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# Influence of Green Enterprises on Circular Economy Practices in Developing Countries: A Framework for AI-driven Environmental Policies

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**Abstract**

This study aims to examine the role of green enterprises and their corporate activities in circular economy practices, particularly in the context of developing economies. The modern world is facing enormous environmental concerns, *e.g.*, climate change and pollution, and corporate activities that degrade the environment are primarily responsible for these concerns. Therefore, green entrepreneurship has the potential to reverse the trend and create an eco-friendly environment through circular economy activities. To further strengthen this perspective, the present study proposes a framework for AI-driven environmental policies that can support and enhance these eco-friendly efforts. To achieve the aforementioned objectives, this study uses firm-level data collected from the most recent (2023) World Bank Enterprise Surveys. Moreover, based on the nature of the dataset, diverse econometric models are constructed and multiple proxies for both green enterprises and circular economy practices are used. The empirical results suggest that all the indicators of green enterprises show positive coefficient values together with statistically significant *p*-values. These findings are aligned with prior studies and confirm that green enterprises play a vital role in enhancing circular economy practices, which are integral components of the proposed framework for AI-driven environmental policies. The policy implications of this study highlight the importance of green enterprises and the role of circular economy practices within a framework for AI-driven environmental policies for making effective environmental policies and achieving sustainable development goals for a better future.

**Keywords:** Green enterprises, circular economy practices, AI-driven environmental policies, sustainable development goals, developing countries

**JEL Classification:** Q56, Q53, Q58, O44, O13

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# 1. Introduction

In the current global landscape, there is growing recognition of the urgent need to address climate change, resource scarcity and sustainability (Abrahms *et al.*, 2023). These challenges are harmful not only to human health but also to the environment. The major causes of such challenges are corporate activities, which consistently create fear and threats to society. Consequently, the concepts of green entrepreneurship and circular economy practices have gained prominence as catalysts for significant and positive transformation. Collectively, these entities embody a significant transformation in the perception and implementation of commercial activities, which challenges established frameworks that prioritize financial gain while disregarding the well-being of the environment (Mondal *et al.*, 2023b). The discipline of green entrepreneurship is a growing area of interest that emphasizes the integration of economic development and ecological care. The domain comprises a wide range of enterprises, including startups in the renewable energy sector and brands in the sustainable fashion industry. These entities share a collective objective to foster innovation and conduct business operations that prioritize both financial gain and environmental sustainability (R. Chen *et al.*, 2023; Ulanov, 2024).

Green entrepreneurs effectively promote innovation at the convergence of commerce and sustainability by strategically aligning their ventures with the concepts of circular economy practices (Hällerstrand *et al.*, 2023). Their efforts contribute significantly to a broader framework for AI-driven environmental policies, which aims to support sustainable practices at both the micro and macro levels. The company's actions extend beyond simply reacting to market trends; instead, they actively exert influence over these trends by using environment-friendly technologies, adopting circular design concepts and incorporating sustainable practices into their supply chain (Dsouza *et al.*, 2025; Hojnik *et al.*, 2023). Through these practices, green entrepreneurs play a vital role in directing industries towards a more sustainable path within the proposed framework for AI-driven environmental policies, either by advancing energy-efficient technology or by designing goods with longer lifecycles (Rose and Bharadwaj, 2023; Ulanov, 2024).

There are various advanced tools that can be combined in defining a framework for AI-driven environmental policy. These tools can help improve predictive analytics, expand decision-making and develop automated enforcement (Bibri *et al.*, 2024). Predictive tools driven by AI enable policymakers to forecast climate trends and potential hazards by using big environmental data and make pre-emptive plans (Singh *et al.*, 2024). Moreover, AI-based decision support systems can simulate policy implications under various situations and subsequently optimize strategies for sustainable compliance (Balasubramanian, 2024).

Furthermore, automation in enforcement and real-time data processing using AI algorithms assures rapid identification of environmental threats and subsequent policy modifications (Van Hoang, 2024). Such benefits of using AI-enabled tools strengthen the environmental framework and its efficient implementations.

Environment-friendly businesses promote circular economy practices, which are important for sustainably managing waste (Maroušek, 2023), land (Arisanty *et al.*, 2020;) and air pollution (Y. Guo *et al.*, 2022; Manová *et al.*, 2018). To reduce the environmental effects, these businesses primarily focus on resource efficiency, waste minimization and recycling. These entities also use circular economy models to improve and redevelop products and materials after their use. Moreover, these companies also incorporate AI tools to improve circular economy practices (Dvorský *et al.*, 2023; Kliestik *et al.*, 2023).

The nexus between green entrepreneurship and circular economy practices is not just a business approach. It is, in fact, an alternative way to govern a company in an eco-friendly way. Nowadays, sustainability has become an essential aspect of business operations, irrespective of the size and nature of the business (Sohns *et al.*, 2023). In a world where customers are becoming more environmentally conscious and regulatory environments are shifting to favour sustainable practices, this transition is not just motivated by philanthropy but is increasingly recognized as necessary for long-term success (Cal *et al.*, 2024; ). Based on the aforementioned arguments, it is important to investigate the answers to critical research questions about the importance of green enterprises and how they affect circular economy practices. Therefore, the objective of this study is to empirically investigate the influence of green enterprises on circular economy practices in developing countries.

Moreover, prior to the COVID-19 pandemic, economic priorities often overshadowed environmental sustainability. However, the disruption caused by the COVID-19 pandemic can serve as an alarm call, highlighting the fragility of our connected world and the need to create a balance between human or corporate activities and the environment. Therefore, in the post-COVID-19 era, the world is witnessing an increasing trend towards environmentally sustainable models, circular economy practices and renewable energy consumption, and has thus shown corporate commitments towards environmental, social and governance indicators. These initiatives have a profound impact on achieving economic progress and environmental sustainability.

