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Impact of green supply chain management on competitiveness and performance: a case study of Ghana's renewable energy sector

Wpływ zielonego zarządzania łańcuchem dostaw na konkurencyjność i wydajność: studium przypadku sektora energii odnawialnej w Ghanie

Abstract. Green supply chain management (GSCM) is emerging as a key driver in Ghana's renewable energy sector, yet its impact on firms' performance remains underexplored. This study aimed to assess the effect of GSCM practices on the competitiveness and financial performance of five leading firms in the sector. A quantitative, explanatory research design was employed, using linear regression analysis on annual report data from 2019 to 2023, analyzed with SPSS (v.26). The findings show that practices such as reverse logistics, organic sourcing, and investment in solar energy significantly enhance profitability (+26.8%, +17.7%, and +17.2%, respectively). However, high initial costs hinder broader adoption. The study recommends government support through tax incentives to accelerate the growth of GSCM and contribute to Ghana's low-carbon development goals.

Keywords: supply chain management, green supply chain management, renewable energy, performance and competitiveness

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Synopsis. Zielony łańcuch dostaw (GSCM) staje się istotnym czynnikiem rozwoju sektora energii odnawialnej w Ghanie, jednak jego wpływ na wyniki przedsiębiorstw jest wciąż niedostatecznie zbadany. Celem niniejszej analizy było określenie wpływu praktyk GSCM na konkurencyjność oraz wyniki finansowe pięciu czołowych firm tego sektora. Zastosowano ilościowe podejście badawcze oraz analizę regresji liniowej na podstawie danych pochodzących z raportów rocznych z lat 2019–2023, z wykorzystaniem oprogramowania SPSS (v.26). Wyniki wskazują, że działania, takie jak logistyka zwrotna, organiczne zaopatrzenie i inwestycje w energię słoneczną, pozytywnie wpływają na rentowność firm (odpowiednio: +26,8%, +17,7%, +17,2%). Wysokie koszty początkowe ograniczają jednak tempo wdrażania GSCM. Rekomenduje się wprowadzenie ulg podatkowych i innych zachęt inwestycyjnych w celu wsparcia transformacji energetycznej i redukcji emisji gazów cieplarnianych (GHG) w Ghanie.

Słowa kluczowe: zarządzanie łańcuchem dostaw, zielone zarządzanie łańcuchem dostaw, energia odnawialna, wydajność i konkurencyjność

JEL codes: Q42, Q56, M11, L25, O13

Introduction

Green supply chain management is conceptualized as the strategic incorporation and achievement of a firm's social, environmental and economic goals in the systematic coordination of a key inter-organizational business process that seeks to improve the long-term performance of the traditional supply chain scheme of the firm [Vangeri et al. 2024]. The drive to mitigate human-induced contributions to climate change has been the major facilitator of growth in the renewable energy sector across the globe. Thus, several firms are relying on the renewable energy sector to improve their carbon footprint and performance through investment in green and eco-friendly energies such as solar, wind, hydro, biofuels, etc. [Al-Masri & Wimanda 2024]. Ghana's renewable energy sector is no different from the global scenario [Osei-Mensah et al. 2024]. The renewable energy sector in Ghana has progressively focused on diversifying the country's energy mix through investments in energy sources such as hydro, solar and biofuels. Renewable energy is generally harvested from natural sources that are able to replenish themselves faster than the rate at which they are consumed. The renewable energy sector in Ghana is largely dominated by solar energy. Thus, government and private investors have overly focused on pushing nearly 80% of their investments into solar energy to drive the country's transitional goal on green energy [Fumey et al. 2024, Osei-Mensah et al. 2024]. The ultimate goal of this investment drive is to reduce the country's reliance on fossil fuels in productive sectors. While the investment drive in the renewable energy sector in Ghana has increased, research has not properly captured the nexus between industries' appetite for green supply chain management and performance, and the competitiveness of the renewable energy sector in Ghana [Fumey et al. 2024, Osei-Mensah et al. 2024]. Thus, the relationship between green supply chain management and competitiveness, and the performance of renewable energy sector firms has not been well grounded in the literature.

Purpose of study

This study therefore sought to investigate the effect of supply chain management practices on the financial performance and competitiveness of five renewable energy sector firms in Ghana between 2020 and 2024. In addressing the research objectives, the study set out two statistical hypotheses:

H1: There is a positive relationship between green supply chain management and the financial performance (net profit margins) of renewable energy firms.

