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Factors shaping corporate green economy practices in Kyrgyzstan and Georgia

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ABSTRACT

Environmental practices by private businesses are important for transiting to green economy. Against the backdrop of scarce empirical literature on green economy practices in the Central Asian Region, this study aims to examine factors affecting corporate green economy practices in Georgia and Kyrgyzstan using the most recent enterprise survey dataset, as well as contribute to the discussion of the green economy driving factors from enterprises' perspective. Green economy practices are assessed based on CO2 monitoring and energy management actions. The study's empirical findings suggest that along with general business characteristics access to finance and energy costs drastically impact the adoption of green economy routines in the private sector. Interestingly, the use of foreign technology and international certification have demonstrated positive effects only in the sample of Georgia, without any statistically significant mani-festations in Kyrgyzstan. Moreover, only large firms have shown positive trends in adopting CO2 monitoring and energy management measures. These findings imply the need for adjusting targeted green economy state policies to specific country contexts.

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1. Introduction

Climate change poses complex challenges for economies to adjust to and mitigate the corresponding effects. Both from consumers' and producers' perspectives, resource-efficient behavior is required (Thøgersen, 2021). On the one hand, producers globally face risks associated with extreme weather events and other related operational and long-term risks; on the other hand, compliance with government environmental regulations puts additional pressure on them via mounting corporate operational costs (Tingey-Holyoak et al., 2024; Unepfi, 2023). Green economy practices by firms are essential for achieving sustainable development objectives (Weick, 2016).

Climate change is an issue of planetary scale with no exception for developed countries or the Global South, and financing climate adaptation efforts continues to be an important topic of discussion. The establishment of state-funded institutions to promote sustainable development, including support for technological innovation of enterprises to reduce greenhouse gas (GHG) emissions and promote energy-saving production, is essential across jurisdictions (Guo et al., 2020). However, adaptation to environmental challenges and transition to green economy is costly for most enterprises in developing nations (International Monetary Fund, 2022). In addition, the dominance of small and medium-sized enterprises (SMEs) in developing countries complicates the deployment of green economy innovations due to the insufficient capacities and resources of most SMEs compared to large enterprises (Rodrigues & Franco, 2023).

The empirical literature suggests that green corporate practices are driven by a multitude of factors, ranging from company characteristics to state environmental regulations (Alraja et al., 2022; Harakati et al., 2024; Jun et al., 2019; Siewers et al., 2024). However, there is a lack of understanding of the factors behind firms' behavior towards green practices in the context of developing countries, given various constraints that small and medium enterprises face.

Central Asian economies are considered extremely vulnerable to climate change, and sustaining economic growth requires government policy to meet multiple challenges, including protecting the environment, reducing GHG emissions, as well as the business community and environment internally adapting to the emerging conditions (Brollo, 2023; Vakulchuk et al., 2023). Yet, the literature on green economy for the region is rather limited. To the best knowledge of the authors, no studies so far have focused on the sustainable development practices of enterprises specifically in Central Asian economies, although rare investigations include target countries in larger samples and examine the impacts of environmental trends on general economic indicators (Brunelli et al., 2022; Isiksal et al., 2022).

To contribute to filling this gap, this study has aimed to analyze the factors affecting green economy practices of private firms in Georgia and Kyrgyzstan using the World Bank Enterprise Surveys (WBES) 2023 data. Along with firm characteristics, the dataset includes the Green Economy Module allowing to evaluate factors affecting the adoption of CO2 monitoring and energy management measures. Thus, this study contributes to the discussion of green economy driving factors from enterprises' perspectives, an almost not explored matter for the Central Asian Region and Georgia. Moreover, given the challenges related to data availability to examine the climate change topic in developing countries, the use of the most recent firm-level dataset with specific questions on sustainability practices enriches the understanding of potential barriers for green transition. In its turn, the empirical analysis based on the data from Kyrgyzstan and Georgia underlines the importance of the institutional context varying by country.

2. Literature review

Environmental innovations by enterprises play a pivotal role in explaining green economy dynamics. Studies indicate that environmentally friendly innovations by firms depend on different factors ranging from company characteristics to specific local business operation conditions, and government regulations. Among them, participation in external economic activities often manifests itself as a strong factor affecting green economic activities in the private sector. Thus, while examining this relationship based on the global data, including the Central Asian Region, Siewers et al. (2024) found that enterprises with higher participation in global value chains demonstrated a more efficient use of energy and monitoring of CO2.

Using India's data, Ali and Singh (2024) revealed a significant correlation between the size of a firm and adoption of green economy practices. They concluded that the impact of enterprise characteristics varies by firm size. For instance, female ownership positively affects adoption in large firms but negatively in SMEs. However, lean operations, research and development (R&D) spending, and international quality certification positively influence the adoption of green practices in both SMEs and large companies.

Some other firm characteristics, including managerial features and labor force composition, are likewise argued as significant drivers of environmentally sensitive behavior among enterprises. Harakati et al. (2024), examining the role of CEO's gender on climate change adaptation in Mediterranean countries, showed that entities with female CEOs had a stronger commitment to environmental regulations, such as CO2 emission control. Yet, studies indicate that not only internal corporate features but also relevant government policies may explain green practices by firms.

For instance, the study by Jun et al. (2019), focusing on the case of pakistan, argued that – along with internal factors of firms, such as skilled labor and managerial approaches to green practices – awareness about green products in the relevant market and existence of government support are important for SMEs in leveraging green innovation.

Government efforts to mitigate environmental challenges have some effect on enterprises adopting more environmentally friendly practices. Thus, Lin & Ho (2011) found that among logistics firms in China regulatory pressure and state support successfully stimulated green practices, whereas uncertainties related to the environment and complexity of green practices hindered their adoption. Public environmental policies may have an effect on the financial aspects of enterprises. Based on the data for firms in China during 2007-2020, Li et al. (2022) found that the CO2 emission trading system had a positive impact on the cash holdings of firms, with the effect more expressed in enterprises subject to more rigorous government monitoring and enjoying fewer investment opportunities.

