International Journal of Accounting and Economics Studies, 12 (6) (2025) 684-695

International Journal of Accounting and Economics Studies

Website: www.sciencepubco.com/index.php/IJAES
https://doi.org/10.14419/6qqb7b27
Research paper

The 6-Go Digital Intellectual Capital Model: Enhancing Financial Sustainability Through Green Innovation in Small and Medium Enterprises

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Received: August 30, 2025, Accepted: October 1, 2025, Published: October 19, 2025

Abstract

Purpose -- This study develops and validates a novel 6-Go Digital Intellectual Capital (6G-DIC) model that extends traditional intellectual capital theory by incorporating digital, cultural, and green capital dimensions to enhance financial sustainability in small and medium enterprises through green innovation.
Design/methodology/approach -- This research advances intellectual capital theory by developing a six-dimensional framework that extends traditional three-dimensional models. Using partial least squares structural equation modeling on 324 Indonesian SMEs, the study tests the expanded framework's impact on financial sustainability through green innovation mediation.
Findings -- Contrary to digital transformation assumptions, green capital emerges as the strongest predictor of green innovation ($\beta = 0.275$), followed by cultural capital ($\beta = 0.243$), while digital capital shows moderate effects ($\beta = 0.158$). The model explains 77.2% of the variance in financial sustainability and 69.2% in green innovation, with green innovation mediating 21.46% to 28.72% of intellectual capital effects on financial outcomes.
Research limitations/implications -- Geographic specificity to Indonesian SMEs limits generalizability. The unexpected hierarchy challenges digital primacy assumptions and suggests that intellectual capital effectiveness varies across institutional contexts.
Practical implications -- SME managers should prioritize green capital and cultural capital development over digital-only approaches, though contextual adaptation is essential given the study's geographic limitations.
Originality/value -- This research contributes to intellectual capital theory by demonstrating that expanded six-dimensional frameworks achieve superior explanatory power while revealing contextual sensitivity in resource value hierarchies that contradict universal digital transformation assumptions.

Keywords: *Digital Intellectual Capital; Green Innovation; Financial Sustainability; SMEs; Digital Transformation; Sustainability.*

1. Introduction

The contemporary business landscape has undergone a fundamental shift toward knowledge-intensive operations, where intellectual capital (IC) has emerged as a critical determinant of organizational success and sustainable competitive advantage (Tortora et al., 2024; Hu et al., 2024; Arena et al., 2022). For small and medium enterprises (SMEs), which constitute the backbone of most economies globally, effective management of intellectual capital has become crucial given their resource constraints and increased vulnerability to market volatility (Le et al., 2024; Arshad et al., 2023; Demartini & Beretta, 2020). Statistical evidence underscores the critical importance of SMEs in global economic systems, with SMEs representing 99.8% of all businesses in the European Union and over 96% of all enterprises in Asia-Pacific economies (European Commission, 2023; OECD, 2023).
Intellectual capital theory, built upon the foundational work of Stewart (1997) and Edvinsson and Malone (1997), has traditionally encompassed three dimensions: human capital, structural capital, and relational capital (Bontis, 1998; Roos et al., 1997). While this tripartite framework has demonstrated robust empirical support across various contexts (Demartini & Beretta, 2020; Tortora et al., 2024), recent studies suggest opportunities for theoretical advancement through dimensional expansion. Contemporary research by Shahzad et al. (2025) indicates that emerging dimensions such as renewal capital and trust capital significantly influence innovation outcomes, while Arena et al. (2022) demonstrate how digital technologies create new forms of intellectual capital that extend beyond traditional conceptualizations.
The evolving business environment presents particular challenges for SMEs navigating simultaneous digital transformation and sustainability transitions. Digital transformation has fundamentally altered how knowledge assets are created, shared, and utilized within organizations (Zhang et al., 2025; Broccardo et al., 2024), while growing environmental consciousness and sustainability imperatives require new forms of knowledge and capabilities (Liu et al., 2025; Martínez Falcó et al., 2024). Indonesian SMEs exemplify these challenges. According to Indonesian Chamber of Commerce and Industry data, MSMEs contribute 61% to Indonesia's GDP and absorb 97% of the

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total workforce, with around 66 million units representing 99% of all business units (Indonesian Chamber of Commerce and Industry, 2024). However, digital transformation remains limited, as government targets indicate only 24 million MSMEs are expected to enter digital markets by 2023, increasing to 30 million by 2024, indicating significant digital adoption gaps. Indonesia's environmental performance ranking of 163rd out of 180 countries in the Environmental Performance Index further highlights sustainability challenges (Environmental Performance Index, 2024)

This research addresses the theoretical gap by proposing a 6-Go Digital Intellectual Capital (6G-DIC) framework that extends traditional intellectual capital theory through the systematic incorporation of three additional dimensions: digital capital, cultural capital, and green capital. The study examines how this expanded framework influences financial sustainability through green innovation mediation, focusing on SMEs in Deli Serdang Regency, North Sumatra, Indonesia. The research contributes to intellectual capital theory by: (1) developing and validating a six-dimensional framework that captures contemporary knowledge assets; (2) investigating the mechanisms through which expanded intellectual capital dimensions drive financial sustainability via green innovation; and (3) providing empirical evidence for dimensional expansion within the specific context of developing economy SMEs facing digital and environmental transformation pressures. The theoretical contribution advances intellectual capital theory by demonstrating how dimensional expansion enhances explanatory power while revealing contextual patterns in resource value hierarchies that warrant further investigation across different institutional environments. The study provides insights into intellectual capital dynamics within the specific context of Indonesian SMEs while highlighting the need for continued theoretical development to address contemporary business complexities.