H2: There is a positive relationship between green supply chain management and the competitiveness of renewable energy firms.

Green supply chain management focuses on integrating interest in environmental preservation into supply chain activities [Kipkoech et al. 2024]. Despite several efforts to place the concept of responsible business models at the heart of supply chain functions, several firms tend to overlook the long-term financial benefits and competitive drive that investing in green supply chain management brings [Nyasapoh et al. 2022, Gyimah et al. 2022, Fumey et al. 2024, Osei-Mensah et al. 2024]. Thus, the initial investment cost in renewable energies as part of supply chain functions induces a level of fear and uncertainty in firms. The lack of research in this area has added fuel to the uncertainty that undermines investment in green energy in Ghana. Justifiably, this research not only resolves a theoretical gap but also provides evidence-based findings that project the short- and long-term benefits of green supply chain management in the area of green energy investment. The findings of this study provide motivation to firms on the need to accelerate the integration of renewable energies as part of their green supply chain practices and investments. From the national perspective, it is anticipated that accelerated investment in green energies through higher investment in green supply chain management will increase the country's emission performance and global contribution to climate change mitigation actions.

The study relied on assumptions from the stakeholders' and institutional theories that explain why renewable energy sector firms implement green supply chain management practices based on pressure from government and customers, as well as institutional commitment toward environmental aspects of the United Nations sustainable development goals. The study relied on the quantitative research method and an explanatory research design through the application of numerical data and statistical models that were able to explain the statistical effect of various green supply chain management practices on the financial performance and competitiveness of renewable energy sector firms. The study was structured into four different sections: introduction, review of concepts such as supply chain management, green supply chain management, firms' performance and competitiveness theoretical perspectives, research methodology; results, and discussions and conclusions.

Supply chain management

Supply chain management (SCM) is described as multifaceted, complex and interdisciplinary since the concept is applied in almost every academic discipline and its related industries or businesses. Chen et al. [2024] described supply chain management as the organization's business function that creates a viable and efficient channel for obtaining

or acquiring logistics, information, products and services through an end-to-end system. According to Chen et al. [2024], supply chain management focuses on feeding the firm's productive departments with information and logistics as well as getting the finished goods and services delivered to customers. Thomas et al. [2024], therefore, describe supply chain management as an end-to-end system that ensures the inflow of information and logistics to the organization for production and the outflow of products and services to the consumer, either directly or through third party agents. While several definitions of supply chain management exist in the literature, this current study relies on the comprehensive definition proposed by Handfield and Nicholas [1999], who defined supply chain management as a set of strategic approaches utilized efficiently to integrate suppliers, manufactures, producers, stores, warehouse and other departments of the organization such that goods and merchandise produced are in their right quantities, timely, and in the right location, to minimize the unit cost of production while satisfying the needs of customers.

Essentially, supply chain management is described as the parallel management and coordination of a more complex system that involves many processes that aim at providing consumers with quality products and services in a more cost-efficient manner [Boyer 2024]. According to Boyer [2024], the process of supply chain management begins with the procurement or sourcing of raw materials, capital-intensive logistics, spares and parts, through the conversion of the resources into goods and services, to supplying the finished goods to consumers. In the view of Luzzini et al. [2024], the logistics and supply chain department coordinates with the production unit to ensure that quality products and services are supplied to the consumer through an efficient distribution channel. Distribution as a primary function of supply chain management explains the process of delivering the finished goods and services to the consumer, either through a direct delivery mechanism or through third-party agents [Richey et al. 2022]. The task of distribution is made up of transportation, stores and warehousing of finished goods. According to Chen et al. [2024], the task of distribution can also assist the organization by minimizing and saving costs if effective and timely mechanisms are deployed to enhance the delivery of services to the end-users. The financial aspect of supply chain management has over the years gained attention since it allows the organization to assess its true profitability and viability. Thomas et al. [2024] describe this function as the assessment of the input cost against the output cost in the supply chain system. The focus of this function is to ensure that all supply chain activities of the organization are converted to create sustainable monetary value for the organization.

