship between dependent and independent variables. The constant values are –1.546 and –3.567 for Models 1 and 2, respectively, at the 1% significance level.

3.3. Relationship between SDG 2 and SMEs' development indicators

Hypothesis 1 was confirmed regarding a significant relationship between three of four SDG 2 indicators measuring sustainable agriculture and SMEs' development in EU-27 countries. A positive significant relationship was found between both SMEs' development indicators and the "Agricultural factor income," "Area under organic farming," and "Government support to agricultural research and development" indicators.

An increase in agricultural factor income (i.e., labor productivity in agriculture) by 10% for EU-27 in 2011–2020 results in an increase in SMEs' turnover by 1.4% and an increase in SMEs' persons employed by 0.5%. Additionally, a 10% growth in the organic farming area results in a 1.2% and a 0.5% increase in SMEs' turnover and persons employed, respectively. It means that more productive and organic agriculture enhances SMEs' development in the country. With a 10% growth in budget allocations for R&D for agriculture, a 0.5% and 0.3% increase in SMEs' turnover and persons employed is observed, respectively. Ammonia emissions significantly positively affect SMEs' turnover; with a 10% increase in ammonia emissions from agricultural manufacture, SMEs' turnover increases by 3.6%.

3.4. Relationship between SDG 12, SDG 13, and SMEs' development indicators

Hypothesis 2 was partially confirmed regarding a significant relationship between SDG 12 indicators measuring sustainable sourcing, CO2 emissions, responsible manufacturing, and SMEs' development in EU-27 countries.

A significant positive relationship was found between both SMEs' development indicators and raw material consumption, and circular material use rate. An increase in raw material consumption (i.e., the worldwide need for material extraction driven by the utilization of goods and services within a specific geographic region (Eurostat, n.d.a)) by 10% for EU-27 in 2011–2020 results in an increase in SMEs' turnover by 5.2% and an increase in SMEs' persons employed by 2%. However, a 10% growth in circular material use rate leads to a 0.9% and 0.5% increase for SMEs' turnover and employment indicators, respectively. This indicates that although SMEs' activities remain material-intensive, the transition to the use of secondary materials influences SMEs' development positively, which reduces the environmental consequences of harvesting primary materials. A negative significant relationship was found between both SMEs' development indicators and the "Average CO2 emissions per km from new passenger cars" indicator. With a 10% increase in CO2 emissions of new passenger cars in the selected countries, a 4.3% and 2.1% decrease in SMEs' turnover and persons employed is observed, respectively. It means that responsible manufacturing (e.g., more environmentally efficient cars with less emissions) positively affects SMEs' development.

One of the two SDG13 indicators has a positive significant relationship with SMEs' employment only. A 10% increase in population covered by the Covenant of Mayors for Climate & Energy signatories results in SMEs' employment growth by 0.2%. Under the Covenant, cities commit to mea-

http://dx.doi.org/10.21511/ppm.22(2).2024.07

suring and publicly reporting carbon emissions to achieve a minimum 40% reduction in CO2 emissions by 2030 while enhancing resilience to climate change (European Commission, n.d.). This finding indicates that employment in SMEs was higher for EU-27 countries in 2011–2020, where municipalities implemented energy policies.

However, the regression results do not identify a significant relationship between net greenhouse gas emissions and SMEs' development.

3.5. Relationship between SDG 8 and SMEs' development indicators

Hypothesis 3 was confirmed regarding a significant relationship between SDG 8 indicators measuring inclusive employment and SMEs' development in EU-27 countries.

A significant negative relationship was found between both SMEs' development indicators and youth unemployment and the long-term unemployment rate. A 10% increase in youth unemployment results in a 1.9% and a 1.5% decrease in SMEs' turnover and employment, respectively. That proves the crucial contribution of young people aged 15 to 29 in SMEs' development as employees or entrepreneurs. Moreover, a 10% increase in long-term unemployment, a 0.6% increase in SMEs' unemployment, and a 1.2% decrease in turnover are observed. Thus, the segment of the workforce aged 15 to 74 who have experienced unemployment for 12 months or longer significantly influences SMEs' development.

It is worth mentioning that there was no significant relationship between the investment share of GDP, fatal accidents at work, and SMEs' development indicators.

3.6. Relationship between SDG 9 and the SMEs' development indicators

Hypothesis 4 was partially confirmed regarding a significant relationship between SDG 9 indicators measuring the environmental impact of responsible industrial practices, transport infrastructure, and SMEs' development in EU-27 countries.

The results prove that only two SDG 9 indicators have a significant relationship with at least one SMEs' development indicator. Air emission intensity from industry has a negative significant relationship with both SMEs' development indicators. A 10% increase in emissions from the manufacturing sector leads to a 1.8% and a 0.8% decrease in SMEs' turnover and employment, respectively. This outcome means that SMEs develop better (in terms of turnover and number of employees) in EU countries with fewer production emissions (i.e., cleaner industry).

