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Examining the Relationship of Green Intellectual Capital and Environmental Innovation with Sustainable Financial Performance

ABSTRACT

In today's world, growing concerns about environmental issues and climate change have made sustainable development one of the most important priorities of human societies. Organizations and companies are no exception and seek to adopt innovative and sustainable approaches that both protect the environment and improve their financial performance. In this context, green intellectual capital and environmental innovation have emerged as two key factors that may play an important role in achieving sustainable financial performance. Accordingly, the present study aimed to examine the relationship of green intellectual capital and environmental innovation with sustainable financial performance. In terms of data-collection method, this study employed a descriptive-survey and correlational design, and in terms of purpose, it was applied research. The statistical population consisted of all employees working in the financial departments of paper and paperboard manufacturing companies. Based on the Krejcie and Morgan sample-size table, a sample of 384 participants was selected through nonprobability convenience sampling. Questionnaires were used to measure the study variables. The questionnaire data were extracted, classified, and analyzed using SmartPLS software. The results of the data analysis indicated that green intellectual capital had a significant effect on environmental innovation and sustainable financial performance. Environmental innovation also had a significant effect on sustainable financial performance. Finally, environmental innovation moderated the relationship between green intellectual capital and sustainable financial performance.

Keywords: green intellectual capital, sustainable financial performance, environmental innovation

Introduction

The intensification of climate change, resource depletion, environmental pollution, and ecological degradation has increased pressure on organizations to reconsider the conventional foundations of competitiveness and financial success. Contemporary firms are no longer evaluated exclusively on the basis of profitability, market share, or short-term economic returns; they are also expected to demonstrate environmental responsibility, efficient resource utilization, and the capacity to create value without undermining ecological systems. This shift has placed sustainable performance at the center of management research and practice. Sustainable financial performance, in this context, refers to an organization's ability to maintain economic viability, profitability, resilience, and long-term value creation while simultaneously incorporating environmental considerations into its decisions and operations. Achieving such performance requires organizations to move beyond compliance-oriented environmental policies and develop strategic capabilities that connect knowledge, innovation, environmental management, and financial outcomes [1, 2].

Environmental challenges have altered the nature of organizational resources that are considered strategically valuable. Traditional physical and financial assets remain important, but they are increasingly insufficient for ensuring long-term competitiveness in environmentally sensitive markets. Knowledge-based resources, organizational learning, employee capabilities, environmental relationships, and innovation capacity have become essential sources of sustainable advantage. This development has led to growing interest in green intellectual capital, which extends the concept of intellectual capital by incorporating environmental knowledge, competencies, values, routines, relationships, and organizational structures. Green intellectual capital represents the stock of intangible assets related to environmental protection and green management that can assist organizations in responding to ecological pressures, identifying environmental opportunities, and implementing sustainable strategies [3, 4].

Green intellectual capital is generally understood as a multidimensional construct composed of green human capital, green structural capital, and green relational capital. Green human capital includes employees' environmental knowledge, skills, awareness, creativity, commitment, and experience. Green structural capital refers to the organizational systems, databases, routines, technologies, processes, cultures, and policies that preserve and institutionalize environmental knowledge. Green relational capital encompasses relationships with customers, suppliers, governmental bodies, communities, and other stakeholders that support environmental cooperation and value creation. Together, these dimensions allow environmental knowledge to be generated, shared, retained, and converted into organizational practices. Accordingly, green intellectual capital is not merely an accumulation of environmental information but a strategic capability through which organizations integrate environmental considerations into their operations, products, relationships, and decision-making processes [5, 6].

The strategic relevance of green intellectual capital is particularly evident in industries characterized by substantial resource consumption, waste generation, energy use, and environmental exposure. Manufacturing firms, including paper and paperboard companies, operate in settings where raw material utilization, water consumption, chemical processing, waste disposal, and emissions have direct environmental and financial implications. In such industries, environmental knowledge can contribute to process optimization, waste reduction, cleaner technologies, efficient energy consumption, improved material recovery, and stronger stakeholder relationships. When environmental expertise is embedded in employees, organizational routines, and external networks, firms may become better positioned to identify inefficiencies, anticipate regulatory changes, and respond to growing environmental expectations. Consequently, green intellectual capital may support both environmental responsibility and the long-term preservation of financial value [7, 8].

Research has increasingly connected green intellectual capital with different dimensions of organizational performance. Firms that invest in environmental knowledge and environmentally oriented intangible assets may improve their capacity to reduce costs, strengthen their reputation, enhance resource efficiency, and develop products or processes that meet emerging market expectations. A strong base of green intellectual capital can also enable organizations to incorporate environmental concerns into strategic planning, supply-chain relationships, internal controls, and investment decisions. Evidence suggests that green intellectual capital contributes to sustainable performance by improving organizational preparedness, environmental responsiveness, and strategic alignment [4, 9]. It may also strengthen corporate economic sustainability by transforming environmental competencies into market, operational, and financial advantages [2].

The relationship between green intellectual capital and financial performance, however, is neither automatic nor necessarily direct. Intangible environmental resources create value when they are effectively mobilized and applied through

organizational processes. Employees may possess environmental knowledge, and organizations may establish environmentally oriented structures, but these assets will produce limited financial benefits unless they are translated into operational improvements, innovative solutions, and strategic actions. This distinction is important because the possession of green knowledge differs from its effective exploitation. Green intellectual capital must therefore be converted into capabilities that enhance efficiency, innovation, stakeholder responsiveness, and competitive differentiation. Recent research has shown that green absorptive capacity, green business strategies, and environmental management mechanisms can determine whether green intellectual capital generates meaningful organizational outcomes [10, 11].

Green absorptive capacity is particularly important because it enables firms to identify, acquire, assimilate, transform, and exploit environmental knowledge. Organizations are frequently exposed to new information concerning environmental technologies, market expectations, regulatory standards, and sustainable business models. Without adequate absorptive capacity, such information may remain fragmented and fail to influence organizational practices. Green intellectual capital can strengthen the knowledge base required for absorptive processes, while absorptive capacity can help convert existing and external environmental knowledge into green strategies and innovation. Accordingly, the effect of green intellectual capital may depend on the organization's ability to transform knowledge into practical responses and commercially valuable outcomes [10, 11].

