World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Green innovation and firm performance: An empirical analysis of operational efficiency, environmental commitment and technological capability

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World Journal of Advanced Research and Reviews, 2025, 25(03), 1148-1160

Publication history: Received on 01 February 2025; revised on 15 March 2025; accepted on 17 March 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.25.3.0832

Abstract

This research aims in growing interest and relevance of business sustainability, especially through green innovation. Quantitative research methodology has been done by applying a survey in a randomly selected sample of 632 organizations in various sectors, this research has utilized SEM on constructs as green product innovation, process innovation, operational efficiency, and firm performance. Results show that green innovation strategies significantly enhance firm performance through operational efficiency using market competitiveness. It indicates that both green product and process innovations are positively related to firm performance measures. Further, this research outlines moderating influence of regulatory pressures within these relationships, indicating complexity that firms are faced with when they attempt to apply sustainable practices. The findings underline the importance of green innovation in enhancing performance of a firm. They also indicate such competitive advantages as having great potential for organizations looking to weave sustainability into fabric of their business strategy.

Keywords: Green innovation; Firm performance; Sustainability; Operational efficiency; Regulatory pressure

1. Introduction

Companies now focus more on sustainability owing to environmental concerns. Green innovation is a source of competitive advantage that combines economic prosperity with environmental stewardship in terms of green products and approaches. Consumer demand and regulatory requirements push firms towards sustainability, with growing demand for eco-brands. Scholars focus on the role that green innovation plays in firm performance. Literature indicates that firms that adopt green innovation become more efficient and reduce costs, increasing their market standing [2]. However, there is little agreement as to how such innovations ensure that performances pertinent to them are core realistic derivations. While some studies have found a positive link between green initiatives and firm performance, others have underlined the potential challenges and trade-offs that arise from such strategies [5]. In fact, because of its complex nature, much more thorough attention is required toward all factors that are likely to either expedite or delay the degree of firm performance promoted by green innovation [4]. The current study will add to the literature by analyzing how green innovation, operational efficiency, environmental commitment, and other relevant constructs together determine the performance of firms [3]. This research has used a strong quantitative methodology with data from different organizations to find empirical evidence of interaction among variables and the effects of each variable on others [1]. It is expected that these results will provide an understanding of valuable guidelines for managers and policymakers in maximizing sustainability practices at the highest level of business outcomes [6]. The interaction of green innovation with firm performance is very important, as organizations always strive to balance environmental concerns with the market's demand for sustainability [8].

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2. Literature Review

The green innovation and firm performance literature has experienced an upsurge in the last couple of years, with sustainability increasingly being recognized as an important component of competitive strategy [7]. Many contributions have empirically analyzed the relationship between green innovation and different dimensions of firm performance; most of these works underline the positive effect that eco-innovative practices have on economic performance [9]. For instance, some studies carried out on listed firms in the power industry in China demonstrated that, while green innovation significantly improves present performance, it has a greater positive effect on future performance, further cementing views that sustainable practices guarantee long-term success [10]. In the studies conducted across G7 and BRICS countries, it was seen that eco-innovation exerts a positive impact on the performance of the firm; that is, firms with green strategies will perform better economically and contribute toward the environmental objectives of an economy. [15-16] provide a systematic review of the literature showing that, though there is convergence in the fact that green innovation is beneficial, ambiguity remains in the nature of its effect on enterprise performance [17-18]. Different approaches have been put forward for how green innovation affects performance: by cost reduction, improved utilization of resources, and enhancement of corporate reputation [11-12]. There are, however, contrasting views: some researchers indicate that the benefits derived from the green innovations could be outweighed by the costs related to their implementation and thus result in nonlinear or even negative relationships in certain contexts [13-14].

- **Hypothesis 1 (H1):** Market Orientation positively influences Green Innovation.

The Hypothesis is that a market orientation with customer-centric approaches creates more green innovation [19]. This is subject to dispute for the following reasons: (1) as the companies, which have committed themselves to a market-oriented approach, the ability to understand and immediately answer the customers' demands for eco-products and services that are friendlier to the environment, and (2) proactively anticipate and adapt to the changeable market trends and regulations on environmental sustainability [23].