The "Share of buses and trains in inland passenger transport" indicator has a negative significant relationship with SMEs' employment. With the increase in the percentage of collective transportation in the overall productivity of domestic transport in EU countries by 10%, the number of persons employed in SMEs decreases by 0.9%. Since the total inland transport includes transport by passenger cars, buses (including coaches and trolleybuses), and trains, the findings can be interpreted as follows: growth in the percentage of passenger cars in inland passenger transport increases SMEs' employment.

However, a significant relationship was not found between the "Share of rail and inland waterways in inland freight transport" indicator, the "Gross domestic expenditure on R&D" indicator, and SMEs' development indicators.

4. DISCUSSION

The findings on a positive statistically significant relationship between indicators of productivity and organic farming development and indicators of SMEs' development align with Sau et al. (2023), who stated that there is a significant positive relationship between economic indicators and organic production variables in the sample of 219 Sardinian sheep farms. Moreover, the finding of a positive significant relationship between R&D funding of agriculture and SMEs' development indicators aligns with Stoian et al. (2022), who found a positive correlation between governmental spending on agricultural R&D and farmers' income across most EU countries in 2004–2020.

The finding on a positive significant impact of ammonia emissions on SMEs' turnover supports the fact that despite a positive trend in the transition of agriculture to environmental friendliness, a substantial part of it uses methods that affect the environment negatively. The amount of ammonia used fertilizers is nearly 70% (International Energy Agency, 2021). Moreover, the share of ammonia emission from agriculture, forestry, and fishing in the total emissions for EU-27 countries is nearly 96.6% in 2011–2021 (Eurostat, n.d.b). Thus, minimizing the use of ammonia and implementing sustainable practices by SMEs in agriculture are crucial steps to ensure worker safety, preserve natural resources, and diminish the harmful impact of production on the environment.

The outcome of a significant positive impact of material footprint on SMEs' development is consistent with the findings of Kafel and Nowicki (2023), who found that restricting the utilization of primary raw materials poses a significant challenge for SMEs seeking to adopt circular economy methods.

The findings on a significant favorable influence of circular material use on SMEs' development support Sabău-Popa et al. (2022), who found a significant positive relationship between the recycling rate of municipal waste and GDP per capita for EU-27 countries in 2012–2020. In addition, Arion et al. (2023) found that the recycling rate for all waste categories except significant mineral waste significantly influences economic growth (i.e., GDP per capita).

The finding on the positive impact of decreasing new cars' CO2 emissions on SMEs' development supports Tsai et al. (2021), who found a positive significant relationship between environmental-related indicators and firm performance in Vietnam. Moreover, Sáez-Martínez et al. (2016) stated that corporate environmental responsibility and green practices positively correlate with sales growth in European SMEs.

The outcome of a positive relationship between coverage by the Covenant of Mayors for Climate & Energy and SMEs' development supports Pablo-Romero et al. (2015), who investigated the factors influencing the decision of Spanish local authorities to join the Covenant. It was found that unemployment significantly affects the probability of signing the Covenant, which can be explained by leading energy policy implementation to a strengthening of industry and, accordingly, an increase in employment.

The outcome of the negative impact of youth unemployment on SMEs' development supports by Hutagaol et al. (2020), who stated that youth play a crucial role in enhancing the growth of SMEs in Medan (Indonesia). In turn, Bal-Domańska (2022) found that strengthening the economy's efficiency helps decrease the rate of unemployment among young individuals.

The findings on the reversal correlation between long-term unemployment and SMEs' development align with Buterin et al. (2023), who found a statistically significant and inverse correlation between prolonged female unemployment and GDP per capita for the EU-27 countries in 2009–2022.

The findings of the negative impact of industrial air emission intensity on SMEs' development support Dong et al. (2021), who reported a crucial immersive influence of air pollution (assessed by the concentration of PM2.5) on the macroeconomic growth of China (measured by GDP per capita growth rate) based on a sample representative of a province's demographics in 2002–2017. Moreover, Dechezleprêtre et al. (2019) identified that increasing PM2.5 concentration decreased GDP throughout the European Union in 2000–2015. Finally, Hao et al. (2018) found a similar negative significant relationship between PM2.5 concentrations and GDP per capita based on Chinese cities panel data in 2013–2015.

The findings of a negative relationship between the share of collective transportation and SMEs' development align with Dėdelė et al. (2020), who found that individuals with a higher socioeconomic status (in terms of income, educational attainment, and employment status) exhibited a higher propensity to utilize cars for travel than those with a lower socioeconomic status. Moreover, Lunke (2022) proved that employment accessibility with vehicles is higher than with public transport. Also, Dobbs (2005) stated that women tend to have higher employment rates when they have unrestricted access to private transportation. Conversely, they are less prone to unemployment, and when employed, they are more likely to secure full-time positions.

http://dx.doi.org/10.21511/ppm.22(2).2024.07

CONCLUSION AND LIMITATIONS

The study aimed to determine whether there is a connection between indicators of sustainable development and indicators of SMEs' development in EU-27 countries. Four hypotheses designed to investigate within research were confirmed partially or entirely.