2. Literature Review

2.1. Intellectual capital: evolution and contemporary relevance

Intellectual capital, broadly defined as the sum of knowledge-based assets that contribute to organizational value creation, has undergone significant conceptual evolution since its initial articulation by Stewart (1997) and subsequent refinement by Edvinsson and Malone (1997). The traditional tripartite classification encompasses human capital (knowledge, skills, and capabilities of employees), structural capital (organizational processes, systems, and intellectual property), and relational capital (external relationships and networks) (Bontis, 1998; Roos et al., 1997).

The empirical foundation for intellectual capital theory demonstrates robust support across diverse contexts. Research by Hu et al. (2024) on Chinese SMEs reveals that intellectual capital not only directly promotes innovation inputs and patent applications but also indirectly fosters innovation by enhancing dynamic capabilities. Similarly, Ginesti et al. (2018) found that intellectual capital significantly influences company reputation and financial performance in Italian listed companies. Meta-analytic evidence from Demartini and Beretta (2020), synthesizing studies across multiple countries, confirms the robust relationship between intellectual capital and SME performance.

However, the evolution of intellectual capital research demonstrates a clear progression from Stewart's initial conceptualization through various refinements by scholars such as Edvinsson and Malone, Bontis, and, more recently, frameworks incorporating contemporary business dimensions. This evolutionary trajectory suggests that intellectual capital theory benefits from periodic expansion to address emerging business realities rather than remaining static within its original three-dimensional boundaries.

2.2. Theoretical gaps and extension opportunities

Contemporary intellectual capital research reveals specific gaps that warrant theoretical attention. Recent research by Shahzad et al. (2025) on multidimensional intellectual capital suggests that emerging dimensions such as renewal capital, entrepreneurial capital, and trust capital significantly influence innovation outcomes, indicating opportunities for dimensional expansion beyond traditional models. Similarly, Arena et al. (2022) demonstrate how digital technologies create new forms of intellectual capital that extend traditional conceptualizations, particularly in academic contexts where digital capabilities mediate relational capital effects.

The three-dimensional framework, while foundational, exhibits limitations in capturing contemporary business complexities. Studies increasingly recognize that traditional models, developed before widespread digital adoption and environmental consciousness, may inadequately represent the full spectrum of knowledge assets available to modern organizations (Di Vaio et al., 2024; Broccardo et al., 2024). This recognition has prompted calls for expanded conceptualizations that incorporate emerging forms of intellectual capital relevant to current business environments (Dumay & Garanina, 2013; Edvinsson, 2013). The gap becomes particularly evident when examining SME contexts, where resource constraints require a comprehensive understanding of all available knowledge assets. Traditional intellectual capital frameworks may overlook critical capabilities that enable SMEs to compete effectively in contemporary markets characterized by digital transformation requirements and sustainability imperatives (Švarc et al., 2021).

These identified gaps warrant examination of intellectual capital theory relative to alternative theoretical frameworks that address organizational knowledge and capabilities. The resource-based view (RBV) posits that sustainable competitive advantage derives from valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). While intellectual capital theory aligns conceptually with RBV by treating knowledge assets as strategic resources, RBV emphasizes resource characteristics rather than providing dimensional specificity for knowledge categorization. The dynamic capabilities perspective (Teece et al., 1997) extends RBV by focusing on organizational abilities to integrate, build, and reconfigure competencies in response to environmental changes. This framework complements intellectual capital theory by illuminating transformation mechanisms through which knowledge assets generate competitive advantages, though it provides less guidance regarding specific knowledge asset categories. The knowledge-based view (Grant, 1996) positions knowledge as the firm's most strategically significant resource, directly supporting intellectual capital's theoretical foundations. However, KBV emphasizes knowledge processes—creation, transfer, and integration—rather than offering the dimensional structure that characterizes intellectual capital frameworks.

Emerging theoretical perspectives further highlight intellectual capital theory's need for expansion. Digital transformation theory (Vial, 2019) positions technological capabilities as foundational rather than supplementary strategic assets, challenging traditional frameworks where digital competencies remain implicit within existing dimensions. Natural resource-based view and sustainability frameworks (Hart, 1995; Bansal and Roth, 2000) similarly emphasize environmental knowledge and green capabilities as distinct strategic assets essential for contemporary competitive advantage. These theoretical developments suggest that intellectual capital's traditional three-dimensional structure, while robust, requires expansion to explicitly incorporate dimensions addressing digital transformation and sustainability imperatives. This comparative analysis reveals that intellectual capital theory offers superior dimensional specificity compared to alternatives, though

necessitating periodic evolution to capture knowledge assets not fully anticipated in its original conceptualization. The following section examines the contemporary business context that creates demand for this dimensional expansion.

2.3. Contemporary business context and emerging intellectual capital dimensions

The contemporary business environment presents three critical dimensions that warrant incorporation into intellectual capital frameworks: digital capabilities, organizational culture, and environmental knowledge. These dimensions reflect fundamental shifts in how organizations create, manage, and deploy knowledge assets.

Digital transformation has fundamentally altered knowledge asset utilization, creating new forms of intellectual capital centered on technological competencies, digital infrastructure, and data analytics capabilities (Zhang et al., 2025; Broccardo et al., 2024). Research demonstrates that digital technologies enable new forms of knowledge creation and sharing while requiring specific competencies for effective deployment (Liu et al., 2025). However, the extent to which digital capabilities constitute distinct intellectual capital dimensions rather than enhancements to traditional dimensions remains empirically underexplored.

Organizational culture represents another dimension warranting theoretical attention, as cultural factors significantly influence how knowledge is created, shared, and utilized within organizations. While traditional intellectual capital models acknowledge culture implicitly through human and structural capital, the growing recognition of culture as a distinct knowledge asset suggests potential for explicit incorporation into intellectual capital frameworks (Tortora et al., 2024).