Previous empirical studies also indicate that environmental concerns and state regulations have implications beyond firm's internal financial behavior and may spill over to the financial market. Perdichizzi et al. (2024) examined the relationship between CO2 emissions and corporate values using the data for European private businesses. The authors argued a negative relation between CO2 emissions by firms and their market value, as high intensity of GHG emissions may lead to higher environmental liability risks. Yet, this causal relationship may not be present or be weak in developing countries, where financial markets are not fully matured to reflect environmental conditions and regulations.

On the opposite, even without the corresponding government regulations environmental concerns, including climate change effects, may represent a distinct exogenous modifier of corporate behavior. The study by Benincasa et al. (2024), investigating the coping strategy of firms in the face of climate change damages – focusing on the sample of both developing and developed economies – argued that companies experiencing losses due to weather conditions demonstrated a higher probability of applying green practices and investing in long-term assets.

Other studies suggest that the movement towards a sustainable green economy is closely related to technological innovation intensity in a market (for instance, Alraja et al., 2022), i.e. Low technological innovation in an economy may not be favorable for wider green economy practices.

Investment in green economy practices can be beneficial for firms by boosting their performance. Petreski et al. (2024) investigated the impacts of investment in environmentally sustainable practices on labor productivity in central and Southeast Europe, as well as the Commonwealth of Independent States (CIS). They found that

such investments had a strong effect on labor productivity, especially in firms with prevailing low-skill labor force. Moreover, they underlined regional differences as well – SMEs in Central European countries demonstrated higher labor productivity effects than those in Southeast Europe and CIS countries.

Central Asia is no exception in terms of the climate change challenges that the region is facing, and the priority of green economy objectives is underlined by national policy frameworks, regional cooperation agendas, as well as the increasing vulnerability to climate-related risks. And yet, the literature on green economy in the region is rather scarce. The literature review revealed no research focusing specifically on corporate green economy practices inside the region although, as mentioned above, several empirical investigations encompassed Central Asian states in larger country samples. Some studies explored the relationship of environmental indicators with economic trends. For instance, Isiksal et al. (2022) studied the role of human capital in the relationship between natural resources, economic expansion, and CO2 in Central Asian countries. The authors argued that exploitation of natural resources would inflate emissions, and that raising environmental awareness would facilitate the positive impact of human capital on improving the environment. Ergasheva et al. (2023), focusing on ESG investment in Russia and Central Asian states, stressed the importance of green finance instruments in the region. Brunelli et al. (2022), examining environmental auditing in Central Asia, concluded the need for active elaboration and implementation of government enforcement and regulation towards environmental standards. The aim of this study, focusing on the green economy practices of firms in Georgia and Kyrgyzstan, is to contribute to better understanding the dynamics of private sector involvement in sustainable development efforts by providing a comparative analysis of the two countries – one from Central Asia and one from the Caucasus.

3. Green economy in Georgia and Kyrgyzstan

As in the majority of developing countries, green economy mechanisms in Georgia and Kyrgyzstan are not fully developed albeit existing national strategies and targets to achieve green economy objectives related to GHG emission reduction, green energy, and energy efficiency. In fact, Georgia's strategy on SME development comprises measures to mainstream environmental practices, as well as anticipates alignment with international standards in the long run. The overview of the green economy transition experiences of both target countries indicates prevalence of activities related to endorsing national strategies incorporating green economy targets and passing green legislation. Alongside with these, the countries have been taking active steps to introduce financial measures to support green investments,

encourage environmentally friendly business practices, and reduce cost barriers for firms transitioning to sustainable operations. Thus, following the post-COVID-19 period, the recovery plan in Georgia included green stimulus mechanisms and introduction of sustainable finance principles (OECD, 2022). In a similar vein, Kyrgyzstan's Green Economy Development Program envisages mechanisms to support the transition to an inclusive green economy, such as sustainable finance measures, fiscal stimuli, and sustainable public procurement. In particular, at the policy level, it is noted that climate change creates conditions for inequality among the population, including gender disparity in accessing labor market opportunities. This challenge underscores the importance of comprehensive actions to ensure a just transition in both target countrie (Government of Georgia, 2021; Ministry of Economy and Commerce of the Kyrgyz Republic).

The introduction of Environment, Social and Governance (ESG) standards represents one of the recent milestones in the realm of sustainable development goals (SDGs) within the region's financial sector. The National Bank of Georgia has drafted the ESG Reporting and Disclosure Principles and is publishing the Sustainable Finance Report (National bank of Georgia, 2024). The National Bank of Kyrgyzstan has likewise developed and adopted the roadmap for the implementation of ESG in the banking sector (24.kg, 2024). Along with this, targeted activities are taking place in several other economic sectors oriented towards low-carbon transition, such as clean energy, energy-efficient buildings, green transportation, etc. Although both countries' practices confirm the priority of SDGs in relevant strategic documents, data evidence suggests the need for urgent and active domestic measures to reduce emissions and increase energy efficiency. The production-based CO2 emissions index shows a strong increase, especially after 2010 (see Figure 1). The same indicator shows a declining trend for the European OECD countries. In most developing countries, improving public welfare requires ramping up production, including in the sectors which are intensive CO2 emitters. Meeting these sustainable development requirements – less pollution and higher incomes – necessitates the efficient use of energy resources. Yet, as shown in Figure 2, energy productivity in Georgia rapidly dropped after 2001 – most likely due to the increased reliance on energy-intensive sectors, outdated infrastructure, and limited efficiency measures, with a slight improvement only after 2020. The situation in Kyrgyzstan did not change substantially over the review period, with only a minor difference between the values in 2000 and in 2022. In contrast, the OECD group's curve indicates a long-term improvement in energy productivity. The stagnating trend in Georgia and Kyrgyzstan points to higher energy consumption for producing relatively smaller volumes of goods and services. Furthermore, it underlines the importance of rolling out energy-saving technologies in both the manufacturing and household sectors.

The latter is clearly demonstrated in Figure 3 – energy intensity per capita exhibits an analogous improving long-term trend for the OECD group, whereas in Georgia it shows rising intensity over the last decade, resulting in a value exceeding “one” (1). Despite some fluctuations, in Kyrgyzstan there is a small increase in energy intensity per capita in 2022 compared to the early 2000s.