Among the principal mechanisms through which green intellectual capital can create organizational value is environmental innovation. Environmental innovation, also referred to as eco-innovation or green innovation, encompasses new or substantially improved products, services, processes, technologies, practices, and managerial systems that reduce environmental harm or improve environmental efficiency. It may involve reducing resource consumption, lowering emissions, minimizing waste, increasing recyclability, improving energy efficiency, adopting cleaner production methods, or redesigning supply chains. Environmental innovation allows firms to respond actively to ecological challenges rather than relying solely on corrective or compliance-based actions. It can also create opportunities for differentiation, cost reduction, market expansion, legitimacy, and long-term competitiveness [12, 13].

The development of environmental innovation is fundamentally knowledge-intensive. Organizations must understand environmental problems, recognize technological alternatives, integrate knowledge from different functions, and collaborate with external stakeholders. Green intellectual capital provides many of the cognitive, structural, and relational foundations required for these activities. Employees with strong environmental expertise can propose cleaner solutions and identify inefficiencies. Green structural capital can support the documentation, diffusion, and institutionalization of environmental practices. Green relational capital can facilitate access to information, technologies, suppliers, customers, and collaborative networks. Consequently, organizations with stronger green intellectual capital may be more capable of generating and implementing environmental innovations [14, 15].

Empirical studies have supported the positive association between green intellectual capital and green innovation. In the Spanish wine industry, green intellectual capital was found to contribute to green innovation performance by strengthening the intangible resources needed for environmentally oriented change [14]. Research on manufacturing firms has similarly indicated that green intellectual capital supports ambidextrous green innovation, including both exploratory and exploitative forms of innovation [7, 15]. Exploratory green innovation involves experimentation, the acquisition of new knowledge, and the development of fundamentally new environmental solutions, whereas exploitative green innovation focuses on refining

existing products, processes, and environmental practices. The ability to balance these forms of innovation can improve an organization's capacity to respond to current environmental requirements while preparing for future ecological and market conditions.

Environmental innovation may also be influenced by broader organizational and interorganizational conditions. Supplier integration, customer orientation, environmental information systems, and green supply-chain management can facilitate the exchange of knowledge required for innovation. Environmental information systems, for example, can improve the acquisition and processing of environmental data, while integration with suppliers and customers can reveal opportunities for product redesign, material substitution, and process improvement [16]. Similarly, green supply-chain practices can strengthen the relationship between environmental knowledge and sustainable performance by extending sustainability principles beyond organizational boundaries [17]. These findings indicate that environmental innovation is embedded in a broader system of organizational knowledge, information flows, stakeholder engagement, and strategic coordination.

Environmental innovation is also expected to influence financial performance. Although environmental initiatives are often associated with initial investment costs, they may generate financial benefits through resource efficiency, waste reduction, operational savings, regulatory risk reduction, enhanced corporate image, and improved access to environmentally conscious markets. Process innovations can reduce energy, water, and material costs, while product innovations can create differentiated offerings and strengthen customer loyalty. Environmental innovations may also improve the organization's ability to adapt to regulatory changes and avoid environmental liabilities. Thus, environmental innovation can become a source of both environmental improvement and economic value, particularly when it is aligned with strategic objectives and supported by effective management systems [1, 12].

The concept of sustainable financial performance emphasizes that financial outcomes should be evaluated over an extended time horizon. Short-term profitability may be achieved through practices that generate environmental costs, regulatory exposure, reputational damage, or resource dependency. Such performance is vulnerable and may not be maintained under changing environmental, social, and market conditions. Sustainable financial performance, by contrast, reflects the firm's ability to preserve financial stability and value creation through strategies that reduce environmental risk and strengthen organizational resilience. The disclosure of environmental information may support this process by improving transparency, reducing information asymmetry, and influencing stakeholder assessments of organizational risk and accountability [18]. Green accounting practices may likewise strengthen the measurement and management of environmental resources, costs, and intellectual assets, thereby supporting more informed financial and managerial decisions [19].

Environmental orientation can also contribute to financial performance by shaping supplier management and relational capital. Organizations with a strong environmental orientation are more likely to incorporate ecological criteria into purchasing, collaboration, and stakeholder relations. Green supplier management can reduce supply-related environmental risks and improve access to sustainable materials, whereas relational capital can strengthen trust, information exchange, and joint problem solving. These mechanisms may enable firms to lower costs, improve quality, and enhance financial outcomes [20]. Therefore, green intellectual capital and environmental innovation should not be examined in isolation from the relational and informational systems through which environmental value is created.

Despite increasing evidence, findings regarding the financial consequences of green intellectual capital remain context-dependent. Some studies have reported a positive relationship between green intellectual capital and financial performance, while others have suggested that this relationship may vary according to ownership structure, organizational characteristics, market conditions, and the effectiveness of resource deployment. For example, family ownership may alter the manner in which firms invest in and exploit green intellectual capital because family-controlled organizations may differ in their risk preferences, strategic horizons, and commitment to socioemotional or environmental goals [21]. Evidence from the Indonesian manufacturing industry has also shown that green intellectual capital can affect financial performance under adverse and uncertain conditions, although the strength of the effect may depend on firms' capacity to preserve and mobilize intangible resources during disruption [22].

The mixed nature of previous findings suggests that environmental innovation may clarify how green intellectual capital contributes to sustainable financial performance. Green intellectual capital can provide the knowledge and capabilities required for innovation, while environmental innovation can transform those intangible assets into measurable operational and financial outcomes. In this sense, environmental innovation may function as a pathway, enabling condition, or interaction mechanism that strengthens the financial value of green intellectual capital. Recent evidence from Indonesia indicates that green intellectual capital and eco-innovation jointly shape sustainable financial performance, highlighting the importance of examining their combined influence rather than treating them as disconnected predictors [23]. This perspective is theoretically important because it explains why organizations possessing similar levels of environmental knowledge may achieve different financial outcomes: firms differ in their ability to convert such knowledge into innovative environmental practices.

The interaction between green intellectual capital and environmental innovation can be understood through the resource-based and knowledge-based perspectives of the firm. From the resource-based perspective, valuable, rare, inimitable, and organizationally embedded intangible resources can generate competitive advantage. Green intellectual capital satisfies these conditions when environmental knowledge is specialized, accumulated through experience, embedded in routines, and supported by stakeholder relationships. From the knowledge-based perspective, organizational performance depends on the creation, integration, and application of knowledge. Environmental innovation represents a practical outcome of these knowledge processes. Green intellectual capital may therefore provide the resource base, while environmental innovation serves as the mechanism through which knowledge is applied to products, processes, and business models.