Environmental knowledge and sustainability competencies constitute a third emerging dimension, as organizations increasingly require specific capabilities to address environmental challenges and capitalize on sustainability opportunities. The growing importance of green innovation and environmental compliance creates demand for intellectual capital frameworks that explicitly recognize environmental knowledge as a strategic asset (Martínez Falcó et al., 2024).

2.4. Theoretical framework development

Building on the identified theoretical gaps and contemporary business requirements, this study proposes a comprehensive 6-Go Digital Intellectual Capital (6G-DIC) framework that extends traditional intellectual capital theory through systematic incorporation of three additional dimensions. The framework integrates the foundational dimensions of human capital, structural capital, and relational capital with three emerging dimensions: digital capital, cultural capital, and green capital.

Human capital encompasses employee knowledge, skills, competencies, and learning capabilities, maintaining its traditional conceptualization while recognizing contemporary requirements for digital literacy and environmental awareness. Structural capital includes organizational processes, systems, intellectual property, and knowledge management infrastructure, expanded to incorporate digital systems and environmental management capabilities. Relational capital represents external networks, customer relationships, supplier partnerships, and stakeholder engagement, enhanced to include digital platforms and sustainability-oriented relationships.

Digital capital captures technological competencies, digital infrastructure, data analytics capabilities, and digital innovation capacity that have become essential for competitive advantage in contemporary business environments. Cultural capital addresses organizational culture, values, shared beliefs, and cultural adaptability that influence knowledge creation, sharing, and utilization processes. Green capital encompasses environmental knowledge, sustainability competencies, eco-innovation capabilities, and green practices that enable organizations to address environmental challenges and capitalize on sustainability opportunities.

The 6G-DIC framework recognizes that contemporary SMEs operate in complex environments where digital transformation and sustainability considerations are paramount for long-term viability. The integration of these six dimensions provides a comprehensive understanding of how knowledge assets function in modern business contexts, particularly for resource-constrained SMEs navigating multiple transformation pressures simultaneously.

2.5. Green innovation as mediating mechanism and financial sustainability outcomes

Green innovation, defined as "the development and implementation of new products, processes, services, or business models that contribute to environmental sustainability while creating economic value" (Ji et al., 2024; Chen et al., 2006), emerges as a critical pathway through which intellectual capital dimensions influence organizational outcomes. Empirical evidence demonstrates multifaceted benefits of green innovation for SMEs, with recent studies examining Chinese SMEs finding that green product innovation significantly enhances financial performance while green process innovation contributes to operational efficiency (Ji et al., 2024).

Meta-analytic evidence provides robust support for green innovation-performance relationships. Escoz-Barragán et al. (2024), synthesizing studies across multiple countries, report significant positive correlations between eco-innovation and SME sustainable performance, with green product innovation demonstrating stronger performance impacts compared to process and organizational innovations. Conceptual frameworks suggest that green innovation mediates relationships between organizational capabilities and sustainability performance (Kiranantawat and Ahmad, 2023; Afum et al., 2020), particularly for resource-constrained SMEs, where strategic alignment between innovation activities and sustainability objectives becomes essential.

Financial sustainability, conceptualized as the ability to maintain financial performance while addressing environmental and social responsibilities, represents a multifaceted construct encompassing profitability, cash flow stability, and long-term viability (Aslam et al., 2023). Research demonstrates complex relationships between sustainability initiatives and financial outcomes, with systematic reviews revealing that SMEs engaging in environmental innovation achieve substantially higher financial returns compared to traditional counterparts (Mukherjee et al., 2024).

The theoretical linkage between intellectual capital, green innovation, and financial sustainability suggests that knowledge assets enable environmental innovation capabilities, which in turn generate both ecological and economic value. This mediation mechanism positions green innovation as a critical translation pathway through which intellectual capital dimensions achieve financial outcomes while addressing contemporary sustainability requirements.

2.6. Hypotheses development

Based on the preceding literature review and theoretical foundations, the following hypotheses are proposed:

H1: The 6-Go Digital Intellectual Capital model positively influences financial sustainability in SMEs.

- H1a: Human capital positively affects financial sustainability

- H1b: Structural capital positively affects financial sustainability
- H1c: Relational capital positively affects financial sustainability
- H1d: Digital capital positively affects financial sustainability
- H1e: Cultural capital positively affects financial sustainability
- H1f: Green capital positively affects financial sustainability

H2: The 6-Go Digital Intellectual Capital dimensions positively influence green innovation in SMEs.

- H2a: Human capital positively affects green innovation
- H2b: Structural capital positively affects green innovation
- H2c: Relational capital positively affects green innovation
- H2d: Digital capital positively affects green innovation
- H2e: Cultural capital positively affects green innovation
- H2f: Green capital positively affects green innovation

H3: Green innovation positively influences financial sustainability.

H4: Green innovation mediates the relationship between the 6G-DIC dimensions and financial sustainability.

- H4a: Green innovation mediates the HC-financial sustainability relationship
- H4b: Green innovation mediates the SC-financial sustainability relationship
- H4c: Green innovation mediates the RC-financial sustainability relationship
- H4d: Green innovation mediates the DC-financial sustainability relationship
- H4e: Green innovation mediates the CC-financial sustainability relationship
- H4f: Green innovation mediates the GC-financial sustainability relationship

H5: Digital capital moderates the relationship between traditional IC dimensions and green innovation.

- H5a: Digital capital moderates the HC-green innovation relationship
- H5b: Digital capital moderates the SC-green innovation relationship
- H5c: Digital capital moderates the RC-green innovation relationship

H6: Cultural capital moderates the relationship between green capital and green innovation.

The theoretical framework positions intellectual capital as a multidimensional construct enabling SMEs to develop green innovation capabilities while achieving financial sustainability. The expanded six-dimensional conceptualization captures contemporary knowledge assets, while the mediation and moderation relationships reveal mechanisms through which intellectual capital creates value in modern business environments.

