



# The Impact of Green Entrepreneurship to Knowledge Acquisition, Product Innovation, and Supply Chain Towards Green Competitive Advantages

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**Abstract.** This research delves into the complex interplay between green practices and competitive advantages within the construction industry, a sector facing increasing pressure to embrace sustainability. Utilizing Structural Equation Modeling, the study analyzes survey data from a diverse group of construction stakeholders to examine the intricate relationships between four key factors: Green Entrepreneurship, Green Knowledge Acquisition, Green Product Innovation, and Green Supply Chain, and their combined impact on achieving Green Competitive Advantages. The findings strongly suggest that Green Entrepreneurship and Green Product Innovation are significantly and positively correlated with Green Competitive Advantages, echoing previous research in the field. Furthermore, the study highlights the critical role of Green Knowledge Acquisition as a significant driver for both Green Entrepreneurship and Green Product Innovation, emphasizing the importance of knowledge dissemination and adoption in promoting sustainable practices. While the relationship between the Green Supply Chain and Green Competitive Advantages is found to be more moderate, it remains a significant factor. This suggests that while integrating sustainability throughout the supply chain is important, its impact on competitive advantage might be realized over a longer term or require a more comprehensive approach. By providing a nuanced understanding of these complex relationships, this research offers a robust theoretical framework for construction industry stakeholders. It underscores the strategic importance of embracing green practices across different organizational functions to foster a more sustainable and competitive construction industry.

**Keywords:** *Green Competitive Advantages, Green Entrepreneurship, Green Knowledge Acquisition, Green Product Innovation, Construction Industry*

## 1. INTRODUCTION

The global construction industry is facing increasing pressure to address sustainability challenges, driven by concerns such as climate change and resource depletion. Rising

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energy demand and CO<sub>2</sub> emissions from construction operations underscore the urgency for more sustainable practices [1]. Developing countries like Indonesia also confront sustainability issues like resource depletion, waste generation, and energy inefficiency in construction activities [2]. Addressing these challenges requires a multi-faceted approach involving regulatory frameworks, industry standards, and community engagement.

Recognizing the importance of sustainability, businesses are increasingly integrating green practices into their strategies. In the construction sector, sustainability and competitive advantage are intertwined concepts. Green entrepreneurship, knowledge acquisition, product innovation, and green supply chains play pivotal roles in achieving green competitive advantage. Green entrepreneurs drive innovation, collaborate for knowledge exchange, and promote sustainability awareness. Green product innovation involves developing environmentally friendly products and processes, while green supply chain management aims to reduce environmental impact throughout the supply chain.

Green Competitive Advantage (GCA) reflects a company's strategic shift towards sustainability, leading to operational efficiency, stakeholder trust, and project wins. While previous research acknowledges the significance of green practices in gaining a competitive advantage, there remains a gap in understanding their contributions.

Green Competitive Advantage (GCA) refers to the competitive advantage gained by a company through implementing sustainable practices in its operations. In the context of the construction industry, GCA reflects the transformation of the business paradigm towards sustainability, which has a positive impact on several key aspects. Research has shown that the adoption of sustainable practices in the construction industry contributes to operational efficiency, reduced environmental impact, and compliance with increasingly stringent regulations. For example, research by Xie et al. [3] highlights that construction companies that prioritize energy efficiency and waste management tend to have better financial performance. Sustainability in the construction industry is also closely linked to the demands and expectations of stakeholders, including project owners, investors, and society. Research by Simatupang and Sridharan [4] shows that construction companies that integrate sustainability practices in their business strategies gain higher trust from stakeholders, which can improve brand image and competitive advantage. In the context of auctions and projects, research by Alshboul et al. [5] and Jaafar et al. [6] noted that construction contractors with a focus on sustainability tend to win more project bids. Project owners are now increasingly appreciating contractors who demonstrate a commitment to sustainable practices. The positive effects of GCA can also be seen in the increased sustainability of the construction supply chain. Research by Demirel et al. [7] emphasizes that sustainability practices implemented by contractors can catalyze the growth of more sustainable and efficient supply chains.

Overall, GCA in the construction industry is not just about regulatory compliance but is also a strategic approach to improving operational efficiency, gaining stakeholder trust, and winning project bids. These studies show that construction companies that successfully implement GCA can experience significant positive impacts in various aspects of their business.

