



WORKING PAPER SERIES

235, 2025

Business processes and environmental sustainability

Forthcoming: International Journal of Social Economics

Elvis D. Achuo

University of Dschang, Cameroon

E-mail: elvisachuo21@yahoo.com

Simplice A. Asongu*

(Corresponding author)

School of Economics, University of Johannesburg,
Johannesburg, South Africa

E-mails : asongusimplice@yahoo.com / asongus@afridev.org



Abstract

Purpose – The question of environmental sustainability continues to attract rapidly growing attention as it has become a central debate topic among academics, policymakers and business practitioners across the globe. Besides, extant literature highlights that the choices made about industrial processes, products and services are likely to have substantial environmental repercussions. However, the pursuit of profits by business organisations often undermines the inherent environmental impacts. Consequently, this study aims to empirically investigate the effects of business processes on environmental sustainability.

Design/methodology/approach – The focus of this study is on 132 developing countries over the period 2005-2019. The empirical evidence is based on both robust OLS estimators and the Driscoll and Kraay robust standard errors.

Findings – We find that business processes, proxied by Gross value added in the agriculture, industry and services sectors contribute to environmental degradation through increased greenhouse gas emissions. These results are consistent across various income groups and geographical regions. Contingent on these findings, it is necessary for developing countries to provide incentives to business operations concerned with green processes while enforcing regulatory sanctions on environment-unfriendly practices.

Originality/value – Despite the growing research interest on green business processes, very little has been done beyond the confines of developed countries. Consequently, it becomes necessary to probe into the link between various business processes and environmental sustenance of developing countries. Besides, to the best of our knowledge, this study is the first attempt to comprehensively examine the relationship between business processes in the context of a panel of developing countries. The study therefore complements the extant literature by assessing the nexus between business processes and environmental sustainability in developing countries.

Keywords: Environmental sustainability, Business processes, Gross value added, Eco-innovation

1. Introduction

The question of environmental sustainability continues to attract rapidly growing attention as the green economy has become a central debate topic among academics, policymakers and business practitioners across the globe. Besides, extant literature highlights that the choices made regarding industrial processes, products and services are likely to have substantial environmental repercussions. However, business processes have become increasingly recognised as major propellers of sustainable development. Even though none of the seventeen (17) Sustainable Development Goals (SDGs) defining the 2030 global development agenda explicitly focuses on business processes or entrepreneurship, these SDGs however recognise the importance of inclusive education and decent employment which are key determinants of entrepreneurship. Although the pursuit of profits by business organisations often undermines the inherent environmental impacts, environmental quality is greatly threatened by the inherent negative externalities from business operations (Jiménez-Parra et al., 2018). Thus, motivated by the importance attached to entrepreneurship and environmental sustainability in the recent SDGs (United Nations, 2015), this study aims to empirically investigate the effects of business processes on environmental sustainability in developing countries.

Business processes are perceived as the manner of doing work within an organisation in view of creating value for the satisfaction of customer exigencies (Melão and Pidd, 2000). However, the concept of business processes has evolved significantly in recent years. While business processes were initially considered as a sequence of production activities, concerned with the conversion of raw materials into outputs, modern considerations insist on the inclusion of efficiency and cost reduction-oriented coordination processes to the initially predominant production processes (Lindsay et al., 2003). According to Mustapha et al. (2020), business processes refer to the set of interrelated and well-thought-out individual actions that allow the attainment of the organisational goals of ensuring the provision of high-quality products and service delivery to clients. Yet, to Munsamy et al. (2019), business processes involve the ordering of goods, hiring of personnel, remuneration of personnel and manufacturing of various goods. From these definitions, business processes can be viewed as a multifaceted concept coexisting with the natural environment. Thus, the increasing automation of business activities to enhance productivity and boost business profits has the inherent tendency of releasing greenhouse gases (GHGs), which dampens environmental sustainability.

However, environmental sustainability is considered as an equilibrium and flexible situation that enables the human society to sustainably satisfy its current and future needs without neither shrinking biological diversity nor exceeding the regeneration capacity of the supporting ecosystems (Morelli, 2011). The world's resolve in achieving such a desirably sustainable environment necessitated concerted efforts aimed at mitigating global GHG emissions. This is evidenced by the weight placed on climate change and pollution abatement actions by world leaders during the adoption of the SDGs (Achuo et al., 2022).

Moreover, the growing use of information and Communication Technologies (ICTs) within business organisations has the potential of exacerbating GHG emissions across the globe. This could be evident from the current growing research interest on the nexus between ICT and environmental pollution (Asongu et al., 2018; Asongu et al., 2019; Avom et al., 2020; Ahmed and Le, 2021). Although N'dri et al. (2021) opine that ICT use is environment-enhancing for low-income developing economies, Avom et al. (2020) contend that ICTs contribute to environmental degradation in Africa. This further threatens the sustainability of the natural ecosystem and human environment (Achuo et al., 2022; Nchofoung et al., 2022). ICT tools (notably internet penetration and telephone use) can therefore be considered as the main channels through which the environmental impacts of business processes are felt.

In recent years, a growing body of research has advocated for a shift towards green business processes (Recker et al., 2012). Thus, as part of their corporate social responsibility (CSR), companies are not only expected to provide information regarding their GHG emissions, but also to publicly account for contributing to environmental degradation. In this light, a few extant studies have shown that carbon disclosure by companies has the potential of enhancing technological innovation, profitability, business competitiveness and environmental quality (Tang and Demeritt, 2018; Ooi et al., 2019). Furthermore, CSR initiatives by business organisations not only contribute to socioeconomic development in developing countries, but also have the potential of enhancing environmental preservation. Jiménez-Parra et al. (2018) affirm that CSR mediated through environmental regulation improves environmental quality. The authors further contend that eco-innovations¹ have a moderating effect on the link between business organisations and environmental quality. Eco-innovation has the potential of mitigating biodiversity and climate change challenges if new business processes, technologies and services that make businesses greener are encouraged (European Commission, 2017; Gente and Pattanaro, 2019). Thus, before signing conventions with multinational companies, which are potential vectors of negative externalities, developing countries ought to enforce not only environmental regulations but to orientate CSR towards eco-innovation.