Dynamic capability theory provides an additional explanation. Environmental conditions, technologies, regulations, and stakeholder expectations are continuously evolving. Firms must therefore sense environmental opportunities and threats, seize opportunities through strategic investment, and reconfigure resources and capabilities. Green intellectual capital enhances the knowledge base needed for sensing and interpretation, whereas environmental innovation reflects the organization's capacity to reconfigure operations and develop new solutions. Remanufacturing and related circular practices, for example, can strengthen dynamic capabilities, stakeholder engagement, eco-innovation, and business performance by creating systems through which resources are recovered and reused [12]. Environmental innovation thus represents not only a discrete output but also a dynamic process of adaptation and renewal.

Corporate environmental image is another relevant outcome of green intellectual capital and innovation. Firms that successfully apply environmental knowledge and develop green innovations may improve their reputation among customers,

investors, regulators, and communities. A favorable green corporate image can increase legitimacy, customer trust, and market acceptance, thereby contributing indirectly to financial performance. However, such reputational benefits are more likely when the organization possesses a supportive green innovation climate and when environmental commitments are reflected in actual practices rather than symbolic communication [8]. Similarly, managers' environmental awareness can influence the extent to which external ESG pressures are translated into green innovation, particularly when financial constraints affect the availability of resources for environmental investment [13].

The governance of green intellectual capital is therefore essential. Organizations require mechanisms that coordinate environmental knowledge across departments, prevent knowledge loss, encourage employee participation, and support collaboration with external partners. Eco-knowledge hubs and similar structures may facilitate the collection, integration, and dissemination of environmental knowledge, improving the governance of green intellectual assets [6]. Human resource management also plays a central role by recruiting environmentally aware employees, providing green training, establishing sustainability-oriented performance criteria, and encouraging employee involvement in environmental initiatives [5]. Without such systems, green intellectual capital may remain dispersed and fail to generate innovation or sustainable financial benefits.

Prior research has made important contributions, but several gaps remain. First, many studies have focused primarily on environmental or green performance rather than sustainable financial performance. Although environmental improvement is essential, organizations also need evidence regarding whether green intellectual capital and environmental innovation contribute to enduring financial outcomes. Second, previous studies have often examined direct relationships without fully considering the interaction between intangible environmental resources and innovation capability. Third, findings obtained in specific industries and national settings may not be directly transferable to paper and paperboard manufacturing firms, whose production processes are closely associated with resource use, waste generation, and environmental scrutiny. Finally, the financial personnel and managers of these companies may offer particularly relevant insights because they participate in evaluating environmental costs, investments, risks, and returns.

Examining these relationships in paper and paperboard manufacturing companies is especially important because environmental and financial decisions are deeply interconnected in this sector. Investments in cleaner technologies, recycling systems, energy efficiency, waste reduction, and sustainable sourcing may require substantial financial resources, but they can also reduce long-term costs and strengthen market competitiveness. Green intellectual capital may improve the quality of these decisions by providing specialized knowledge and organizational learning, while environmental innovation may increase the effectiveness with which such knowledge is converted into operational and financial results. A clearer understanding of these relationships can therefore assist managers in allocating resources to intangible environmental assets and innovation initiatives that support both ecological responsibility and financial sustainability.

Accordingly, the present study aimed to examine the relationships among green intellectual capital, environmental innovation, and sustainable financial performance and to determine whether environmental innovation moderates the relationship between green intellectual capital and sustainable financial performance in paper and paperboard manufacturing companies.

Methodology

Based on the nature of the research, the present study employed a mixed-methods design consisting of qualitative and quantitative components. Data were collected through field and library research. First, previous studies were reviewed and the theoretical foundations of the research were examined using the library research method. Interviews were used to collect the required data.

The statistical population consisted of financial managers working in paper and paperboard manufacturing companies. Because the population was limited but its exact size was unknown, a sample of 384 participants was selected. Structural equation modeling was used to analyze the data, and the analyses were conducted using SmartPLS software.

Findings and Results

The demographic characteristics of the sample included gender, age, educational level, and work experience. As shown below, of the 384 participants, 326 (84.9%) were men and 58 (15.1%) were women. Regarding age, 38 participants (9.9%) were between 20 and 30 years old, 91 (23.7%) were between 31 and 40 years old, 179 (46.6%) were between 41 and 50 years old, and 76 (19.8%) were older than 50 years. Regarding educational attainment, 227 participants held bachelor's degrees, 115 held master's degrees, and 42 held doctoral degrees or higher. Regarding work experience, 216 participants had less than 10 years of experience, 116 had between 11 and 20 years of experience, and 52 had between 21 and 30 years of experience.

Table 1

Descriptive Statistics for the Characteristics of the Study Sample

Characteristic	Category	Frequency	Percentage
Gender	Male	326	84.9
	Female	58	15.1
Age	20–30 years	38	9.9
	31–40 years	91	23.7
	41–50 years	179	46.6
	Older than 50 years	76	19.8
Educational level	Bachelor's degree	227	59.1
	Master's degree	115	29.9
	Doctoral degree	42	10.9
Work experience	Less than 10 years	216	56.3
	10–20 years	116	30.2
	More than 20 years	52	13.5

Before conducting factor analysis, it was necessary to determine whether the available data were suitable for this type of analysis. Therefore, the adequacy of the data for factor analysis was initially assessed. Given that the Kaiser–Meyer–Olkin measure was greater than 0.70 and Bartlett's test of sphericity was statistically significant ($p < .05$), the data were considered suitable and met the necessary conditions for factor analysis.

Table 2

Kaiser–Meyer–Olkin Measure and Bartlett's Test of Sphericity

Test	Statistic	Value
Kaiser–Meyer–Olkin measure of sampling adequacy	KMO	.884
Bartlett's test of sphericity	Approximate chi-square	29,845.519
	df	528
	Significance	< .001

In this section, the research hypotheses were tested using partial least squares structural equation modeling.

Figure 1

Structural model of the study with factor loading coefficients.