Studies have demonstrated that firms engaging in green knowledge acquisition, enacting green entrepreneurial strategies, innovating green products, and integrating green supply chains can attain competitive advantages [8], [9], [10]. Nonetheless, variations exist in the degree to which these factors contribute to achieving sustainable competitive advantages. Despite recognizing the significance of these factors, a gap in comprehension persists, to the extent to which each of these factors influences creating sustainable competitive advantage.

For this reason, this research will focus on the impact of green entrepreneurship on knowledge acquisition, product innovation, and the supply chain toward green competitive advantages.

Several inquiries emerge as potential research questions, which can be categorized as follows:

1. Does green entrepreneurship impact green knowledge acquisition, green product innovation, and green supply chain?
2. Does green knowledge acquisition impact green product innovation and green supply chain?
3. Does a green supply chain impact green product innovation and green competitive advantage?
4. Does green product innovation impact green competitive advantage?

## **2. Literature Review**

### *2.1 Construction Industry*

According to Siew, the construction sector broadly encompasses all tasks or enterprises associated with land preparation and construction processes, including alterations, renovations, and maintenance of buildings, structures, and related facilities [11]. A construction project refers to a series of interconnected activities aimed at accomplishing a specific objective (construction) within defined parameters of time, cost, and quality. Such projects invariably necessitate various resources, including manpower, construction materials, machinery, techniques, finances, data, and time. In construction projects, the three main factors that must be considered are time, cost and quality [6]. The construction industry can be further divided into three basic categories, namely:

- a) Construction will involve both heavy and civil engineering, with construction of large projects such as roads or bridges falling into this category.
- b) General construction, which would involve real estate construction of, among other things, residential or commercial real estate assets.
- c) General construction, which would involve real estate construction of, among other things, residential or commercial real estate assets.

### *2.2 Green Entrepreneurship*

Green Entrepreneurship is a type of entrepreneurship that focuses on creating, developing, and managing ventures or business initiatives that not only have the goal of generating financial returns but are also committed to reducing negative impacts on

the environment and society, as well as promoting sustainability in all aspects of their operations.

Experts on Green Entrepreneurship [10]

- a. Dr. Shrivastava: Dr. Shrivastava, an expert in the field of sustainability, defines Green Entrepreneurship as "the practice of creating and running businesses that aim to achieve sustainable economic growth, improve environmental quality, and deliver positive social benefits."
- b. Stevens and Mellor: In the journal "Entrepreneurship & Regional Development," Stevens and Mellor state that Green Entrepreneurship "involves creating and managing businesses that create products or services that have a positive impact on the natural, economic, and social environment."

The objectives of Green Entrepreneurship are [10]:

- a. Generate sustainable financial gains.
- b. Reduce the negative impact on the natural environment.
- c. Improve the quality of the environment.
- d. Creating job opportunities and local economic growth.
- e. Provide positive social benefits to the community.
- f. Drive positive change in global business practices towards sustainability.

The Green Entrepreneurship process involves several stages, including [12]:

- a. Recognition of Sustainable Business Prospects  
Search for and recognize business prospects centered on sustainable methodologies or environmentally friendly solutions.

- b. Conceptualization of Ideas

Formulating business concepts that capitalize on these identified sustainable opportunities.

- c. Formulation of Business Strategies

Devising strategies for business operations, resource management, marketing approaches, and sustainable business objectives.

- d. Implementation and Operationalization

Putting the business plan into action and executing operations with a focus on sustainable practices.

- e. Assessment and Enhancement

Continuously assessing the environmental, economic, and social repercussions and implementing necessary enhancements.

Green Entrepreneurship aims to achieve an equilibrium between economic advancement and environmental as well as social accountability, thereby fostering enduring sustainability.