3. Methods

3.1. Research design and context

This study employs a quantitative research design using cross-sectional survey methodology. The research focuses on testing the hypothesized relationships within the 6G-DIC framework through structural equation modeling. The study was conducted in Deli Serdang Regency, North Sumatra, Indonesia, selected for its diverse SME landscape spanning manufacturing, services, and agriculture sectors. Deli Serdang represents a typical Indonesian regency with significant SME presence but limited digital adoption and sustainability practices, making it an appropriate context for testing the 6G-DIC model.

3.2. Data collection

Data were collected through a structured survey targeting SMEs registered with the local Cooperative and SME Office. Following Hair et al. (2019) guidelines for PLS-SEM, the target sample size was determined based on the "10-times rule," requiring a minimum of 80 observations (8 constructs × 10). To ensure adequate statistical power and account for potential non-responses, 380 questionnaires were distributed through stratified random sampling across different sectors and firm sizes.

The survey was administered through face-to-face interviews conducted by trained enumerators over three months. This approach was chosen to ensure high response rates and data quality, particularly important given the complexity of the constructs being measured. After removing incomplete responses and outliers through rigorous screening procedures, the final dataset comprised 324 usable responses, representing an 85.3% response rate and substantially exceeding the minimum requirements for PLS-SEM analysis.

3.3. Measurement instruments

All constructs were measured using 7-point Likert scales ranging from "strongly disagree" (1) to "strongly agree" (7). The measurement instruments were developed based on established scales from previous literature, adapted to the SME context through translation and back-translation procedures to ensure conceptual equivalence. Traditional intellectual capital dimensions were assessed using established scales: human capital through six items capturing employee knowledge and learning capabilities (adapted from Tortora et al., 2024), structural capital via five items evaluating organizational processes and systems (adapted from Hu et al., 2024), and relational capital using five items focusing on external relationships (adapted from Le et al., 2024).

For the emerging dimensions in the 6G-DIC framework, measurement scales were systematically developed through a rigorous multi-stage validation process. Digital capital items were adapted from Zhang et al. (2025) and Broccardo et al. (2024), with seven items measuring technological competencies, digital infrastructure adequacy, data analytics capabilities, digital platform utilization for knowledge sharing, digital innovation capacity, systems integration efficiency, and technology-enabled opportunity creation. Cultural capital items were drawn from organizational culture literature and Tortora et al. (2024), employing five items evaluating shared organizational values, innovation-oriented culture, employee commitment to objectives, knowledge sharing facilitation, and cultural adaptability to environmental changes. Green capital items were developed based on Martínez Falcó et al. (2024) and environmental management literature, using six items assessing environmental regulatory knowledge, operational impact awareness, eco-practice implementation competencies, eco-innovation capabilities, sustainable resource management knowledge, and strategic sustainability integration.

Green innovation measurement employed eight items adapted from Ji et al. (2024), covering green product innovation (development of environmentally friendly products), green process innovation (implementation of resource-efficient production methods), and green business model innovation (integration of sustainability into value creation mechanisms). Financial sustainability was measured through six items capturing profitability maintenance, cash flow stability, long-term financial viability, ability to meet financial obligations, sustainable revenue growth, and financial resilience to market fluctuations.

To ensure content validity and contextual appropriateness, the initial item pools for emerging dimensions underwent expert panel review involving three academics specializing in intellectual capital research and two sustainability consultants with SME experience. Based on expert feedback, several items were reworded to enhance cultural relevance and eliminate ambiguous terminology. Subsequently, cognitive interviews with five SME owner-managers confirmed that items were comprehensible and relevant to their business contexts. This validation process enhanced confidence that the measurement instruments appropriately captured the intended constructs within the Indonesian SME context. All final measurement items and their psychometric properties are presented in Table 2 (Section 4.2), demonstrating excellent reliability and validity with factor loadings ranging from 0.713 to 0.942.

3.4. Data analysis

The analytical approach followed a two-stage methodology using SmartPLS 4.0, recognized for its robust handling of complex structural equation models and non-normal data distributions. The first stage involved assessment of the measurement model, examining internal consistency reliability through Cronbach's alpha and composite reliability coefficients, convergent validity via average variance extracted and factor loadings, and discriminant validity using both the Fornell-Larcker criterion and HTMT ratios.

The second stage focused on structural model evaluation, beginning with path coefficient significance testing through bootstrap resampling with 5,000 samples. The analysis examined coefficients of determination to assess explanatory power, effect sizes using Cohen's f-squared to determine practical significance, and predictive relevance through Stone-Geisser Q-squared values. Mediation analysis employed the variance accounted for method to determine the extent to which green innovation mediates the relationships between intellectual capital dimensions and financial sustainability, while moderation effects were tested using product indicator approaches to examine interaction effects.

3.5. Common method bias

Several procedural and statistical remedies were implemented to address potential common method bias concerns. Procedurally, temporal separation was introduced between predictor and criterion variable measurements, with intellectual capital dimensions assessed first, followed by green innovation measures, and financial sustainability metrics collected last. Anonymous data collection procedures were employed throughout to reduce social desirability bias and encourage honest responses.

Statistically, two tests were conducted to assess common method bias. First, Harman's single-factor test was performed using principal component analysis. The results revealed that the first unrotated factor explained 42.555% of the total variance, well below the 50% threshold, indicating problematic common method bias. Second, the full collinearity test (Kock, 2015) was applied to examine variance inflation factors (VIF) for all structural paths. All VIF values ranged from 1.124 to 2.729, substantially below the 3.3 threshold suggested by Kock (2015), confirming the absence of multicollinearity issues that could indicate common method bias. These measures provide confidence that common method bias does not threaten the validity of the findings.