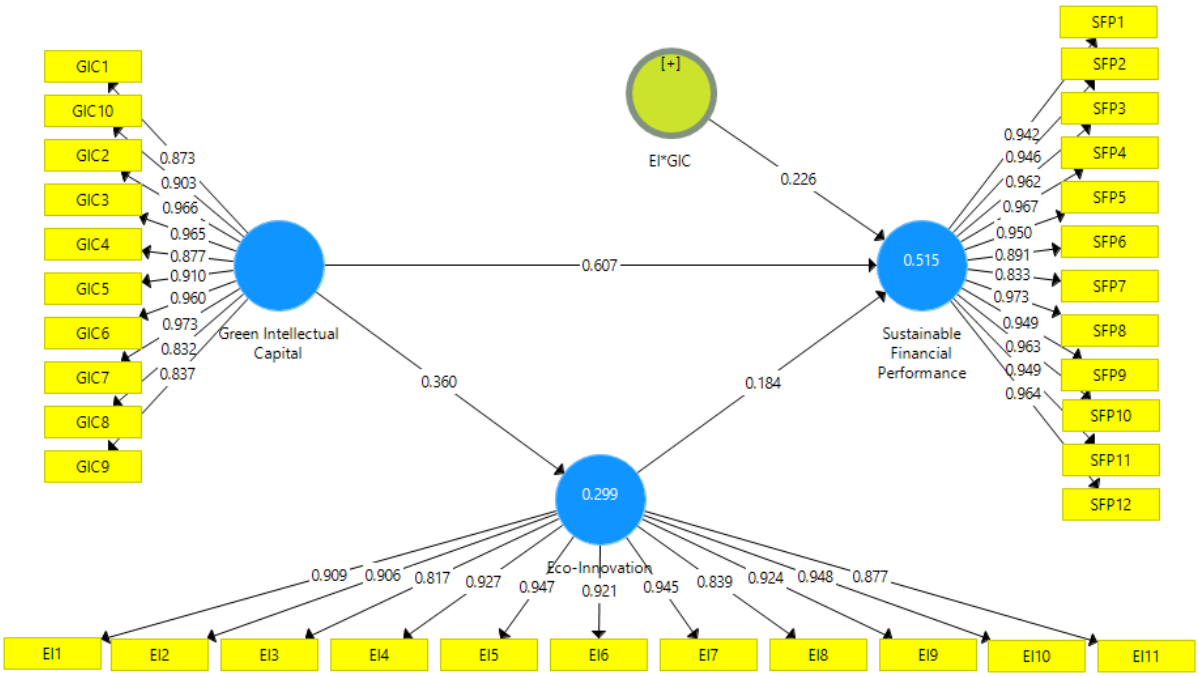
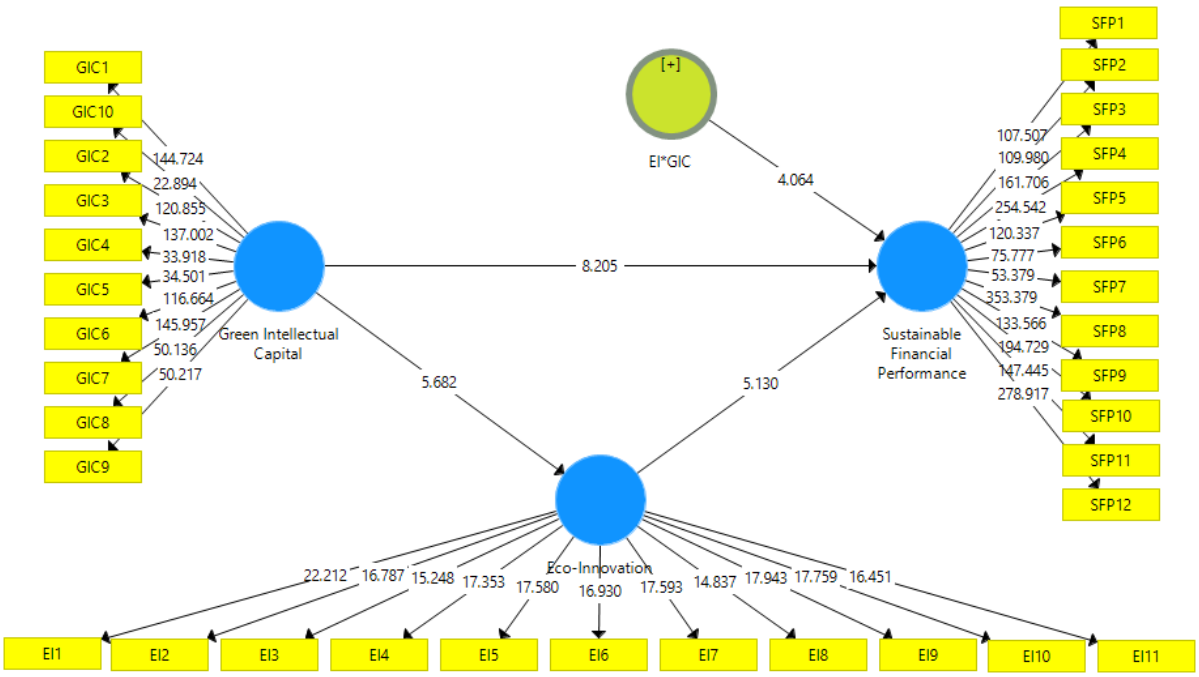


Figure 2

Structural model of the study with significance coefficients.



Model fit was evaluated by examining the measurement model fit, structural model fit, and overall model fit.

To assess the reliability of the measurement model, factor loading coefficients, Cronbach's alpha coefficients, and composite reliability coefficients were examined.

Table 3

Factor Loading Coefficients

Construct	Indicator	Factor Loading
Green intellectual capital	GIC1	.873
	GIC2	.966
	GIC3	.965
	GIC4	.877
	GIC5	.910
	GIC6	.960
	GIC7	.973
	GIC8	.832
	GIC9	.837
	GIC10	.903
Environmental innovation	EI1	.909
	EI2	.906
	EI3	.817
	EI4	.927
	EI5	.947
	EI6	.921
	EI7	.945
	EI8	.839
	EI9	.924
	EI10	.948
	EI11	.877
Sustainable financial performance	SFP1	.942
	SFP2	.946
	SFP3	.962
	SFP4	.967
	SFP5	.950
	SFP6	.891
	SFP7	.833
	SFP8	.973
	SFP9	.949
	SFP10	.963
	SFP11	.949
	SFP12	.964

The threshold for acceptable factor loading coefficients was .40. As shown in Table 3, all factor loading coefficients were greater than .40, indicating that this criterion was satisfactorily met.