Despite the growing research interest on green business processes, very little has been done beyond the confines of developed countries. Consequently, it becomes necessary to probe into the link between various business processes and environmental sustenance of developing countries. The contribution of this study is thus threefold. First, to the best of our knowledge, this study is the first attempt to comprehensively examine the relationship between business processes in the context of a panel of developing countries. The study therefore contributes to extant literature in the light of developing countries by systematically investigating the direct channels through which business processes impact the environment. Second, in modelling the underlying environmental impacts of business processes, this study employs the Driscoll and Kraay (1998) approach, corrects for cross-sectional dependence inherent with large panel datasets. Finally, besides empirically establishing the environmental consequences of business processes for the global panel of 132 developing countries, we further investigated the sensitivity of our findings by classifying the countries into various income groups and geographical regions.

¹ According to the European Commission (2017), eco-innovation refers to “*all forms of innovation – technological and non-technological – that create business opportunities and benefit the environment by preventing or reducing their impact, or by optimising the use of resources. Eco-innovation is closely linked to the way we use our natural resources, to how we produce and consume and also to the concepts of eco-efficiency and eco-industries*”.

2. Theoretical and empirical literature

2.1 Theoretical underpinnings

Earlier environmental studies largely focussed on the relation between economic growth and carbon dioxide (CO₂), leading to the development of the celebrated Environmental Kuznets Curve (EKC) hypothesis propounded by Grossman and Krueger (1995). The EKC hypothesis stipulates that the economic growth of an economy is associated with environmental degradation, although growth becomes environment-enhancing beyond a certain threshold. A phenomenon termed by environmental economists as the inverted U-shaped EKC, which has received several criticisms. Recently, several extensions of the EKC hypothesis with the inclusion of other key determinants of environmental quality such as Foreign Direct Investment (FDI) and globalisation have led to the development of other variants of the initial works of Grossman and Krueger (1995). For instance, while Yoon and Heshmati (2021) find a positive relationship between FDI and environmental degradation, Bulus and Koc (2021) reveal that FDI is environment upgrading. These findings respectively corroborate the postulates of the pollution haven hypothesis and the pollution halo hypothesis² (Achuo and Ojong, 2024).

Moreover, analysing the EKC hypothesis from a demand and supply side perspective, Dinga et al. (2022) propose a dualistic approach to the EKC analysis. Although the proposed model essentially uses geometry, the authors equally employed other novel econometric estimation techniques and confirm the existence of the dualistic U-shaped and N-shaped EKC hypothesis for a global panel of 109 countries. The present study is therefore an extension of the theoretical underpinnings of the EKC from income levels to business processes.

2.2 Empirical literature

Besides the predominance of growth oriented environmental research examining the applicability of the EKC hypothesis, ecofeminist studies have equally emerged (Sturgeon, 2009; Ergas and York, 2012; Rao, 2012; Ghasemi et al., 2021). These studies have delved into various dimensions of women empowerment, encompassing economic, political and social empowerment. Generally, besides studies focussing on women political empowerment (Asongu et al., 2021) and women socioeconomic empowerment (Asongu and Odhiambo, 2021; Achuo et al., 2022) which provide conflicting results, advocates of ecofeminism are unanimous that women empowerment is environment-friendly (Rao, 2012).

The role of CSR on environmental sustainability has equally been explored. For example, looking at CSR from three dimensions (financial, social, and environmental) and eco-innovation from two dimensions (pollution prevention and sustainable environmental innovation), Pan et al. (2021) examine the nexus between CSR and eco-innovation in China and conclude that while a direct relationship exist between the environmental dimension of CSR and pollution mitigation, a U-shaped relation exist between the environmental dimension of CSR and sustainable environmental innovation. This implies that sustainable environmental innovation may only be achieved at higher levels of environmental commitment. These findings are consistent with the works of Zofio and Prieto (2001). It has been shown that relatively newer and expensive production technologies (ICTs) have the ability to increase industrial output with minimal environmental contamination.

² The pollution haven hypothesis is associated with a positive effect of FDI on environmental quality, while the pollution halo hypothesis holds that FDI reduces CO₂ emissions.

However, the impact of the use of ICT tools within the industrial sphere on environmental sustainability remains debatable. While some academics conclude that ICTs are environment-friendly (Asongu et al., 2019; Haseeb et al., 2019; Ahmed and Le, 2021; Ahmed et al., 2021), others contend that ICTs contribute to environmental degradation especially in developing countries (Park et al., 2018; Avom et al., 2020). However, based on interactive regressions, Asongu et al. (2018) found the existence of an inverted U-shaped curve between ICTs and environmental quality, implying that beyond a certain threshold of ICT adoption, ICTs are environment-enhancing. Although ICT tools (internet penetration and telephone use) are the principal channels through which business processes affect GHG emissions, the level of ICT development in developing countries currently falls below the established thresholds beyond which further developments in ICT can mitigate environmental degradation.

In addition, among the few studies particularly focusing on business processes within organisations in developing countries, a number of issues have been raised with regard to the ease of doing business. For instance, Asongu and Odhiambo (2019) reveal that high taxes, limited access to finance and numerous administrative bottlenecks that increase the cost of starting and doing business constitute the major challenges faced by business operators in Africa. These constraints to doing business constitute a setback to inclusive development (Asongu and Odhiambo, 2018). Moreover, Asongu et al. (2019) contend that business dynamics³ have a bearing on the firm's value which in turn affects the knowledge economy, characterised by suitable information infrastructure, effective innovation systems and economic inducements. The economic growth effects of these business challenges have the ability to improve or destroy the ecosystem, thereby affecting environmental sustainability.

Nevertheless, while several studies have explored various determinants of environmental pollution, extant literature on the nexus between business processes and environmental sustainability especially in developing countries remains sparse. This study therefore endeavours to model the underlying relationship between business processes and environmental pollution for a global panel of 132 developing countries.

³ According to Asongu et al. (2019), business dynamics represent any environment likely to influence the process of starting and running a business.

3. Econometric strategy

3.1 Model specification

As clarified in Section 2.1, the present study is an extension of the theoretical underpinnings of the EKC from income levels to business processes. In modelling the environmental impact of various development indicators, several studies have been inspired by the STIRPAT model developed by Dietz and Rosa (1994). This stochastic model that is employed to empirically test hypotheses can be specified as follows in Equation (1):

$$I_{it} = \alpha P_{it}^{\delta} A_{it}^{\lambda} T_{it}^{\beta} \omega_{it} \quad (1)$$

Where: I represents environmental impact; P is population size; A is per capita GDP; T is technology; α denotes the intercept; δ , λ and β respectively represent the estimable exponents of P , A and T ; ω is the stochastic error term; subscripts i and t respectively denote cross-section and time dimensions of the panel.