The rationale behind this study suggests that green entrepreneurship and circular economy practices emerge as essential methods within the broader context of the Sustainable Development Goals (SDGs), particularly in the context of developing countries. Aligned with the United Nations' 2030 Agenda for Sustainable Development for developing

countries, these principles play a crucial role in accomplishing numerous SDGs (Khizar *et al.*, 2023). SDG 8 outlines how green entrepreneurship significantly aids economic growth. By supporting innovation and job creation, green entrepreneurship effectively addresses environmental problems. Circular economy practices are a comprehensive approach that focuses on promoting sustainable consumption and production, as outlined in SDG 12 (Ncube *et al.*, 2023). This approach provides a systematic solution for effectively mitigating waste generation and minimizing the adverse environmental consequences associated with resource extraction in developing economies (Hegab *et al.*, 2023).

Therefore, this study contributes to the field of environmental economics by investigating the importance of green enterprises and the role of circular economy practices within a framework for AI-driven environmental policies to create effective environmental policies and achieve sustainable development goals for a better future. The integration of green entrepreneurship and circular economy practices is a comprehensive strategy that aligns with several Sustainable Development Goals (SDGs). This approach offers a structured framework for both businesses and societies, and within the framework for AI-driven environmental policies, it enables economic advancement while simultaneously promoting environmental sustainability and enhancing social welfare.

The novelty of this study lies in its approaches to measuring variables, empirical modelling, unique methodology and extensive discussion of the topic. It clarifies the fundamentals of creating green enterprises for a brighter future and implementing circular economy strategies in developing countries. In fact, developing economies are the ones suffering from environmental changes the most, so it is important to consider developing countries, particularly in the context of green enterprises and circular economy practices. This present study tries to fill the existing gap by using statistical data, empirical modelling and focusing on developing economies.

The remainder of this study is organized as follows: Section 2 introduces the philosophy of the study including recent literature and hypothesis development. Section 3 documents the methodology. Section 4 presents the empirical analysis. Section 5 discusses the results. Section 6 lays out the conclusion, policy implications, limitations and future research directions.

## 2. Study Philosophy

Green entrepreneurship has gained significant attention, particularly as the world faces tremendous environmental and health challenges. Some of the recent studies have analysed green entrepreneurship, *e.g.*, Castillo-Benancio *et al.* (2023) examined the increased benefits

of global green businesses. Their findings concerned how companies are currently using technology and innovation to implement various green initiatives. Contrary to the widely held belief, there is a disconnect between public and governmental knowledge of these venture capitals and green entrepreneurship. Similarly, Prasetyo *et al.* (2023) argued that gender equality and social inclusion in green entrepreneurship have consequences, showing how community institutions play a role in fostering the growth of green entrepreneurship, which is one of the mutually beneficial ways to lessen the effects of climate change and promote accomplishment of the SDGs. Similarly, Yasir *et al.* (2023) explored environmental development as a dynamic factor to achieve green entrepreneurial intentions. They investigated the relationship between attitudes towards sustainable business, environmental values and the moderating effect of entrepreneurial experience on perceived behavioural control.

Recently, Qing *et al.* (2024) used advanced panel data techniques (cointegration test and mean estimation) to look at how trade openness, environmental damage and oil prices affect the use of green energy in OECD countries. Their results suggest a negative linkage between environmental degradation and the consumption of green energy. Moreover, Fu *et al.* (2024) evaluated the novel nexus between environmental attention and green cryptocurrencies. Using index-level data and time series analysis techniques, the results found a dynamic pattern between the studied variables.

Like green entrepreneurship, various social scientists also study circular economy practices. For example, Majumder *et al.* (2023) explored the impact of electricity resources on $CO_2$ emissions. Using quantile regression, their findings suggest that all kinds of traditional energy sources have a positive impact on $CO_2$ emissions. In the same context, Majumder *et al.* (2023) explored the solution to reduce $CO_2$ emissions in the context of Bangladesh. Using the GMM method, the results confirmed that agricultural production could significantly reduce $CO_2$ emissions.

Recently, Voumik *et al.* (2023) identified the impact of traditional and renewable energy on $CO_2$ emissions, particularly in the context of SAARC countries. Using various econometric techniques (*e.g.*, unit root, cointegration and AMG), they found that use of fissile fuel can enhance $CO_2$ emissions; however, the use of renewable energy could significantly reduce $CO_2$ emissions in the long run. However, using Algeria as a case study, Khan *et al.* (2024) examined the role of natural resources in achieving sustainable development goals. Using dynamic OLS models, the results testified that natural resources reduce $CO_2$ emissions and therefore increase economic growth.

Trend analysis of the impact of green entrepreneurship and circular economy practices highlights a growing focus on sustainable development in response to pressing envi-

ronmental challenges, although green entrepreneurship and circular economy practices are a new arena of research, particularly in the fields of environmental economics and entrepreneurship. However, some studies have been conducted to investigate their diverse aspects. For instance, in a study of N-11 countries, M. H. Rahman and Majumder (2022) examined the impact of economic growth, infrastructure and energy consumption on $CO_2$ emissions. Using the variance decomposition method, the results support the established narrative and confirm a positive impact. Similarly, Deb *et al.* (2022) investigated environmental management accounting and green financial performance. Ali *et al.* (2022) also explored the impact of green management practices on corporate environmental and financial performance.

Moreover, M. M. Rahman and Islam (2023) considered evaluating green accounting and environmental performance; Uddin *et al.* (2023) accounted for green taxation and green efficiency; M. M. Rahman, Deb *et al.* (2023) evaluated trade openness and global entrepreneurship; and M. M. Rahman, Hasan *et al.* (2023) evaluated social media entrepreneurship and sustainable development. Similarly, Liu *et al.* (2023) investigated the ecological footprints caused by green energy production, green technology and green international trade. Shafi *et al.* (2023) evaluated the nexus between the incentivization of green taxation and environmental protection. Ramzan *et al.* (2023) empirically examined the impact of green innovation and environmental neutrality, particularly in the context of the top ten green economies.

Recently, N. Zhang *et al.* (2023) inspected the trilogy between environmental demand, environmental governance and technological innovation. Aftab *et al.* (2023) explored the importance of green innovation, green capabilities and perceived environmental volatility. Abid *et al.* (2023) provided policy implications for attaining sustainable corporate performance, particularly in cases of resource constraints. Moreover, in the context of China, J. Li *et al.* (2024) examined the relationship between green finance, renewable energy, technological progress and sustainable environmental development. Using ARDL and VECM approaches, the results showed a robust and statistical relationship between the said indicators. Similarly, Aftab *et al.* (2024) identified the role of green practices in making businesses successful.