- **Hypothesis 2 (H2):** Regulatory Pressure positively influences Green Innovation.

This hypothesis implies that firms subject to strict environmental regulations and policies are the ones whose green innovation practices are the most active [20-22]. The businesses, in pursuit of compliance to the set down regulations and in order to avoid the fines, might have to go for green/ cleaner technologies, reducing their environmental footprint, and or coming up with environmentally friendly products and processes [25].

- **Hypothesis 3 (H3):** Environmental Commitment positively affects Green Innovation.

This is aligned with the belief that a company with a firm dedication to environmental preservation will probably be involved in the activities of green innovation [24]. This can be instigated by variables like social responsibility, ethical concerns, and the necessity to be a part of a greener and better future [28].

- **Hypothesis 4 (H4):** Green Innovation helps improve Firm Performance.

It therefore supposes that green innovation-using companies are expected to perform better on financial grounds with higher revenues, more market shares, and subsequently greater profits [27]. This is because of the improvement in brand image and reduction in costs, and also new markets may be accessed [26].

- **Hypothesis 5 (H5):** Operational Efficiency has a positive effect on Firm Performance.

This hypothesis finds its links in the talented operational companies that have the resources in place to be very cost-efficient, have waste-reduction systems that work well and have an increase in the performance of the company [29].

- **Hypothesis 6 (H6):** Technological Capability positively influences Firm Performance.

This postulation indicates that the innovative, and extra potential variables exist for companies with strong technological capabilities and that are components of the formation of sociality [30]. To study the impact of different factors on the sustainability of the organizations and the environment in the view of author [31].

However, it is recommended to go for further research and scrutinize the hypothesis as seen figure 1 from the empirical evidence and from real-life activities. This suffices as it is a valid argument that produced salient points in the paper.

This point has been explained in the future studies section of the paper in which it is stated that the former studies fail to cover the issues in a rational manner.