### 2.3 Green Knowledge Acquisition

Green Knowledge Acquisition involves the process of obtaining, accumulating, and comprehending information related to environmental concerns, sustainability, and practices aimed at mitigating adverse impacts on the environment and society. This process is essential for businesses to make more sustainable and responsible decisions in their operations. According to Dr. Wayne Visser, a sustainability expert, Green Knowledge Acquisition is described as the continuous process through which organizations seek, acquire, analyze, and utilize sustainable knowledge to enhance their environmental and social performance. Similarly, the International Environmental Organization (IEMA) defines Green Knowledge Acquisition as the effort to identify, collect, and share relevant knowledge about sustainable practices and environmental impacts to support companies in making sustainable decisions. Overall, Green Knowledge Acquisition emphasizes the active pursuit, collection, and utilization of knowledge about environmental and sustainability issues to inform sustainable practices in business operations, involving continuous analysis, adaptation, and integration of knowledge into business strategies and policies.

### 2.4 Green Product Innovation

Green Product Innovation is the process of developing and improving products or services that aims to reduce negative impacts on the environment and improve sustainable performance by utilizing environmentally friendly materials, technology or design [13]. According to experts:

- a. Dr. Robert P. Bernier: Dr. Bernier, an expert in the field of sustainable innovation, defines Green Product Innovation as "the process of developing products or services that create added value and reduce negative impacts on the environment throughout the product's life cycle."
- b. Dr. Stuart Walker: Dr. Walker, a sustainable design expert, describes Green Product Innovation as "innovation that takes into account sustainable aspects, such as environmentally friendly materials, efficient energy, and wise waste management in product development" [13].
- c. The objectives of Green Product Innovation are [14]  
Reduce Environmental Impact Reduce the use of natural resources, carbon emissions, and waste in the product life cycle.
- d. Produce Environmentally Friendly Products  
Develop products or services that have a smaller environmental footprint and are more sustainable.
- e. Increasing Energy Efficiency  
Introducing technologies and designs that are more efficient in energy use.
- f. Sustainable Performance Improvement  
Improve product performance in terms of economic, social and environmental sustainability.
- g. Meeting Market Demands  
Providing products that meet the demands of increasingly environmentally conscious consumers.
- h. Regulatory Compliance  
Comply with applicable environmental regulations and standards.

### 2.5 *Green Supply Chain*

Green Supply Chain refers to a supply chain system or procedure structured and executed with environmental sustainability as a priority, emphasizing the mitigation of adverse effects on the natural environment throughout the entire lifecycle of the supplied product or service. According to experts [15]:

- a. Professor Hui-Ming Wee: Professor Hui-Ming Wee, a supply chain expert, defines Green Supply Chain as “the process of planning, executing and controlling the flow of materials, information and funds from the source of origin to the consumer with a minimum negative impact on the environment. ”
- b. Dr. Joseph Sarkis: Dr. Joseph Sarkis, an expert in the field of sustainable supply chains, describes Green Supply Chain as "a company's efforts to leverage sustainable practices in planning, implementing, and controlling their supply chains to achieve sustainability goals."

The objectives of the Green Supply Chain are [8]:

- a. Reducing Environmental Footprint: Reducing negative impacts on the natural environment along the supply chain, including reducing carbon emissions and over-using resources.
- b. Energy Efficiency: Optimizing energy use in the supply chain.
- c. Waste Management: Reducing wastage and wise waste management.
- d. Improved Sustainability Performance: Improve sustainability performance in all aspects of the supply chain.
- e. Regulatory Compliance: Comply with applicable environmental regulations and standards.
- f. Business Benefits: Increase operational efficiency and competitive advantage in the market.

The Green Supply Chain process involves several stages [8], including:

- a. Supply Chain Mapping and Assessment: This involves identifying components of the supply chain that have environmental impacts and assessing their sustainability performance.
- b. Sustainable Planning: Developing strategies to incorporate sustainable practices into the supply chain.
- c. Sustainable Supplier Selection: Choosing suppliers committed to environmental sustainability. Logistics Optimization: Enhancing logistics operations to minimize fuel consumption and carbon emissions.
- d. Waste Management: Implementing measures to reduce, recycle, or efficiently utilize waste.
- e. Reporting and Monitoring: Conducting regular performance reporting and monitoring the implementation of green practices throughout the supply chain.

- f. Continuous Improvement: Making ongoing enhancements to the supply chain to achieve greater sustainability performance.