In order to render the model coefficients easily interpretable, a logarithmic transformation of Equation (1) is carried out. Consequently, following recent extensions of the original STIRPAT model (Yasmeen et al., 2021) and consistent with existing theoretical foundations and empirical research regarding various determinants of environmental sustainability, we attempt to capture the environmental effects of business processes with the help of the following econometric model in Equation (2).

$$\text{Environment}_{it} = \varphi_0 + \varphi_1 \text{Business}_{it} + \varphi_2 Z_{it} + \omega_{it} \quad (2)$$

Where Environment represents environmental sustainability; φ_0 is the intercept; φ_1 and φ_2 are slope coefficients; Business represents business processes, Z is a vector of control variables.

3.2 Data and descriptive statistics

This study makes use of panel data for a sample of 132 developing countries⁴ over a period of 15 years (2005-2019). These data are sourced from the World Development Indicators of the World Bank (WDI, 2021) and the World Governance Indicators (WGI, 2021). The time frame and number of countries constituting the sample was conditioned by data availability for our variables of interest. While an extensive description (definition) of the modelled variables and the matrix of correlations among variables are respectively outlined in Appendices 2 and 3, a synopsis of descriptive statistics of the variables is presented in Table 1.

3.2.1 Dependent variable

The outcome variable is environmental sustainability, captured with the help of total greenhouse gas (GHG) emissions (measured in kilotons of CO₂ equivalent). The adoption of total GHG emissions in this study as an appropriate proxy to measure environmental quality is consistent with recent literature (Achuo et al., 2022).

3.2.2 Independent variable

Our predictor variable of interest is business processes, captured by gross value added (GVA) in the agriculture, industry and services sectors (expressed in constant 2015 U.S. dollars). The employment of GVA in this study is motivated by the definition of business processes by Lindsay

⁴ The complete list of countries included in the sample are provided in Appendix 1.

et al. (2003). Accordingly, we consider the value added per worker for agriculture, industry and services. While value added generally represents the net output of a given sector after summing up all outputs and deducting intermediate inputs, value added per worker measures the productivity of labour, which is a key consideration in modern business processes.

3.2.3 Control variables

In addition to our independent variable of interest, several control variables are included in the model in order to adjust for omitted variable bias. For example, real GDP per capita is used. Although conflicting results have been found regarding the environmental consequences of GDP, it remains a key indicator (Dinga et al., 2022). Another variable employed is women empowerment. This study adopts a socioeconomic indicator for women empowerment which has been found to be environment-enhancing (Achuo et al., 2022). Governance quality is equally used as a key determinant of GHG emissions. Thus, consistent with Ngouhouo et al. (2021), we construct a governance index, by taking the average of the six classical governance indicators (control of corruption; government effectiveness, rule of law, political stability, regulatory quality, voice and accountability). Furthermore, ICTs (proxied by mobile phone penetration per 100 people) and foreign direct investment are employed. The inclusion of ICT use and other financial variables as key determinants of environmental sustainability is in conformity with extant literature (Munsamy et al., 2019) that stresses the importance of ICT and financial aspects of business corporations in modulating business processes.

Besides the use of GVA as the main proxy of business processes in the specified model, other alternative proxies have been adopted following extant literature. For instance, Asongu and Odhiambo (2018) and Asongu et al. (2019) look at business processes from the point of view of the ease of doing business. These authors consider a number of constraints to doing business which can be employed as alternative measures of businesses processes. In this perspective, this study employs the following variables as control variables for GVA: start-up procedures to register a business, cost of business start-up procedures, taxes less subsidies on products, time required to register property, as well as the time required to start a business. Intuitively, these variables can serve as catalysts or speed brakes to firm's productivity, thereby having a bearing on environmental sustainability. The definition and measurement of the modelled variables is provided in Appendix 2.

Table 1 shows that the modelled variables exhibit moderate variability, as evidenced by their mean and standard deviation values. Although the variability (standard deviation) of the outcome variable (GHG emissions) and the main explanatory variable (GVA) from their mean values is relatively low (respectively 2.032 and 1.89), that of other independent and control variables such as GDP per capita (7492.61), cost of business procedures (97.484), time to start a business (54.331) and ICT (43.599) are relatively volatile. This is however indicative of inherent non-normality of the dataset.

Table 1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Minimum	Maximum
GHG emissions	1835	10.137	2.032	2.996	16.33
Gross value added (GVA)	1732	23.676	1.89	16.969	28.519
GDP per capita	1949	5405.216	7492.61	278.319	65129.379
Foreign direct investment	1949	4.663	6.469	-37.155	103.337
Governance	1965	-.372	.609	-1.998	1.251
ICT	1925	82.365	43.599	.538	210.049
Women empowerment	1950	66.497	16.604	23.75	96.875