According to the PLS data-analysis procedure, after assessing the factor loadings of the indicators, Cronbach's alpha and composite reliability coefficients were calculated and reported. The results are presented in Table 4.

Table 4

Cronbach's Alpha and Composite Reliability of the Latent Variables

Latent Variable	Cronbach's Alpha ($\alpha > .70$)	Composite Reliability (CR > .70)
Green intellectual capital	.924682	.928844
Environmental innovation	.895362	.913141
Sustainable financial performance	.946629	.965693

Because .70 is considered the minimum acceptable value for Cronbach's alpha and composite reliability, and because the coefficients reported in Table 4 exceeded this threshold for all latent variables, the reliability of the study measures was confirmed.

The second criterion used to evaluate the fit of the measurement model was convergent validity, which assesses the degree to which each construct is correlated with its corresponding indicators.

Table 5

Convergent Validity of the Latent Variables

Latent Variable	Average Variance Extracted (AVE > .50)
Green intellectual capital	.656341
Environmental innovation	.639444
Sustainable financial performance	.903776

Because .50 is considered the minimum acceptable value for the average variance extracted, and because the AVE values reported in Table 5 exceeded this threshold for all latent variables, the convergent validity of the study measures was confirmed.

The second criterion used to evaluate structural model fit was the coefficient of determination, R^2, for the endogenous latent variables in the model. The R^2 coefficient indicates the extent to which an exogenous variable explains the variance in an endogenous variable. Values of .19, .33, and .67 are commonly interpreted as weak, moderate, and substantial levels of explanatory power, respectively. As shown in Figure 1, the R^2 values were calculated for the endogenous constructs. Based on the stated threshold values, the structural model demonstrated an acceptable level of fit.

Table 6

R^2 Values for the Endogenous Constructs

Latent Variable	R^2
Environmental innovation	.299532
Sustainable financial performance	.515473

The goodness-of-fit index was used to evaluate the overall model fit. Values of .01, .25, and .36 have been proposed as indicative of weak, moderate, and strong GOF, respectively. The mean communality value was obtained by calculating the average communality values of the latent variables.

Table 7

Communality and R^2 Values of the Study Variables

Latent Variable	Communality	R^2
Green intellectual capital	.656341	.000000
Environmental innovation	.639444	.299532
Sustainable financial performance	.903776	.515473

Table 8

Overall Model Fit Results

Mean Communality	Mean R^2	GOF
.733187	.407502	.546603

Given the obtained GOF value of approximately .55, the overall model demonstrated a very satisfactory level of fit.

Table 9

Direct Relationships and Significance Coefficients for the Model Hypotheses

Hypothesis	Path Coefficient	*t* Statistic	Test Result
1. Green intellectual capital has a significant effect on environmental innovation.	.360	5.682	Supported
2. Green intellectual capital has a significant effect on sustainable financial performance.	.607	8.205	Supported
3. Environmental innovation has a significant effect on sustainable financial performance.	.184	5.130	Supported
4. Environmental innovation moderates the relationship between green intellectual capital and sustainable financial performance.	.226	4.064	Supported

Hypothesis 1: Green Intellectual Capital Has a Significant Effect on Environmental Innovation

As shown in Table 9, the path coefficient for the effect of green intellectual capital on environmental innovation was .360. The corresponding *t* statistic was 5.682, which exceeded the critical value of 1.96. Therefore, the positive and statistically significant effect of green intellectual capital on environmental innovation was confirmed.

Hypothesis 2: Green Intellectual Capital Has a Significant Effect on Sustainable Financial Performance

As shown in Table 9, the path coefficient for the effect of green intellectual capital on sustainable financial performance was .607. The corresponding *t* statistic was 8.205, which exceeded the critical value of 1.96. Therefore, the positive and statistically significant effect of green intellectual capital on sustainable financial performance was confirmed.

Hypothesis 3: Environmental Innovation Has a Significant Effect on Sustainable Financial Performance

As shown in Table 9, the path coefficient for the effect of environmental innovation on sustainable financial performance was .184. The corresponding *t* statistic was 5.130, which exceeded the critical value of 1.96. Therefore, the positive and statistically significant effect of environmental innovation on sustainable financial performance was confirmed.

Hypothesis 4: Environmental Innovation Moderates the Relationship Between Green Intellectual Capital and Sustainable Financial Performance

As shown in Table 9, the path coefficient for the effect of the interaction between environmental innovation and green intellectual capital on sustainable financial performance was .226. The corresponding *t* statistic was 4.064, which exceeded the critical value of 1.96. Therefore, environmental innovation was found to significantly moderate the relationship between green intellectual capital and sustainable financial performance.

Discussion and Conclusion

The present study examined the relationships among green intellectual capital, environmental innovation, and sustainable financial performance in paper and paperboard manufacturing companies. The findings showed that green intellectual capital had a positive and statistically significant effect on environmental innovation. Green intellectual capital also had a positive and significant effect on sustainable financial performance. In addition, environmental innovation positively and significantly affected sustainable financial performance. Finally, environmental innovation significantly moderated the relationship between green intellectual capital and sustainable financial performance. Taken together, these findings indicate that environmentally oriented knowledge resources not only improve organizations' innovation capabilities but also contribute directly and interactively to the achievement of durable financial outcomes.

The first finding showed that green intellectual capital had a positive and significant effect on environmental innovation. The path coefficient for this relationship was .360, and the corresponding *t* statistic was 5.682, confirming that organizations

with stronger environmental knowledge, employee competencies, organizational systems, and stakeholder relationships are more likely to develop environmental innovations. This result suggests that environmental innovation is not generated solely through investment in physical technologies. Rather, it depends substantially on the availability and effective integration of intangible environmental resources. Employees must possess the knowledge and creativity required to identify environmental problems, organizational structures must support the retention and application of environmental knowledge, and external relationships must provide access to information, expertise, technologies, and market expectations.

This finding is consistent with research showing that green intellectual capital functions as an important antecedent of green and environmental innovation. Asiaei et al. found that green intellectual capital supports ambidextrous green innovation by enabling firms to engage in both exploratory and exploitative environmental innovation activities [7]. Exploratory innovation requires the acquisition of unfamiliar knowledge and the development of new environmental solutions, whereas exploitative innovation involves improving existing products, processes, and environmental practices. Both forms require a strong foundation of human, structural, and relational environmental knowledge. The present findings therefore reinforce the view that green intellectual capital provides the cognitive and organizational infrastructure needed for environmental innovation.