Green supply chain management

The green supply chain has become an integral aspect of traditional supply chain management over the last two decades; focusing on the integration of environmentally friendly and responsible practices through the supply chain functions of firms [Vangeri et al. 2024]. The concept reflects firms' commitments to adopting environmentally friendly principles in their procurement of raw materials, production, distribution and end-of--life product management with the ultimate aim of improving their environmental score and performance [Kamra et al. 2024]. Environmental performance in this context focuses on waste reduction, responsible consumption, reverse logistics and minimizing pollution

through the supply chain cycle [Nozari 2024]. Key aspects of green supply chain management include green procurement, which reflects the selection of suppliers based on their environmental performance and footprint in areas of waste management, energy efficiency, emission rate and eco-friendly products and services. Supplier involvement is a key aspect of green supply chain management. It explains an integrated approach where organizations ensure that their suppliers adhere to the principles of sustainability. According to Tsai et al. [2025], organizations rely on the expertise of other companies, which are referred to as professional service firms. These firms supply third-party services to augment the supply chain systems of the principal companies [Saini et al. 2023]. In the business environment, these professional service providers provide transportation services, energy products and services, packaging, warehousing, supply of raw materials and support services such as cleaning and janitorial services, maintenance among others [Hosain & Mustafi 2024]. Organizations that position the concept of sustainability in the business strategy will ensure that their third-party suppliers adhere to the principles of sustainability in their service delivery [Nozari 2024]. For example, companies that are aligned toward green or renewable energies will always rely on the services of renewable energy sector firms to drive their investments, and the procurement of renewable energies to enhance their production and distribution of products and services.

Renewable energy sector in Ghana

Renewable energy is gaining ground in Ghana, with investment in the sector reaching 300 billion US dollars in 2024 [Kipkoech et al. 2024]. As part of its drive to improve the carbon footprint and sustainability performance of the economy, Ghana is making great strides in terms of investments in solar energy and biofuels. Ghana's renewable energy sector comprises firms that specialize in the provision of biomass energy, hydropower, solar energy, biogas, biofuels and wind power [Gyimah et al. 2022]. Solar energy and biofuels are among the top two tiers of Ghana' renewable energy sector, with these two areas accounting for more than 80% of the sector's total investment [Nyasapoh et al. 2022]. Ghana's strategic location gives the country very good exposure to solar radiation, making investments in solar energy production very viable. The total output of solar energy in Ghana is currently estimated at nearly 175 megawatts. This figure is expected to increase to 500 megawatts by the end of 2030, suggesting significant growth and interest in the sector [Kipkoech et al. 2024]. The government has laid the right investment grounds for private sector participation in solar energy production [Agyapong 2024]. Key players in the solar energy sector in Ghana include Deep Solar Ghana, SunPower Innovations, Trina Solar, Redavia Solar Power, Translight Solar, and others. Solar power is currently harvested for electricity and thermal energy applications in both domestic and industrial perspectives [Agyapong 2024]. Wind power, in contrast, retains strong potential but with little evidence of actual investment and applications. The coastal belt of Ghana has great potential for wind energy. The Volta River Authority, a major player and investor in the renewable energy sector, is currently developing two wind energy projects, which include the Vestas and EI Sewedy, seeking to produce an estimated 150 megawatts of wind power in four locations across the coastal belt of Ghana [Odoi-Yorke et al. 2023]. Bolstering this investment drive in wind power requires the right legislation that provides adequate incentives to private sector investors. In fact,

wind power is regarded as one of the forms of renewable energy that can be effectively harnessed in Ghana in the coming decades [Odoi-Yorke et al. 2023]. While the renewable energy sector, with its emphasis on solar and wind power, is expected to grow, its significant growth largely depends on the green supply chain management practices and principles of firms. Thus, firms that align their supply chain management practices with the tenets of sustainability create the market for renewable energy sector firms, thereby providing the right platform to generate substantial returns on investment in terms of financial performance and competitiveness.

Performance and competitiveness

Performance assessment and management have become essential to organizations in recent times due to market dynamism and competition [Alia & Ratnamurni 2025]. Companies that traditionally enjoyed a monopoly position have also taken performance management seriously in recent times [Abbas 2024]. Every organization leverages its productivity to achieve organizational performance and sustained competitiveness. Several benchmarks and tools are used to measure the performance of renewable energy sector firms; however, this study focuses on the financial performance metrics approach as the performance assessment tool. Data on indicators such as return on assets, return on equity, liquidity ratio, net profit margin, etc. are used to determine the financial stability of organizations [Asamoah et al. 2024]. Ultimately, the primary goal of green supply chain systems is to deliver a competitive advantage to the organization through customer loyalty and positive public perception and reviews. According to Nazir et al. [2024], when goods and services meet the environmental expectations of customers, they feel satisfied, so become loyal to the organization, which translates into competitive advantage. The focus of green supply chain management marketing has become established in the literature over the years. Most often, the literature has explained green supply chain management as the process of communicating and creating awareness of firms' green supply chain initiatives within customers to create value and competitive advantage. Asamoah et al. [2024] stressed that green supply chain marketing focuses on planning, controlling, organizing and controlling marketing actions and programs to meet the needs and wants of customers who are sustainability inclined. Thus, green supply chain marketing seeks to establish a long-term relationship with consumers that creates a competitive advantage for firms. While firms are increasing their investment in the three aspects of green supply chain management (social, economic and environment), they tend to communicate the impacts of their initiatives to create a long-term competitive advantage, which enhances progressive financial growth and marketing outcomes.