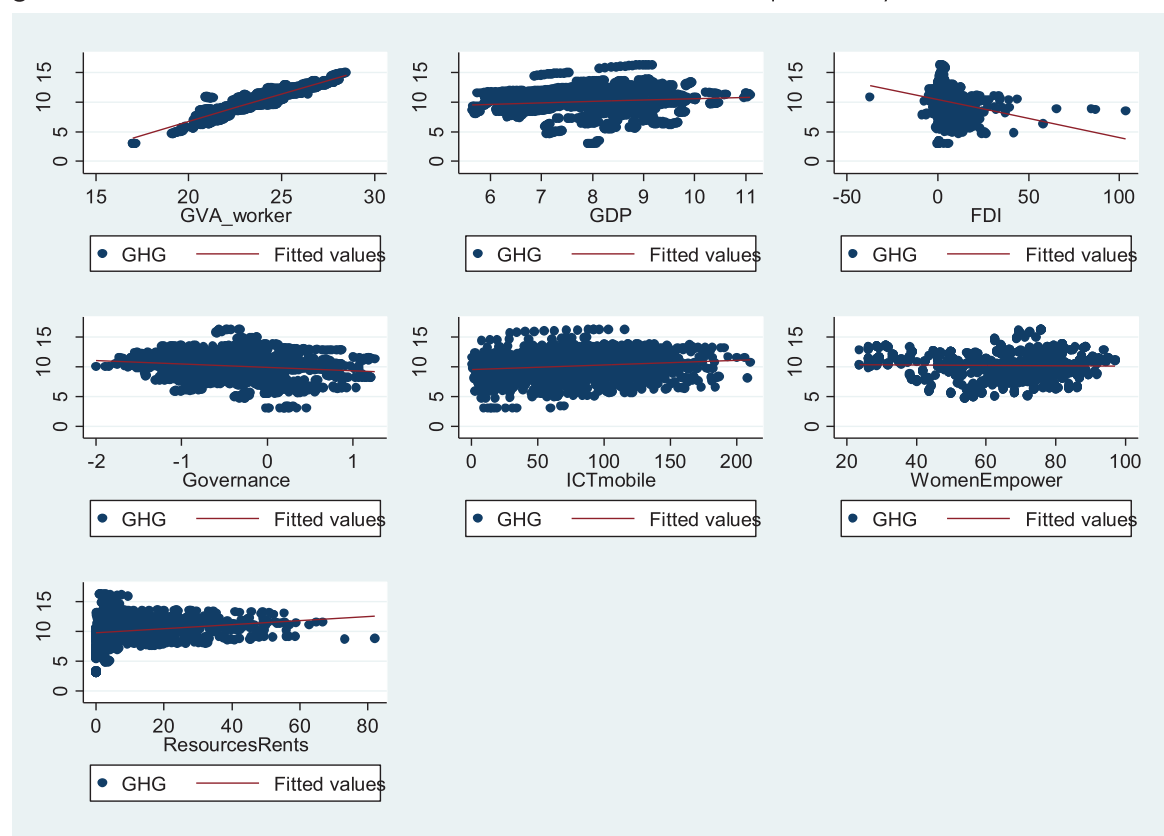
Resource rents	1946	8.772	11.674	0	81.95
Taxes less subsidies	1696	21.117	1.91	14.495	26.695
Cost of business procedures	1874	52.282	97.484	0	1314.6
Time to register property	1854	3.68	.945	0	6.537
Time to start a business	1874	35.802	54.331	1	697
Start-up procedures	1874	8.808	3.265	1	21

Notes: Std. Dev. = Standard deviation; Obs=observations; GHG=greenhouse gas;
GDP=Gross domestic product; ICT=Information and communication
technologies

Source: Authors own work

In addition to the summary statistics, Figure 1 provides a pictorial visualisation of the perceived correlations between environmental sustainability (GHG emissions) and various explanatory variables.

Figure 1. Correlation between GHG emissions and various explanatory variables



Source: Authors own work

Figure 1 reveals the existence of a positive relationship between GHG emissions and GVA per worker. This implies that as GVA rises, environmental quality deteriorates due to the increasing release of GHG emissions from the business processes. Likewise, a positive relationship is observed between GHG emissions and other explanatory variables like GDP per capita, mobile phone penetration, and total natural resource rents. Conversely, environmental quality is enhanced by governance quality, women empowerment, and foreign direct investment, as revealed by the negative relationship observed between these variables and GHG emissions.

3.3 Estimation methods

In analysing the environmental effects of business processes, this study initially employs the classical robust Ordinary Least Squares (OLS) estimator, which relies on the assumptions that the error term is independently and identically distributed (idd). However, based on the inherent weaknesses of the OLS estimator especially with large panels, we employ the more robust Driscoll and Kraay (1998) standard errors. The Driscoll-Kraay approach is adopted due to its ability to adjust for cross-sectional dependence inherent with panel data. Equally, this approach overcomes the weaknesses of the classical OLS estimator, especially following any violation of the classical OLS assumptions made on the error term. Furthermore, the normality and IDD (Independently and Identically Distributed) assumptions of the error term which are critical in ensuring the consistency of the OLS estimators cannot be guaranteed with very large cross-sections. Besides, the Driscoll-Kraay approach can be conveniently employed when dealing with either unbalanced or balanced panels.

Moreover, Hoechle (2007) asserts that the Driscoll-Kraay methodology yields consistent estimates irrespective of the number of cross-sections, which is not the case with alternative estimation techniques such as Random effects, Fixed effects and generalised method of moments (GMM). Thus, Driscoll-Kraay approach is appropriate even when the number of cross-sectional dimensions tends to infinity (i.e., as $N \rightarrow \infty$), as it is the case in this study with a relatively large sample size ($N=132$). On the basis of the foregoing merits and consonant to recent environmental studies (Yasmeen et al., 2021), this study adopts the Driscoll and Kraay (1998) robust standard errors.

4. Regression Results

4.1 Baseline Analysis

This section presents the regression results for OLS estimator and Driscoll and Kraay standard errors. The OLS results in Table 2 highlight six (6) different models, consisting of various alternative measures of business processes. Looking at our main variable of interest in the baseline model (1), we observe a significant positive effect of gross value added (GVA) on greenhouse gas (GHG) emissions. This implies that increased GVA is environment-unfriendly. This may be due to the fact that most developing countries are yet to adopt eco-innovative methods of production, which have proven to be environment-enhancing (Gente and Pattanaro, 2019). A look at other control variables in Model (1) shows that unlike governance and GDP per capita which contribute to environmental sustainability (revealed by their respectively significant negative coefficients), forest rents and women empowerment are environment unfriendly, probably because such empowerment is linked to activities that engender more emissions of GHG. While the positive relation between forest rents and GHG emissions suggests the existence of the environmental resource curse hypothesis (Achuo et al., 2024), the positive environmental effect of women empowerment is in disaccord with the recent findings of Achuo et al. (2022) who adopt a similar measure for women socioeconomic empowerment. Surprisingly, the environmental effects of mobile phone penetration (ICT) and foreign direct investment (FDI) are insignificant, although respectively positive and negative.

Table 2. OLS Estimations: Dependent variable: Greenhouse gas (GHG) emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Gross value added (GVA)	0.977*** (0.00854)					
GDP per capita	-0.350*** (0.0169)	-0.133*** (0.0274)	0.243*** (0.0552)	0.325*** (0.0548)	0.188*** (0.0571)	0.223*** (0.0534)
Foreign direct investment	-0.00459 (0.00294)	-0.0296*** (0.00368)	-0.0611*** (0.00952)	-0.0626*** (0.00967)	-0.0584*** (0.00999)	-0.0629*** (0.00978)
Governance	-0.111*** (0.0356)	-0.292*** (0.0449)	-0.966*** (0.0834)	-0.944*** (0.0825)	-0.840*** (0.0843)	-0.861*** (0.0818)
ICT	0.000540 (0.000380)	-0.00150** (0.000596)	0.00777*** (0.00124)	0.00745*** (0.00124)	0.0115*** (0.00129)	0.00834*** (0.00122)
Women empowerment	0.00255** (0.000988)	-0.0129*** (0.00186)	0.0105*** (0.00264)	0.0120*** (0.00265)	0.0109*** (0.00265)	0.0107*** (0.00255)
Resource rents	0.0136*** (0.00146)	0.0372*** (0.00292)	0.0282*** (0.00444)	0.0296*** (0.00440)	0.0236*** (0.00421)	0.0312*** (0.00389)
Taxes less subsidies		0.911*** (0.0143)				
Cost of Business procedures			-0.00210*** (0.000562)			
Time to start a business				-0.00414*** (0.000404)		
Start-up procedures					0.101*** (0.0125)	
Time to register property						-0.230*** (0.0401)
Constant	-10.56***	-7.331***	6.621***	5.940***	5.788***	7.493***