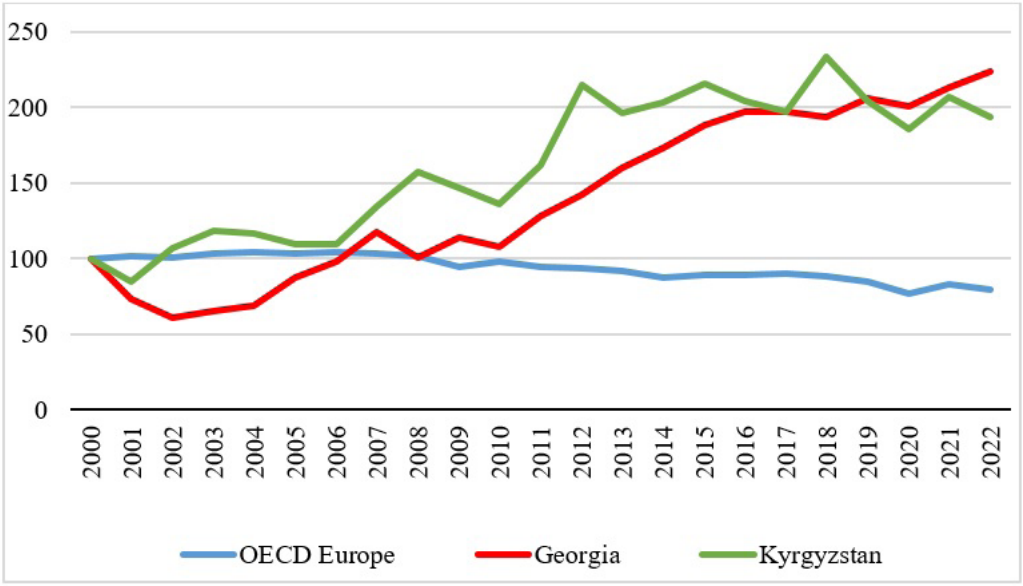

Figure 1. Production-based CO2 emissions (Index, 2000).

Source: OECD, 2022.

Figure 1 illustrates a significant upturn in production-related CO_2 emissions in Georgia and Kyrgyzstan, contrasting with a consistent decline in OECD Europe. This upward trend indicates an increase in the environmental externalities of industrial and energy-intensive sectors. These developments intensify the regulatory pressure on firms to implement cleaner production technologies, invest in emission-reducing innovations, and meet global standards in order to obtain green finance and access to export markets.

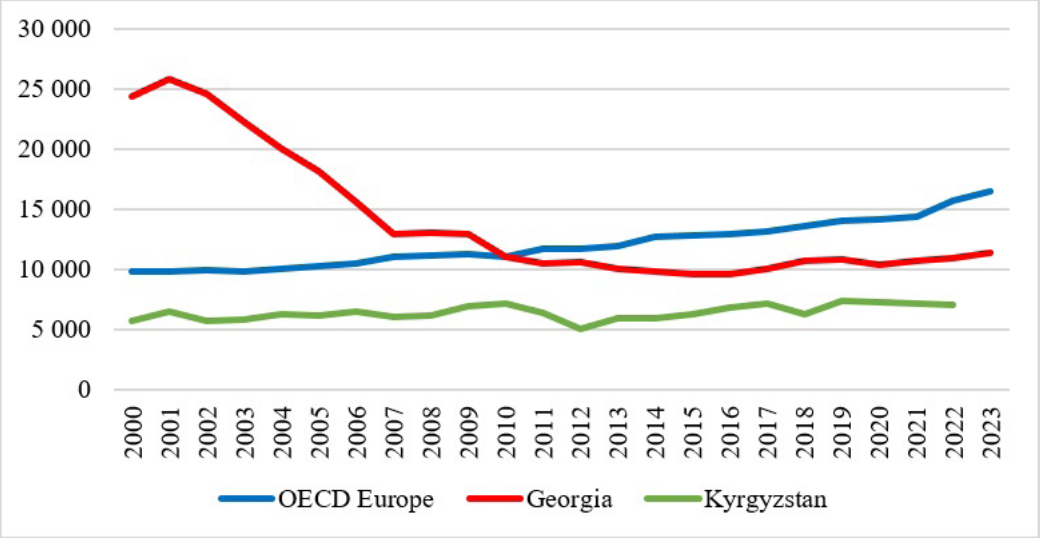

Figure 2. Energy productivity, GDP per unit of TES (US dollars per ton of oil equivalent, 2015).

Source: OECD, 2022.

As shown in Figure 2, the low and generally steady energy productivity in Georgia and Kyrgyzstan in recent years indicates that enterprises are producing comparatively less economic output per unit of energy utilized. Enhancing energy efficiency is essential for businesses aiming to reduce operational expenses and satisfy sustainability standards increasingly expected by investors and governments. This inefficiency may indicate outdated technologies and insufficient incentives for energy-efficient attempts.