The institutional theory and stakeholder theory are used as the underlying theories of the study to explain the facilitators and advantages of green supply chain management in the renewable energy sector in Ghana.

Renewable energy sector firms are governed by rules and regulations that form the norms and corporate values. Risi et al. [2023] termed these rules, regulations and norms as the institutional culture of the organization. According to Sahin and Mert [2023], every organization has norms, values, principles and beliefs that guide every strategic decision and action. Essentially, this theory is used in the study to explain why certain inter-

nal organizational cultures, norms, principles and values trigger the decision of firms to align their supply chain management practices to the tenets of sustainable development. The behavioral intentions of employees, shareholders and management toward sustainable development are shaped by how the organization considers the principles of green supply chain management [Risi et al. 2024]. The assumption in the institutional theory is that weak institutional will toward sustainable development will trigger poor integrations of green supply chain management [Nazir et al. 2024]. On the other hand, a strong institutional culture toward sustainable development predicts an effective implementation of green supply chain practices by energy renewable energy sector firms.

It is imperative to note that the concept of green supply chain management is considered one of the strategic pathways to supporting the attainment of the UN Sustainable Development Goals on environmental conservation, responsible waste management, and support for societies and people [Gu et al. 2024]. In effect, aligning business principles to climate change issues, environmental protection and resource conservation cannot be discussed without the concerns of stakeholders. Such stakeholders include individuals, firms, entities, institutions, communities, etc. who have a direct or indirect interest in the operations of the organization [Tetteh et al. 2025]. These entities include employees, government, consumers, competitors, suppliers, and pressure groups, among others. Prataviera et al. [2024] noted that stakeholders have, over the years, raised concerns about the need for firms to contribute their quota to the mitigation of climate change and environmental pollution, and also to support achieving the sustainable development goals on the environment. Critically, responsible business operating models (for example, green supply chain management) largely depend on the pressure that stakeholders exert on companies. According to Gu et al. [2024], most firms that are profit-oriented feel morally unconcerned about creating environmental, social and economic value for stakeholders if they are not legally pressured to do so. According to Prataviera et al. [2024], consumers have over the years highlighted concerns about transnational security threats such as climate change, environmental conservation, resource efficiency, corporate social responsibility, etc. They tend to favor enterprises that support this global agenda. In effect, renewable energy firms become compelled by these stakeholders to make a significant commitment toward the sustainable development goals through green supply chain management practices [Tetteh et al. 2025].

Materials and methodology

The study adopted a quantitative research method, which made it possible to apply numerical data to develop statistically verifiable findings that aided in arriving at evidence-based conclusions and generalizations. Applying the quantitative research method also enabled the study to adopt a statistical model (linear regression) that aided in subjecting the research hypotheses to appropriate statistical scrutiny. Significantly, adopting this method translated into arriving at objective findings based on logical analysis of the data on the research issues.

The study was based on an explanatory research design, which aligns with the selected research method. Justifiably, applying the explanatory research design enabled the study to test the statistical associations between the study's variables and also measure

the statistical difference (magnitude of change) between the predictor variables (supply chain management practices) and outcome variables (financial performance and competitiveness of firms).

The study relied on annual reports and financial statements of five major renewable energy firms: Deep Solar Ghana, SunPower Innovations, Trina Solar, Redavia Solar Power, and Translight Solar. The data covered a five-year period between 2020 and 2024. The financial performance data include: return on investment, net profit margin, and return on equity. Market competitiveness was also measured by the customer loyalty index of the five firms over the five-year period. Including the secondary data enabled the study to maintain a higher level of objectivity since the data were not based on opinions or expert views of respondents.

Table 1 highlights the variables that were used in the study.