The result is also aligned with Shehzad et al., who demonstrated that green intellectual capital strengthens ambidextrous green innovation in manufacturing firms and subsequently contributes to green performance [15]. Manufacturing organizations frequently face pressure to reduce waste, improve energy efficiency, redesign production systems, and comply with environmental standards. Such responses require the integration of technical, managerial, and market knowledge. Green intellectual capital helps firms combine these forms of knowledge and convert them into practical environmental solutions. Similarly, Marco-Lajara et al. reported that green intellectual capital positively affects green innovation performance, showing that environmentally oriented intangible resources can strengthen an organization's capacity to create and implement green products and processes [14].

The positive relationship may also be explained through green absorptive capacity. Organizations are exposed to environmental knowledge from regulators, customers, suppliers, competitors, research institutions, and technological partners. However, external knowledge produces innovation only when the organization is capable of recognizing its value, assimilating it, and applying it. Begum et al. showed that green absorptive capacity plays a central role in converting green intellectual capital into green business strategies [10]. Forghani and Salehi similarly emphasized the role of absorptive capacity in strengthening the effect of green intellectual capital on green strategic practices [11]. Therefore, the present finding may reflect the ability of environmentally knowledgeable firms to acquire, interpret, and apply external and internal knowledge in the development of new environmental initiatives.

The finding is also compatible with evidence that knowledge governance and information infrastructure support environmental innovation. Capatina et al. emphasized the role of eco-knowledge hubs in organizing, sharing, and governing green intellectual capital [6]. In the absence of appropriate knowledge systems, valuable environmental expertise may remain isolated within departments or individual employees. By contrast, formal structures for documenting and exchanging knowledge can increase the likelihood that environmental ideas are transformed into organizational innovation. Mahmoudzadeh and Mahmoudzadeh also showed that green information systems can strengthen the effects of supplier integration and customer orientation on green innovation [16]. These studies support the conclusion that green intellectual

capital enhances environmental innovation when knowledge is systematically collected, communicated, and incorporated into operational decisions.

The second finding revealed that green intellectual capital had a positive and significant effect on sustainable financial performance. The path coefficient was .607, representing the strongest direct effect in the model, and the *t* statistic was 8.205. This result indicates that organizations with stronger green intellectual capital are more capable of maintaining financial performance over time. Green human capital may improve employees' ability to identify environmental inefficiencies and cost-saving opportunities. Green structural capital may institutionalize environmentally efficient procedures, monitoring systems, and decision-making routines. Green relational capital may strengthen cooperation with suppliers, customers, regulators, and other stakeholders. Together, these resources can reduce operating costs, improve risk management, strengthen legitimacy, and create market advantages.

The result is consistent with Yusliza et al., who found that green intellectual capital contributes significantly to sustainable organizational performance [4]. Their structural model demonstrated that environmental knowledge resources can support organizational sustainability by embedding environmental values and capabilities throughout the firm. The present findings extend this logic to sustainable financial performance, suggesting that green intellectual capital is economically valuable as well as environmentally relevant. Wang and Juo also showed that green intellectual capital, when embedded within environmental policy and green innovation strategy, supports performance sustainability [9]. Accordingly, the financial value of green intellectual capital may arise from its capacity to align environmental policy, organizational learning, and long-term strategic performance.

The finding further agrees with Welly et al., who reported that green intellectual capital contributes to corporate economic sustainability [2]. Organizations that develop green knowledge and environmental competencies may improve resource productivity, reduce waste-related costs, and strengthen their position in markets where customers increasingly value environmentally responsible firms. Similarly, Nurmalasari et al. found that green intellectual capital influenced financial performance in the manufacturing sector, including under the difficult conditions created by the pandemic [22]. This suggests that green intellectual capital may improve not only efficiency but also organizational resilience during periods of disruption and uncertainty.

Sukirman and Dianawati also demonstrated a relationship between green intellectual capital and financial performance, although they showed that organizational ownership characteristics can influence the strength of this relationship [21]. Their results suggest that green intellectual capital does not operate in an institutional vacuum. Governance arrangements, managerial priorities, and strategic time horizons may determine whether environmental intangible assets are transformed into financial value. Nevertheless, the significant direct effect found in the present study indicates that green intellectual capital constitutes an important strategic resource for paper and paperboard manufacturing companies, even before considering the additional role of environmental innovation.

The positive effect of green intellectual capital on sustainable financial performance may also be understood through environmental accounting and disclosure. Mohammadi and Moradi highlighted the role of green accounting in improving the performance and management of green intellectual capital [19]. Green accounting can assist organizations in identifying environmental costs, evaluating environmental investments, and incorporating ecological considerations into financial decisions. Abgineh et al. also showed that environmental information disclosure can be incorporated into models of financial

performance [18]. Greater transparency may reduce information asymmetry, improve investor confidence, and signal that the organization is capable of managing environmental risks. Thus, green intellectual capital may improve financial performance partly by strengthening the quality of environmental information, internal measurement, and external reporting.

The result also aligns with Farahabadi and Heydarpour, who found that environmental orientation can improve financial performance through green supplier management and relational capital [20]. This supports the relational component of green intellectual capital. Strong relationships with suppliers can improve access to sustainable materials, reduce supply-chain risks, and facilitate collaborative environmental improvements. Relationships with customers may provide information about emerging environmental preferences and create demand for greener products. Therefore, green relational capital can generate financial value by improving coordination, trust, responsiveness, and access to strategically relevant environmental resources.

The third finding showed that environmental innovation had a positive and significant effect on sustainable financial performance. The path coefficient for this relationship was .184, and the *t* statistic was 5.130. Although the coefficient was smaller than the direct effect of green intellectual capital, the relationship remained statistically meaningful. This finding indicates that the development of cleaner products, more efficient processes, improved recycling systems, reduced waste, and environmentally responsible management practices can contribute to enduring financial outcomes. Environmental innovation may initially require investment, but it can produce longer-term benefits through cost reduction, product differentiation, risk mitigation, and stronger stakeholder acceptance.