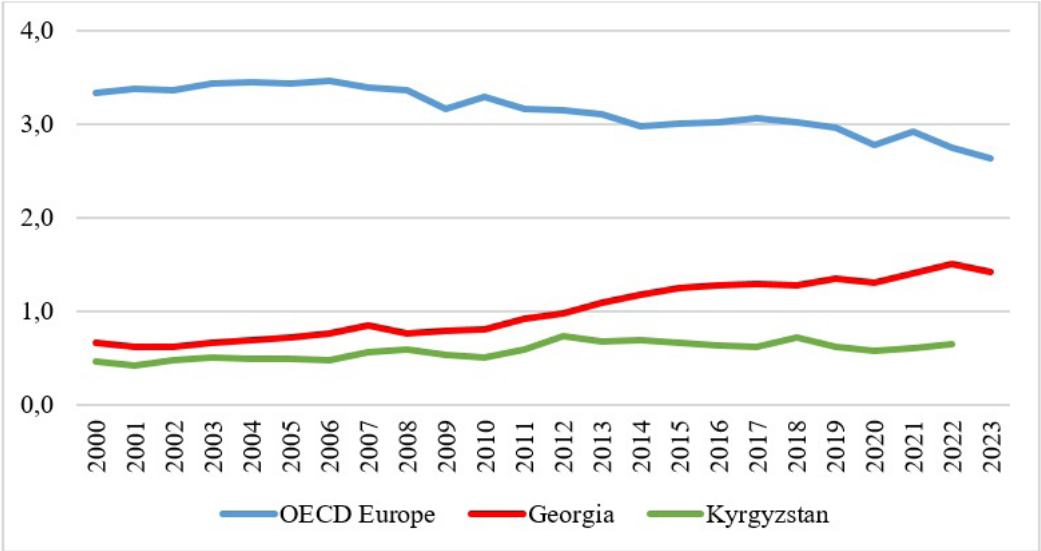

Figure 3. Energy intensity per capita (Tons of oil equivalent per person).

Source: OECD, 2022.

The notable rise in per capita energy consumption depicted in Figure 3 for both Georgia and Kyrgyzstan, especially evident in Georgia, shows a growing energy demand. The pattern indicates that firms experience crucial constraints, such as inadequate access to energy-efficient infrastructure and technologies. This situation highlights the importance of adopting energy-saving practices to allow businesses to maintain cost competitiveness while also complying with evolving environmental standards. Consequently, businesses are incentivized to adopt energy-saving practices and invest in modern and efficient technologies to maintain cost-effectiveness, as well as satisfy increasingly stringent environmental regulations.

These data indicate that carbon emissions are rapidly growing while energy productivity is falling, and the population consumes more energy in Georgia and Kyrgyzstan. Nevertheless, these developments do not distinguish between residential and production sectors' energy consumption and CO2 emissions. It is often argued that both households and enterprises play a role in these developments, but it is enterprises – as key economic growth drivers – that are expected to be more energy-efficient and emit less carbon dioxide. Green policies are a government priority, and both target governments have launched various measures to forge favorable conditions for a broader application of green economy practices among private sector actors by setting environmental standards via direct regulations and financial reporting norms. However, the relevant literature argues that beyond state regulatory efforts there are other important factors affecting the adoption of sustainable development practices by firms.

4. Methodology

4.1. Analytical approach

To investigate the determinants of environmental and energy management practices at the firm level, this study utilized a logistic regression (logit) model estimating the probability of adopting CO2 monitoring and energy management measures. The basic logistic regression model, exploring the linear relationship of explanatory covariates X with the predicted logit, is specified as follows (Pampel, 2020):

$$logit(p) = \mathrm{Ln}\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon$$

, where p represents the probability of a firm adopting a specified measure,

$X_1, X_2, \ldots, X_k$ denote the explanatory variables,

β_0 is the intercept term,

And ε represents the error term.

The coefficients $\beta_1, \beta_2, \ldots, \beta_k$ are estimated using maximum likelihood estimation procedures.

The calculations use two binary dependent variables. The first variable indicates whether a firm has monitored its CO2 emissions over the past three years. The value of “one” (1) denotes that the firm has engaged in CO2 monitoring, while “zero’ (0) indicates that it has not. The second dummy dependent variable indicates whether a firm has adopted energy management measures over the last three years to reduce emissions, waste, or pollution. The set of explanatory variables include various indicators related to corporate characteristics. A detailed description of the variables is given in Table I. The age of firm, or years since establishment, may have an important effect on sustainability practices. Older firms may have established frameworks and resources, yet might be more resistant to change, whereas younger firms may be more agile and open to innovation. Therefore, the effect of firm age might be nonlinear, and in order to incorporate this potential effect the square of the firm age is included among the explanatory variables (Karymshakov et al., 2019). Firm size is another potential important factor, as larger companies generally have more financial and operational capacities to implement environmental practices. They may also face greater regulatory scrutiny, pushing them to adopt sustainability measures. Conversely, smaller enterprises – while resource-constrained – may still adopt energy-efficient practices in a cost-effective manner.

The manager’s experience influences how firms approach sustainability. For instance, experienced managers are more likely to recognize the strategic value of environmental initiatives, drawing on a broad range of challenges and solutions in the process. Furthermore, manager’s gender can also shape firm’s environmental decisions – studies suggest that female managers tend to prioritize long-term sustainability goals, often driving more environmental actions (Ullah et al., 2022). Thus, the study team factored in both gender and experience of the top manager, measured as the number of years she/he has worked in the sector to which the firm belongs. As mentioned above, foreign market experience and connections with foreign partners significantly influence corporate performance. To approximate this potential effect, the calculations included two dummy variables. The first one indicates whether a firm is using a foreign-licensed technology, since the utilization of foreign-licensed technologies may have implications for technological and operational improvements, which could positively influence their environmental performance too. This variable can also reflect the degree of internationalization and competitiveness of a firm linked to a higher likelihood of adopting practices that align with sustainability standards. The second variable refers to whether a firm has a quality certification as a potential indicator of external standards effecting corporate environmental practices. Quality certifications signal a firm's commitment to high operational and environmental standards, driving them to adopt best practices, including energy management and CO2 monitoring. Companies with certifications such as ISO14001

or ISO50001 are likely to already have environmental management systems in place, making them more fit for engaging in sustainable practices (Frondel et al., 2018). Enterprises, following their profit maximizing behavior, may simply adopt energy-saving measures due to the higher costs of energy consumption for their production activities. High electricity costs create a strong economic incentive for businesses to adopt energy-saving measures, reduce consumption, and comply with environmental regulations. Therefore, in the estimations the study team considers the electricity cost ratio, which helps to explore the influence of operational costs on corporate sustainability practices, i.e. offering insights into how economic pressures stimulate the adoption of energy management and environmental monitoring systems.