### 2.6 Green Competitive Advantages

Green Competitive Advantages denote an organization's capacity to gain a competitive edge by implementing sustainable or eco-friendly practices resulting in enhanced efficiency, innovation, and a favorable reputation among customers and stakeholders. Scholars such as Michael Porter, a Harvard Business School professor, advocate for leveraging sustainability to drive productivity gains through waste reduction and resource optimization, alongside developing environmentally sustainable products and services that align with evolving market preferences for sustainability. Similarly, Stuart Hart, a prominent figure in sustainable business studies, views green sustainable excellence as the ability of organizations to innovate by offering environmentally friendly products, services, and business models that address consumer demands while enhancing operational efficiencies. (Nureen et al., 2023).

The primary aim of Green Competitive Advantages is to attain sustainability within the organization's operations and business endeavors. This encompasses endeavors such as minimizing environmental footprints, ensuring regulatory adherence, enhancing efficiency, fostering growth in the market share of sustainable products, and enhancing the organization's reputation.

Based on the analysis provided in the literature review and the study discussed earlier, this research puts forward several hypotheses:

- H1: green entrepreneurship has a significant effect on green knowledge acquisition.  
 H2: green entrepreneurship has a significant effect on green product innovation.  
 H3: green entrepreneurship has a significant effect on green supply chain.  
 H4: green knowledge acquisition has a significant effect on green product innovation.  
 H5: green knowledge acquisition has a significant effect on green supply chain.  
 H6: green supply chain has a significant effect on green product innovation.  
 H7: green product innovation has a significant effect on green competitive advantages.  
 H8: green supply chain has a significant effect on green competitive advantages.

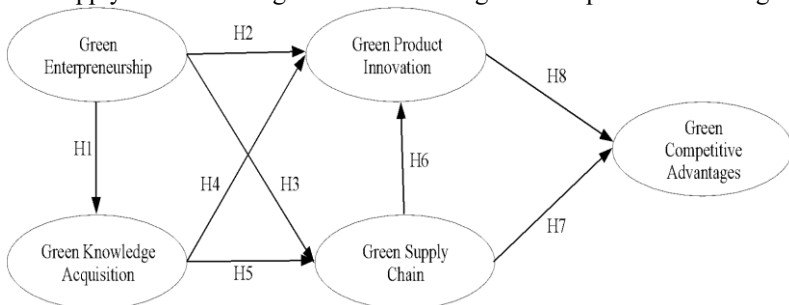


Figure 1 Research Model  
 Source: Researcher Data, 2024

### **3. Research Method**

The study focuses on analyzing companies within the construction industry in Indonesia, particularly those engaged in green practices. By examining various organizations with different levels of involvement in sustainable initiatives, the research aims to uncover the impact of these practices on sustainable excellence. Additionally, factors such as organizational size, corporate culture, and contextual influences will be considered to understand their moderating effects. Through a purposive sampling method, a representative sample of around 110 industrial and heavy construction companies out of a population of 300 will be selected. Stratified sampling will ensure adequate representation across different segments of the population, allowing for a comprehensive analysis of the industry's sustainable practices and their outcomes.

#### *3.1 Type of Data & Collection*

The research focuses on analyzing Indonesian construction companies, particularly those committed to green practices. It seeks to understand how these initiatives impact sustainable excellence across various organizations. Factors like organizational size, corporate culture, and contextual influences will be explored for their moderating effects. Using a purposive sampling method, approximately 110 companies out of a total population of 300 will be selected to ensure representation across different segments. This stratified approach will facilitate a thorough investigation into the industry's sustainable practices and their implications. Additionally, the study employs a multi-level data processing system. First Step, assessment data from subordinates are collected and analyzed manually using Excel and SPSS, focusing on factors including Green Entrepreneurship, Green Knowledge Acquisition, Green Product Innovation, Green Supply Chain, and Green Competitive Advantages. The findings from data analysis will not only reveal the impact of green practices on sustainable excellence but also validate the hypotheses proposed in this research. In the second stage, variables of Green Entrepreneurship, Green Knowledge Acquisition, Green Product Innovation, Green Supply Chain, and Green Competitive Advantages analyzed using SPSS, including outlier tests, normality tests, correlation tests, and multi-collinearity tests. The final dataset is then used for hypothesis testing through Structural Equation Modeling (SEM) using SmartPLS.