Green entrepreneurship and circular economy practices are based on three prominent theories that enlighten their validation and application, *i.e.*, the theory of ecology, the theory of innovation and the theory of institutions. The theory of ecology explains the basic association between economic activities and environmental sustainability, highlighting the limitations of resources and their importance for the corporate sector (Lewis *et al.*, 2023). This theory also supports the idea that adopting green practices within the corporate sector will eventually improve circular economy practices. Furthermore, the theory of innovation suggests that entrepreneurial activities play an important role in fostering environmental in-

novation and adopting circular economy practices (Jesus and Jugend, 2023). Lastly, the theory of institutions establishes the fact that governing institutions provide an opportunity to make green entrepreneurship successful through effective regulatory frameworks, thus helping improve circular economy practices (Bag *et al.*, 2023).

After thoroughly evaluating the available literature on the topic, we discovered several critical gaps. Most of the studies on the topic covered developed countries (Qing *et al.*, 2024; M. H. Rahman and Majumder, 2022; Q. Zhang and Udemba, 2023) or developing countries (J. Chen *et al.*, 2022; Khan *et al.*, 2024; C. Li *et al.*, 2024; Majumder *et al.*, 2023) from the same regions. The present study fills the existing gap by sampling developing countries from different regions, thus helping get a holistic view of the developing world. Moreover, we also find that most of the studies used a time series dataset (Hamid *et al.*, 2021; J. Li *et al.*, 2024; M. M. Rahman, Deb *et al.*, 2023). This study, on the other hand, uses a panel dataset and relevant econometric approaches.

Green entrepreneurs, driven by both the need for prosperity and ecological responsibility, are essential in leading businesses towards adopting circular processes (Yasir *et al.*, 2023). The realm of invention is one of the principal consequences (Gold, 2021). These entrepreneurs are fostering a creative culture that goes beyond traditional boundaries by actively seeking sustainable technologies, circular design concepts and alternative materials (Brenner and Drdla, 2023). Through challenging established beliefs and embracing a mindset of continuous enhancement, they contribute to the development of products and services that possess extended durability, reduced ecological impact and better recyclability (Patel, 2023).

Consumers also play a crucial role in this revolutionary process (Rayna and Striukova, 2021). As societal consciousness regarding the ecological consequences of consumerism expands, individuals are increasingly opting for choices that are in line with their personal beliefs and principles (Mondal *et al.*, 2023b). Consumers are actively searching for products and services that not only fulfil their needs but also have a favourable effect on the environment (Jaiswal *et al.*, 2022). The increasing emphasis on sustainability driven by consumer demand is motivating firms to embrace environmentally friendly and circular practices (Patel, 2023). This trend creates a mutually reinforcing cycle that underscores the significance of aligning economic activities with ecological issues (Bai and Li, 2023).

Additionally, green entrepreneurship stimulates industry-wide structural transformation. Businesses in this sector frequently act as pioneers, proving that sustainability and profitability do not have to conflict (Bartkutė et al., 2023). Their success stories force established companies to reevaluate their business strategies and incorporate circular ideas into their

daily operations (Yusuf and Lytras, 2023). This knock-on impact produces a revolutionary dynamic that affects customer behaviour, production processes and supply networks (Priyadarshini *et al.*, 2023).

Green entrepreneurship is critical to resource efficiency because it maximizes material utilization while minimizing waste. Remanufacturing and product refurbishment are examples of circular economy practices that fit in perfectly with the sustainability philosophy that green entrepreneurs uphold (Carissimi *et al.*, 2023). Adopting circular practices thus turns into a competitive advantage and promotes a more accountable and robust method of resource management. This influence goes beyond specific companies to support a more general change in industry standards where the focus on waste reduction becomes a distinguishing feature (Karmaker *et al.*, 2023).

Collaboration is a significant domain where green entrepreneurship has a noticeable impact on circular economy practices. Entrepreneurs in this sector often form alliances, networks and ecosystems to enhance their collective influence (Herbst, 2023). They promote the implementation of circular concepts by creating a conducive environment through the exchange of exemplary methods, resources and specialized knowledge (Soni *et al.*, 2023). This culture fosters a collaborative approach to sustainability, where collective efforts lead to significant and lasting transformation (Kumar *et al.*, 2021).

In the framework of the circular economy, the growth of green entrepreneurship also has a substantial impact on financial systems and investment trends. Investors are becoming more aware of how resilient and sustainable companies with integrated sustainable and circular practices are in the long run (Di Paola *et al.*, 2023). This change in investment trends gives green entrepreneurs the money they need to grow their businesses, thereby establishing the circular economy as a significant factor in most financial decisions (Arfaoui *et al.*, 2024; Kuzior *et al.*, 2023).

Green entrepreneurship significantly affects circular economy practices, leading to changes in consumer knowledge and behaviour (Vidal-Ayuso *et al.*, 2023). The rise in consumer consciousness regarding the environmental impact of their choices has led to a higher demand for products and services that adhere to sustainable and circular business models, spearheaded by environmentally conscious entrepreneurs. Firms are facing pressure to adhere to circular economy concepts to remain competitive and meet the evolving demands of consumers, as highlighted by Villalba-Eguiluz *et al.* (2023).