The financial resources that firms may use represent one of the fundamental factors for sustainable practices. In this study, the corporate financial potential is based on the indicator of whether a firm has a credit line or loan. Enterprises with access to loans can more easily fund the technologies and processes needed for sustainability initiatives. Apart from the internal firm characteristics, the sectors of the economy where firms operate may demonstrate varying performance in response to environmental changes due to both internal characteristics and different regulatory and operational requirements. Businesses in high-emission sectors, such as manufacturing in general, are more likely to face these regulations. In the empirical model, companies are classified as per four main sectors of the economy: food, non-food manufacturing, trade, and services.

Table I. Description of variables (World Bank, n.d.).

Variable	Description
Dependent variables:	
CO2 monitoring	1 – firm has monitored its CO2 emissions over the last three years, 0 – otherwise
Energy management adoption	1 – firm has adopted energy management measures to reduce emissions, waste, or pollution in the last three years, 0 – otherwise
Explanatory variables:	
Firm age	Number of years from the year that firm began operations to 2023
Squared firm age	Square of the firm age
Manager experience	Number of years of experience of the top manager in the sector
Female manager	1 – top manager is female, 0 – otherwise
Capital city	1 – firm is located in the capital city, 0 – otherwise
Electricity cost ratio	Percentage share of the firm's total annual electricity cost relative to total annual sales in 2022
International certification	1 – firm has an internationally recognized quality certification, 0 – otherwise

Table I. Cont.

Foreign technology	1 – firm uses technology licensed from a foreign-owned company (excluding office software), 0 – otherwise
Access to finance	1 – firm has a line of credit or loan from a financial institution, 0 – otherwise
Firm size	1 – small firm, 2 – medium-sized firm, 3 – large firm (based on the number of employees: small = 5-19, medium = 20-99, large = 100 or more)
Firm sector	1 – food, beverages, and tobacco; 2 – manufacturing; 3 – trade and wholesale; 4 – services
Country	1 – Georgia; 2 – Kyrgyz Republic

4.2. Data source

This study has utilized the firm-level data from the 2023 World Bank Enterprise Surveys (WBES) for Georgia and the Kyrgyzstan. The survey dataset includes corporate characteristics including innovation, access to finance, corruption, infrastructure, energy, business-government relations, barriers to growth, and performance indicators. Notably, the 2023 WBES includes the Green Economy Module, which assesses firms' adoption of sustainable practices and climate change mitigation measures. For this analysis, the datasets for Georgia and the Kyrgyz Republic were merged based on the variables specified in the empirical models. The resulting combined dataset comprised 946 firms, including 592 from Georgia and 354 from Kyrgyzstan. This dataset represents the most recent information available for these countries, offering a valid perspective on sustainability practices at the firm level. The dataset includes responses from businesses operating in diverse industries, providing information on corporate characteristics, managerial attributes, financial access, and technological capabilities.

Table II provides descriptive statistics for the total sample, as well as the breakdown by country. On average, 22% of companies in the total sample monitor their CO2 emissions, with Georgia demonstrating a higher percentage compared to Kyrgyzstan. Georgia also demonstrates a higher share of energy management adoption than the Kyrgyz Republic. These differences may reflect regional variations in environmental awareness or regulatory pressure, which could influence corporate sustainability practices. The average firm age in Kyrgyzstan is 19.5 years and 12.7 years in Georgia, suggesting the former having a higher proportion of enterprises with longer years since establishment.

Enterprises across the two target countries do not show large variation in their managerial characteristics – managerial experience is almost similar, with slightly more experienced managers in Kyrgyzstan. Female managers make up 20.5% of the

total sample, with a higher percentage in Georgia, which could indicate domestic gender dynamics in leadership positions between the examined countries.

The location of businesses also varies, with the concentration of firms in the capital city higher in Kyrgyzstan. Additionally, companies in Kyrgyzstan, on average, have a slightly higher electricity cost ratio than these in Georgia, which might encourage the adoption of more energy-efficient practices. Finally, the data for Georgia exhibits a notably higher proportion of companies with quality certifications and access to credit, potentially linked to greater international exposure or stronger integration into global markets. These factors could facilitate the adoption of sustainability measures, such as CO2 monitoring and energy management.

Table II. Descriptive statistics.

Variable	Total sample	Georgia	Kyrgyz Republic
Number of observations	946	592	354
Dependent Variables			
CO2 monitoring (% of firms)	22.30	24.80	18.10
Energy management adoption (% of firms)	27.10	28.00	25.40
Explanatory Variables			
Firm age (years)	15.23	12.67	19.50
Squared firm age	344.30	227.10	539.70
Manager experience (years)	18.21	17.65	19.12
Firms managed by female (% of firms)	20.50	21.60	18.60
Firms located in capital city (% of firms)	41.40	38.20	46.90
Electricity cost ratio (% of total sales)	3.80	3.70	4.00
Firms using foreign technology (% of firms)	16.40	16.20	16.70
Firms having quality certificates (% of firms)	18.40	23.00	10.70
Firms having line of credit or loan (% of firms)	45.90	57.10	27.20
firm size			
Small (% of firms)	49.30	50.70	46.90
Medium (% of firms)	33.40	30.20	38.70
Large (% of firms)	17.30	19.10	14.40

Table II. Cont.

firm sector			
Food, beverages, and tobacco (% of firms)	17.90	21.80	11.30
Manufacturing (% of firms)	23.40	15.90	35.90
Trade and wholesale (% of firms)	24.50	27.20	20.10
Services (% of firms)	34.20	35.10	32.80

Authors' calculations based on the enterprise surveys data (World Bank, n.d.).

5. Estimation results

To account for potential differences between the target countries, the analysis was conducted separately for the total sample and for the subsamples of Georgia and Kyrgyzstan. These models were estimated with robust standard errors to address potential heteroscedasticity. Table III presents the average marginal effects from the logit models analyzing the probability of firms adopting CO2 monitoring. Firm age demonstrates a significant negative effect on the likelihood of implementing CO2 monitoring in the total sample, suggesting that older firms are less likely to adopt such practices. However, the squared term is positive and significant, indicating a potential U-shaped relationship – i.e. that very mature companies might eventually adopt these practices. Yet, this relationship is not statistically significant in the individual country sample estimations.