It was empirically proved that SMEs' development positively depends on sustainable agriculture development in terms of productivity, R&D funding, and spreading organic farming (hypothesis 1); sustainable sourcing, responsible manufacturing in terms of circular material use and new cars' CO2 emissions (hypothesis 2), inclusive employment in terms of youth and long-term unemployment (hypothesis 3), and responsible industrial practices, transport infrastructure in terms of industrial air emissions and the share of passenger cars (hypothesis 4).

However, this paper has several limitations enabling further research. First, co-occurrence analysis was limited to publications from two subject areas. Thus, further analysis could cover other subject areas that lead to identifying keywords referring to other SDGs. Second, sustainable development indicators were limited to SDG 2, 8, 9, 12, and 13. Further research needs to be conducted to determine the relationship between SME development and other SDGs. Third, dependent variables of SMEs' development reflected SMEs' turnover and employment. Further studies could investigate SMEs' development through other indicators, such as value added. Fourth, dependent variables for regression models were selected from the proposed list of sustainable development indicators in Eurostat. The availability of data for EU-28 countries in 2011–2020 limited the choice of indicators. The UK was not included in the sample as data were missing for many indicators in 2019 and 2020. Finally, this analysis was based on panel data for countries, but further research could focus on analyzing SME companies' data for one or more countries.

AUTHOR CONTRIBUTIONS

Conceptualization: Bohdan Kovalov.
Data curation: Bohdan Kovalov.
Formal analysis: Bohdan Kovalov.
Funding acquisition: Bohdan Kovalov.
Investigation: Bohdan Kovalov.
Methodology: Bohdan Kovalov.
Project administration: Bohdan Kovalov.
Resources: Bohdan Kovalov.
Software: Bohdan Kovalov.
Supervision: Bohdan Kovalov.
Validation: Bohdan Kovalov.
Visualization: Bohdan Kovalov.
Writing – original draft: Bohdan Kovalov.
Writing – review & editing: Bohdan Kovalov.

ACKNOWLEDGMENT

This study is supported by the British Academy's Researchers at Risk Fellowships Program (Award Reference: RaR\100673).