#### *3.2 Research Variable*

This research constructs its framework based on five key dimensions related to sustainable business practices: Green Competitive Advantages, Green Entrepreneurship, Green Knowledge Acquisition, Green Product Innovation, and Green Supply Chain. Each dimension comprises several variables sourced from prominent literature in the field. The dimension of Green Competitive Advantages encompasses nine variables [16], [17]. Green Entrepreneurship, includes nine variables [18]. Green Knowledge Acquisition, a crucial aspect, comprises eleven variables [19]. Green Product Innovation, a pivotal driver of sustainability, involves ten variables [3]. Lastly, Green Supply Chain, vital for sustainability efforts, includes ten variables gathered from prior research [15], [20].



This research incorporates various control variables, including demographic factors such as age, gender, education level, and tenure at the workplace by the respondents. These variables are considered to ascertain that the participants possess the requisite qualifications to provide accurate responses in the survey, effectively representing their respective firms.

## 4. Result and Discussion

### 4.1 Demographic of Respondents

In this study, 80 representatives from the construction industry provided responses related to four key factors: Gender, Age, Education, and Tenure. Concerning gender distribution, most respondents were male, comprising 85% of the total sample, while females accounted for 15%. No data were missing or invalid in this category. Regarding age demographics, it was observed that the largest proportion of respondents fell within the 42-49 age group, constituting 71.3% of the total. Individuals over 50 represented 2.5% of the respondents, while none were in the 18-25 and 26-33 age brackets. Regarding educational background, the majority (90%) held bachelor's degrees, while the remaining 10% possessed diplomas. None of the respondents had completed Senior High School or its equivalent. Finally, in terms of tenure, the majority (75%) had worked for 7-9 years. Those with over 12 years of experience accounted for 16.3%, while none had tenure ranging from 1-3 or 4-6 years. Respondents with a work period of 10-12 years comprised 8.8% of the total.

Table 1 Demographic of Respondents  
Source: Researcher Data, 2024

	Factor	Frequency	Percent (%)
Gender	Male	68	85.0
	Female	12	15.0
	Total	80	100.0
Age	18-25 Years Old	0	0
	26-33 Years Old	0	0
	34-41 Years Old	21	26.3
	42-49 Years Old	57	71.3
	>50 Years Old	2	2.5
	Total	80	100.0
Education	Senior High School or Equivalent	0	0
	Diploma	8	10.0
	Bachelor Degree	72	90.0
	Total	80	100.0
Tenure	1-3 Years	0	0
	4-6 Years	0	0
	7-9 Years	60	75.0
	10-12 Years	7	8.8
	>12 Years	13	16.3
	Total	80	100.0

4.2 Data Analysis

The available sample data was subsequently analyzed for outliers using SPSS software version 25. Multivariate outliers were identified through Mahalanobis Distance (MD) analysis, a technique used to examine the distance of each data point from the center of the sample data. This analysis helps identify any data points that significantly deviate from the norm and may skew the results.

Table 2 Data Analysis  
Source: Data processed with SmartPLS,2024

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Green Competitive Advantages	0,969	0,970	0,973	0,802
Green Entrepreneurship	0,973	0,974	0,977	0,823
Green Knowledge Acquisition	0,981	0,982	0,983	0,841
Green Product Innovation	0,972	0,978	0,977	0,811
Green Supply Chain	0,983	0,983	0,985	0,865

The test conducted using SmartPLS software on the measurement instruments in this study demonstrates that all constructs, including Green Competitive Advantages (GCA), Green Entrepreneurship (GE), Green Knowledge Acquisition (GKA), Green Product Innovation (GPI), and Green Supply Chain (GSC), exhibit high levels of reliability. For instance, Cronbach's Alpha value for GCA is 0.969, rho\_A is 0.970, Composite Reliability is 0.973, and Average Variance Extracted (AVE) is 0.802, indicating strong consistency and reliability in measurement. Similarly, GE displays robust reliability with Cronbach's Alpha of 0.973, rho\_A of 0.974, Composite Reliability of 0.977, and AVE of 0.823. Likewise, GKA exhibits very high reliability, evidenced by a Cronbach's Alpha value of 0.981, rho\_A of 0.982, Composite Reliability of 0.983, and AVE of 0.841. GPI and GSC also demonstrate high levels of reliability, with respective Cronbach's Alpha values of 0.972 and 0.983, rho\_A values of 0.978 and 0.983, Composite Reliability values of 0.977 and 0.985, and AVE values of 0.811 and 0.865. These findings collectively affirm the reliability, consistency, and validity of the measurement instruments across all constructs, underscoring their efficacy in assessing Green Competitive Advantages, Green Entrepreneurship, Green Knowledge Acquisition, Green Product Innovation, and Green Supply Chain.