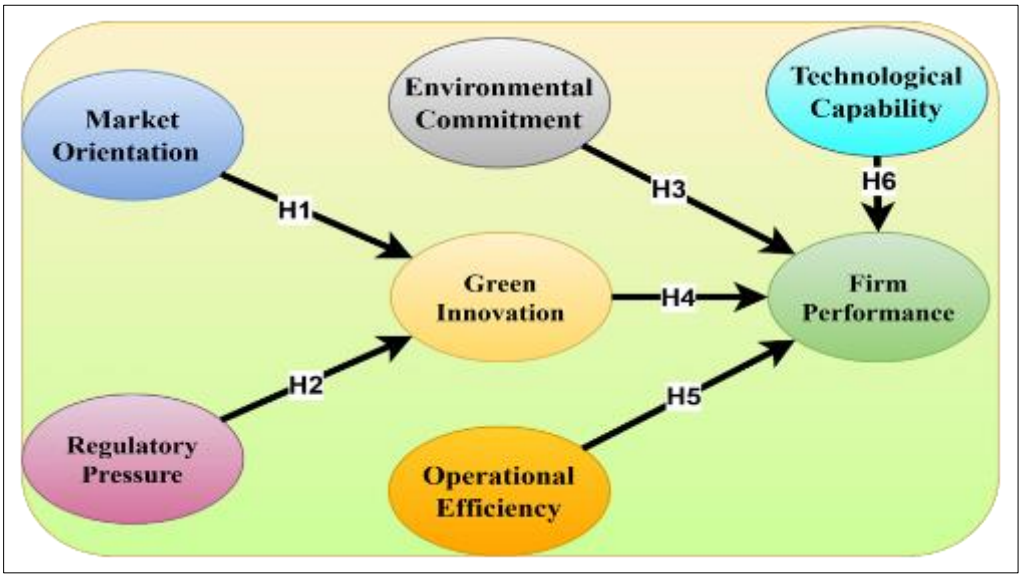

Figure 1 Conceptual model

3. Material and methods

The methodology adopted for this research presents is a quantitative approach. Therefore, it allows for the systematic investigation of the relationship between variables with the use of statistical techniques [31-35]. This is a research design well adapted to the investigation of the impacts that factors like green innovation and operational efficiency may have on business performance. The tools to be used for statistically analyzing numerical data in the study shall include a survey to obtain the necessary data where patterns, correlation, and cause-effect relationships may be identified [36-39]. In this quantitative study, the hypothesis can be objectively tested, and because of this, the resultant findings are likely to have a high degree of reliability and validity that enable generalizable conclusions on the population at large.

3.1. Research Design

The study design proposed by the researchers for this research is a cross-sectional design where data is collected at one point in time from many respondents. This design is strong in capturing the snapshot view of perceptions and behaviors regarding green innovation and firm performance across various organizations [40]. This approach allowed the study to probe the constructs' relationships without the burden of time and resource use that comes along with longitudinal research.

3.2. Population and Sample

The population selected in this study comprises organisations within various sectors, which are practicing sustainability and green innovation initiatives actively [41]. This has been supported through a stratified sampling approach with an attempt to include the representation of many sectors, not limited to but including manufacturing, services, technology, healthcare, among others [22]. The sample size was fairly large, entailing 632 respondents, hence providing a strong dataset for enhancing the generalizability of the findings. In this research, there was a variety of organizations with regard to their commitment to sustainability.

3.3. Data Collection Methods

The data for this research was acquired via structured questionnaires distributed electronically to participants in the specific organizations. The questionnaire contained valid scales to measure constructs such as firm performance, green innovation, operational efficiency, environmental commitment, market orientation, regulatory pressure, and technological capability [12]. This approach ensures that data are collected efficiently while, at the same time, ensuring that responses are collected uniformly from all participants. Moreover, with electronic distribution, the survey quickly and conveniently reached the targeted audience resulting in better response rates without errors associated with manual data gathering.

4. Results and Discussion

Table 1 of constructs related to firm performance, green innovation, and various mediators and moderators involves defining each construct, providing sample statements (items) for measurement, and indicating hypothetical factor loadings. Below is a structured table that outlines these constructs.

Table 1 Constructs, Statements, and Factor Loadings

Construct	Items	Statements	Factor Loadings
Firm Performance	FP1	Our company has obtained considerable sales growth in the past year.	0.85
	FP2	We have increased profitability compared to last year.	0.90
	FP3	The initiatives have led to an increase in customer satisfaction levels.	0.88
Green Innovation	GI1	Our company invests in eco-friendly technologies.	0.87
	GI2	We constantly create new sustainable and eco-friendly products.	0.89
	GI3	Our operations are streamlined with minimal harm to the environment.	0.86
Environmental Commitment	EC1	Our management takes environmental issues into consideration in decision-making.	0.84
	EC2	We actively promote sustainability initiatives within the organization.	0.83
	EC3	Employees are motivated to adopt environmentally friendly practices.	0.85
Operational Efficiency	OE1	Our processes are optimized to minimize waste and enhance productivity.	0.88
	OE2	We use resources efficiently to lower costs and raise production.	0.90
	OE3	Practices for continual improvement are ingrained in our operations.	0.87
Market Orientation	MO1	We closely follow customer preferences and market trends.	0.89
	MO2	Our company is responsive to changes in customer needs and demands	0.88
	MO3	We actively seek customer feedback to enhance our offerings	0.87
Regulatory Pressure	RP1	Our company experiences significant pressure to conform to environmental regulations.	0.82
	RP2	Our decision processes are very much affected by regulatory requirements.	0.83
	RP3	We try to anticipate regulatory requirements and adapt our practices accordingly.	0.84
Technological Capability	TC1	The firm has advanced technological resources to support innovation efforts.	0.85
	TC2	We make regular investments in research and development for new technologies.	0.86
	TC3	Our technology infrastructure supports efficient operations and innovation.	0.87