	(0.207)	(0.262)	(0.463)	(0.444)	(0.455)	(0.486)
Observations	1,582	1,556	1,705	1,705	1,705	1,696
Adjusted R-squared	0.910	0.826	0.194	0.201	0.213	0.206
Rank	8	8	8	8	8	8

Notes: GDP=Gross domestic product; ICT=Information and communication technologies;

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Authors own work

Besides the baseline results in Model (1), we controlled for other alternative measures of business processes in Model (2) through Model (6). Just like GVA, business taxes (taxes less subsidies) and start-up procedures to register business (Models 2 and 5) exacerbate GHG emissions. This may be justified by the fact that higher taxes and cumbersome business procedures may discourage business enthusiasts from adopting environment-friendly production approaches. However, cost of business start-up procedures, time required to start a business and register property (respectively Models 3, 4 and 6) improve environmental sustainability. Intuitively, increasing cost of business start-up procedures and the corresponding time required to register and start-up the business constitute disincentives to potential business organisations, thus limiting the number of effectively created business units, thereby limiting environmental pollution. Throughout Models (2) to (6), the environmental effects of the established explanatory variables in Model (1) remain consistent, except for ICT and FDI whose effects become significant. Thus, the results for GDP and FDI validates the environmental Kuznets Curve and pollution halo hypothesis in the context of developing countries.

Likewise, the regression results of the more robust Driscoll-Kraay standard errors (Table 3) remain largely consistent with the OLS results, but for governance quality and women empowerment whose effects become insignificant in the baseline Model (1).

Table 3. Regressions with Driscoll-Kraay Standard Errors: Dependent variable: GHG emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Gross value added (GVA)	0.976*** (0.0317)					
GDP per capita	-0.370*** (0.0591)	-0.171** (0.0791)	0.151 (0.161)	0.239 (0.149)	0.143 (0.159)	0.127 (0.168)
Foreign direct investment	-0.00581 (0.00670)	-0.0306*** (0.00817)	-0.0633** (0.0218)	-0.0650** (0.0223)	-0.0588** (0.0221)	-0.0652** (0.0223)
Governance	-0.124 (0.137)	-0.307* (0.147)	-1.017*** (0.278)	-0.993*** (0.278)	-0.863*** (0.288)	-0.906*** (0.268)
ICT	0.00172 (0.00149)	0.000486 (0.00226)	0.0125** (0.00508)	0.0123** (0.00510)	0.0140** (0.00503)	0.0135** (0.00516)
Women empowerment	0.00271 (0.00303)	-0.0127* (0.00626)	0.0107 (0.00819)	0.0124 (0.00827)	0.0109 (0.00847)	0.0110 (0.00854)
Resource rents	0.0137*** (0.00423)	0.0376*** (0.00824)	0.0283** (0.0102)	0.0297** (0.0102)	0.0240** (0.00998)	0.0314*** (0.00960)
Taxes less subsidies		0.911*** (0.0469)				
Cost of Business procedures			-0.00235 (0.00136)			
Time to start a business				-0.00444*** (0.000893)		
Start-up procedures					0.0960** (0.0352)	

Time to register property						-0.243 (0.138)
Constant	-10.49*** (0.854)	-7.204*** (0.934)	6.953*** (1.566)	6.195*** (1.414)	5.971*** (1.498)	7.861*** (1.657)
Observations	1,582	1,556	1,705	1,705	1,705	1,696
Number of groups	15	15	15	15	15	15
R-squared	0.911	0.829	0.200	0.207	0.213	0.214

Notes: GDP=Gross domestic product; ICT=Information and communication technologies;

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Authors own work

4.2 Sensitivity Analysis

In order to check for the robustness of our baseline findings, we split the global sample into various income groups and geographical regions. While Table 4 presents the results on the basis of four (4) income groups (Low-income, Lower-middle-income, Upper-middle-income, and High-income), Table 5 groups the countries into six (6) geographical regions.

Table 4. Sensitivity of environmental sustainability indicators across income groups

	(1)	(2)	(3)	(4)
	Low-income	Lower-middle-income	Upper-middle-income	High-income
Regressions with Driscoll-Kraay Standard Errors				
Variables	Dependent variable: Greenhouse gas (GHG) emissions			
Gross value added (GVA)	0.844*** (0.112)	1.011*** (0.0353)	1.001*** (0.0394)	0.979*** (0.0413)
GDP per capita	0.137 (0.545)	-0.558*** (0.113)	-0.556** (0.200)	0.278 (0.164)
Foreign direct investment	0.00196 (0.00813)	-0.00799 (0.00785)	0.00286 (0.00923)	-0.0172*** (0.00401)
governance	-1.043** (0.468)	-0.0242 (0.167)	-0.150 (0.173)	-0.402*** (0.110)
ICT	-0.00670 (0.00611)	0.00292 (0.00223)	0.00175 (0.00238)	-0.00401 (0.00232)
Women empowerment	0.0223 (0.0136)	0.00211 (0.00396)	0.00774** (0.00268)	-0.00220 (0.00405)
Resource rents	-0.0239 (0.0183)	0.0223** (0.00849)	0.0124** (0.00548)	-0.0103*** (0.00303)
Constant	-11.82*** (2.468)	-10.04*** (1.347)	-9.902*** (1.450)	-15.06*** (1.890)
Observations	279	592	554	157
Number of groups	14	15	14	14
R-squared	0.738	0.927	0.954	0.976

Notes: GDP=Gross domestic product; ICT=Information and communication technologies;

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Authors own work

Table 5. Sensitivity of environmental sustainability indicators across geographical regions