Table 3 Hypotheses Test  
Source: Data processed with SmartPLS,2024

	<b>Hypotheses</b>	T Value	Total Effect	% Total Effect
H1	green entrepreneurship on green knowledge acquisition	91,812	0,944	94%
H2	green entrepreneurship on green product innovation	51,867	0,92	92%
H3	green entrepreneurship on green supply chain	14,03	0,722	72%
H4	green knowledge acquisition on green product innovation	287,071	0,978	98%
H5	green knowledge acquisition on green supply chain	12,06	0,694	69%
H6	green supply chain on green product innovation	28,974	0,817	82%
H7	green supply chain on green competitive advantage	60,367	0,751	75%
H8	green product innovation on green competitive advantage	59,13	0,918	92%

Based on Table 3, From the results of the hypothesis analysis, it can be seen that the Green Entrepreneurship variable has a significant influence on Green Knowledge Acquisition (H1), Green Product Innovation (H2), and Green Supply Chain (H3) with t values of 91.812, 51.867, and 14 respectively. .03. However, the highest influence of Green Entrepreneurship occurs in Green Knowledge Acquisition with a total effect of 94%, followed by Green Product Innovation with a total effect of 92%, and Green Supply Chain with a total effect of 72%. Furthermore, the Green Knowledge Acquisition variable also has a significant influence on Green Product Innovation (H4) and Green Supply Chain (H5) with t values of 287.071 and 12.06 respectively. However, the highest influence of Green Knowledge Acquisition occurs in Green Product Innovation with a total effect of 98%, while in Green Supply Chain it is only 69%. Apart from that, the Green Supply Chain variable also has a significant influence on Green Product Innovation (H6) and Green Competitive Advantage (H7) with t values of 28.974 and 60.367 respectively. The highest effect of Green Supply Chain occurs in Green Product Innovation with a total effect of 82%, while in Green Competitive Advantage it is 75%. Finally, the Green Product Innovation variable has a significant influence on Green Competitive Advantage (H8) with a t value of 59.13 and a total effect of 92%.