REFERENCES

1. Abisuga-Oyekunle, O. A., Patra, S. K., & Muchie, M. (2020). SMEs in sustainable development: Their role in poverty reduction and employment generation in sub-Saharan Africa. *African Journal of Science, Technology, Innovation and Development, 12*(4), 405-419. https://doi.org/10.1080/20421338.2019.1656428
2. Al-Mutawa, B., & Saeed Al Mubarak, M. M. (2024). Impact of cloud computing as a digital technology on SMEs sustainability. *Competitiveness Review, 34*(1), 72-91. https://doi.org/10.1108/CR-09-2022-0142
3. Arion, F. H., Aleksanyan, V., Markosyan, D., & Arion, I. D. (2023). Circular pathways to sustainable development: Understanding the links between circular economy indicators, economic growth, social well-being, and environmental performance in EU-27. *Sustainability, 15*(24), Article 16883. https://doi.org/10.3390/su152416883
4. Bal-Domańska, B. (2022). The impact of macroeconomic and structural factors on the unemployment of young women and men. *Economic Change and Restructuring, 55*(2), 1141-1172. https://doi.org/10.1007/s10644-021-09341-9
5. Bilan, Y., Lyeonov, S., Vasylieva, T., & Samusevych, Y. (2018). Does tax competition for capital define entrepreneurship trends in Eastern Europe? *Online Journal Modelling the New Europe, 27,* 34-66. https://doi.org/10.24193/OJMNE.2018.27.02
6. Bucci, G., Bentivoglio, D., & Finco, A. (2018). Precision agriculture as a driver for sustainable farming systems: State of art in literature and research. *Quality – Access to Success, 19* (S1), 114-121. Retrieved from https://www.researchgate.net/publication/324212481_Precision_agriculture_as_a_driver_for_sustainable_farming_systems_State_of_art_in_literature_and_research
7. Buterin, V., Fajdetić, B., & Funarić, B. (2023). Understanding the macroeconomic effects of female participation in the labour market. *Economies, 11*(11), Article 280. https://doi.org/10.3390/economies11110280
8. da Silva, A.R., Cirani, C. B. S., Serra, F. A. R., Pigola, A., da Costa, P. R., Scafuto, I. C., Ruas, R. L., & Mazieri, M. R. (2023). Determining factors on green innovation adoption: An empirical study in Brazilian agribusiness firms. *Sustainability, 15*(7), Article 6266. https://doi.org/10.3390/su15076266
9. Dechezleprêtre, A., Rivers, N., & Stadler, B. (2019). *The economic cost of air pollution: Evidence from Europe* (OECD Economics Department Working Papers No. 1584). Paris: OECD Publishing. https://doi.org/10.1787/56119490-en
10. Dėdelė, A., Miškinytė, A., Andrušaitytė, S., & Nemaniūtė-Gužienė, J. (2020). Dependence between travel distance, individual socioeconomic and health-related characteristics, and the choice of the travel mode: A cross-sectional study for Kaunas, Lithuania. *Journal of Transport Geography, 86,* Article 102762. https://doi.org/10.1016/j.jtrangeo.2020.102762
11. Dey, P. K., Malesios, C., Chowdhury, S., Saha, K., Budhwar, P., & De, D. (2022). Adoption of circular economy practices in small and medium-sized enterprises: Evidence from Europe. *International Journal of Production Economics, 248,* Article 108496. https://doi.org/10.1016/j.ijpe.2022.108496
12. Dobbs, L. (2005). Wedded to the car: Women, employment and the importance of private transport. *Transport Policy, 12*(3), 266-278. https://doi.org/10.1016/j.tranpol.2005.02.004
13. Dong, D., Xu, B., Shen, N., & He, Q. (2021). The adverse impact of air pollution on China's economic growth. *Sustainability, 13*(16), Article 9056. https://doi.org/10.3390/su13169056
14. European Commission. (2023a, June 27). *Number of people employed by small and medium-sized enterprises (SMEs) in the European Union from 2008 to 2023, by enterprise size* [Graph]. Statista. Retrieved January 31, 2024, from https://www-statista-com.bris.idm.oclc.org/statistics/936845/employment-by-smes-in-europe-an-union/
15. European Commission. (2023b, June 27). *Value added by small and medium-sized enterprises (SMEs) in the European Union (EU27) from 2008 to 2023, by enterprise size (in million Euro)* [Graph]. Statista. Retrieved January 31, 2024, from https://www-statista-com.bris.idm.oclc.org/statistics/936386/value-added-by-smes-in-eu-member-states/
16. European Commission. (n.d.). *EU Covenant of Mayors – Europe: Signatories.* Retrieved February 2, 2024, from https://eu-mayors.ec.europa.eu/en/signatories
17. Eurostat. (n.d.a). *Database*. Retrieved January 31, 2024, from https://ec.europa.eu/eurostat/web/main/data/database
18. Eurostat. (n.d.b). *Air emissions accounts by NACE Rev. 2 activity.* Retrieved January 31, 2024, from https://ec.europa.eu/eurostat/databrowser/view/env_ac_ainah_r2__custom_9811708/default/table?lang=en
19. Farja, Y., Gimmon, E., & Greenberg, Z. (2017). The developing in the developed: Rural SME growth in Israel. *International Journal of Entrepreneurship and Innovation, 18*(1), 36-46. https://doi.org/10.1177/1465750316686239
20. Gomes, S., & Pinho, M. (2023). Can we count on the commitment of European SMEs to achieve SGD12? An exploratory study of business sustainability. *Journal of Cleaner Production, 425,* Article 139016. https://doi.org/10.1016/j.jclepro.2023.139016
21. Hao, Y., Peng, H., Temulun, T., Liu, L., Mao, J., Lu, Z., & Chen, H. (2018). How harmful is air

http://dx.doi.org/10.21511/ppm.22(2).2024.07

pollution to economic development? New evidence from PM2.5 concentrations of Chinese cities. *Journal of Cleaner Production, 172,* 743-757. https://doi.org/10.1016/j.jclepro.2017.10.195

22. Horobchenko, D., & Voronenko, V. (2018). Approaches to the formation of a theoretical model for the analysis of environmental and economic development. *Journal of Environmental Management and Tourism, 9*(5), 1108-1119. Retrieved from https://journals.aserspublishing.eu/jemt/article/view/2603

23. Hrytsenko, P., Voronenko, V., Kovalenko, Y., Kurman, T., & Omelianenko, V. (2021). Assessment of the development of innovation activities in the regions: Case of Ukraine. *Problems and Perspectives in Management, 19*(4), 77-88. http://dx.doi.org/10.21511/ppm.19(4).2021.07

24. Hutagaol, S. J. A., Erlina, & Tarmizi, H. B. (2020). The effect of youth's role in improving micro, small and medium enterprises (MSMEs) in Medan city. *International Journal of Research and Review, 7*(2), 332-343. Retrieved from https://www.ijrrjournal.com/IJRR_Vol.7_Issue.2_Feb2020/IJRR0052.pdf

25. Inegbedion, H. E., Thikan, P. R., David, J. O., Ajani, J. O., & Peter, F. O. (2024). Small and medium enterprise (SME) competitiveness and employment creation: The mediating role of SME growth. *Humanities and Social Sciences Communications, 11,* Article 11. https://doi.org/10.1057/s41599-023-02434-y

26. International Energy Agency. (2021). *Ammonia Technology Roadmap.* Retrieved January 31, 2024, from https://iea.blob.core.windows.net/assets/6ee41bb9-8e81-4b64-8701-2acc064ff6e4/AmmoniaTechnologyRoadmap.pdf