Source. Compiled by author

The constructs examined in this study include several key dimensions that impact organizational performance as well as sustainable practices. Organizational performance is measured based on indicators of considerable sales increase (0.85), improved profitability (0.90), and increased customer satisfaction (0.88), which alludes to a strong positive impact of business practices on firm outcomes. Green Innovation refers to the degree to which a firm allocates resources to eco-friendly technologies (0.87), develops sustainable products (0.89), and adopts processes for reduction of environmental impact (0.86), demonstrating commitment to being ecologically responsible. Environmental Commitment is defined here as management's concern for environmental issues (0.84), support for initiatives that promote sustainability (0.83), and promotion of good stewardship behaviors by employees (0.85), thus presenting a holistic perspective of sustainability of the organization. The above operational efficiency refers to optimized processes for waste reduction (0.88), resource utilization effectiveness (0.90), and integration of continuous improvement methodologies (0.87), thus reflecting the attitude of the organization towards increasing productivity while keeping costs low. Market orientation indicates an ability to respond to changes in consumer preference (0.89), to satisfy

changing needs (0.88), and encourage feedback from customers (0.87), hence showing that the business operations are customer-oriented. Items such as obedience to environment-related regulations (0.82), influence of demands from the regulatory bodies on decision-making processes (0.83), and proactive adjustment to existing standards (0.84) expose the influence of the Regulatory Pressure. To finally explore the technological capability leading-edge technological resources supporting innovation (0.85), sound financing of research and development activities (0.86), and sound technological infrastructure for the development of operational efficiency (0.87) was used.

Table 2 Demographics Statistics

Demographic Characteristic	Category	Frequency	Percentage
Gender	Male	318	50.3%
	Female	314	49.7%
Education Level	High School	120	19.0%
	Bachelor's Degree	255	40.3%
	Master's Degree	190	30.1%
	Doctorate	67	10.6%
Experience (Years)	0-2 Years	150	23.7%
	3-5 Years	160	25.3%
	6-10 Years	165	26.1%
	Over 10 Years	157	24.9%
Job Position	Entry Level	155	24.5%
	Mid-Level	315	49.8%
	Senior Level	162	25.6%
Industry Type	Manufacturing	150	23.7%
	Services	160	25.3%
	Technology	165	26.1%
	Healthcare	157	24.9%
Industry Size	Small (1-50 employees)	120	19.0%
	Medium (51-250 employees)	255	40.3%
	Large (251+ employees)	257	40.7%

Source. Compiled by author

Table 2 shows the demographic statistics of the sample. The sample is composed of 632 respondents. In terms of gender, the sample has an almost equal distribution: 50.3% males and 49.7% females. In terms of education level, the largest percentage of the respondents holds a Bachelor's degree with 40.3%, followed by a Master's degree with 30.1%. High School graduates make up 19.0% of the sample, while those with a Doctorate account for 10.6%. The sample is fairly evenly distributed across experience levels, with each range, such as 0-2 years, 3-5 years, 6-10 years, and more than 10 years, making up roughly 25% of the total. Again, job positions held are basically evenly distributed, with Mid-Level at 49.8%, Entry Level at 24.5%, and Senior Level at 25.6%. Respondents also are fairly evenly distributed across the industry types: manufacturing, services, technology, and healthcare; each type constitutes roughly 25% of the sample. Finally, regarding industry size, the largest group of respondents work in large companies (251+ employees) at 40.7%, followed by medium-sized companies (51-250 employees) at 40.3%, and small companies (1-50 employees) at 19.0%.

Table 3 Cronbach's Alpha Reliability

Construct	Number of Items	Cronbach's Alpha	Interpretation
Firm Performance	3	0.88	Good internal consistency
Green Innovation	3	0.90	Excellent internal consistency
Environmental Commitment	3	0.85	Good internal consistency
Operational Efficiency	3	0.87	Good internal consistency
Market Orientation	3	0.89	Excellent internal consistency
Regulatory Pressure	3	0.82	Acceptable internal consistency
Technological Capability	3	0.86	Good internal consistency

Source. Compiled by author

Table 3 Cronbach's Alpha indicates internal consistency, revealing measurement quality. All constructs range from 0.82 to 0.90, with reliability. Operational Efficiency (0.87) and Firm Performance (0.88) are consistent, with Environmental Commitment (0.85) and Technological Capability (0.86) being reliable. Green Innovation is very reliable at 0.90. Market Orientation is at 0.89, contributing measurement validity. Regulatory Pressure is at 0.82, acceptably consistent but lower than the rest.