Additionally, green entrepreneurship affects both knowledge distribution and education in relation to circular economy practices. These entrepreneurs frequently take part in outreach and educational programmes, offering their insights into sustainable business

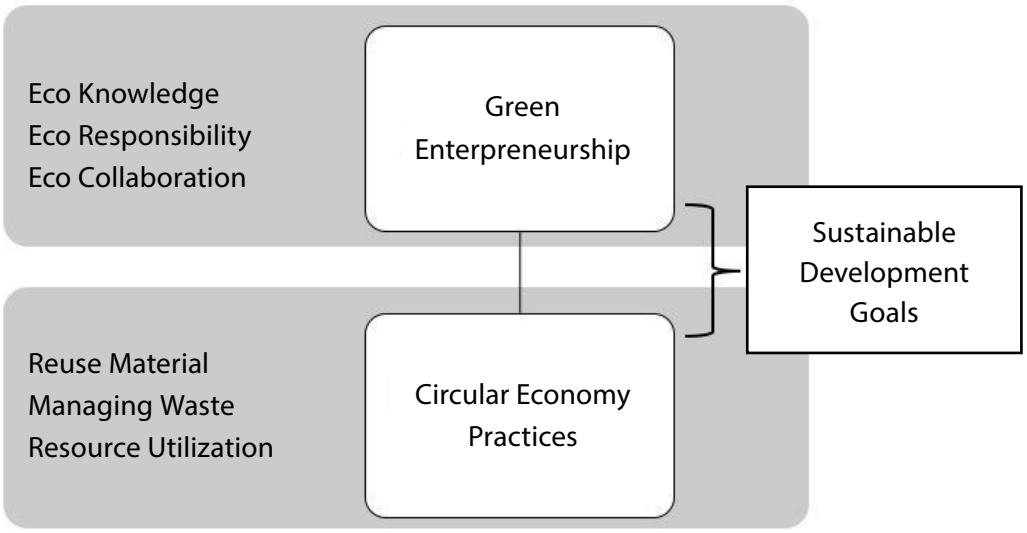
practices and the concepts of circular economy practices (Guerreschi *et al.*, 2023). This educational function lays the foundation for a more knowledgeable and ethical society by fostering a wider understanding of the connections between corporate operations and environmental stewardship (Zakopoulos *et al.*, 2023).

Nevertheless, this revolutionary impact is not without its challenges. Green entrepreneurs may have challenges when it comes to achieving scalability due to the need for substantial initial investments and operational reorganization to incorporate circular economy practices (Bilgili *et al.*, 2023). The successful resolution of these difficulties requires collaborative endeavours from both the entrepreneurial community and key actors in the financial and policy domains to establish an environment that facilitates the smooth incorporation of circular ideas into business practices (Freeman *et al.*, 2023; J. Guo and Kou, 2025). Thus, it can be hypothesized that:

***Hypothesis 1:*** *There is a positive nexus between green entrepreneurship and circular economy practices.*

Figure 1 explains the conceptual framework for the relationship between green entrepreneurship and circular economy practices. The figure explicitly shows some of the activities conducted by green entrepreneurs, *i.e.*, eco-knowledge, eco-responsibility and eco-collaboration. On the other hand, circular economy practices include material reuse, waste management and improved resource utilization. These initiatives could be beneficial not only for the environment but also for achieving sustainable development goals.

**Figure 1: Conceptual framework**




Source: Authors' own elaboration

# 3. Methodology

## 3.1 Sample and data sources

The primary objective of this research is to assess the impacts of green entrepreneurship on circular economy practices using corporate-level indicators. The World Bank Enterprise Surveys (WBES) serve as the source of the data (WB, n.d.). WBES is a secondary data source with an extensive database where World Bank experts collect data from corporations operating in developing countries at non-random intervals. WBES uses a survey-based methodology to gather data, covering a variety of topics such as company information, management composition, ownership structure, corporate innovation, green business practices and more. The data are freely available for researchers and policymakers.

This study concentrates on seven countries (Central African Republic, El Salvador, Georgia, Nepal, Pakistan, Peru and the West Bank and Gaza). The selected countries represent diverse geographic regions, *i.e.*, Africa, Latin America, Asia, Europe and the Middle East. This diversity allows us to provide insights into countries from different regions. Another similarity among the sample countries is that they are all developing economies. There are multiple reasons for selecting only developing counties. Firstly, developing countries have high expectations for growth and green innovation. Secondly, green entrepreneurship and circular economy practices are important for developing economies to achieve sustainable development. Finally, developing countries are more vulnerable to the consequences of environmental challenges compared to developed countries.

The study includes a sample of 4,701 firms, exclusively from the manufacturing sector. There are two reasons for choosing the manufacturing sector, specifically in developing countries. Firstly, selecting developing countries is important because these countries face resource constraints and environmental challenges. Therefore, offering valuable insights can be beneficial to the efficacy and applicability of sustainable practices in overcoming said hurdles. Secondly, in developing countries, the manufacturing sector plays an important role in economic progress. By examining this sector, we aim to explore the potential for green entrepreneurship and circular economy practices to drive sustainable development in developing countries. Moreover, we only use the surveys conducted in 2023. The reason for choosing only 2023 surveys is that, contrary to the previous surveys, WBES-2023 contains variables related to the green economy. Therefore, we have a country-level cross-sectional dataset.

## 3.2 Measurement of variables

### *Dependent variables*

The dependent variable of this study is circular economy practices. Most of the previous studies used diverse proxies to quantify circular economy practices. For instance, Mondal *et al.* (2023a) used driving and dependence power, Nuringsih and Nuryasman (2022) measured environmental citizenship behaviour, green entrepreneurship intention and perceived circular economy, and Soleimani *et al.* (2023) incorporated green entrepreneurship in manufacturing SMEs, strategic planning, green purchasing and corporate social responsibility motivation.

However, contrary to the aforementioned proxies, we use two novel indicators to estimate circular economy practices. The first proxy is energy consumption, measured in kilowatt-hours (kWh). Particularly, it refers to the consumption of energy generated through fossil fuels, a non-renewable energy source and it is assumed that firms that consume more energy are not contributing to or adversely contributing to circular economy practices. Similarly, the second proxy for measuring circular economy practices is ISO 14000 certification. This certification is awarded to firms based on their attitude towards circular economy practices and eco-friendly activities.

Energy consumption and ISO 14000 certification can be considered effective proxies for circular economy practices because of their close linkage with sustainability and resource efficiency. Adoption of energy-efficient technologies and reducing energy consumption indicates adopting circular economy practices through minimizing resource use and waste generation. Moreover, ISO 14000 certifications show a commitment to environmental management and compliance with sustainability standards, reflecting efforts to integrate circular economy practices. Moreover, these proxies also reflect the ideologies of sustainability and resource efficiency of the product life cycle. Particularly, the energy consumption variable represents production process effectiveness, material utilization and waste reduction. These elements are important not only to extend the product life cycle but also to minimize resource depletion. Similarly, the ISO 14000 certification variable signifies a structured environmental management framework and ensures that firms adopt sustainable practices across different stages of the product life cycle.