27. Jasińska-Biliczak, A. (2023). How to ensure the development of SMEs in post-pandemic economy? A start-ups case study. *TalTech Journal of European Studies, 13*(1), 201-225. https://doi.org/10.2478/bjes-2023-0010

28. Kafel, P., & Nowicki, P. (2023). Circular economy implementation based on ISO 14001 within SME organization: How to do it best? *Sustainability, 15*(1), Article 496. https://doi.org/10.3390/su15010496

29. Koblianska, I., & Kalachevska, L. (2019). Problems of the institutional legal and organizational provision of systemic innovation policy: The case of Ukraine. *Comparative Economic Research. Central and Eastern Europe, 22*(1), 53-73. https://doi.org/10.2478/cer-2019-0004

30. Lopes de Sousa Jabbour, A. B., Ndubisi, N. O., & Roman Pais Seles, B. M. (2020). Sustainable development in Asian manufacturing SMEs: Progress and directions. *International Journal of Production Economics, 225,* Article 107567. https://doi.org/10.1016/j.ijpe.2019.107567

31. Lunke, E. B. (2022). Modal accessibility disparities and transport poverty in the Oslo region. *Transportation Research Part D: Transport and Environment, 103,* Article 103171. https://doi.org/10.1016/j.trd.2022.103171

32. Melnyk, L., Matsenko, O., Kubatko, O., Korneyev, M., & Tulyakov, O. (2022). Additive economy and new horizons of innovative business development. *Problems and Perspectives in Management, 20*(2), 175-185. https://doi.org/10.21511/ppm.20(2).2022.15

33. Mishenin, E., Koblianska, I., & Mishenina, N. (2015). Strategy of implementation of ecologically-oriented logistical management of enterprise's production system. *Economic Annals-XXI, 3-4*(1), 64-67. Retrieved from https://ea21journal.world/index.php/ea-v149-15/

34. Mota, J., Santos, J. N., & Alencar, R. (2023). Intertwining innovation and business networks for sustainable agricultural systems: A case study of carbon-neutral beef. *Technological Forecasting and Social Change, 190,* Article 122429. https://doi.org/10.1016/j.techfore.2023.122429

35. OECD. (n.d.). *SDBS Structural Business Statistics (ISIC Rev. 4): Number of SMEs and large firms.* Retrieved January 31, 2024, from https://stats.oecd.org/Index.aspx?QueryId=81354#

36. Pablo-Romero, M. d. P., Sánchez-Braza, A., & Manuel González-Limón, J. (2015). Covenant of mayors: Reasons for being an environmentally and energy friendly municipality. *Review of Policy Research, 32*(5), 576-599. https://doi-org.bris.idm.oclc.org/10.1111/ropr.12135

37. Sabău-Popa, C. D., Bele, A. M., Dodescu, A. O., & Boloș, M. I. (2022). How does the circular economy applied in the European Union support sustainable economic development? *Sustainability, 14*(16), Article 9932. https://doi.org/10.3390/su14169932

38. Sáez-Martínez, F. J., Díaz-García, C., & González-Moreno, Á. (2016). Factors promoting environmental responsibility in European SMEs: The effect on performance. *Sustainability, 8*(9), Article 898. https://doi.org/10.3390/su8090898

39. Sau, P., Arru, B., Cisilino, F., Furesi, R., Pulina, P., & Madau, F. A. (2023). Economic and environmental sustainability trade-off analysis in sheep farming using the farm accountancy data network database. *Sustainability, 15*(24), Article 16621. https://doi.org/10.3390/su152416621

40. Sidik, I. G. (2012). Conceptual framework of factors affecting SME development: Mediating factors on the relationship of entrepreneur traits and SME performance. *Procedia Economics and Finance, 4,* 373-383. https://doi.org/10.1016/S2212-5671(12)00351-6

41. Song, M., & Ahn, Y. (2024). The determinants of SME success in the long run: An ecosystem perspective. *Applied Economics.* https://doi.org/10.1080/00036846.2023.2301220

42. Sonntag, R., Lewis, G. J., & Raszkowski, A. (2022). The importance of implementing SDGs by small and medium size enterprises: Evidence from Ger-

many and Poland. *Sustainability, 14*(24), Article 16950. https://doi.org/10.3390/su142416950

43. Stoian, M., Ion, R. A., Turcea, V. C., Nica, I. C., & Zemeleaga, C. G. (2022). The influence of governmental agricultural R&D expenditure on farmers' income – Disparities between EU Member States. *Sustainability, 14*(17), Article 10596. https://doi.org/10.3390/su141710596

44. Tambunan, T. T. H. (2009). SME development pattern: A theoretical consideration. In *SMEs in Asian Developing Countries* (pp. 17-36). London: Palgrave Macmillan. https://doi.org/10.1057/9780230250949_2