	(1)	(2)	(3)	(4)	(5)	(6)
	EAP	ECA	LAC	MENA	South Asia	SSA
Regressions with Driscoll-Kraay Standard Errors						
Variables	Dependent variable: Greenhouse gas (GHG) emissions					
Gross value added (GVA)	0.967*** (0.0682)	1.022*** (0.0687)	0.940*** (0.0290)	1.040*** (0.0604)	0.949*** (0.0302)	0.960*** (0.0833)
GDP per capita	-0.460*** (0.116)	-0.409** (0.182)	-0.0978 (0.170)	-0.0836 (0.102)	-0.627*** (0.127)	-0.245** (0.0979)
Foreign direct investment	0.0188* (0.00877)	-0.0140* (0.00788)	-0.00473 (0.0106)	-0.0283*** (0.00743)	0.0178 (0.0131)	-0.0135* (0.00764)
governance	0.294 (0.383)	-0.239* (0.119)	-0.199 (0.141)	-0.200 (0.171)	-0.331** (0.143)	-0.321 (0.352)
ICT	0.00563 (0.00390)	0.00600* (0.00309)	0.000563 (0.00213)	0.00476** (0.00212)	0.000324 (0.00185)	-0.00383 (0.00378)
Women empowerment	-0.00174 (0.0160)	-0.00548 (0.00717)	0.00504 (0.00752)	-0.00631* (0.00345)	0.000828 (0.00495)	0.00451 (0.00784)
Resource rents	0.0231*** (0.00669)	0.0165 (0.0114)	0.0202 (0.0119)	-0.00846** (0.00324)	0.157*** (0.0306)	-0.00160 (0.00995)
Constant	-9.647*** (1.682)	-10.74*** (1.124)	-12.26*** (1.307)	-14.12*** (1.363)	-8.276*** (0.682)	-10.70*** (1.723)
Observations	128	261	345	175	107	566
Number of groups	14	14	14	14	14	15
R-squared	0.956	0.949	0.960	0.964	0.990	0.854

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; EAP=East Asia and Pacific; ECA=Europe and Central Asia; LAC=Latin America and the Caribbean; MENA=Middle East and North Africa; SSA=Sub-Saharan Africa; GDP=Gross domestic product; ICT=Information and communication technologies

Source: Authors own work

Overall, the results in Tables 4 and 5 reveal the existence of a significantly positive effect of gross value added (GVA) on greenhouse gas emissions across all income groups and geographical regions. However, it appears that the environmental impacts are more severe in lower-middle income, upper-middle income, Europe and Central Asia, and Middle East and North African countries with a GVA coefficient above one. The relatively lower coefficient of GVA in high-income countries may be suggestive of the fact that high-income countries invest in green business processes with less GHG emission capacities.

Looking at control variables like per capita GDP and governance, we notice that while increased GDP per capita significantly improves environmental quality in lower-middle income, upper-middle income, East Asia and Pacific, Europe and Central Asia, South Asia and sub-Saharan African countries; governance enhances environmental quality in Europe and Central Asia, South Asia, low- and high-income countries. Conversely, mobile phone penetration (ICT), women empowerment and resource rents are environment degrading in upper-middle income, Europe and Central Asia and Middle East and North African countries. Although these results corroborate the findings of Avom et al. (2020), they contradict the findings of Asongu et al. (2018) and Achuo et al. (2022) that respectively posit that the use of ICT tools and women empowerment bring about abatements in environmental degradation in Africa. Overall, the environmental effects of various control variables are negative and insignificant in the context of sub-Saharan Africa (SSA) countries.

5. Conclusion and policy implications

The question of environmental sustainability has become a central debate topic among academics, policymakers and business practitioners across the world. Moreover, existing research reveals that the choices made regarding business processes greatly affect environmental quality. However, the pursuit of profits by business organisations often undermines the inherent environmental impacts. The aim of this study was therefore to empirically examine the effects of business processes on environmental sustainability in developing countries.

The study employs both the robust OLS estimators and Driscoll and Kraay robust standard errors. The key finding reveals that business processes, proxied by Gross value added (GVA) in the agriculture, industry and services sectors contribute to environmental degradation. These results are consistent across various income groups and geographical regions. Contingent on these findings, it is necessary for developing countries to provide incentives to business operations concerned with green processes while enforcing regulatory sanctions on environment-unfriendly practices. Policymakers should thus encourage the adoption of eco-innovation within business organisations. Equally, policymakers should encourage good governance practices and women's socioeconomic empowerment, as they have the capacity to mitigate the devastating environmental impacts of business processes.

Cognizant of the fact that findings of the study are limited to the direct effects of business processes on environmental sustainability for a global panel of developing countries, it thus leaves room for future studies to exploit potential indirect channels through which business processes can affect environmental sustainability. Accordingly, future research can leverage on interactive regressions to assess policy variables that can be employed to mitigate the unfavourable effect of business processes on environmental sustainability. Green innovation proxies including green patents, green Research and Development (R&D) expenditure, eco-friendly product launches, green investment and ESG (environmental, social, governance) ratings, and ISO 14001 certification, are some policy variables that can be considered within the remit of interactive regressions. Equally, country-specific studies are worthwhile for the design of country-specific policies with regard to the link between business processes and environmental sustainability. In engaging the future research directions, alternative ecological biocapacity and/or ecological footprint measures should be considered. Moreover, updated and/or alternative data on business processes should be employed in future research and the underlying relationships evaluated with other contemporary econometric estimation techniques.