### *Independent variables*

This study uses the variable for green enterprises as an independent variable, although it is quite challenging to estimate any business entity concerning green initiatives. However,

some of the prior studies have documented various measures, *e.g.*, Mondal *et al.* (2023a) used technology-based enablers and effective technological infrastructure facilities, Nuringsih and Nuryasman (2022) quantified green entrepreneurship through education, and Soleimani *et al.* (2023) used total quality management and circular supply chain management.

However, the present study uses two new proxies to quantify green initiatives. Monitoring $CO_2$ emissions is the first proxy. As a dummy variable, this variable takes a value of 1 if the firm monitors its $CO_2$ emissions and 0 otherwise. We assume that green enterprises consistently track their carbon emissions. Similarly, the second proxy pertains to the implementation of a control mechanism for $CO_2$ emissions. This is also a dummy variable, having a value of 1 if the firm adopts a control mechanism and 0 otherwise. We can assume that firms that have implemented control mechanisms to prevent carbon emissions are considered green enterprises.

Green enterprises are entities that design their activities in a way that does not harm the environment. Both of our proxies (*i.e.*, monitoring of $CO_2$ emissions and control mechanisms for $CO_2$ emissions) efficiently quantify independent variables because green firms frequently monitor and control their $CO_2$ emissions and therefore contribute positively towards the environment and society.

### *Control variables*

Along with the dependent and independent variables, the study incorporates the following control variables:

- *Firm size*: In this study, the total number of employees is used to quantify firm size.
- *Firm age*: This study uses firm age as a control variable to measure the difference between the year of incorporation and the survey year.
- *Firm ownership status*: The sample firms were segregated into domestic and non-domestic based on their ownership status.
- *Firm legal status*: The sample of the study consists of both companies and non-companies based on firm legal status.
- *Managerial experience*: Lastly, managerial experience is used as a control variable in this study and quantified in terms of total experience in years held by the top manager.

**Table 1: Description of variables**

| Variable name | Description | Source |
|---|---|---|
| **Dependent variable – circular economy practices** | | (WB, n.d.) |
| *Energy consumption* | Firm consuming electricity in kWh | |
| *ISO 14000 certification* | A firm having ISO 14000 certifications | |
| **Independent variable – green entrepreneurship** | | |
| *$CO_2$ emissions* | Firm monitoring its $CO_2$ emissions | |
| *Control mechanism $CO_2$ Emission* | Firms adopting any energy mechanism to reduce emissions | |
| **Control variables** | | |
| *Firm size* | Total number of employees working in the firm | |
| *Firm age* | Total number of years since the firm incorporated | |
| *Firm ownership status* | Firms classified as domestic and non-domestic firms | |
| *Firm legal status* | Firms classified as company and non-company | |
| *Managerial experience* | Total experience of top managers in terms of years | |

Source: Authors' own elaboration

## 3.3 Empirical models

Based on the nature of the dataset and the composition of the variables, we construct one baseline model and four sub-models to empirically testify the study hypothesis. Each model contains dependent, independent and control variables, as well as constants and error terms. These indicators are specific to their respective countries. As we have cross-sectional data where all the variables are not time variants, we apply neither time series techniques, such as unit root or autocorrelation tests, nor panel data techniques, such as endogeneity or heteroscedasticity tests. As a result, we employ least squares and probit regression methods, as well as county-specific controls. Furthermore, to address endogeneity concerns, we have incorporated two-stage least squares regression and instrumental variable probit regression techniques. To further check the significance of overidentified instruments, we also use the Sargan test.

$$Circular\ Economic\ Practices_{ik} = \beta_0 + \beta_1 Green\ Entreprenuership_{ik} + \\ + \sum_{j=1}^{05} \beta_j\ Control\ Variables_{ik} + \varepsilon \quad (1)$$

As far as the empirical methodology is concerned, we adopt least squares techniques, particularly for models 1.1. and 1.2. The reason for choosing this regression technique is because of the construction of the dependent variable. For the aforementioned two models, we have a continuous variable, *i.e.*, energy consumption (kWh).

$$Energy\ Consumption_{ik} = \beta_0 + \beta_1 CO_2 Monitor_{ik} + \sum_{j=1}^{05} \beta_j\ Control\ Variables_{ik} + \varepsilon \quad (1.1)$$

$$Energy\ Consumption_{ik} = \beta_0 + \beta_1 CO_2 Control_{ik} + \sum_{j=1}^{05} \beta_j\ Control\ Variables_{ik} + \varepsilon \quad (1.2)$$

Furthermore, we construct models 1.3 and 1.4 to test the robustness of our main results. For these two empirical models, we use the probit regression analysis technique. The reason for choosing this technique is due to the binary composition of the dependent variable, *i.e.*, ISO certification.

$$ISO\ Certificate_{ik} = \beta_0 + \beta_1 CO_2 Monitor_{ik} + \sum_{j=1}^{05} \beta_j\ Control\ Variables_{ik} + \varepsilon \quad (1.3)$$

$$ISO\ Certificate_{ik} = \beta_0 + \beta_1 CO_2 Control_{ik} + \sum_{j=1}^{05} \beta_j\ Control\ Variables_{ik} + \varepsilon \quad (1.4)$$

The above equations represent regression models where the dependent variable is *Circular Economic Practices*$_{ik}$; they are further segregated into energy consumption and ISO certification. Moreover, *Green Enterprenuership*$_{ik}$ represents an independent variable and is divided into $CO_2$ monitoring and control mechanisms. *Control Variables*$_{ik}$ include firm size, age, ownership status, legal status and managerial experience. In these contexts, *i* denotes individual firms and *k* denotes countries. $\beta_0$ is an intercept term representing the expected value of circular economic practices when all independent variables are zero. $\varepsilon$ is an error term, representing the difference between the observed value of circular economic practices and the value predicted by the model. It captures the effects of unobserved factors and random variation.