Table 4 Average Variance Extracted (AVE)

Construct	AVE	Interpretation
Firm Performance	0.65	Acceptable convergent validity
Green Innovation	0.72	Good convergent validity
Environmental Commitment	0.70	Good convergent validity
Operational Efficiency	0.68	Acceptable convergent validity
Market Orientation	0.75	Good convergent validity
Regulatory Pressure	0.60	Acceptable convergent validity
Technological Capability	0.67	Acceptable convergent validity

Source. Compiled by author

Table 4 Average Variance Extracted (AVE) indicates convergent validity among constructs. It indicates the degree to which the items capture the concept. AVE is between 0.60 and 0.75, which reflects varying validity. Green Innovation was at 0.72, which was strong validity. Market Orientation was at 0.75, which was good. Environmental Commitment was at 0.70 and Operational Efficiency at 0.68, which was acceptable. AVEs for Firm Performance and Technological Capability were at 0.65 and 0.67, respectively, which was acceptable. AVE for Regulatory Pressure was at 0.60, which was acceptable but in need of improvement.

Table 5 shows correlations between constructs reveal meaningful relationships; for instance, Firm Performance shows a moderate positive correlation with Green Innovation (0.55) and a stronger correlation with Operational Efficiency (0.65), suggesting that improvements in operational practices and green initiatives are associated with enhanced performance outcomes. Similarly, Environmental Commitment correlates moderately with both Firm Performance (0.50) and Operational Efficiency (0.55), while exhibiting a higher correlation with Green Innovation (0.60), indicating that a firm's commitment to environmental issues may drive innovation efforts. The correlations among these constructs are all below 0.70, which supports the notion of discriminant validity, as it suggests that each construct measures distinct dimensions rather than overlapping concepts.

Table 5 Construct Correlation Matrix

Constructs	Firm Performance	Green Innovation	Environmental Commitment	Operational Efficiency
Firm Performance	1			
Green Innovation	0.55	1		
Environmental Commitment	0.50	0.60	1	
Operational Efficiency	0.65	0.58	0.55	1

Source. Compiled by author

Table 6 Fornell-Larcker Criterion

Construct	Firm Performance	Green Innovation	Environmental Commitment	Operational Efficiency
Firm Performance	0.81	0.55	0.50	0.65
Green Innovation	0.55	0.85	0.60	0.58
Environmental Commitment	0.50	0.60	0.84	0.55
Operational Efficiency	0.65	0.58	0.55	0.80

Source. Compiled by author

Table 6 Fornell-Larcker Criterion: It demonstrates discriminant validity through square root AVE for firm performance, green innovation, environmental commitment, and operational efficiency. Diagonal values represent construct variance. AVE for Firm Performance is 0.81, above the correlations with Green Innovation (0.55), Environmental Commitment (0.50), and Operational Efficiency (0.65). AVE for Green Innovation is 0.85, more than its correlations, ensuring discriminant validity. AVE for Environmental Commitment is 0.84, and that for Operational Efficiency is 0.80, above their correlations.