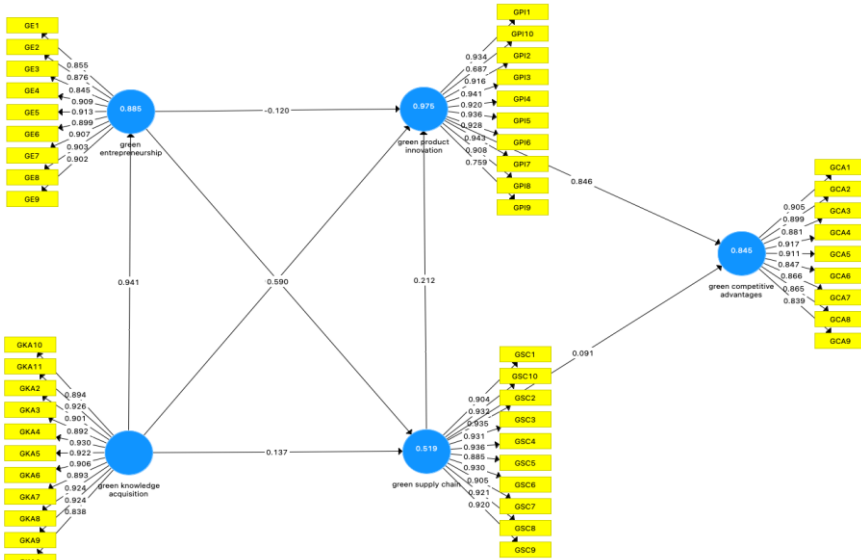


Figure 2 Hypothetical relationship

The results of the total effect show in Table 4, that the Green Entrepreneurship variable has a significant influence on Green Knowledge Acquisition (GKA), Green Product Innovation (GPI), and Green Supply Chain (GSC) with large t statistical values of 78.602, 49.147, and respectively. 12,454. The interpretation of these results is that the relationship between Green Entrepreneurship and these three variables is statistically significant. In the context of Green Knowledge Acquisition, every one unit increase in Green Entrepreneurship has an impact of 0.942 on Green Knowledge Acquisition. Likewise, every one unit increase in Green Entrepreneurship has an impact of 0.919 on Green Product Innovation and 0.719 on Green Supply Chain. Thus, these results show that Green Entrepreneurship has an important role in encouraging Green Knowledge Acquisition, Green Product Innovation, and Green Supply Chain in the construction industry.

Table 4 Total Effect  
Source: Data processed with SmartPLS,2024

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics ((O/STDEV)	P Values
GE-> GKA	0,942	0,943	0,012	78,602	0,000
GE -> GPI	0,919	0,921	0,019	49,147	0,000
GE -> GSC	0,719	0,720	0,058	12,454	0,000

### 4.3 Discussion

The findings from the study highlight the pivotal role of Green Knowledge Acquisition (GKA) in fostering sustainable business practices, particularly reflected in Green Entrepreneurship (GE). These results are consistent with existing literature emphasizing the significance of environmental knowledge in promoting eco-friendly business initiatives. Previous studies [21] further reinforce these findings, indicating a positive correlation between GKA and GE. These results contribute substantially to understanding the dynamics between GKA and GE within sustainable business contexts, offering valuable insights for practitioners and policymakers to design effective strategies for promoting environmentally conscious entrepreneurship.

Moreover, the analysis indicates a significant influence of Green Entrepreneurship (GE) on Green Product Innovation (GPI), with approximately 84.6% of the variation in GPI explained by GE, suggesting a robust positive impact. These findings are supported by prior research, suggesting that organizations embracing green business practices or entrepreneurship tend to exhibit higher levels of innovation in developing sustainable products. Therefore, the results underscore the pivotal role of GE in driving green product innovation, contributing to the growing body of knowledge on sustainable business practices.

Furthermore, the study reveals a substantial influence of Green Entrepreneurship (GE) on the Green Supply Chain (GSC), indicating that around 52.2% of the variation in the Green Supply Chain can be attributed to GE. This finding underscores the importance of integrating sustainability principles, including green entrepreneurship practices, into supply chain strategies to develop sustainable supply chains [22].

The analysis demonstrates the significant impact of Green Knowledge Acquisition (GKA) on both Green Product Innovation (GPI) and the Green Supply Chain (GSC). Approximately 95.7% of the variation in GPI and 48.2% of the variation in GSC can be explained by GKA, indicating strong positive impacts. These findings align with previous research, emphasizing the importance of sustainable knowledge acquisition in driving innovation and fostering greener supply chains.

The study highlights the strong influence of the Green Supply Chain (GSC) on both Green Product Innovation (GPI) and Green Competitive Advantages (GCA). The results indicate that approximately 66.8% of the variation in GPI and 56.5% of the variation in GCA can be attributed to GSC, suggesting significant positive impacts. These findings underscore the importance of implementing sustainable supply chain practices in enhancing overall competitiveness and fostering innovation, as supported by previous research.

Overall, the analysis reveals the intricate relationships between various factors within sustainable business contexts, emphasizing the importance of environmental knowledge, green entrepreneurship, and sustainable supply chain practices in driving innovation and gaining competitive advantages. Among the hypotheses tested, the highest total effect is observed for the influence of Green Knowledge Acquisition on

Green Product Innovation (98%), indicating the critical role of knowledge acquisition in fostering innovation within sustainable business practices.

Based on the analysis of the findings, Green Product Innovation (GPI) emerges as a dimension that is comprehensively elucidated by the model, demonstrating an exceptionally high R Square value of 97.5%. This suggests that the model's independent variables adeptly account for variations in Green Product Innovation. Previous studies [23], [24] align with these results, highlighting the significance of GPI in sustainable business contexts. supports these findings, showing that the implementation of environmentally based innovation or green innovation has a positive impact on productivity results and company innovative performance.