Firms located in capital cities are significantly less likely to monitor CO2 emissions across all models. This finding is contradictory to the general expectation, as urban areas typically have stricter regulations. One possible explanation may be that enterprises in capital cities may prioritize other competitive pressures or rely on existing infrastructure and services, potentially leading to less focus on independent environmental initiatives. Another possible explanation could be related to market dynamics and customer demands. Urban businesses might operate in highly competitive environments, where immediate profitability and operational efficiency are prioritized over long-term sustainability practices. In addition, such companies might rely more on service-based industries, which generally have lower direct emissions and may not feel the same urgency to deploy CO2 monitoring as these operating in emission-intensive sectors typically located outside the capital city.

Table III. Estimation results for logit models on the probability of adopting CO2 monitoring (marginal effects).

	Total sample	Georgia	Kyrgyz Republic
Firm age	-0.00674** (0.00341)	-0.00654 (0.00581)	-0.00671 (0.00506)
Squared firm age	0.000118** (0.0000545	0.000139 (0.000131)	0.000110 (0.0000683)
Capital city	-0.147*** (0.0345)	-0.195*** (0.0448)	-0.0864* (0.0518)
Manager experience	0.00162 (0.00147)	-0.00106 (0.00195)	0.00655*** (0.00237)
Female manager	-0.0204 (0.0367)	-0.0249 (0.0452)	-0.0287 (0.0588)
Access to finance	0.0121 (0.0318)	-0.0410 (0.0379)	0.0914** (0.0452)
Foreign technology	0.0680* (0.0358)	0.0515 (0.0468)	0.0792 (0.0524)
International certification	0.0837** (0.0348)	0.0930** (0.0426)	0.00974 (0.0751)
Electricity cost ratio	0.493** (0.193)	0.232 (0.280)	0.718*** (0.243)
Firm size (small – reference category)			
Medium	0.0812** (0.0317)	0.0769* (0.0429)	0.102** (0.0496)
Large	0.203*** (0.0473)	0.223*** (0.0491)	0.165** (0.0651)
Firm sector (food, beverages, and tobacco – reference category)			
Manufacturing	-0.0524 (0.0484)	-0.0900 (0.0573)	0.0588 (0.0670)
Trade and wholesale	-0.143*** (0.0487)	-0.221*** (0.0576)	0.0615 (0.0774)
Services	-0.0927** (0.0448)	-0.0883* (0.0471)	-0.0625 (0.0743)
Country	+	+	+
Number of observations	802	512	290
Pseudo r-squared	0.122	0.134	0.180

Standard errors are in parentheses. ***, **, and * indicate statistical significance of 1%, 5%, and 10%, respectively. Authors' calculations based on the enterprise surveys data (World Bank, n.d.).

The lack of a significant effect of managerial experience in the total sample might indicate that CO2 monitoring is influenced more by external factors – such as regulatory pressures, market demands, or financial resources – than by the expertise of the top manager. However, the positive and significant effect in the Kyrgyz Republic suggests that experienced managers may be better at leveraging environmental practices, navigating regulatory requirements, or securing sustainability-focused resources from financial institutions.

Access to credit or loans is positively associated with the monitoring of CO2 emissions in Kyrgyzstan, which may reflect more robust environmental standards on behalf of financial institutions in the country compared to Georgia. Banks and other financial institutions can require borrowers to adopt environmentally sustainable measures as a condition for financing. This suggests that access to finance is an effective tool to incentivize businesses to engage in CO2 monitoring and other green practices. The use of foreign-licensed technology is positively associated with CO2 monitoring in the total sample, indicating that firms adopting advanced foreign technologies are more likely to engage in environmental practices like CO2 monitoring. Yet, this relationship is not significant in the country-specific models, suggesting that the effect may be driven by broader trends that do not hold consistently across individual countries. On the opposite, companies possessing international quality certifications are significantly more likely to adopt CO2 monitoring, particularly in Georgia. This finding confirms the expectation that certification such as ISO14001 reinforces corporate commitment to environmental standards and encourages the implementation of sustainable practices. In Georgia, the emphasis on international certifications may be more prominent, driving businesses toward adherence to global environmental practices due to the country's strategic approach to integrating with EU standards. These results are consistent with previous studies (Sam & Song, 2022; Arocena et al., 2021; Hu et al., 2024) that also revealed a positive association between the adoption of international quality certifications and improvements in corporate environmental performance, including co_2 emission monitoring and reduction.

Estimation results show that operational cost pressures related to electricity drive firms to adopt CO2 monitoring practices. A higher electricity cost ratio significantly increases the likelihood of businesses in Kyrgyzstan adopting measures to monitor CO2, highlighting that enterprises facing greater energy-related expenses are more motivated to implement sustainability measures to reduce operational burden. Firm size is one of the important factors in explaining business performance. This finding aligns with previous studies that indicate that increased energy prices result in better energy use and lower CO2 emissions by companies (Brucal & Dechezleprêtre, 2021).

Estimation results likewise indicate that mid-size and large firms are significantly more likely to adopt CO2 monitoring practices compared to small enterprises. This effect is consistent across all samples and indicates that larger firms are better equipped to allocate resources toward sustainability initiatives. They may also have more complex operations necessitating greater attention to environmental impacts. At the same time, these findings reflect the potential difficulties for small and even some medium-sized enterprises in meeting sustainable development requirements. This result matches prior studies showing that larger companies are

more likely to adopt environmental practices (Reis et al. 2020; Bodjongo et al., 2023; Ali & Singh, 2024). Finally, firm sector analysis reveals that these working in the trade, wholesale and service sectors are less likely to implement CO2 monitoring, particularly in Georgia, compared to these in the food, beverages, and tobacco sector. This could reflect sector-specific differences in environmental awareness, regulation, or perceived benefits of CO2 monitoring, with some industries potentially facing fewer external pressures to engage in sustainability practices. Interestingly, the estimations based on Kyrgyzstan's sample do not demonstrate any significance by economic sectors, which may imply that enterprises are adopting green practices as measured by CO2 monitoring and energy management measures universally, without any sectoral differences. The factors affecting corporate energy-consuming behavior can differ between countries, sectors, or firm characteristics. Table IV presents the average marginal effects from the logit models on the probability of adopting energy management practices. For reference, the corresponding logit coefficients are reported in the Appendix.