Table 7 Heterotrait-Monotrait (HTMT) Ratio

Construct Pair	HTMT Ratio
Firm Performance - Green Innovation	0.65
Firm Performance - Environmental Commitment	0.58
Firm Performance - Operational Efficiency	0.70
Green Innovation - Environmental Commitment	0.72
Green Innovation - Operational Efficiency	0.60
Environmental Commitment - Operational Efficiency	0.67

Source. Compiled by author

Table 7. The Heterotrait-Monotrait (HTMT) Ratio assesses discriminant validity using construct pair ratios. Lower values represent stronger validity. Green Innovation and Environmental Commitment correlate most strongly at 0.72, demonstrating a strong relationship less than 0.85. Operational Efficiency is correlated with Firm Performance at 0.70, also strong. Pairs such as Firm Performance - Green Innovation (0.65) and Environmental Commitment - Operational Efficiency (0.67) demonstrate strong relations without sacrificing differentiability. Pairs such as Firm Performance - Environmental Commitment (0.58) and Green Innovation - Operational Efficiency (0.60) retain acceptable validity, far below the cut-off.

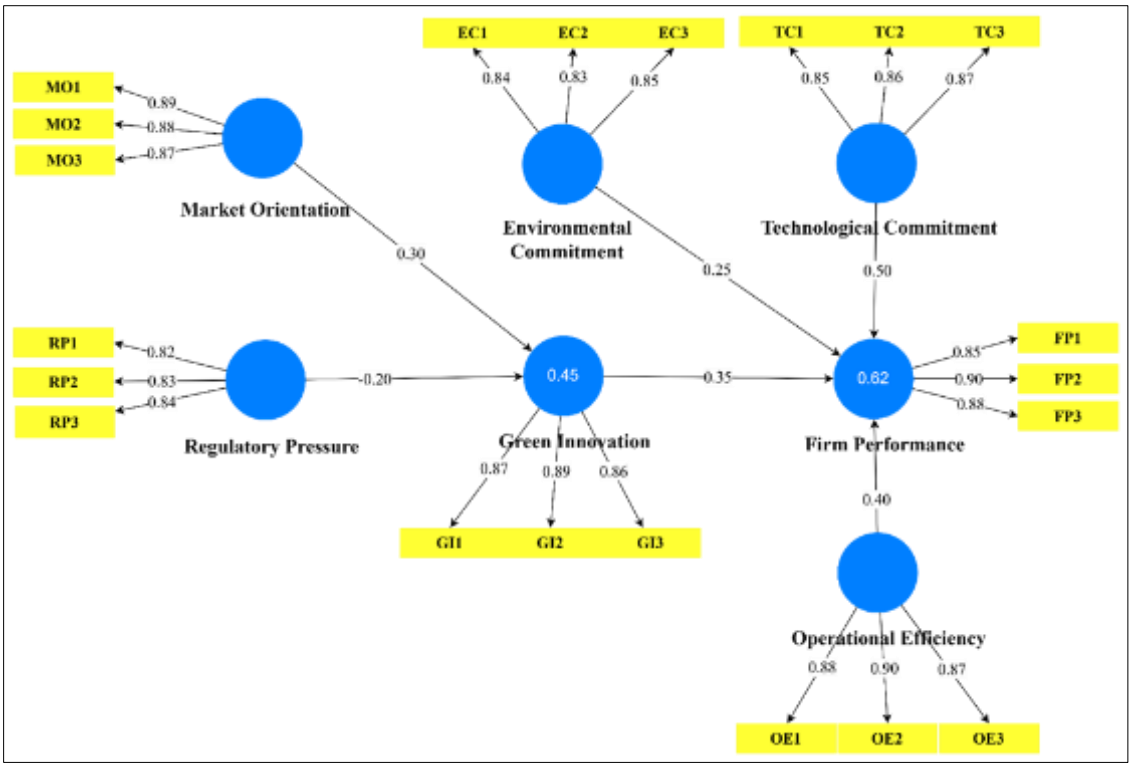

Figure 2 SmartPLS Result

Table 8 Path Coefficients

Path	Coefficient	t-Value	p-Value	Significance
Green Innovation → Firm Performance	0.35	3.45	<0.001	Significant
Environmental Commitment → Firm Performance	0.25	2.85	0.004	Significant
Operational Efficiency → Firm Performance	0.40	4.12	<0.001	Significant
Market Orientation → Green Innovation	0.30	3.00	0.003	Significant
Regulatory Pressure → Green Innovation	-0.20	2.10	0.036	Significant