4. Results

4.1. Sample characteristics

Rigorous data screening procedures were implemented, including outlier detection and multivariate normality assessment. After removing incomplete responses and outliers, the final analytical sample substantially exceeded the minimum requirements for PLS-SEM analysis. The demographic characteristics and descriptive statistics of the participating SMEs are presented in Table 1, which reveals a diverse sample across sectors, sizes, and organizational characteristics.

Table 1: Sample Characteristics

Variable	Category	n	%
Sector	Manufacturing	137	42.3
	Services	114	35.2
	Agriculture	73	22.5
Size	Micro (1-9)	124	38.3
	Small (10-49)	135	41.7
	Medium (50-250)	65	20.0
Age (years)	1-5	75	23.1
	6-10	91	28.1
	11-20	108	33.3
	>20	50	15.5
Ownership	Family	218	67.3
	Partnership	63	19.4
	Corporation	43	13.3
Revenue (IDR)	<1B	123	38.0
	1-5B	135	41.7
	>5B	66	20.3
Digital Adoption	Low (0-30%)	108	33.3
	Medium (31-70%)	146	45.1
	High (71-100%)	70	21.6
Green Practices	None	156	48.1
	Basic	117	36.1
	Advanced	51	15.8

Note: IDR = Indonesian Rupiah; B = Billion.

4.2. Measurement model assessment

Following established PLS-SEM procedures (Hair et al., 2019; Sarstedt et al., 2017), the measurement model was evaluated for internal consistency reliability, convergent validity, and discriminant validity. All constructs demonstrated excellent psychometric properties, substantially exceeding recommended thresholds. The comprehensive reliability and validity indicators for all constructs are presented in Table 2, which demonstrates the excellent psychometric properties of the measurement model.

Table 2: Measurement Model Assessment and Factor Loadings

Construct	Items	Loadings	α	CR	AVE
			0.922	0.943	0.768
Cultural Capital (CC)	CC1	0.939			
	CC2	0.781			
	CC3	0.929			
	CC4	0.774			
	CC5	0.942			
			0.948	0.958	0.765
Digital Capital (DC)	DC1	0.794			
	DC2	0.931			
	DC3	0.925			
	DC4	0.791			
	DC5	0.925			
	DC6	0.810			
	DC7	0.930			
			0.944	0.956	0.783
Financial Sustainability (FS)	FS1	0.802			
	FS2	0.922			
	FS3	0.913			
	FS4	0.806			
	FS5	0.927			
	FS6	0.929			
			0.939	0.953	0.773
Green Capital (GC)	GC1	0.713			
	GC2	0.932			
	GC3	0.934			
	GC4	0.924			
	GC5	0.806			
	GC6	0.939			
			0.953	0.962	0.759
Green Innovation (GI)	GI1	0.745			
	GI2	0.922			
	GI3	0.926			
	GI4	0.942			
	GI5	0.913			
	GI6	0.795			
	GI7	0.906			
	GI8	0.798			
			0.929	0.944	0.739
Human Capital (HC)	HC1	0.842			
	HC2	0.860			
	HC3	0.859			
	HC4	0.866			
	HC5	0.924			
	HC6	0.801			
			0.926	0.944	0.773
Relational Capital (RC)	RC1	0.848			
	RC2	0.923			
	RC3	0.826			
	RC4	0.930			
	RC5	0.863			
			0.921	0.941	0.761
Structural Capital (SC)	SC1	0.825			
	SC2	0.844			
	SC3	0.894			
	SC4	0.940			
	SC5	0.852			

Note: α = Cronbach's Alpha; CR = Composite Reliability; AVE = Average Variance Extracted.

The results show strong reliability across all constructs, with Cronbach's alpha values ranging from 0.921 to 0.953, well above the 0.70 threshold. Composite reliability coefficients range from 0.941 to 0.962, indicating excellent internal consistency. Average variance extracted (AVE) values range from 0.739 to 0.783, substantially exceeding the 0.50 minimum requirement, confirming strong convergent validity.

Discriminant validity was assessed using both the Fornell-Larcker criterion and HTMT ratios. All constructs demonstrate adequate discriminant validity, with square roots of AVE exceeding inter-construct correlations and HTMT ratios below 0.85. The discriminant validity assessment results are displayed in Table 3, which provides comprehensive evidence that each construct captures distinct phenomena.

Table 3: Discriminant Validity Assessment

Variable	CC	DC	FS	GC	GI	HC	RC	SC
Fornell-Larcker Criterion								
CC	0.876							
DC	0.361	0.875						
FS	0.628	0.572	0.885					
GC	0.416	0.359	0.630	0.879				
GI	0.578	0.528	0.780	0.591	0.871			
HC	0.353	0.439	0.563	0.345	0.512	0.859		
RC	0.370	0.398	0.568	0.359	0.504	0.283	0.879	
SC	0.362	0.403	0.577	0.362	0.533	0.286	0.326	0.872
HTMT Ratios								
DC	0.382	-						
FS	0.670	0.601	-					
GC	0.445	0.377	0.667	-				
GI	0.615	0.552	0.821	0.625	-			
HC	0.377	0.466	0.599	0.366	0.541	-		
RC	0.398	0.422	0.604	0.381	0.535	0.301	-	
SC	0.391	0.427	0.616	0.386	0.568	0.307	0.351	-

Note: Bold diagonal values = √AVE. Discriminant validity confirmed: √AVE > inter-construct correlations and HTMT < 0.85

4.3. Structural model results

The structural model's stability was verified through a comprehensive bootstrapping analysis with 5,000 resamples, confirming the robustness of all path estimates and their statistical significance. Figure 1 demonstrates the bootstrapping results, providing confidence in the reliability of subsequent hypothesis testing procedures.