45. Tsai, J.-F., Nguyen, P.-H., Lin, M.-H., Nguyen, D.-V., Lin, H.-H., & Ngo, A.-T. (2021). Impacts of environmental certificate and pollution abatement equipment on SMEs' performance: An empirical case in Vietnam. *Sustainability, 13*(17), Article 9705. https://doi.org/10.3390/su13179705

46. Wang, W., Melnyk, L., Kubatko, O., Kovalov, B., & Hens, L. (2023). Economic and technological efficiency of renewable energy technologies implementation. *Sustainability, 15*(11), Article 8802. https://doi.org/10.3390/su15118802

http://dx.doi.org/10.21511/ppm.22(2).2024.07

APPENDIX A. Multicollinearity checking calculations

Table A1. Pearson correlation matrix for SDG2 and SMEs indicators

Variable	SMEpersperCa	SMEturnperCa	AgFaIn	AgriRnD	OrgFarmArea	AmmonEmis
SMEpersperCa	1.0000					
SMEturnperCa	0.4819	1.0000				
AgFaIn	0.0516	0.6558	1.0000			
AgriRnD	–0.0746	0.2013	0.5137	1.0000		
OrgFarmArea	0.0919	0.0719	0.1792	0.2879	1.0000	
AmmonEmis	0.1824	0.5815	0.4584	0.0292	–0.4128	1.0000

Table A2. Pearson correlation matrix for SDG12-13 and SMEs indicators

Variable	SMEpersperCa	SMEturnperCa	CrclrMtrlSRt	NewCarEmis	RwMtrlCnsmptn	NtGrnhsGsEms	PopCovMayAgr
SMEpersperCa	1.0000						
SMEturnperCa	0.4821	1.0000					
CrclrMtrlSRt	0.0291	0.4584	1.0000				
NewCarEmis	0.1164	–0.1753	–0.0863	1.0000			
RwMtrlCnsmptn	0.1591	0.1754	–0.1345	0.3212	1.0000		
NtGrnhsGsEms	0.3373	0.6000	0.2475	0.2250	0.2852	1.0000	
PopCovMayAgr	–0.2309	–0.3263	–0.1917	–0.3239	–0.2162	–0.5070	1.0000

Table A3. Pearson correlation matrix for SDG8 and SMEs indicators

Variable	SMEpersperCa	SMEturnperCa	InvInGDP	UnempYouth	EmpltmntRt	EmpltmntRt	FatAccid
SMEpersperCa	1.0000						
SMEturnperCa	0.4953	1.0000					
InvInGDP	–0.0371	0.1465	1.0000				
UnempYouth	–0.4911	–0.6649	–0.2652	1.0000			
EmpltmntRt	0.5043	0.4937	0.4837	**–0.8226**	1.0000		
EmpltmntRt	–0.2517	–0.4341	–0.4934	0.7313	**–0.7712**	1.0000	
FatAccid	–0.0108	–0.2704	0.1340	0.3556	–0.2755	0.2072	1.0000

Table A4. VIF values for SDG8 indicators and SMEs' persons employed as the dependent variable (EmpltmntRt included)

Variable	VIF	1/VIF
EmpltmntRt	**4.53**	0.220711
UnempYouth	3.97	0.251763
LngTrmNmpl	2.94	0.340317
InvInGDP	1.65	0.604401
FatAccid	1.25	0.800201
Mean VIF	2.87	

Table A5. VIF values for SDG8 indicators and SMEs' persons employed as the dependent variable (EmpltmntRt excluded)

Variable	VIF	1/VIF
LngTrmNmpl	2.71	0.368431
UnempYouth	2.42	0.412777
InvInGDP	1.43	0.701642
FatAccid	1.24	0.808548
Mean VIF	1.95	

Table A6. VIF values for SDG8 indicators and SMEs' turnover as the dependent variable (EmpltmntRt included)

Variable	VIF	1/VIF
EmpltmntRt	**4.42**	0.225999
UnempYouth	3.87	0.258271
LngTrmNmpl	2.94	0.340147
InvInGDP	1.67	0.599248
FatAccid	1.24	0.808025
Mean VIF	2.83	

Table A7. VIF values for SDG8 indicators and SMEs' turnover as the dependent variable (EmpltmntRt excluded)

Variable	VIF	1/VIF
LngTrmNmpl	2.72	0.368204
UnempYouth	2.39	0.418740
InvInGDP	1.44	0.693389
FatAccid	1.23	0.816310
Mean VIF	1.94	

Table A8. Pearson correlation matrix for SDG9 and SMEs indicators

	SMEpersperCa	SMEturnperCa	RDinGDP	Patent_Inv	ShrBssNTrn	ShrRlNWtrWs	AirEmis
SMEpersperCa	1.0000						
SMEturnperCa	0.4933	1.0000					
RDinGDP	0.0811	0.5961	1.0000				
Patent_Inv	0.1136	0.8098	**0.8624**	1.0000			
ShrBssNTrn	–0.2355	–0.0652	–0.0853	–0.0296	1.0000		
ShrRlNWtrWs	0.1257	–0.2214	–0.0598	–0.1474	0.0152	1.0000	
AirEmis	–0.0163	–0.5483	–0.6000	–0.7018	–0.1852	0.2064	1.0000