Table IV. Estimation results for logit models. On the probability of energy management adoption (marginal effects).

	Total sample	Georgia	Kyrgyz Republic
Firm age	-0.00886** (0.00363)	-0.0192*** (0.00578)	-0.00177 (0.00555)
Squared firm age	0.000115** (0.0000571)	0.000389*** (0.000121)	0.0000121 (0.0000745)
Capital city	-0.0979*** (0.0344)	-0.164*** (0.0433)	-0.0149 (0.0547)
Manager experience	0.00209 (0.00156)	0.000389 (0.00191)	0.00421 (0.00280)
Female manager	-0.0636 (0.0407)	-0.0977** (0.0474)	0.00962 (0.0651)
Access to finance	0.0502 (0.0337)	0.0194 (0.0398)	0.0920* (0.0535)
Foreign technology	0.0450 (0.0407)	0.0295 (0.0527)	0.0728 (0.0632)
International certification	0.0662* (0.0383)	0.0854* (0.0448)	-0.136 (0.101)
Electricity cost ratio	0.332* (0.177)	-0.0678 (0.307)	0.587** (0.254)
Firm size (small – reference category)			
Medium	0.0706** (0.0349)	0.118*** (0.0435)	0.0178 (0.0562)
Large	0.169*** (0.0513)	0.175*** (0.0576)	0.226*** (0.0729)

Table IV. Cont.

Firm sector (food, beverages, and tobacco – reference category)			
Manufacturing	-0.000382 (0.0534)	0.000716 (0.0615)	0.0654 (0.0789)
Trade and wholesale	-0.164*** (0.0494)	-0.202*** (0.0598)	-0.0434 (0.0935)
Services	-0.0699 (0.0480)	-0.0429 (0.0510)	-0.0697 (0.0842)
Country	+		
Number of observations	802	512	290
Pseudo r-squared	0.0839	0.122	0.109

Standard errors are in parentheses. *, **, and * indicate statistical significance of 1%, 5%, and 10%, respectively. Authors' calculations based on the enterprise surveys data (World Bank, n.d.).

In the total sample, firm age shows a significant negative affect on the adoption of energy management practices. However, the positive and significant squared term for firm age suggests a potential U-shaped relationship. Thus, businesses do not consider energy management as a priority within a few years since establishment, but after some time – becoming more mature – companies may eventually implement energy management practices. Nevertheless, this trend is statistically significant in the sample of Georgia only. Businesses located in capital cities are generally less likely to adopt energy management practices, and this result is consistent across the total sample and in Georgia. The negative effect is especially strong in Georgia, where enterprises operating in the capital city are significantly less likely to implement energy management practices. In the Kyrgyz Republic, however, the effect is not significant, indicating that location plays a more substantial role in the former than in the latter. There is no significant relationship between managerial experience and adoption of energy management practices in any of the country models. Additionally, the presence of a female manager does not significantly influence the likelihood of adopting energy management practices in the total sample. Yet, in Georgia, businesses with female managers are less likely to implement energy management practices, suggesting that gender dynamics may influence decision-making processes in this country. Access to finance is positively associated with the adoption of energy management practices in both the total sample and Kyrgyzstan. Therefore, it can be argued that financial resources – potentially from international financial organizations or green financing initiatives – play a crucial role in facilitating the adoption of energy management practices. These findings are consistent with prior studies (Iram and Zhang, 2022; Zhou et al.,2022; Bouchmel et al., 2024) that highlight positive impacts

of better access to finance on investments in energy-efficient technologies. These findings underline the key role of financial access in enabling energy management practices. The use of foreign-licensed technology does not have a significant impact on the adoption of energy management practices, either in the total sample or in the country-specific models for Georgia and Kyrgyzstan. Analogous to CO2 monitoring estimations, businesses with international quality certifications in the total sample and in Georgia are more likely to adopt energy management practices. These results align with prior research (Laskurain et al., 2017; Arocena et al., 2021; Otrachshenko et al., 2023), which also report a positive correlation between international quality system certifications and improvements in corporate environmental performance, including energy management. To an extent, this could reflect institutional differences between the two target countries. The electricity cost ratio is positively associated with energy management adoption in the total sample, with a particularly strong effect in the Kyrgyz Republic. Firms with higher electricity costs are more keen to adopt energy management practices to reduce operational expenses. This effect is statistically significant in Kyrgyzstan, where high energy costs likely drive companies to implement measures enhancing their energy efficiency and reducing costs. In Georgia, the effect is negative but not statistically significant. The positive relationship between higher electricity costs and the likelihood of adopting energy management practices is similar to previous studies (Kök et al.,2016; Naimoglu, 2023), which argue that higher energy prices incentivize enterprises to improve energy efficiency.

Larger companies are more apt to adopt energy management practices compared to smaller entities, and this effect holds consistently across all samples. Both medium and large enterprises are significantly more likely to adopt energy management practices than small ones, perhaps due to greater resources required for sustainability initiatives and deploying energy management systems. Firms in the trade and wholesale sector are significantly less inclined to adopt energy management practices than these in the food sector, especially in Georgia. In Kyrgyzstan, sectoral differences are not statistically significant, suggesting that sector-specific factors have a limited impact on adoption.

6. Conclusions

This study has investigated the factors affecting corporate green economy practices in Georgia and the Kyrgyz Republic using the most recent World Bank's enterprise survey dataset. Green economy practices were measured by whether firms adopted CO2 monitoring and energy management measures. To explore the determinants of environmental and energy management practices at the firm

level in the two target countries, the empirical approach was based on a logistic regression model. The study findings suggest that along with corporate managerial characteristics, access to finance, foreign technology, international certification and energy costs are important for green economy practices by businesses. Enterprises with a broader financial access demonstrate a higher probability of implementing sustainable development practices, and these facing higher energy costs are inclined to introduce energy management measures. On the one hand, this effect is in line with the corresponding previous literature on corporate behavior, yet it does not indicate intrinsic motivation among companies for sustainable development, but can be rather explained as a cost-reducing approach for profit maximizing. On the other hand, the effect of foreign economic mechanisms significantly influences the adoption of green economy practices through foreign technology and international certification. Moreover, these effects vary by firm size, with larger enterprises display positive trends in adopting CO2 monitoring and energy management measures.