Table 1. Variables used in the study
Tabela 1. Zmienne przyjęte do badania

Variable	Measurement	Description
Dependent	Financial performance	Measured in terms of net profit margin, which is accumulated after all operational and administrative expenses have been deducted from aggregate sales
	Market competitiveness	Measured in terms of customer loyalty, which reflects the decision of the customer to engage in repeat purchases and to show brand attachment to the firm
Independent	Green supply chain management practices	Measured with variables such as the investment index in renewable energy, eco-friendly project design, reverse logistics, and organic sourcing

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

Validity and reliability are two unique characteristics that every researcher must recognize in the process of designing, analyzing, and judging the quality of a study or piece of research, especially with regard to quantitative studies. Validity is the extent to which a selected tool measures its intended research objectives [Mariel et al. 2020]. It is therefore necessary that every design adopted, data gathered, and assessment technique used are reliable and valid, or the study is considered futile. A Cronbach's Alpha (CA) analysis was used to perform the statistical validity and reliability test of the data to determine its internal consistency before the descriptive and regression analysis. Confirmatory factor analysis (CFA) is a statistical tool that examines the homogeneity of a group of items to determine its internal consistency. The CFA values for each of the variables were greater than 0.7, meaning they can be relied on for the analysis, as recommended by Griffiths et al. [2022].

Both descriptive (mean, standard deviation, skewness, etc.) and inferential statistics were used as the data analysis technique. Linear regression analysis was used to test the hypothesis at a 95% confidence level. The Statistical Package for Social Sciences (SPSS v.26) was used as the data analysis software.

A linear regression model was used to estimate the predictive effect of the independent variable on each dependent variable. It is generally assumed in a linear regression

analysis that the two variables – the independent and dependent variables – are linearly related. That is, any movement in one of the variables automatically affects the other. In essence, the study assumed that movement in the GSCM variables triggered an equally linear movement in financial performance and competitiveness. The linear function in the context of this study that predicted the change in the dependent variable was denoted as y. The model is expressed below:

$$y_i = \beta_0 + \beta_1 X_i1 + \beta_2 X_i2 + \cdots + \beta_p X_{ip} + \varepsilon_i, \quad i = 1,\cdots, n$$

where:
n – number of observations,
y_i – i-th response,
β_k – k-th coefficient, where β_0 is the constant term in the model. Sometimes, design matrices might include information about the constant term. However, `fit-lm` or `stepwise-lm` by default includes a constant term in the model, so you must not enter a column of 1s into your design matrix X,
X_{ij} – i-th observation on the j-th predictor variable, $j = 1,\ldots, p$,
ε_i – i-th noise term, that is, random error.

If a model includes only one predictor variable ($p = 1$), then the model is called a simple linear regression model.
In general, a linear regression model can be a model of the form:

$$y_i = \beta_0 + \sum_{k=1}^{K} \beta_k f_k(X_i1, X_i2, \cdots, X_{ip}) + \varepsilon_i, \quad i = 1,\cdots, n$$

where $f(.)$ is a scalar-valued function of the independent variables, $X_{ij}s$. The functions, $f(X)$, might be in any form, including nonlinear functions or polynomials. The linearity in the linear regression models refers to the linearity of the coefficients β_k. That is, the response variable, y, is a linear function of the coefficients, β_k.
The usual assumptions for linear regression models are:
The noise terms, ε_i, are uncorrelated.
The noise terms, ε_i, have independent and identical normal distributions with mean zero and constant variance, σ^2. Thus:

$$E(y_i) = E\left(\sum_{k=0}^{K} \beta_k f_k(X_i1, X_i2, \cdots, X_{ip}) + \varepsilon_i\right) = \sum_{k=0}^{K} \beta_k f_k(X_i1, X_i2, \cdots, X_{ip}) + E(\varepsilon_i) =$$
$$= \sum_{k=0}^{K} \beta_k f_k(X_i1, X_i2, \cdots, X_{ip})$$

And:

$$V(y_i) = V\left(\sum_{k=0}^{K} \beta_k f_k(X_i1, X_i2, \cdots, X_{ip}) + \varepsilon_i\right) = V(\varepsilon_i) = \sigma^2$$

So, the variance of y_i is the same for all levels of X_{ij}.
The responses y_i are uncorrelated.
The fitted linear function is:

$$\hat{y}_i = \sum_{K=0}^{k} b_k f_k(X_{i1}, X_{i2}, \cdots, X_{ip}), \quad i = 1, \cdots, n$$

In a linear regression model of the form $y = \beta_{1X1} + \beta_{2X2} + \ldots + \beta_p X_p$, the coefficient β_k expresses the impact of a one-unit change in the predictor variable, X_j, on the mean of the response $E(y)$, provided that all other variables are held constant. The sign of the coefficient gives the direction of the effect.