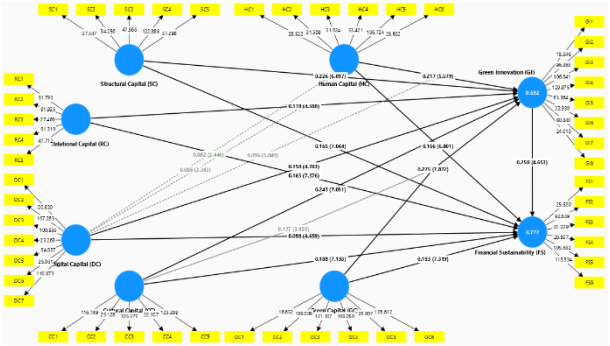

Fig. 1: Structural Model Path Coefficients and Significance Testing.

The structural model analysis reveals systematic support for all hypothesized direct relationships. The comprehensive results for all main effects hypotheses are presented in Table 4, which displays path coefficients, significance levels, and effect sizes for each proposed relationship. The analysis of H1a through H1f demonstrates that all intellectual capital dimensions significantly influence financial sustainability, though with varying magnitudes. Cultural capital and green capital emerge as the strongest predictors (H1e: β = 0.189, t = 7.193; H1f: β = 0.193, t = 7.319), while traditional intellectual capital dimensions show relatively uniform effects (H1a-H1c: β ranging from 0.163 to 0.166). Digital capital demonstrates the most modest direct effect on financial sustainability (H1d: β = 0.098, t = 4.659), though the relationship remains statistically significant. The examination of H2a through H2f reveals an unexpected hierarchy among intellectual capital dimensions in predicting green innovation. Green capital demonstrates the strongest influence (H2f: β = 0.275, t = 7.872), followed by cultural capital (H2e: β = 0.243, t = 7.051). Traditional intellectual capital dimensions exhibit moderate but significant effects, with structural capital showing the strongest performance among traditional dimensions (H2b: β = 0.226, t = 6.017), followed by human capital (H2a: β = 0.217, t = 5.579) and relational capital (H2c: β = 0.178, t = 4.588). Digital capital demonstrates the most modest effect among all dimensions (H2d: β = 0.158, t = 4.783). The analysis confirms that green innovation significantly influences financial sustainability (H3: β = 0.250, t = 4.653), supporting the theoretical proposition that environmental innovation creates both ecological and economic value for SMEs.

Table 4: Hypothesis Testing Results

Hypothesis	Path	β	SE	t-value	p-value	95% CI	Decision	f²
H1: 6G-DIC on FS								
H1a	HC → FS	0.166	0.024	6.801	<0.001	[0.119, 0.213]	Supported	0.084
H1b	SC → FS	0.165	0.023	7.044	<0.001	[0.120, 0.210]	Supported	0.083
H1c	RC → FS	0.163	0.022	7.376	<0.001	[0.120, 0.206]	Supported	0.083
H1d	DC → FS	0.098	0.021	4.659	<0.001	[0.057, 0.139]	Supported	0.027
H1e	CC → FS	0.189	0.026	7.193	<0.001	[0.138, 0.240]	Supported	0.101
H1f	GC → FS	0.193	0.026	7.319	<0.001	[0.142, 0.244]	Supported	0.103
H2: 6G-DIC on GI								
H2a	HC → GI	0.217	0.039	5.579	<0.001	[0.141, 0.293]	Supported	0.111
H2b	SC → GI	0.226	0.038	6.017	<0.001	[0.152, 0.300]	Supported	0.122
H2c	RC → GI	0.178	0.039	4.588	<0.001	[0.102, 0.254]	Supported	0.076
H2d	DC → GI	0.158	0.033	4.783	<0.001	[0.093, 0.223]	Supported	0.053
H2e	CC → GI	0.243	0.034	7.051	<0.001	[0.176, 0.310]	Supported	0.133
H2f	GC → GI	0.275	0.035	7.872	<0.001	[0.206, 0.344]	Supported	0.173
H3: GI → FS								
H3	GI → FS	0.250	0.054	4.653	<0.001	[0.144, 0.356]	Supported	0.100

Note: SE = Standard Error; CI = Confidence Interval; f² = Effect Size Effect Size: 0.02 = small, 0.15 = medium, 0.35 = large

The structural model demonstrates excellent explanatory power and predictive capability. The model explains 77.2% of variance in financial sustainability ($R^2 = 0.772$) and 69.2% of the variance in green innovation ($R^2 = 0.692$), substantially exceeding benchmarks for acceptable explanatory power in social science research. Stone-Geisser Q^2 values confirm strong predictive relevance, with green innovation achieving $Q^2 = 0.497$ and financial sustainability demonstrating $Q^2 = 0.598$, both substantially exceeding the 0.35 threshold for large predictive relevance.

4.4. Mediation analysis

Mediation analysis was conducted following Preacher and Hayes' (2008) methodology, employing bias-corrected bootstrap confidence intervals with 5,000 resamples. The Variance Accounted For (VAF) method determined mediation types, with all relationships demonstrating partial mediation ($20\% \leq VAF \leq 80\%$). The detailed results of the mediation analysis are presented in Table 5, which shows the indirect effects and their significance levels for all hypothesized mediation relationships.

Table 5: Mediation Analysis Results

Hypothesis	Indirect Path	Indirect Effect	SE	t-value	p-value	95% CI	VAF%	Type
H4a	HC → GI → FS	0.054	0.016	3.432	<0.001	[0.023, 0.085]	24.65	Partial
H4b	SC → GI → FS	0.056	0.016	3.465	<0.001	[0.025, 0.087]	25.45	Partial
H4c	RC → GI → FS	0.044	0.015	2.882	0.004	[0.015, 0.073]	21.46	Partial
H4d	DC → GI → FS	0.040	0.012	3.169	0.002	[0.016, 0.064]	28.72	Partial
H4e	CC → GI → FS	0.061	0.018	3.378	<0.001	[0.026, 0.096]	24.29	Partial
H4f	GC → GI → FS	0.069	0.019	3.565	<0.001	[0.032, 0.106]	26.32	Partial

Note: VAF = Variance Accounted For.