# 4. Empirical Analysis

Table 2 provides information on the central tendency, variability and distribution of each variable used to test the hypothesis. We use a sample of 4,701 firms across seven developing and emerging countries. The descriptive statistics show an average *Energy consumption* of 12.165 (log value), with a deviation of 2.131. The average number of firms with ISO certifications in the sample is 0.200. The *$CO_2$ monitoring* variable shows an average value of 0.169. Similarly, companies that implement *$CO_2$ control mechanisms* have an average value of 0.384.

**Table 2: Summary statistics**

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| ***Energy consumption*** | 4,701 | 12.165 | 2.131 | 1 | 19.441 |
| ***ISO 14000 certification*** | 4,701 | 0.200 | 0.400 | 0 | 1 |
| ***$CO_2$ monitoring*** | 4,701 | 0.169 | 0.375 | 0 | 1 |
| ***$CO_2$ control mechanisms*** | 4,701 | 0.384 | 0.486 | 0 | 1 |
| ***Firm ownership (domestic /foreign)*** | 4,701 | 0.331 | 0.471 | 0 | 1 |
| ***Firm legal status (non-company/company)*** | 4,701 | 0.930 | 0.255 | 0 | 1 |
| ***Firm age*** | 4,701 | 2.868 | 0.761 | 0 | 5.130 |
| ***Firm size*** | 4,701 | 2.508 | 1.281 | 0 | 8.006 |
| ***Managerial experience*** | 4,701 | 2.794 | 0.719 | 0 | 4.248 |

Source: Authors' own elaboration

Table 3 represents the Pearson correlation coefficient matrix for the relationship between variables. According to the correlation table results, the dataset shows no multi-collinearity between variables that could lead to biased results. All the values shown in the table are statistically acceptable and present no multi-collinearity issue in the dataset. In particular, there is a negative correlation between *$CO_2$ monitoring* and *Energy consumption*. We observed a similar correlation between *$CO_2$ control mechanisms* and *Energy consumption*. Moreover, there is a positive correlation between *$CO_2$ monitoring* and ISO certification and

the same correlation was present in the case of the nexus between *$CO_2$ control mechanisms* and *ISO 14000 certification*.

**Table 3: Pearson correlation matrix**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Energy consumption*** | **1** | 1.00 | – | – | – | – | – | – | – | – |
| ***ISO 14000 certification*** | **2** | −0.26* | 1.00 | – | – | – | – | – | – | – |
| ***$CO_2$ monitoring*** | **3** | −0.17* | 0.23* | 1.00 | – | – | – | – | – | – |
| ***$CO_2$ control mechanisms*** | **4** | −0.07* | 0.17* | 0.44* | 1.00 | – | – | – | – | – |
| ***Firm ownership*** | **5** | 0.13* | −0.08* | −0.08* | −0.22* | 1.00 | – | – | – | – |
| ***Firm legal status*** | **6** | −0.01 | −0.09* | −0.09* | −0.07* | 0.09* | 1.00 | – | – | – |
| ***Firm age*** | **7** | −0.19* | 0.15* | 0.06* | 0.06* | 0.04* | 0.04* | 1.00 | – | – |
| ***Firm size*** | **8** | −0.36* | 0.27* | 0.23* | 0.09* | −0.14* | −0.13* | 0.17* | 1.00 | – |
| ***Managerial experience*** | **9** | −0.07* | −0.02 | −0.05* | 0.06* | −0.08* | 0.06* | 0.40* | 0.03*** | 1.00 |

Note: * and *** denote statistical significance at the 1% and 10% levels, respectively.
Source: Authors' own calculations

We faced several methodological issues when empirically analysing the impact of green entrepreneurship on circular economy practices, such as sample selection bias, multicollinearity issues, omitted variable bias, scale differences, *etc*. Addressing these concerns is critical for the analysis; therefore, we chose the least squares and probit techniques. Both techniques can help mitigate sample selection bias by including appropriate control variables. Moreover, we conducted a Pearson correlation analysis before entering the main regression models to ensure that the data were free from multicollinearity issues.

By providing appropriate estimates of coefficients for the included variables, both suggested methods can mitigate the effect of omitted variable bias, providing that the excluded variables have no relationship with the included variables. As the variables used in this study have different scales, least squares and probit regression models can both significantly

reduce such concerns. Least squares regression minimizes the sum of squared differences between observed and predicted values, so it can still handle scale differences to some extent. Similarly, the probit regression model, because of its probabilistic nature, is less sensitive to outliers and can accommodate scale differences. Moreover, as we use a cross-sectional dataset, issues regarding time series (unit root) data and panel data (cross-sectional dependence) do not exist. However, endogeneity concerns prevail in cross-sectional data; therefore, instrumental variable regression models are used.

We use regression techniques to evaluate the hypothesis using firms from seven developing countries. Table 4 documents the outcomes of models 1.1 and 1.2. The models use energy consumption as a dependent variable, as well as $CO_2$ *monitoring* and *control mechanisms* as key independent variables. The results reveal a negative impact, indicating that increasing green activities such as monitoring and controlling emissions significantly reduces energy consumption, which subsequently leads to improved circular economy practices.

Moreover, considering endogeneity as a concern, we use a two-stage least square regression model. The two-stage least square regression technique admittedly has some limitations, *e.g.*, the validity and strength of instruments, weak instrument bias, *etc*. To minimize said limitations, we use female owner and female manager as instrumental variables and the Sargan test to check the validity of instruments. Female ownership and management could be considered strong instrumental variables, as prior studies have suggested that firms led by females usually prioritize sustainability and environmentally responsible practices, influencing green entrepreneurship (Ameer and Khan, 2023). Similarly, we also use the Sargan test to check the validity of instruments. Based on the insignificant *p*-value of the $\chi^2$ statistics, it is verified that the instruments are valid. The findings are still the same, showing that green entrepreneurial activities subsequently enhance circular economy practices in developing countries.

These results support the hypothesis and are in line with the previous studies of De Giovanni and Folgiero (2023), Castillo-Benancio *et al.* (2023) and Harper *et al.* (2023). Moreover, all the regression models are statistically fit and have an acceptable $R^2$ value. As far as the validity of instrumental variables is concerned, we use the Sargan test. The insignificant *p*-values indicate the validity of using both instrumental variables as instruments in the two-stage least square regression model.