References

- Achuo, E.D., Asongu, A.S. & Tchamyau, S.V. (2022). Women empowerment and environmental sustainability in Africa. *Association for Promoting Women in Research and Development in Africa, ASPROWDA WP 22/003*.
- Achuo, E. D., Miamo, C. W., & Kouhomou, C. Z. (2024). Resource rents and environmental pollution in developing countries: Does the quality of institutions matter? *Review of Development Economics*, 28(1), 360-387.
- Achuo, E., & Ojong, N. (2024). Foreign direct investment, economic growth and environmental quality in Africa: Revisiting the pollution haven and environmental Kuznets curve hypotheses. *Journal of Economic Studies*, 51. <https://doi.org/10.1108/JES-02-2024-0065>.
- Ahmed, Z., & Le, H. P. (2021). Linking Information Communication Technology, trade globalization index, and CO2 emissions: evidence from advanced panel techniques. *Environmental Science and Pollution Research*, 28(7), 8770-8781.
- Asongu, S. A., & Odhiambo, N. M. (2019). Challenges of doing business in Africa: A systematic review. *Journal of African Business*, 20(2), 259-268.
- Asongu, S. A., & Odhiambo, N. M. (2021). The green economy and inequality in Sub-Saharan Africa: Avoidable thresholds and thresholds for complementary policies. *Energy Exploration & Exploitation*, 39(3), 838-852.
- Asongu, S. A., Amavilah, V. H., & Andres, A. R. (2020). Business dynamics, knowledge economy, and the economic performance of African countries. *Information Development*, 36(1), 128-152.
- Asongu, S. A., Le Roux, S., & Biekpe, N. (2018). Enhancing ICT for environmental sustainability in sub-Saharan Africa. *Technological Forecasting and Social Change*, 127, 209-216.
- Asongu, S. A., Nwachukwu, J. C., & Pyke, C. (2019). The comparative economics of ICT, environmental degradation and inclusive human development in Sub-Saharan Africa. *Social Indicators Research*, 143(3), 1271-1297.
- Asongu, S., & Odhiambo, N. (2019). Doing business and inclusive human development in Sub-Saharan Africa. *African Journal of Economic and Management Studies*, 10(1), 2-16.
- Asongu, S., Messo, O. O., & Guttemberg, K. T. (2021). *Women political empowerment and vulnerability to climate change: evidence from developing countries* (No. WP/21/010). AGDI Working Paper.
- Avom, D., Nkengfack, H., Fotio, H. K., & Totouom, A. (2020). ICT and environmental quality in Sub-Saharan Africa: Effects and transmission channels. *Technological Forecasting and Social Change*, 155, 120028. <https://doi.org/10.1016/j.techfore.2020.120028>.
- Bulus, G. C., & Koc, S. (2021). The effects of FDI and government expenditures on environmental pollution in Korea: the pollution haven hypothesis revisited. *Environmental Science and Pollution Research*, 28: 38238–38253.
- Dietz, T. & Rosa, E. A. (1994). Rethinking the environmental impacts of population, affluence and technology. *Human Ecology Review*, 1, 277–300.
- Dinga, G. D., Fonchamnyo, D. C., & Achuo, E.D. (2022). Primal–dual approach to environmental Kuznets curve hypothesis: A demand and supply side analyses of environmental degradation. *Environmental Science and Pollution Research*, 29(11), 16484-16502.
- 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.
- Ergas, C., & York, R. (2012). Women's status and carbon dioxide emissions: A quantitative cross-national analysis. *Social Science Research*, 41(4), 965-976.
- European Commission (2017). Eco-innovation: the key to Europe's future competitiveness. <https://ec.europa.eu/environment/pubs/pdf/factsheets/ecoinnovation/en.pdf>. Accessed February 17, 2022.
- Gente, V., & Pattanaro, G. (2019). The place of eco-innovation in the current sustainability debate. *Waste Management*, 88, 96-101.
- Ghasemi, M., Badsar, M., Falahati, L., & Karamidehkordi, E. (2021). The mediation effect of rural women empowerment between social factors and environment conservation

- (combination of empowerment and ecofeminist theories). *Environment, Development and Sustainability*, 23(9), 13755-13777.
- Grossman, G. M., & Krueger, A. B. (1995). Economic Growth and the Environment. *The Quarterly Journal of Economics*, 110(2), 353-377.
- Haseeb, A., Xia, E., Saud, S., Ahmad, A., & Khurshid, H. (2019). Does information and communication technologies improve environmental quality in the era of globalization? An empirical analysis. *Environmental Science and Pollution Research*, 26(9), 8594-8608.
- Hoechle, D. (2007). Robust standard errors for panel regressions with cross-sectional dependence. *The Stata Journal*, 7(3), 281-312.
- Jiménez-Parra, B., Alonso-Martínez, D., & Godos-Díez, J. L. (2018). The influence of corporate social responsibility on air pollution: Analysis of environmental regulation and eco-innovation effects. *Corporate Social Responsibility and Environmental Management*, 25(6), 1363-1375.
- Lindsay, A., Downs, D., & Lunn, K. (2003). Business processes—attempts to find a definition. *Information and software technology*, 45(15), 1015-1019.
- Melão, N., & Pidd, M. (2000). A conceptual framework for understanding business processes and business process modelling. *Information Systems Journal*, 10(2), 105-129.
- Morelli, J. (2011). Environmental sustainability: A definition for environmental professionals. *Journal of Environmental Sustainability*, 1(1), 1-10.
- Munsamy, M., Telukdarie, A., & Fresner, J. (2019). Business process centric energy modelling. *Business Process Management Journal*, 25(7), 1867-1890.
- Mustapha, A. M., Arogundade, O. T., Misra, S., Damasevicius, R., & Maskeliunas, R. (2020). A systematic literature review on compliance requirements management of business processes. *International Journal of System Assurance Engineering and Management*, 11(3), 561-576.
- N'dri, L. M., Islam, M., & Kakinaka, M. (2021). ICT and environmental sustainability: any differences in developing countries? *Journal of Cleaner Production*, 297, 126642. <https://doi.org/10.1016/j.jclepro.2021.126642>.
- Nchofoung, T.N., Asongu, A.S., Njamen, A.A.K., & Achuo, E.D. (2022). Linear and non-linear effects of infrastructures on inclusive human development in Africa. *African Development Review*, 34(1): 1-16.
- Ngouhouo, I., Nchofoung, T., & Njamen Kengdo, A. A. (2021). Determinants of trade openness in sub-Saharan Africa: do institutions matter? *International Economic Journal*, 35(1), 96-119.
- Ooi, S. K., Amran, A., Yeap, J. A., & Jaaffar, A. H. (2019). Governing climate change: the impact of board attributes on climate change disclosure. *International Journal of Environment and Sustainable Development*, 18(3), 270-288.
- Pan, X., Sinha, P., & Chen, X. (2021). Corporate social responsibility and eco-innovation: The triple bottom line perspective. *Corporate Social Responsibility and Environmental Management*, 28(1), 214-228.
- Park, Y., Meng, F., & Baloch, M. A. (2018). The effect of ICT, financial development, growth, and trade openness on CO2 emissions: an empirical analysis. *Environmental Science and Pollution Research*, 25(30), 30708-30719.
- Rao, M. (2012). Ecofeminism at the crossroads in India: A review. *Dep*, 20(12), 124-142.
- Recker, J., Rosemann, M., Hjalmarsson, A., & Lind, M. (2012). Modeling and analyzing the carbon footprint of business processes. In *Green Business Process Management* (pp. 93-109). Springer, Berlin, Heidelberg.
- Sturgeon, N. L. (2009). *Environmentalism in popular culture: Gender, race, sexuality, and the politics of the natural*. University of Arizona Press.
- Tang, S., & Demeritt, D. (2018). Climate change and mandatory carbon reporting: Impacts on business process and performance. *Business Strategy and the Environment*, 27(4), 437-455.
- United Nations (2015). Transforming our world: the 2030 agenda for sustainable development. Available at: <https://sustainabledevelopment.un.org/post2015/transformingourworld/publication>.