All indirect effects are statistically significant, supporting hypotheses H4a through H4f. Green innovation serves as a partial mediator for all intellectual capital dimensions, with the strongest indirect effect occurring through green capital ($\beta = 0.069$), followed by cultural capital ($\beta = 0.061$). The mediation results confirm that intellectual capital dimensions achieve financial sustainability outcomes both directly and indirectly through green innovation pathways.

4.5. Moderation analysis

Moderation effects were tested using product indicator approaches with standardized interaction terms. The analysis reveals significant moderation effects for all hypothesized relationships, supporting the theoretical proposition that intellectual capital dimensions work synergistically rather than independently. The complete moderation analysis results are summarized in Table 6, which demonstrates the interaction effects and their statistical significance.

Table 6: Moderation Analysis Results

Hypothesis	Interaction Path	β	SE	t-value	p-value	95% CI	f^2	Decision
H5a	DC × HC → GI	0.096	0.032	3.049	0.002	[0.033, 0.159]	0.045	Supported
H5b	DC × SC → GI	0.082	0.034	2.446	0.015	[0.016, 0.148]	0.032	Supported
H5c	DC × RC → GI	0.086	0.037	2.343	0.020	[0.014, 0.158]	0.034	Supported
H6	CC × GC → GI	0.177	0.045	3.925	<0.001	[0.089, 0.265]	0.134	Supported

The results confirm that digital capital enhances the innovation potential of traditional intellectual capital dimensions (H5a-H5c), though with modest effect sizes. Most significantly, cultural capital substantially strengthens the relationship between green capital and green innovation (H6: $\beta = 0.177$, $f^2 = 0.134$), demonstrating that organizational culture serves as a critical amplifier of environmental knowledge capabilities.

5. Discussion

This study developed and validated the 6-Go Digital Intellectual Capital framework, revealing patterns that fundamentally challenge prevailing assumptions about resource value hierarchies in contemporary business environments. The empirical analysis provides robust statistical support for all hypotheses while exposing unexpected relationships that demand critical theoretical examination rather than defensive justification.

5.1. Theoretical contributions

The most theoretically significant finding concerns the unexpected hierarchy of intellectual capital effectiveness, where green capital ($\beta = 0.275$) and cultural capital ($\beta = 0.243$) substantially outperform digital capital ($\beta = 0.158$) in driving innovation outcomes. This pattern directly contradicts extensive literature positioning digital capabilities as primary drivers of contemporary competitive advantage (Zhang et al., 2025; Liu et al., 2025; Vial, 2019; Broccardo et al., 2024) and raises fundamental questions about the universal applicability of digital transformation theories.

Three competing theoretical explanations warrant consideration. First, the institutional context hypothesis suggests that Indonesia's evolving environmental regulatory framework creates temporary conditions where green knowledge commands premium value due to scarcity and compliance requirements. This explanation implies that the observed hierarchy reflects transitional market dynamics rather than stable resource value principles, limiting theoretical generalizability. Second, the measurement adequacy hypothesis questions whether the digital capital scale captures sophisticated technological capabilities or merely basic digitalization activities, potentially underestimating digital capital's true contribution. Third, the complementary asset hypothesis proposes that digital capital operates primarily through enabling traditional intellectual capital rather than generating direct innovation effects, consistent with dynamic capabilities theory emphasizing resource complementarity (Teece et al., 1997), as evidenced by significant but modest interaction effects.

The theoretical contribution to intellectual capital theory remains ambiguous pending resolution of these competing explanations. If the findings reflect genuine resource value patterns, they advance intellectual capital theory by demonstrating contextual sensitivity in capability hierarchies and challenging assumptions about universal resource value rankings established in foundational resource-based view

literature (Barney, 1991). However, if the patterns reflect measurement limitations or temporary institutional conditions, the theoretical contribution becomes limited to documenting context-specific anomalies rather than advancing general theoretical understanding.

The validation of the six-dimensional framework achieves substantial empirical success, with the model explaining 77.2% of the variance in financial sustainability and 69.2% of the variance in green innovation. This explanatory power substantially exceeds traditional three-dimensional models documented in prior meta-analytic research (Demartini & Beretta, 2020), supporting arguments for dimensional expansion in intellectual capital frameworks (Shahzad et al., 2025; Arena et al., 2022). However, the theoretical significance of this achievement depends critically on whether the additional dimensions represent genuinely distinct knowledge assets or merely subdivisions of existing intellectual capital components as originally conceptualized by Stewart (1997) and Edvinsson and Malone (1997).

The mediation analysis reveals green innovation as the critical pathway through which intellectual capital influences financial sustainability, with variance accounted for ranging from 21.46% to 28.72%. This finding supports dynamic capabilities theory's emphasis on resource reconfiguration processes (Teece et al., 1997; Hu et al., 2024) while positioning environmental innovation as strategically essential rather than optional for achieving sustainable performance outcomes (Ji et al., 2024; Martínez Falcó et al., 2024). However, the partial nature of mediation indicates that intellectual capital also operates through direct pathways, suggesting multiple value creation mechanisms whose relative importance requires further investigation.

The moderation effects provide insights into intellectual capital synergies, particularly the substantial interaction between cultural capital and green capital ($\beta = 0.177$, $f^2 = 0.134$). This interaction suggests that organizational culture serves as a critical amplifier of environmental knowledge, transforming individual green competencies into collective innovation capabilities through knowledge sharing and organizational learning processes (Huber, 1991; Tortora et al., 2024). However, these mechanisms require critical examination regarding their boundary conditions, as the cultural amplification effect may reflect Indonesia's collectivist orientation, where organizational culture assumes greater importance than in individualistic contexts.

5.2. Practical implications

The empirical findings generate specific implications for SME managers and policymakers, though application requires careful contextual adaptation given the study's geographic specificity.