This finding is consistent with Dharmayanti et al., who showed that eco-innovation contributes to sustainable financial performance within a broader system of sustainability management controls, supply-chain management, and digital adaptability [1]. Their study suggests that environmental innovation becomes financially valuable when it is embedded within appropriate managerial and technological systems. In the context of paper and paperboard manufacturing, eco-innovation may reduce energy consumption, improve material recovery, lower waste-disposal costs, and enable the production of more environmentally acceptable products. These improvements can strengthen both operational efficiency and long-term competitiveness.

The result also corresponds with Moroni et al., who found that eco-innovation, dynamic capabilities, stakeholder engagement, and remanufacturing practices positively influence business performance [12]. Environmental innovation can enhance financial performance by allowing organizations to recover value from used materials, reduce dependence on virgin resources, and respond more effectively to circular-economy expectations. These mechanisms are particularly relevant to paper and paperboard industries, where recycling, material efficiency, and waste management are central strategic concerns.

Tan and Zhu showed that environmental awareness and financial constraints shape the relationship between external environmental pressures and corporate green innovation [13]. Their findings imply that environmental innovation is influenced by both managerial cognition and resource availability. Once implemented, however, green innovation may strengthen performance by improving corporate legitimacy and reducing environmental exposure. Khan et al. similarly found that green innovation climate strengthens the benefits of green intellectual capital for corporate green image [8]. A favorable environmental reputation may lead to stronger customer trust, better stakeholder relations, and enhanced market positioning, thereby contributing indirectly to sustainable financial performance.

The fourth finding indicated that environmental innovation significantly moderated the relationship between green intellectual capital and sustainable financial performance. The interaction coefficient was .226, and the *t* statistic was 4.064. This result means that the positive effect of green intellectual capital on sustainable financial performance becomes stronger when environmental innovation is more developed. In other words, environmental knowledge, capabilities, systems, and relationships generate greater financial value when organizations actively use them to create environmentally improved products, processes, and managerial practices.

This result is closely aligned with Mulatsih, who found that green intellectual capital and eco-innovation jointly shape sustainable financial performance [23]. The finding supports the argument that green intellectual capital should not be treated as a passive stock of knowledge. Its economic value depends on the organization's capacity to activate and apply that knowledge. Environmental innovation serves as an application mechanism that converts green intangible assets into operational improvements, differentiated products, cost savings, and market benefits. Therefore, two firms may possess similar environmental knowledge, yet the firm with stronger environmental innovation capability may obtain greater financial returns from that knowledge.

The moderating effect is also consistent with Martínez-Falcó et al., who showed that green agriculture and green supply-chain management influence the relationship between green intellectual capital and sustainable performance [17]. Their findings demonstrate that complementary environmental practices can strengthen the performance effects of green intellectual capital. Environmental innovation appears to play a similar complementary role in the present study. When green intellectual capital is combined with active innovation, environmental knowledge is more likely to be embedded in production processes, supply-chain arrangements, technologies, and products.

Overall, the findings indicate that green intellectual capital and environmental innovation are mutually reinforcing organizational resources. Green intellectual capital provides the knowledge base, expertise, routines, culture, and relationships needed for environmental change, whereas environmental innovation transforms those assets into practical and financially valuable outcomes. The results therefore support a capability-based interpretation of sustainable financial performance. Financial sustainability is not achieved merely by reducing environmental harm or accumulating environmental knowledge; it emerges when organizations integrate knowledge, innovation, management systems, and stakeholder relationships into a coherent strategic framework.

The present study had several limitations that should be considered when interpreting its findings. First, the research employed a cross-sectional design, which limits the ability to establish definitive causal relationships among green intellectual capital, environmental innovation, and sustainable financial performance. Second, the data were collected using self-report questionnaires, and the findings may therefore have been affected by common method bias, social desirability, or respondents' subjective interpretations. Third, nonprobability convenience sampling was used, which may limit the representativeness and generalizability of the findings. Fourth, the study focused on financial personnel and managers in paper and paperboard manufacturing companies; therefore, the results may not apply directly to other industries, organizational levels, or national contexts. Finally, sustainable financial performance was assessed through perceptual measures rather than audited financial indicators, and the study did not separately analyze the dimensions of green human, structural, and relational capital.

Future studies should employ longitudinal designs to examine how investments in green intellectual capital and environmental innovation influence financial performance over time. Researchers could also combine questionnaire data with objective financial, environmental, and operational indicators to increase measurement accuracy. Probability sampling and larger samples drawn from different manufacturing and service industries would improve the generalizability of the findings. Future research should separately investigate the effects of green human capital, green structural capital, and green relational capital and compare their relative contributions to different forms of environmental innovation. Additional mediating and moderating variables, such as green absorptive capacity, organizational culture, environmental strategy, digital adaptability, ownership structure, regulatory pressure, and green supply-chain integration, could also be incorporated into more comprehensive models. Comparative studies across regions and countries may further clarify the influence of institutional and economic conditions.

Managers should treat green intellectual capital as a strategic investment rather than an optional environmental expense. Organizations should recruit employees with environmental expertise, provide continuous green training, encourage employee participation in environmental problem solving, and establish systems for documenting and sharing environmental knowledge. Paper and paperboard companies should develop formal mechanisms for converting environmental ideas into innovations, including cross-functional green innovation teams, employee suggestion systems, pilot projects, and dedicated budgets for cleaner production. Managers should also strengthen collaboration with suppliers, customers, regulators, and research institutions to gain access to environmental knowledge and technology. Environmental and financial information should be integrated into planning, budgeting, performance evaluation, and investment appraisal so that the long-term financial benefits of environmental initiatives can be identified and measured. Finally, management should align environmental innovation with the organization's competitive strategy to ensure that green knowledge is translated into cost reductions, operational efficiency, improved products, stronger stakeholder relationships, and sustainable financial value.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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References

[1] N. Dharmayanti, T. Ismail, I. A. Hanifah, and M. Taqi, "Exploring sustainability management control system and eco-innovation matter sustainable financial performance: The role of supply chain management and digital adaptability in Indonesian context," *Journal of Open Innovation: Technology, Market, and Complexity,* vol. 9, no. 3, p. 100119, 2023, doi: 10.1016/j.joitmc.2023.100119.

[2] Y. Welly, M. Yehezkiel Sianipar, N. Darmayanti, A. Simanjuntak, and M. I. Alamsyahbana, "Role of green intellectual capital and green innovation to corporate economic sustainability," *Jurnal Akuntansi Manado,* pp. 329-342, 2023, doi: 10.53682/jaim.vi.7260.