## Table 4: Regression estimates

| **Regression estimates** | | | | |
|---|---|---|---|---|
| **Unit of observation – cross-sectional** | | | | |
| **Dependent variable – energy consumption** | | | | |
| | **Least square regression** | | **Two-stage least square** | |
| | **Model – 1.1** | **Model – 1.2** | **Model – 1.1** | **Model – 1.2** |
| | ***Coefficients*** | ***Coefficients*** | ***Coefficients*** | ***Coefficients*** |
| **Independent variables** | | | | |
| *$CO_2$ monitoring* | −0.572<br>(−7.29) *** | – | −0.976<br>(−2.71) *** | – |
| *$CO_2$ control mechanisms* | – | −0.651<br>(−8.74) *** | – | −4.916<br>(−5.77) *** |
| **Control variables** | | | | |
| *Firm ownership* | 0.449<br>(8.02) *** | 0.440<br>(7.88) *** | 0.454<br>(4.94) *** | 1.486<br>(7.07) *** |
| *Firm legal status* | 0.402<br>(2.95) *** | 0.410<br>(3.02) *** | 0.356<br>(2.15) *** | 0.034<br>(5.10) *** |
| *Firm age* | −0.295<br>(−7.35) *** | −0.296<br>(−7.44) *** | −0.404<br>(−6.56) *** | −0.545<br>(−7.58) *** |
| *Firm size* | −0.447<br>(−18.60) *** | −0.447<br>(−18.65) *** | −0.613<br>(−7.18) *** | −0.632<br>(−16.46) *** |
| *Managerial experience* | −0.031<br>(−0.75) | −0.024<br>(−0.58) | −0.057<br>(−0.77) | −0.063<br>(−0.91) |
| *Constant* | 17.334<br>(77.68) *** | 17.429<br>(78.05) *** | 14.719<br>(5,463.68) *** | 13.081<br>(31.76) *** |
| **Model summary** | | | | |
| Number of observations | 4,701 | 4,701 | 4,701 | 4,701 |
| *F*-stats / Wald $\chi^2$ | 194.38 | 197.71 | 825.86 | 822.29 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 |
| $R^2$ | 0.349 | 0.353 | 0.101 | 0.097 |
| **Sargan test** | | | | |
| $\chi^2$ | – | – | 0.990 | 0.397 |
| *p*-value | – | – | 0.319 | 0.528 |

Note: *** denotes statistical significance at the 1% level; *t*- and *z*-statistics are in parenthesis.

Source: Authors' own calculations

To check the robustness of the findings presented in Table 4, we incorporate an alternate proxy for circular economy practices, *i.e.*, ISO 14000 eco-friendly certification, and use regression models 1.3 and 1.4, respectively. The probit regression findings reported in Table 5 reveal a positive relationship, demonstrating that green enterprises have attained ISO certification and have improved circular economy practices. Moreover, to address the endogeneity issue, we use an instrumental variable probit regression model using proxies for female owners and female managers as instrumental variables. Both instrumental variables are valid based on the Sargan statistics and their respective *p*-values. The empirical results are consistent and represent a positive nexus between green entrepreneurship and circular economy practices. These results are statistically significant and testify to our hypothesis. These outcomes are also similar to previous literature, *e.g.*, Wang *et al.* (2023), Lin and Ma (2023) and Jayarathna *et al.* (2023).

**Table 5: Regression estimates (robustness check)**

| **Regression estimates** | | | | |
|---|---|---|---|---|
| **Unit of observation – cross-sectional** | | | | |
| **Dependent variable – ISO 14000 certification** | | | | |
| | **Probit regression** | | **IV probit regression** | |
| | **Model – 1.3** | **Model – 1.4** | **Model – 1.3** | **Model – 1.4** |
| | ***Coefficients*** | ***Coefficients*** | ***Coefficients*** | ***Coefficients*** |
| **Independent variables** | | | | |
| *$CO_2$ monitoring* | 0.483<br>(8.65) *** | – | 0.073<br>(3.69) *** | – |
| *$CO_2$ control mechanisms* | – | 0.464<br>(8.34) *** | – | 0.086<br>(9.72) ** |
| **Control variables** | Yes | Yes | Yes | Yes |
| **Model summary** | | | | |
| Number of observations | 4,701 | 4,701 | 4,701 | 4,701 |
| Wald $\chi^2$ | 590.05 | 572.71 | 493.10 | 453.85 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 |
| Pseudo $R^2$ | 0.143 | 0.142 | 0.095 | 0.087 |
| **Sargan test** | | | | |
| $\chi^2$ | – | – | 1.059 | 0.218 |
| *p*-value | – | – | 0.303 | 0.640 |

Note: *** denotes statistical significance at the 1% level; *t*-statistics are in parenthesis.

Source: Authors' own calculations

Apart from the empirical validation of the topic, there are numerous case studies of successful green enterprises in developing countries. For instance, Green Hope (Kenya) converts waste from plastic and agriculture into biofuels and packing materials. Such practices demonstrate that circular economy practices could reduce landfill waste and promote renewable energy. Ecoplast (India) transmutes post-consumer plastic into materials that can be used in construction and thus contribute to a sustainable environment. Similarly, Cyclo (Bangladesh) also manufactures eco-friendly bricks from industrial waste. Moreover, Trashy Bags (Ghana) transforms waste plastic into reusable bags and promotes waste reduction and sustainable consumption. Avani (Indonesia) develops biodegradable packing material from waste cassava starch and thus addresses plastic pollution.

Policymakers and experienced managers understand the firm's sustainability and the significant impact of eco-friendly behaviours on business leaders' decisions regarding investment, particularly in sustainable firms. Similarly, firms are adopting environmentally friendly practices to gain potential benefits and a competitive edge over their counterparts. Environmental regulations enhance brand reputations and market dynamics. The relationship between operational efficiency and sustainability is more favourable and builds a strong partnership among economic players. Sustainable firms motivate their employees to collaborate with environmentally conscious organizations. Moreover, given the diverse regulatory and institutional contexts, some of the effective policies could include regulatory incentives for sustainable production, frameworks for material reuse and strategies for promoting eco-innovation.

## 5. Discussion

To address the modern challenges of environmental sustainability and economic resilience, it is crucial to examine the correlation between green entrepreneurship and circular economy practices (Hegab *et al.*, 2023).