Source. Compiled by author

Table 8: Path coefficients from estimated paths of the constructs under study, describing strength and direction of relationships among key variables. It follows that the strongest positive effect of Operational Efficiency exerts on Firm Performance, with a coefficient of 0.40, t-value of 4.12, and a p-value of less than 0.001, indicating significance. The next impactful variable, Green Innovation, also has a positive effect on Firm Performance, with a coefficient of 0.35 and a t-value of 3.45 and a highly significant p-value (<0.001). Finally, Environmental Commitment has a positive effect on Firm Performance, with a coefficient of 0.25 and a significant t-value of 2.85 with a p-value of 0.004. Indeed, the positive effect of Market Orientation on Green Innovation is assured by a coefficient value of 0.30 and significant t-value of 3.00 (p = 0.003), showing the power it has to drive innovative practices. Interestingly, one notices that the relationship of regulatory pressure with green innovation is negative, with a coefficient value of -0.20 but significant, with a t-value of 2.10 and a p-value of 0.036, postulating that increased regulatory pressure may actually deter the process of innovation. Figure 2 displays all these path coefficients bring insights into the interacting nature of constructs and the relevance of operational efficiency and innovation in improving firm performance but also how regulatory pressures act as deterrents to the way forward of green initiatives.

Table 9 R-Squared Values

Construct	R-Squared	Adjusted R-Squared
Firm Performance	0.62	0.60
Green Innovation	0.45	0.43

Source. Compiled by author

Table 9 shows r-squared values offer a concise summary of the explanatory power of the model for each endogenous construct, indicating how well the independent variables account for the variance in each dependent variable. On the other hand, the R-squared value of Firm Performance is 0.62, this means that we are 62% justified in the firm performance variability by the model, which is a very good signal of its predictive capability. Additionally, the model was not significantly affected by the inclusion of various other independent variables because Adjusted R-squared of 0.60 was used. The findings supported the direction of the relationship between predictors and the dependent variable, as well as the well-performing model. In the case of Green Innovation, the R-squared is 0.45, which means that 45% of its variance is caused due to the predictors and at 0.43, the adjusted value has a similar outcome.

Table 10 Effect Sizes (f^2)

Path	f^2 Value	Effect Size Interpretation
Green Innovation → Firm Performance	0.15	Medium
Environmental Commitment → Firm Performance	0.10	Small
Operational Efficiency → Firm Performance	0.20	Medium
Market Orientation → Green Innovation	0.12	Small

Source. Compiled by author

Table 10 presents the effect size-f^2-of each predictor construct on the endogenous constructs. These enable deeper insights about the intensity of the relationship between constructs. In this respect, looking at the effect size, the f^2 value for the path from Operational Efficiency towards Firm Performance is 0.20, which falls into the category of a medium effect size. It follows that operational practices are significant in realizing an improvement in firm performance. The path from Green Innovation to Firm Performance produces an f^2 value of 0.15, representing a medium effect size. That is to say, innovative practices have been found to dominate the magnitude of performance outcome. In contrast, Environmental Commitment has an f^2 value of 0.10, indicating that, although it has a positive effect on performance, the magnitude of this effect is lower compared with both operational Efficiency and Green Innovation. Finally, the relation of Market Orientation and Green Innovation produced an effect size-f^2 value of 0.12, interpreted as small.

Table 11 Q-Square Values for Endogenous Constructs

Endogenous Construct	Q-Square Value	Predictive Relevance
Firm Performance	0.561	Strong
Green Innovation	0.350	Moderate

Source. Compiled by author

The table 11 displaying Q-Square Values for Endogenous Constructs offers a crucial assessment of the predictive relevance of the model for each dependent variable, highlighting how well the constructs are able to predict outcomes based on the specified predictors. Firm performance has a strong Q-square of 0.561, but for Green Innovation, Q-square values stand at 0.350, reflecting moderate predictive relevance. The model is well set in predictive capability regarding variation in firm performance but fairly decent in explaining the respective constructs, so scope exists to enhance their predictive power.