Meanwhile, Green Competitive Advantages (GCA) and Green Entrepreneurship (GE) also show a good level of explanation, with an R Square of around 84.5% and 88.5%, respectively. This finding is in line with research by [25], [26], [27], which states that business practices that focus on sustainable competitive advantage and green entrepreneurship can provide strategic and innovative advantages for companies.

On the other hand, Green Supply Chain (GSC) shows a lower R Square of 51.9%, indicating that the model does not fully explain variations in this dimension. Previous research [28], [29], [30], [31], [32], [33] highlight the complexity and challenges in implementing green supply chain practices, with factors such as costs and supplier involvement playing a significant role.

## **5. Conclusion and Recommendation**

### *5.1 Conclusion*

The structural model examines the relationship between Green Entrepreneurship, Green Knowledge Acquisition, Green Product Innovation, Green Supply Chain, and Green Competitive Advantages in the construction industry. Hypothesis analysis reveals the significant impact of each variable on achieving environmentally friendly competitive advantage. Green Entrepreneurship shows a strong correlation with Green Knowledge Acquisition, Green Product Innovation, and Green Supply Chain, as indicated by high T-scores (91.812, 51.867, and 14.03, respectively), highlighting its central role in encourage sustainable practices in construction. In addition, Green Knowledge Acquisition Influences Green Product Innovation and Green Supply Chain significantly, with very high T-values (287.071 and 12.06, respectively), which emphasizes its role in driving innovation and sustainable supply chain practices. Additionally, Green Supply Chains have a positive impact on Green Product Innovation and Green Competitive Advantage, supported by high T-values (28.974 and 60.367 respectively), which underlines its importance as a source of competitive advantage. Lastly, Eco-Friendly Product Innovation has a significant impact on Eco-Friendly Competitive Advantage, as evidenced by its high T-score of 59.13, which shows its role in driving competitive advantage in the construction sector. Overall, the model underscores the importance of green entrepreneurial approaches, sustainable knowledge acquisition, innovative practices, and sustainable supply chains in enhancing green competitiveness in construction, thereby providing valuable insights for industry stakeholders.

## 5.2 Recommendation

Based on the research results, there are several suggestions for further research. Firstly, the industry needs to encourage Green Entrepreneurship. This can be done by encouraging and incentivizing the development of startups and initiatives that focus on green construction technologies, materials, and processes. This can be done through grants, tax deductions, incubator programs, and public-private partnerships. In addition, it is important to promote a culture of innovation and risk-taking within existing construction companies to make it easier for them to adopt and implement green practices. This could involve the establishment of internal innovation funds, recognition and rewards for green initiatives, and collaboration with research institutions.

Second, the industry should facilitate Green Knowledge Acquisition. Investment in industry-wide training and development programs to disseminate knowledge on green building principles, technologies, and best practices is essential. This can be done through partnerships with universities, professional organizations, and industry leaders to develop and deliver relevant training programs. In addition, it is important to establish knowledge-sharing platforms and networks to facilitate communication and collaboration on green building initiatives among construction stakeholders. This could include online forums, industry conferences, and collaborative research projects.

Third, the industry needs to encourage Green Product Innovation. Supporting research and development efforts that focus on the development and commercialization of innovative green building materials, technologies, and design solutions is essential. This can be done by providing research grants, tax incentives for R&D activities, and facilitating collaboration between researchers and industry practitioners. In addition, the adoption of green building standards and certifications (e.g., LEED, BREEAM) needs to be encouraged to increase demand for green building products and services. This could involve integrating green building requirements into public procurement policies and incentivizing private developers to adopt green building certifications.

Fourth, the industry needs to integrate the Green Supply Chain. Promoting collaboration and information sharing across the construction supply chain to identify and implement sustainable practices throughout the value chain is essential. This can be done by setting industry-wide sustainability standards, developing supplier evaluation tools that incorporate environmental criteria, and promoting transparency and traceability in material sourcing. In addition, the use of locally sourced, recycled and recyclable materials needs to be incentivized to reduce the environmental impact of construction projects. This could involve providing tax deductions or subsidies for the use of sustainable materials, promoting the development of local recycling industries, and implementing policies that reduce the use of environmentally harmful materials.

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