This study utilizes empirical data to assess the influence of green entrepreneurship on circular economy practices. It also incorporates various indicators for both green entrepreneurship and circular economy practices, such as $CO_2$ monitoring, $CO_2$ control mechanisms, energy consumption and ISO 14000 certification. According to empirical data, adopting green business activities can provide a firm with numerous benefits and insights. The presence of a negative coefficient in $CO_2$ monitoring and control mechanisms indicates a decrease in energy consumption. Optimizing environmental performance and reducing carbon footprint directly correlate with lower energy consumption. By reducing energy consumption, firms can achieve greater financial savings and boost profitability. Likewise, implementing

sustainable environmental practices improves the company's standing with consumers, investors and other stakeholders (Sharma *et al.*, 2023).

Circular economy practices and green entrepreneurship have a bright future ahead of them as these interconnected ideas continue to develop and influence the course of international trade (Villalba-Eguiluz *et al.*, 2023). Growing awareness of climate change and resource constraints will likely lead to an explosion of creative business models such as aquaculture (Maroušek, Strunecký *et al*., 2023) and the construction sector (Maroušek, Maroušková *et al.,* 2023) that prioritize environmental sustainability in the upcoming years (Hassan *et al.*, 2023). With industries adjusting to closed-loop processes, circular economy practices as a systemic approach are set to become the norm for responsible production and consumption (Mishra *et al.*, 2023). Governments and multinational partnerships will probably fortify the regulations bolstering these endeavours, cultivating a favourable atmosphere for enterprises dedicated to environmentally conscious operations (Yu *et al.*, 2023). The convergence of green entrepreneurship and circular economy practices is not just a fad; rather, it is a revolutionary force that will create a future global economy that is more resource-aware, resilient and ecologically conscious (Reike *et al.*, 2023).

Firms that adopt environmentally friendly practices could gain consequent benefits; similarly, firms that adopt environmental management practices can gain ISO 14000 certification, which enhances their market position. The ISO certificate improves efficiency and reduces excess costs. Firms monitoring sustainable environmental practices can thus change the overall business environment. These results are also documented in the previous studies by Kuwornu *et al.* (2023), Vidal-Ayuso *et al.* (2023) and Zhou *et al.* (2023) and support the hypothesis.

Adoption of sustainable practices ensures cost savings and operational efficiency. These firms actively promote innovation to contribute to a positive perception of long-term financial health, which aligns with the objectives of a framework for AI-driven environmental policies. Environmental management practices also have a positive impact on industrial sectors, as outlined in this framework. Furthermore, energy-efficient practices strengthen brand equity, societal impact and global competitiveness, fitting within the framework for AI-driven environmental policies to support sustainable business operations. Companies are developing training programmes and educating employees about environmentally sustainable practices, further embedding these principles within the framework. These practices broaden the business ecosystem, improve regulatory challenges and provide guidance on technology adoption. Businesses can adopt technology and innovation diffusion and invest in them to enhance environmental sustainability and performance, advancing the goals of the framework for AI-driven environmental policies.

## 6. Conclusion

The world is facing tremendous environmental challenges, such as climate change and pollution. Corporate activities that harm the environment are the root cause of these challenges. Through circular economy practices, green entrepreneurship could turn the tables and create an eco-friendly environment. Therefore, this study explored the nexus between green entrepreneurship and circular economy practices. This study used empirical data from the World Bank enterprise survey (WBES-2023) to investigate this liaison. This study only considered developing economies in its analysis.

To achieve the stated objectives, we hypothesized a positive impact of green entrepreneurship on circular economy practices and the statistical analysis supports said narrative. The findings are important not only for the sample countries, but also for other countries with the same development status. Developing economies are facing severe environmental challenges caused by harmful corporate activities. Replacing those activities with a green business model not only reverses the potential damage but also aids in achieving sustainable development goals.

The rationale behind this study was that green entrepreneurship and circular economy practices emerge as essential methods within the broader context of the Sustainable Development Goals (SDGs), particularly in developing countries. Furthermore, the establishment of circular economy practices through the green business model not only benefits the economic development of both developed and developing countries, but also promotes a sustainable environment.

The policy implications of this study highlight the importance of adopting green entrepreneurial activities and circular economy practices. Policymakers and practitioners can utilize this study to formulate environmental policies that reduce energy consumption. Government and regulatory agencies can strengthen relations to promote environmental sustainability. When it comes to educational initiatives for managers and small businesses, policymakers can promote friendly environmental practices through international collaboration and sustainability standards. The government conducts public awareness campaigns and social movements to educate consumers about the environmental impact of their choices. Policymakers can contribute to promoting sustainability and a resilient economy.

The study is not free from limitations and thus provides valuable future directions for researchers in the fields of corporate and environmental studies. Firstly, the sample size used in this study is minimal and may not capture the diversity within the entire de-

veloping world; therefore, future studies should consider a broader range of countries or explore variations within regions to ensure more robust and diverse findings. Secondly, this study only considered developing countries for analysis purposes; however, developed economies have different institutions and corporate environments. Future studies can take into account developed economies to further analyse the phenomena under investigation. Furthermore, comparisons between developed and developing economies can open new horizons and reveal interesting facts. Moreover, because it solely relied on data from the 2023 WBES, this study lacks time variability. Future studies can use time series analysis to make an in-depth evaluation of the linkage between the studied variables. This study did not account for external shocks, such as government policies and market conditions. These shocks can significantly change corporate decisions and sustainability practices. Future studies can include external factors that may change sustainability practices, such as geopolitical events, economic downturns, or natural disasters. Lastly, future research could expand the framework for AI-driven environmental policies by exploring its applicability across different economic contexts, examining time-based variations and assessing the impact of external factors such as government interventions and global events on sustainability practices.

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**Author contributions:** Muhammad Usman originated and intended the research and accomplished the statistical facts; Shahbaz Imran completed the literature survey on the topic; Ahsan Akbar finalized and prepared the draft.

**Data availability:** The datasets generated and/or analysed during the present study are available in the World Bank Enterprise Survey repository [WB, n.d.: https://www.enterprisesurveys.org/en/enterprisesurveys].

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