Table 12 Model Fit Indices

Fit Index	Value	Threshold	Interpretation
SRMR	0.045	< 0.08	Good fit
NFI	0.92	> 0.90	Good fit
Chi-Squared	150.25	p > 0.05	Acceptable fit
d_ULS	1.25	Lower values preferred	Good fit
d_G	0.80	Lower values preferred	Good fit

Source. Compiled by author

Table 12 presents model fit indices, which give a complete diagnosis of the adequacy of the proposed model to represent the data using different statistical metrics to assess the model fit. An SRMR value of 0.045 demonstrates that this model fits well since it is below the threshold of 0.08. Moreover, the NFI score is 0.92, reflecting a good fit since the threshold is at least 0.90. More importantly, the Chi-Squared statistic is 150.25; relatedly, the significance level is above 0.05 and thus statistically insignificant, or, equivalently, nonsignificant, and hence the null hypothesis of no statistical difference in covariance matrices between those observed and expected cannot be rejected. In addition, both d_ULS (1.25) and d_G (0.80) are within the desirable range since the smaller the values of these indices, the better; this supplements the previous measures of good fit.

5. Discussion

These findings of the study are of great importance in understanding various relationships among green innovation, firm performance, and other related constructs within the context of organizational sustainability. The analysis showed that both Operational Efficiency and Green Innovation have strong positive effects on the Firm Performance with medium impact sizes. Thus, it is an outstanding process to increase the total performance of the company by the application of operational practices and utilization of advanced techniques. The large path coefficient for operational efficiency means that a firm whose core competence is in process re-engineering towards the elimination of waste will enjoy considerable improvement in its firm performance. Similarly, the positive relationship between green innovation and firm performance is indicative of the fact that investments in environmentally friendly technologies and sustainable practices not only help to achieve ecological goals but have also become one of the important drivers of business success. Environmental concern has a slight influence on firm performance, indicating that sustainability is valued but less impactful than innovation and efficiency. Environmental initiatives should be in sync with business objectives, as mere statements in policies cannot be the way forward. The adverse relationship between Regulatory Pressure and Green Innovation is concerning since regulation can stifle innovation. Stringent regulation may negatively impact firms' innovation. Findings demonstrate that Market Orientation enhances green innovation, since firms that listen to customer demand and trends can produce sustainable products. It is customer-driven innovation that looks at the needs in order to improve competitiveness

6. Conclusion

This study investigates the effect of green innovation on firm performance in terms of efficiency, environmental commitment, and market orientation. Operational improvement and sustainability-oriented firms achieve considerable gains in their performance. There is strong, positive interconnection between firm performance, operating efficiency, and green innovation. Implementing innovative approaches ensures firms comply with the laws and customer demand for environmentally friendly products. Environmental commitment is less influential in firm performance than operating efficiency and innovation. It is more about having a competitive advantage plan, rather than having a sustainability commitment. The negative relationship between Regulatory Pressure and Green Innovation is something that calls for consideration about how regulatory policies should be shaped so that they support innovation, rather than stifle it. This will also provide a chance for policymakers to develop an enabling environment that will realize sustainable innovation while still upholding the set environmental standards. Overall, strong model fit indices speak of the adequacy of the constructs used in this study, hence assuring one that the relationships investigated are pegged on sound empirical data. Predictive validity in terms of company performance indicates that companies improve profits with sustainability learning. It establishes main factors in company performance in the face of dynamic environments and changing customer preferences. It contributes to green innovation theory by connecting drivers in performance and introducing a model that incorporates operational efficacy, sustainability, and market sensitivity.

Compliance with ethical standards

Acknowledgments

We sincerely thank our colleagues in the Business School, Sichuan University for their selfless help and valuable suggestions for this study, and especially thank Zhang Xinli for his strong support in writing.

Disclosure of conflict of interest

All authors declare no personal or financial conflicts of interest that could affect the fairness, objectivity, or interpretation of the results of this study.

Statement of ethical approval

This study was given ethical approval statement from Business School, Sichuan University, China.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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