- Yasmeen, R., Padda, I. U. H., Yao, X., Shah, W. U. H., & Hafeez, M. (2021). Agriculture, forestry, and environmental sustainability: the role of institutions. *Environment, Development and Sustainability*, 1-25. <https://doi.org/10.1007/s10668-021-01806-1>.
- Yoon, H., & Heshmati, A. (2021). Do environmental regulations affect FDI decisions? The pollution haven hypothesis revisited. *Science and Public Policy*, 48(1), 122-131.
- Zofio, J. L., & Prieto, A. M. (2001). Environmental efficiency and regulatory standards: the case of CO₂ emissions from OECD industries. *Resource and Energy Economics*, 23(1), 63-83.

Appendices

Appendix 1. List of countries included in the sample

Afghanistan	Cabo Verde	Gabon	Madagascar	Pakistan	Tajikistan
Albania	Cambodia	Gambia, The	Malawi	Palau	Tanzania
Algeria	Cameroon	Georgia	Malaysia	Panama	Thailand
Argentina	Central African Republic	Ghana	Maldives	Papua New Guinea	Timor-Leste
Armenia	Chad	Guatemala	Mali	Paraguay	Togo
Azerbaijan	Chile	Guinea	Mauritania	Peru	Tonga
Bahrain	China	Guinea-Bissau	Mauritius	Philippines	Trinidad and Tobago
Bangladesh	Colombia	Guyana	Mexico	Poland	Tunisia
Barbados	Comoros	Haiti	Moldova	Qatar	Turkey
Belarus	Congo, Dem. Rep.	Honduras	Mongolia	Romania	Tuvalu
Belize	Congo, Rep.	India	Montenegro	Rwanda	Uganda
Benin	Costa Rica	Indonesia	Morocco	Samoa	Ukraine
Bhutan	Cote d'Ivoire	Iran, Islamic Rep.	Mozambique	Sao Tome and Principe	Uruguay
Bolivia	Djibouti	Iraq	Nicaragua	Saudi Arabia	Uzbekistan
Bosnia and Herzegovina	Dominican Republic	Jamaica	Niger	Senegal	Vanuatu
Botswana	Egypt, Arab Rep.	Jordan	Nigeria	Serbia	Vietnam
Brazil	El Salvador	Kazakhstan	North Macedonia	Seychelles	Yemen, Rep.
Brunei	Equatorial Guinea	Kenya	Oman	Sierra Leone	Zambia
Darussalam	Eswatini	Kuwait		South Africa	Zimbabwe
Bulgaria	Ethiopia	Kyrgyz Republic		South Sudan	
Burkina Faso	Fiji	Lao PDR		Sri Lanka	
Burundi		Lebanon		St. Kitts and Nevis	
		Lesotho		St. Lucia	
		Liberia		St. Vincent and the Grenadines	
				Sudan	
				Suriname	

Source: Authors own work

Appendix 2. Description of variables and data sources

Variables	Variable Code	Definition of variable	Source
Greenhouse gas emissions (log)	GHG	Total greenhouse gas emissions (kt of CO2 equivalent)	World Bank (WDI)
Gross value added (log)	GVA_worker	Gross value added at basic prices (GVA) (constant 2015 US\$)	World Bank (WDI)
Start-up procedures	startprocreg	Start-up procedures to register a business (number)	World Bank (WDI)
Cost of Business procedures	costbusproc	Cost of business start-up procedures (% of GNI per capita)	World Bank (WDI)
Taxes less subsidies (log)	taxsubs	Taxes less subsidies on products (current US\$)	World Bank (WDI)
Time to register property	timereg	Time required to register property (days)	World Bank (WDI)
Time to start a business	timestart	Time required to start a business (days)	World Bank (WDI)
Governance		Governance index (estimate)	Authors, from World Bank (WGI)
ICT	ictmobile	Mobile cellular subscriptions (per 100 people)	World Bank (WDI)

Women empowerment	womenempower	Women Business and the Law Index Score (scale 1-100)	World Bank (WDI)
Foreign direct investment	FDI	Foreign direct investment, net inflows (% of GDP)	World Bank (WDI)
Resource rents	resourcesrents	Total natural resource rents (% GDP)	World Bank (WDI)
GDP per capita (log)	gdpk	GDP per capita (constant 2015 US\$)	World Bank (WDI)

Notes: WDI=World development Indicators; WGI=World governance Indicators; log=natural logarithm; ICT=Information and communication technologies

Source: Authors own work

Appendix 3. Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) GHG emissions	1.000												
(2) Gross value added (GVA)	0.916	1.000											
(3) GDP per capita	0.114	0.277	1.000										
(4) Foreign direct investment	-0.255	-0.226	0.012	1.000									
(5) Governance	-0.166	0.029	0.434	0.099	1.000								
(6) ICT	0.135	0.303	0.493	0.054	0.429	1.000							
(7) Women empowerment	-0.025	0.031	-0.044	0.068	0.375	0.262	1.000						
(8) Resource rents	0.194	0.091	0.062	0.046	-0.362	-0.195	-0.378	1.000					
(9) Taxes less subsidies	0.826	0.912	0.162	-0.163	0.147	0.382	0.238	-0.094	1.000				
(10) Cost of Business procedures	-0.094	-0.205	-0.249	-0.047	-0.371	-0.448	-0.214	0.195	-0.291	1.00			
(11) Time to register property	-0.163	-0.225	-0.233	-0.075	-0.139	-0.319	-0.081	-0.011	-0.239	0.26	1.00		
(12) Time to start a business	-0.114	-0.108	-0.015	-0.065	-0.056	-0.155	-0.071	0.173	-0.166	0.28	0.22	1.00	
(13) Start-up procedures	0.165	0.137	0.000	0.010	-0.176	-0.256	-0.175	0.265	0.025	0.31	0.20	0.40	1.00

Notes: GHG=greenhouse gas; GDP=Gross domestic product; ICT=Information and communication technologies

Source: Authors own work