Research results

The presentation of the results and findings begins with a validity and reliability analysis, which determines the internal consistency of the data through Cronbach's Alpha statistics. The section continues with results and analysis of the relationship between green supply chain management and the performance/competitiveness of renewable energy firms. The results and analysis of the relationship between the investment cost and long-term performance of green supply chain management investments are also presented in this section. Descriptive statistics are further used to analyze the challenges and strategies that drive green supply chain management by renewable energy firms.

Cronbach's Alpha analysis

The Cronbach's Alpha analysis was performed to check the internal consistency (validity and reliability) of the data used in the study. Table 2 shows that the data used to assess the financial performance (net profit margins) of the sampled firms over the five-year period had adequate internal consistency, with a CFA value of 0.8932. It can also be seen from the same table that the data on market competitiveness (customer loyalty) also had adequate internal consistency, with its CFA value reported at 0.8391. The implication here is that the data had adequate internal consistency, hence they could be used for the analysis.

Table 2. Cronbach's Alpha analysis
Tabela 2. Analiza alfa Cronbacha

Construct	Cronbach's Alpha
Financial performance	0.8932
Market competitiveness	0.8391

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

Relationship between green supply chain management and financial performance of renewable energy firm

The linear regression analysis was performed at a 5% significant level to determine the statistical difference between the green supply chain management practices and financial performance of renewable energy firms. The independent variables used in the analysis included: investment in solar energy, eco-friendly product design, organic

sourcing, and reverse logistics. The dependent variable in the analysis was financial performance (net profit margin). Tables 3, 4 and 5 show the summary of the model, ANOVA and co-efficient of the analysis.

Table 3. Model summary
Tabela 3. Podsumowanie modelu

Model	*R*	R^2	Adjusted R^2	Std. error of the estimate
1	.896[a]	.502	.767	11.29830

[a] Predictors: (constant), GCMP (investment in renewable energy, green sourcing, reverse logistics, and eco-friendly design)

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

Per the observed multiple correlation coefficient (R) value of .896, it can be said that the multiple independent variables had a strong positive association with the dependent variable. The observed R^2 value of .502 suggests that the independent variables (investment in renewable energy, green sourcing, reverse logistics, and eco-friendly design) could predict at least 50.2% of the change in financial performance (net profit margin).

The data in Table 4 shows that the overall regression model had a good fit for the data. It therefore implies that GSCM has a statistically significant predictive effect on financial performance, with $p < .05$.

Table 4. Analysis of variance
Tabela 4. Analiza wariancji

Model		Sum of squares	*df*	Mean square	*F*	Sig.
1	Regression	8807.588	3	2935.863	22.999	.000[a]
	Residual	2170.077	17	127.652		
	Total	10977.665	20			

Dependent variable (financial performance)
[a] Predictors: (constant), investment in renewable energy, green sourcing, reverse logistics, and eco-friendly design

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

The results in Table 5 show that investment in solar energy projects had a statistically positive association with the net profit margin of the sampled firms ($\beta = .172$; p-value = 0.030 < 0.05). The observed β value of 0.172 shows that a unit increase in solar energy investments caused at least a 17.2% increase in net profit margin. The results further show that eco-friendly project design also had a statistically significant positive association with net profit margin ($\beta = .169$; p-value = 0.039 < 0.05). The observed β value of 0.169 implies that a unit increase in eco-friendly project design predicted at least a 16.9% increase in net profit margins of the organizations. It can further be inferred from Table 2 that organic sourcing and reverse logistics had statistically significant positive associations with the net profit margins of the sampled firms. For instance, the observed β value of 0.268 shows that an increase in reverse logistics (recycling and reuse of supposed waste) caused at least a 26.8% increase in the net profit margins of the

Table 5. Regression coefficients
Tabela 5. Współczynniki regresji

Model		Unstandardized coefficients		Standardized coefficients	*t*	Sig.
		B	Std. error	Beta (β)		
1	(Constant)	2.666	0.610		4.374	0.000
	Investment in solar energy projects	0.172	0.069	0.158	2.510	0.030
	Eco-friendly projects design	0.169	0.619	0.169	2.192	0.039
	Organic sourcing	0.177	0.065	0.170	2.705	0.037
	Reverse logistics	0.268	0.059	0.286	4.546	0.006

Dependent variable (financial performance)

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

sampled firms. The discussion above shows that reverse logistics had the greatest positive influence on net profit margins, which was followed closely by organic sourcing, investment in solar projects, and eco-friendly project designs. The results in this analysis clearly support the research hypotheses, which emphasise a positive association between green supply chain projects and the performance of renewable energy firms.