Table A9. VIF values for SDG9 indicators and SMEs' persons employed as the dependent variable (Patent_Inn included)

Variable	VIF	1/VIF
Patent_Inv	**5.16**	0.193771
RDinGDP	4.18	0.239047
AirEmis	2.27	0.441147
ShrBssNTrn	1.12	0.891356
ShrRlNWtrWs	1.08	0.929808
Mean VIF	2.76	

Table A10. VIF values for SDG9 indicators and SMEs' persons employed as the dependent variable (Patent_Inn excluded)

Variable	VIF	1/VIF
AirEmis	1.86	0.537524
RDinGDP	1.72	0.582038
ShrBssNTrn	1.12	0.894903
ShrRlNWtrWs	1.06	0.939769
Mean VIF	1.44	

http://dx.doi.org/10.21511/ppm.22(2).2024.07

Table A11. VIF values for SDG9 indicators and SMEs' turnover as the dependent variable (Patent_Inn included)

Variable	VIF	1/VIF
Patent_Inv	4.99	0.200378
RDinGDP	4.04	0.247498
AirEmis	2.21	0.452857
ShrBssNTrn	1.11	0.897719
ShrRlNWtrWs	1.07	0.935209
Mean VIF	2.68	

Table A12. VIF values for SDG9 indicators and SMEs' turnover as the dependent variable (Patent_Inn excluded)

Variable	VIF	1/VIF
AirEmis	1.81	0.553714
RDinGDP	1.68	0.594171
ShrBssNTrn	1.11	0.899807
ShrRlNWtrWs	1.06	0.945097
Mean VIF	1.41	

APPENDIX B. Breusch and Pagan Lagrangian multiplier test calculations

Table B1. Estimated results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG2 and SMEs' employment

Variable	Var	SD = sqrt(Var)
ln_SMEpersperCaOECD	0.0355	0.18851
Residual errors	0.002856	0.0534
Squared residuals	0.035028	0.187156
Test: Var(u) = 0 chibar2(01) = 933.67 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

Table B2. Estimated results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG2 and SMEs' turnover

Variable	Var	SD = sqrt(Var)
ln_SMEturnperCaOECD	0.3983	0.6311383
Residual errors	0.0106982	0.1034
Squared residuals	0.1898161	0.4356789
Test: Var(u) = 0 chibar2(01) = 1008.54 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

Table B3. Estimated results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG12-13 and SMEs' employment

Variable	Var	SD = sqrt(Var)
ln_SMEpersperCaOECD	0.0356	0.1887795
Residual errors	0.0025381	0.0504
Squared residuals	0.0328318	0.1811956
Test: Var(u) = 0 chibar2(01) = 896.11 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

Table B4. Results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG12-13 and SMEs' turnover

Variable	Var	SD = sqrt(Var)
ln_SMEturnperCaOECD	0.3971	0.6301213
Residual errors	0.0089223	0.0945
Squared residuals	0.1924869	0.4387333
Test: Var(u) = 0 chibar2(01) = 886.54 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

Table B5. Results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG8 and SMEs' employment

Variable	Var	SD = sqrt(Var)
ln_SMEpersperCaOECD	0.036089	0.189971
Residual errors	0.001618	0.040219
Squared residuals	0.023776	0.154194
Test: Var(u) = 0 chibar2(01) = 848.05 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

Table B6. Results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG8 and SMEs' turnover

Variable	Var	SD = sqrt(Var)
ln_SMEturnperCaOECD	0.4009581	0.6332125
Residual errors	0.0068098	0.0825214
Squared residuals	0.2482128	0.4982096
Test: Var(u) = 0 chibar2(01) = 1019.64 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

Table B7. Results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG9 and SMEs' employment

Variable	Var	SD = sqrt(Var)
ln_SMEpersperCaOECD	0.0362938	0.1905093
Residual errors	0.0028642	0.0535180
Squared residuals	0.0374528	0.1935271
Test: Var(u) = 0 chibar2(01) = 918.36 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

Table B8. Results of Breusch and Pagan Lagrangian multiplier test for random effects for SDG9 and SMEs' turnover

Variable	Var	SD = sqrt(Var)
ln_SMEturnperCaOECD	0.4312489	0.6566954
Residual errors	0.0105787	0.1028527
Squared residuals	0.2766624	0.5259870
Test: Var(u) = 0 chibar2(01) = 976.51 Prob > chibar2 = 0.0000		

Note: The probability is less than 0.05 so it is safe to use random effects.

http://dx.doi.org/10.21511/ppm.22(2).2024.07

APPENDIX C. Breusch and Pagan Lagrangian multiplier test calculations

Table C1. Hausman test for SDG2 and SMEs' employment

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_AgFaIn	0.065215	0.047637	0.017578	0.008797
ln_AgriRnD	0.037655	0.034007	0.003648	0.002313
ln_OrgFarmArea	0.052811	0.053746	–0.00094	0.004076
ln_AmmonEmis	0.078206	0.071047	0.007159	0.048718
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 7.09 Probability (Prob > chi2): 0.1314				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is more than 0.05; thus, the random effects model is more appropriate for the data.