One potential limitation of this study is that the authors did not fully address the possible endogeneity. Efficient dealing with the issue requires more data and information both at the firm level and about local context. Moreover, given the cross-sectional data used in the study, an additional analysis of time-varying corporate characteristics – that might be important for their green economy practices – may be necessary. Future research entailing longitudinal data analysis may provide more insights on the corporate behavior dynamics in the target countries.

The study's empirical findings have several policy implications. First, promotion of sustainable development practices depends on a country-specific context. The comparison of results between Georgia and Kyrgyzstan points to potential positive effects of the internationalization of economic dynamics on green economy practices. International standards for environmental protection and SDGs expressed in financial system standards can be an effective tool. From this standpoint, ESG and other loan requirements in the financial system of Central Asian economies manifest an efficient instrument for stimulating enterprises towards green economy.

Second, though environmental regulations set by governments are not clearly specified in this study's empirical model, they represent the most direct state policy tool. Efficient application of state regulatory measures may inaugurate conditions for businesses to embrace green economy practices.

Third, dealing with environmental regulations and adopting new technologies or measures are costly for enterprises in emerging economies, especially for medium and small operators. Lack of managerial capacity and financial resources to meet environmental standards may create a significant burden for such companies. Government policies on green economy transition should therefore account for a potential differentiated support based on firm size. Specifically, smaller businesses

may require more financial assistance or fiscal relief to offset the high costs associated with adopting green measures. This suggests that state policies should offer targeted financial support for smaller entities, such as loans under favorable conditions or fiscal relief measures, rather than providing uniform assistance across all firm sizes. Larger companies may still require support, but it might be at a lesser level compared to smaller entities.

Fourth, the cost of energy can be an effective tool for forcing enterprises to take effective energy management measures. However, high energy cost may have a negative effect on the production potential of the private sector. Along with energy management enforcement mechanisms, it is important to promote the use of alternative energy resources. In addition, higher energy consumption intensity in both target countries flags residential energy consumption as an important focus of energy saving strategies.

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Appendix

Table a1. Estimation results for logit models on the probability of adopting co2 monitoring (estimated coefficients).

	Total sample	Georgia	Kyrgyz Republic
Firm age	-0.0429** (0.0217)	-0.0399 (0.0353)	-0.0524 (0.0400)
Squared firm age	0.0007** (0.0004)	0.0008 (0.0008)	0.0009 (0.0005)
Capital city	-0.938*** (0.229)	-1.186*** (0.293)	-0.674* (0.407)
Manager experience	0.0103 (0.009)	-0.0065 (0.012)	0.051*** (0.0191)
Female manager	-0.130 (0.233)	-0.152 (0.275)	-0.224 (0.456)
Access to finance	0.0773 (0.202)	-0.250 (0.232)	0.713** (0.354)
Foreign technology	0.433* (0.230)	-0.250 (0.232)	0.618 (0.416)
International certification	0.533** (0.224)	0.567** (0.263)	0.0760 (0.586)
Electricity cost ratio	3.135** (1.230)	1.414 (1.702)	5.598*** (1.965)
Firm size (small – reference category)			
Medium	0.536*** (0.208)	0.469* (0.262)	0.798** (0.388)
Large	1.182*** (0.264)	1.358*** (0.321)	1.291** (0.527)
Firm sector (food, beverages, and tobacco – reference category)			
Manufacturing	-0.290 (0.265)	-0.548 (0.352)	0.458 (0.526)
Trade and wholesale	-0.897*** (0.309)	-1.346*** (0.366)	0.480 (0.607)
Services	-0.539** (0.252)	-0.538* (0.289)	-0.488 (0.581)
Country	+		
Constant	-0.923** (0.368)	-0.225 (0.440)	-2.989*** (0.750)
Number of observations	802	512	290
Pseudo r-squared	0.122	0.134	0.180

Notes: Standard errors are in parentheses. ***, **, and * indicate statistical significance of 1%, 5%, and 10%, respectively.

Source: World Bank, 2024.

Table a2. Estimation results for logit models on the probability of energy management adoption (estimated coefficients).

	Total Sample	Georgia	Kyrgyz Republic
Firm age	-0.049** (0.020)	-0.110*** (0.034)	-0.0107 (0.034)
Squared firm age	0.0006** (0.0003)	0.002*** (0.0007)	0.00007 (0.0005)
Capital city	-0.543*** (0.195)	-0.935*** (0.262)	-0.0902 (0.331)
Manager experience	0.012 (0.009)	0.002 (0.011)	0.025 (0.017)
Female manager	-0.353 (0.227)	-0.557** (0.271)	0.0581 (0.393)
Access to finance	0.279 (0.187)	0.111 (0.227)	0.555* (0.327)
Foreign technology	0.250 (0.226)	0.168 (0.301)	0.439 (0.385)
International certification	0.368* (0.214)	0.487* (0.259)	-0.822 (0.618)
Electricity cost ratio	1.840* (0.990)	-0.387 (1.751)	3.540** (1.576)
Firm size (Small – reference category)			
Medium	0.401** (0.197)	0.673*** (0.253)	0.107 (0.339)
Large	0.880*** (0.258)	0.998*** (0.338)	1.364*** (0.470)
Firm sector (Food, Beverages, and Tobacco – reference category)			
Manufacturing	-0.002 (0.258)	0.004 (0.351)	0.395 (0.478)
Trade and Wholesale	-0.951*** (0.287)	-1.153*** (0.348)	-0.262 (0.563)
Services	-0.359 (0.241)	-0.245 (0.291)	-0.421 (0.509)
Country	+		
Constant	-0.750** (0.333)	0.0188 (0.414)	-1.959*** (0.638)
Number of observations	802	512	290
Pseudo R-squared	0.0839	0.122	0.109