Relationship between green supply chain management and competitiveness of renewable energy firm

Another linear regression analysis was performed to determine the statistical effect that the implementation of green supply chain management projects and practices has on competitiveness, which is measured in this analysis via customer loyalty (repeat purchases) and positive public awareness. The independent variables used in the analysis included: investment in solar energy, eco-friendly product design, organic sourcing, and reverse logistics. The dependent variable in the analysis was competitiveness (customer loyalty). Tables 6, 7 and 8 show the model summary, ANOVA, and regression coefficients, respectively.

Table 6. Model summary
Tabela 6. Podsumowanie modelu

Model	*R*	R^2	Adjusted R^2	Std. error of the estimate
1	.606[a]	.368	.256	8.32356

[a] Predictors: (constant), GCMP (investment in renewable energy, green sourcing, reverse logistics, and eco-friendly design)

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

Per the observed multiple correlation coefficient (R) value of .606, it can be said that the independent variable had a fairly positive association with the dependent variable. The observed R^2 value of .368 suggests that the independent variable could predict a 36.8% change in market competition (customer loyalty index) of the firms.

Table 7. Analysis of variance
Tabela 7. Analiza wariancji

Model		Sum of squares	*df*	Mean square	*F*	Sig.
1	Regression	684.351	3	228.117	3.293	.046[a]
	Residual	1177.789	17	69.282		
	Total	1862.140	20			

Dependent variable (market competitiveness)

[a] Predictors: (constant), GCMP (investment in renewable energy, green sourcing, reverse logistics, and eco-friendly design)

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

The data in Table 7 shows that the overall regression model had a good fit for the data. It therefore implies that green supply chain management practices (investment in renewable energy, green sourcing, reverse logistics, and eco-friendly design) had a statistically significant predictive effect on market competitiveness, which was estimated with the customer loyalty index, with $p < .046$.

Table 8 shows that investment in solar energy projects had a statistically positive association with customer loyalty, which was used as the indicator of the competitiveness of the sampled firms ($\beta = .141$; p-value = 0.041 < 0.05). The observed β value of 0.141

Table 8. Regression coefficients
Tabela 8. Współczynniki regresji

Model	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	Beta (β)	*t*	Sig.
(Constant)	2.493	0.692		4.418	0.000
Investment in solar energy projects	0.141	0.619	0.162	2.318	0.041
Eco-friendly projects design	0.172	0.624	0.169	2.516	0.038
Organic sourcing	0.159	0.420	0.162	2.420	0.039
Reverse logistics	0.208	0.528	0.202	4.021	0.008

Dependent variable (market competitiveness)

Source: authors' construct (2025)
Źródło: opracowanie autorów (2025)

shows that a unit increase in solar energy investments resulted in at least a 14.1% increase in customer loyalty. The results further show that eco-friendly project design also had a statistically significant positive association with customer loyalty (β = .172; p-value = = 0.038 < 0.05). The observed β value of 0.172 implied that a unit increase in eco-friendly project design predicted at least a 17.2% increase in net customer loyalty. It can further be inferred from Table 3 that organic sourcing and reverse logistics had statistically significant positive associations with the customer loyalty of the sampled firms. For instance, the observed β value of 0.208 shows that an increase in reverse logistics (recycling and reuse of supposed waste) resulted in at least a 20.6% increase in the customer loyalty shown to the sampled firms. The regression results above show that reverse logistics had the greatest positive influence on customer loyalty, which was followed closely by eco-friendly project designs, organic sourcing, and investment in solar energy. The results in this analysis clearly support research hypothesis 2, which hypothesizes a positive association between green supply chain projects and the competitiveness of renewable energy firms.