[3] P. Benevene, I. Buonomo, E. Kong, M. Pansini, and M. L. Farnese, "Management of green intellectual capital: Evidence-based literature review and future directions," *Sustainability,* vol. 13, no. 15, p. 8349, 2021, doi: 10.3390/su13158349.

[4] M. Y. Yusliza, J. Y. Yong, M. I. Tanveer, T. Ramayah, J. Noor Faezah, and Z. Muhammad, "A structural model of the impact of green intellectual capital on sustainable performance," *Journal of Cleaner Production,* vol. 249, p. 119334, 2020, doi: 10.1016/j.jclepro.2019.119334.

[5] J. Y. Yong, M. Y. Yusliza, T. Ramayah, and O. Fawehinmi, "Nexus between green intellectual capital and green human resource management," *Journal of Cleaner Production,* vol. 215, pp. 364-374, 2019, doi: 10.1016/j.jclepro.2018.12.306.

[6] A. Capatina, G. Bleoju, A. Micu, and G. B. Dragan, "The role of an eco-knowledge hub in leveraging intellectual capital green governance," in *Intellectual Capital Management as a Driver of Sustainability: Perspectives for Organizations and Society*, F. Matos, V. Vairinhos, P. M. Selig, and L. Edvinsson Eds.: Springer International Publishing, 2019, pp. 157-175.

[7] K. Asiaei, N. G. O'Connor, O. Barani, and M. Joshi, "Green intellectual capital and ambidextrous green innovation: The impact on environmental performance," *Business Strategy and the Environment,* vol. 32, no. 1, pp. 369-386, 2023, doi: 10.1002/bse.3136.

[8] A. Khan, S. Hussain, and A. K. Sampene, "Investing in green intellectual capital to enhance green corporate image under the influence of green innovation climate: A case of Chinese entrepreneurial SMEs," *Journal of Cleaner Production,* vol. 418, p. 138177, 2023, doi: 10.1016/j.jclepro.2023.138177.

[9] C. H. Wang and W. J. Juo, "An environmental policy of green intellectual capital: Green innovation strategy for performance sustainability," *Business Strategy and the Environment,* vol. 30, no. 7, pp. 3241-3254, 2021, doi: 10.1002/bse.2800.

[10] S. Begum, M. Ashfaq, K. Asiaei, and K. Shahzad, "Green intellectual capital and green business strategy: The role of green absorptive capacity," *Business Strategy and the Environment,* 2023, doi: 10.1002/bse.3399.

[11] M. Forghani and S. Salehi, "Investigating the effect of green intellectual capital on green business strategies: The key role of absorptive capacity," 2024.

[12] I. T. Moroni, B. M. Roman Pais Seles, F. L. Lizarelli, D. Guzzo, and J. Mascarenhas Hornos da Costa, "Remanufacturing and its impact on dynamic capabilities, stakeholder engagement, eco-innovation and business performance," *Journal of Cleaner Production,* vol. 371, p. 133274, 2022, doi: 10.1016/j.jclepro.2022.133274.

[13] Y. Tan and Z. Zhu, "The effect of ESG rating events on corporate green innovation in China: The mediating role of financial constraints and managers' environmental awareness," *Technology in Society,* vol. 68, p. 101906, 2022, doi: 10.1016/j.techsoc.2022.101906.

[14] B. Marco-Lajara, P. C. Zaragoza-Sáez, J. Martínez-Falcó, and E. Sánchez-García, "Does green intellectual capital affect green innovation performance? Evidence from the Spanish wine industry," *British Food Journal,* vol. 125, no. 4, pp. 1469-1487, 2023, doi: 10.1108/BFJ-03-2022-0298.

[15] M. U. Shehzad, J. Zhang, M. Dost, M. S. Ahmad, and S. Alam, "Linking green intellectual capital, ambidextrous green innovation and firms' green performance: Evidence from Pakistani manufacturing firms," *Journal of Intellectual Capital,* vol. 24, no. 4, pp. 974-1001, 2023, doi: 10.1108/JIC-02-2022-0032.

[16] M. Mahmoudzadeh and M. Mahmoudzadeh, "Examining the effect of supplier integration and customer orientation on green innovation with the moderating role of green information systems: Case study of Iran Khodro Industrial Group," *Accounting and Management Perspective*, no. 77, pp. 40-58, 2023.

[17] J. Martínez-Falcó, E. Sánchez-García, L. A. Millan-Tudela, and B. Marco-Lajara, "The role of green agriculture and green supply chain management in the green intellectual capital-sustainable performance relationship: A structural equation modeling analysis applied to the Spanish wine industry," *Agriculture*, vol. 13, no. 2, p. 425, 2023, doi: 10.3390/agriculture13020425.

[18] M. Abgineh, M. Ghanbari, and M. Rahmani, "Presenting a financial performance model based on environmental information disclosure in companies listed on the Tehran Stock Exchange," *Knowledge of Management Accounting and Auditing*, no. 45, pp. 17-38, 2023.

[19] S. Mohammadi and F. Moradi, "The role of green accounting in the performance of green intellectual capital," in *First International Conference on Management Capability, Industrial Engineering, Accounting and Economics*, Babol, 2023.

[20] M. Farahabadi and F. Heydarpour, "The effect of environmental orientation on financial performance with emphasis on the effects of green supplier management and relational capital," *Judgment and Decision Making in Accounting*, no. 1, pp. 67-90, 2023.

[21] A. S. Sukirman and W. Dianawati, "Green intellectual capital and financial performance: The moderating role of family ownership," *Cogent Business & Management*, vol. 10, no. 1, p. 2200498, 2023, doi: 10.1080/23311975.2023.2200498.

[22] N. Nurmalasari, N. Laturrohman, E. Widarwati, and E. Wityasminingsih, "The impact of green intellectual capital on financial performance: Case of Indonesian manufacturing industry during pandemic," *Journal of Management and Muamalah*, vol. 14, no. 1, pp. 36-51, 2024, doi: 10.53840/jmm.v14i1.165.

[23] S. N. Mulatsih, "Green intellectual capital and eco-innovation in shaping sustainable financial performance: Evidence from Indonesia," *Social Sciences & Humanities Open*, vol. 11, p. 101345, 2025, doi: 10.1016/j.ssaho.2025.101345.