Table C2. Hausman test for SDG2 and SMEs' turnover

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_AgFaIn	0.1072835	0.1376711	–0.0303876	0.0152638
ln_AgriRnD	0.0550852	0.0508932	0.004192	0.0039045
ln_OrgFarmArea	0.1219986	0.1187891	0.0032094	0.0068478
ln_AmmonEmis	0.1791785	0.3592122	–0.1800337	0.0882008
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 8.79 Probability (Prob > chi2): 0.0666				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is more than 0.05; thus, the random effects model is more appropriate for the data.

Table C3. Hausman test for SDG12-13 and SMEs' employment

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_CrclrMtrlSRt	0.0511618	0.0484359	0.0027259	0.004081
ln_NewCarEmis	–0.1915206	–0.2059254	0.0144048	0.0163306
ln_RwMtrlCnsmptn	0.2117247	0.1978603	0.0138643	0.010537
ln_NtGrnhsGsEms	0.0536117	0.0677375	–0.0141258	0.017438
ln_PopCovMayAgr	0.0248936	0.0232324	0.0016612	0.0014256
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 7.62 Probability (Prob > chi2): 0.1786				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is more than 0.05; thus, the random effects model is more appropriate for the data.

Table C4. Hausman test for SDG12-13 and SMEs' turnover

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_CrclrMtrlSRt	0.0891639	0.1069069	–0.0177430	0.0062374
ln_NewCarEmis	–0.4286014	–0.5329150	0.1043136	0.0250909
ln_RwMtrlCnsmptn	0.5155273	0.4861482	0.0293791	0.0177455
ln_NtGrnhsGsEms	0.0181615	0.1292655	–0.1111040	0.0274882
ln_PopCovMayAgr	0.0098108	0.0047097	0.0051011	0.0021646
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 20.49 Probability (Prob > chi2): 0.0010				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is less than 0.05; thus, the fixed effects model is more appropriate for the data.

Table C5. Hausman test for SDG8 and SMEs' employment

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_InvInGDP	–0.0028837	–0.0081573	0.0052735	0.0039575
ln_UnempYouth	–0.1524380	–0.1603295	0.0078915	0.0091589
ln_LngTrmNmpl	–0.0591442	–0.0570564	–0.0020878	0.0018253
ln_FatAccid	0.0006160	0.0021270	–0.0015110	0.0013919
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 9.80 Probability (Prob > chi2): 0.0439				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is less than 0.05; thus, the fixed effects model is more appropriate for the data.

Table C6. Hausman test for SDG8 and SMEs' turnover

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_InvInGDP	–0.0408250	–0.0447128	0.0038878	0.0052985
ln_UnempYouth	–0.1881668	–0.2291802	0.0410133	0.0129642
ln_LngTrmNmpl	–0.1236210	–0.1159390	–0.0076820	0.0025520
ln_FatAccid	–0.0251776	–0.0259017	0.0007240	0.0018759
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 10.15 Probability (Prob > chi2): 0.0380				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is less than 0.05; thus, the fixed effects model is more appropriate for the data.

Table C7. Hausman test for SDG9 and SMEs' employment

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_RDinGDP	0.0074091	–0.0104170	0.0178262	0.0136968
ln_ShrBssNTrn	–0.0756434	–0.0918972	0.0162539	0.0086048
ln_ShrRlNWtrWs	–0.0262821	0.0032958	–0.0295779	0.0265688
ln_AirEmis	–0.0818768	–0.0759635	–0.0059133	0.0073842
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 4.93 Probability (Prob > chi2): 0.2941				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is more than 0.05; thus, the random effects model is more appropriate for the data.

Table C8. Hausman test for SDG9 and SMEs' turnover

Variable	Coefficient (b)	Coefficient (B)	Difference (b – B)	Std. Error
ln_RDinGDP	0.0456184	0.0852719	–0.0396535	0.0203893
ln_ShrBssNTrn	–0.0681581	–0.0547116	–0.0134465	0.0124968
ln_ShrRlNWtrWs	–0.0878412	–0.0948630	0.0070218	0.0423213
ln_AirEmis	–0.1669567	–0.1768964	0.0099398	0.0115267
Test of H0: Difference in coefficients not systematic				
Test Statistic (chi2): 5.95 Probability (Prob > chi2): 0.2033				

Note: *b* refers to coefficients consistent under both *H0* and *Ha*, obtained from xtreg. *B* refers to coefficients inconsistent under *Ha* but efficient under *H0*, also obtained from xtreg. The probability is more than 0.05; thus, the random effects model is more appropriate for the data.

http://dx.doi.org/10.21511/ppm.22(2).2024.07