Discussion: effects of GSCM on competitiveness and performance

Green supply chain management practices and business performance in terms of competitive advantage and profitability have gained research attention over the last decades [Al-Khawaldah et al. 2022]. The concept of sustainability has become a going concern for governments, consumers, and global leaders. Hence, firms are compelled to implement various responsible business practices that encourage sustainable production and consumption. One area of business management in which firms are integrating different aspects of sustainability is supply chain management. Green supply chain practices highlight efforts that are implemented by firms to ensure that their supply chain functions, such as procurement, production, handling, warehousing, packaging, transport and distribution, align with the concept of sustainable development [Kamra et al. 2024]. The study showed that effectively implemented green supply chain practices have positive effects on both the performance and competitiveness of firms in the renewable energy sector. The study showed that organizations are faced with different strands of pressure from different stakeholders to implement sustainable business practices. While firms are not obliged to implement, for instance, reverse logistics, pressure from consumers and the general public are reported as one of the key drivers of implementing such practices as part of green supply chain practices. Essentially, firms in emerging markets that adopt these practices tend to gain favor and positive buying behaviors from customers who are inclined to the concept of sustainability [Nozari 2024].

The discussion here is that firms are more likely to remain profitable and competitive as long as they continue to implement green supply chain practices. Despite the positive association between green supply chain practice and sustained business competitiveness, the study can argue from the stakeholder theory that institutional will and leadership are seen as a moderator of the association between the two variables [Prataviera et al. 2024]. The study observed leadership as a key facilitator that influences the alignment of supply chain functions to the concept of environmental preservation through green

sourcing, reverse logistics, eco-friendly project design, and investment in solar energy. The argument has been advanced that firms are not under any legal obligation to implement green supply chain practices unless management decisions are aligned to enhancing environmental performance requirements. This essentially means that the leadership and management of firms must align the concept of sustainability with all aspects of business management. This decision drives the implementation of green supply chain practices, which in turn enhances business advantage and competitiveness. Investment in solar energy is gaining prominence in Ghana. Nonetheless, its huge initial investment cost often undermines the growth of the sector.

The government of Ghana is therefore encouraged to provide some level of incentives to renewable energy firms that are committed to supporting the carbon performance of the economy through investments in clean energies [Famey et al. 2024]. Regardless of this, the study demonstrated that, while the initial cost of solar energy investments is high, its long-term positive effect on profitability is significant. Vangeri et al. [2024] explained that investing in solar energy offsets the cost of conventional electricity from the nation's service provider for a minimum of 30 years. This explains why this study observed at least a 14% positive change in solar energy investments and profitability of the sampled firms. Reverse logistics also translates into positive returns on profitability. According to Saini et al. (2023), the recall and recycling of supposed waste products offset the cost of procuring new raw materials and production inputs, translating into reduced production costs and increased profitability.

To summarize, the study is in agreement with literature, showing that renewable energy firms that invest in environmentally inclined sustainability practices, such as eco-friendly project design, organic sourcing, reverse logistics, and investment in solar energy, are able to increase their brand image among consumers. That is, ecologically oriented supply chain actions are able to influence the consumption patterns and behavior of consumers in the renewable energy sector. Inherently, consumers tend to increase their loyalty to firms that invest in sustainability-inclined supply chain management practices.

Summary and conclusion

The study sought to investigate the effect of green supply chain management practices on financial performance and competitiveness among five renewable energy firms in Ghana. The study was based on a quantitative research method and explanatory research design, where data were gathered from financial and annual reports of selected firms between 2020 and 2024. Linear regression analysis was used as the statistical model. The study has provided enough evidence that show the empirical relationship between green supply chain management practices and the performance and competitiveness of firms operating in the renewable energy sector in Ghana. Generally, the study demonstrated that firms that invest in solar energy are able to offset their long-term electricity costs by at least 14%, which in turn enhances long-term profitability. Reverse logistics also demonstrated a positive effect on both profitability and competitiveness, resulting in at least a 20% improvement in both profitability and competitiveness. Customers are increasingly becoming aware of sustainable development, hence firms that align their supply

chain management to the environmental aspect of sustainable development in areas of responsible production and consumption are able to increase brand awareness, image, and loyalty, which in turn translates into positive competitiveness. The implementation of green supply chain management practices in the renewable energy sector is showing positive returns on business performance and competitiveness, nonetheless, the initial cost of such investments is significant, thereby undermining the investment drive. The government of Ghana must provide the right investment incentives, such as tax waivers, to encourage investors to accelerate the growth of green supply chain management practices in the renewable energy sector to bolster the country's drive toward achieving low emissions rates at the national level. This study relied on secondary data from the annual reports of the sampled firms, thereby undermining the originality of the study. Future studies can therefore rely on primary data through a field questionnaire to provide new dimensions to the research theme.

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