The unexpected dominance of green capital and cultural capital suggests that SME managers should prioritize environmental knowledge acquisition and organizational culture strengthening alongside digital transformation initiatives. Specifically, managers should: (1) invest in employee training programs focusing on environmental compliance, sustainable practices, and eco-innovation capabilities; (2) develop organizational cultures that explicitly value sustainability and innovation through leadership commitment and incentive alignment; (3) integrate environmental considerations into strategic planning processes rather than treating sustainability as peripheral concerns; and (4) pursue digital transformation as an enabler of green innovation rather than as an isolated objective.

The substantial interaction effects between intellectual capital dimensions indicate that isolated capability development generates limited outcomes. SME managers should adopt integrated approaches that simultaneously develop multiple intellectual capital dimensions, recognizing that synergistic benefits require coordinated investments across human, structural, relational, digital, cultural, and green capital. However, this complexity may challenge resource-constrained SMEs, suggesting the need for phased implementation strategies that prioritize dimensions based on specific business contexts and competitive requirements.

The findings challenge current policy frameworks emphasizing digital transformation as the primary pathway to SME competitiveness. Evidence suggesting green capital's superior influence on innovation outcomes warrants policy reconsideration. Specific policy recommendations include:

1) Environmental Knowledge Development Programs: Establish government-subsidized training initiatives providing SMEs with environmental compliance knowledge, sustainable business practices, and eco-innovation capabilities. Programs should target both management and operational personnel, with particular focus on resource-constrained micro and small enterprises.
2) Green Technology Adoption Incentives: Implement tax incentives, grants, and low-interest financing mechanisms specifically supporting SME investments in environmentally friendly technologies, renewable energy systems, and waste reduction infrastructure. Current digital transformation incentives should be expanded to explicitly include green technology components.
3) Sustainability Certification and Recognition Systems: Develop government-backed certification programs recognizing SME environmental performance, creating market differentiation opportunities for sustainability leaders while establishing clear standards and pathways for environmental improvement.
4) Digital-Green Integration Frameworks: Rather than treating digital transformation and environmental sustainability as separate policy domains, develop integrated frameworks supporting digital technologies that enable environmental innovation. This includes support for digital monitoring systems, data analytics for resource optimization, and digital platforms facilitating green supply chain coordination.
5) Culture and Organizational Development Support: Establish programs supporting organizational culture strengthening in SMEs, recognizing that cultural capital significantly influences innovation outcomes. This could include management development programs emphasizing cultural leadership, peer learning networks facilitating best practice sharing, and organizational development consulting subsidies.
6) Regional Innovation Ecosystems: Create regional hubs connecting SMEs with environmental expertise, green technology providers, and sustainability-focused research institutions, facilitating knowledge transfer and collaborative innovation. These ecosystems should integrate digital infrastructure with environmental knowledge resources.

However, these policy recommendations require qualification. The moderate effect sizes observed throughout the study suggest that intellectual capital represents one of multiple factors influencing SME performance. Policymakers should avoid overestimating intellectual capital interventions' potential while recognizing that broader economic conditions, market access, financing availability, and regulatory environments significantly influence SME outcomes. The geographic specificity of findings further indicates that policy applications require validation across different institutional contexts before large-scale implementation.

5.3. Limitations and future research

Several methodological limitations fundamentally constrain the interpretation and theoretical significance of findings. The cross-sectional design prevents causal inference, limiting conclusions to associational patterns that may reflect reverse causality or unmeasured confounding variables. The possibility that successful SMEs subsequently develop stronger green capabilities rather than green capabilities driving success cannot be dismissed without longitudinal validation.

The geographic specificity of findings presents the most serious limitation for theoretical generalization. The study's focus on a single Indonesian regency creates conditions where local institutional factors, regulatory pressures, and cultural characteristics may generate patterns that do not replicate in other environments. The possibility that findings reflect idiosyncratic local conditions rather than generalizable principles requires explicit acknowledgment and constrains theoretical contributions beyond the specific study context.

Measurement limitations introduce additional concerns about finding validity. The reliance on self-reported measures may inflate correlations through common method variance despite statistical controls. The development of new scales for emerging intellectual capital dimensions, while methodologically necessary, lacks extensive cross-cultural validation that would support broader generalization. The strong correlation between green innovation and financial sustainability ($r = 0.780$), while statistically robust, may partially reflect conceptual overlap or measurement artifacts.

The sample selection process, while methodologically sound, may introduce systematic bias toward environmentally conscious SMEs more likely to participate in sustainability research. This selection bias could artificially amplify green capital effects while understating digital capital importance, particularly if digitally advanced SMEs were less likely to participate in face-to-face interviews.

Future research should prioritize longitudinal validation and cross-cultural replication to establish boundary conditions and temporal stability of observed patterns. Longitudinal research examining intellectual capital development trajectories and their performance consequences over extended time periods represents the highest priority for establishing causal relationships. Cross-cultural replication studies become essential for determining whether the green and cultural capital dominance reflects universal principles or context-specific anomalies.

Methodological advancement requires the development of more sophisticated measures for emerging intellectual capital dimensions, particularly digital capital scales that capture advanced technological capabilities rather than basic digitalization activities. Objective performance measures and longitudinal designs could address current limitations while providing stronger evidence for causal relationships.

Mechanism exploration studies employing qualitative methodologies could investigate the processes through which green capital and cultural capital generate innovation outcomes, addressing current gaps in understanding about why environmental knowledge outperforms digital capabilities in specific contexts. Such research could identify boundary conditions and contingency factors that determine when different intellectual capital dimensions assume primary importance.

6. Conclusion

This research makes three primary theoretical contributions to intellectual capital literature. First, it validates a six-dimensional framework that substantially exceeds traditional three-dimensional models in explanatory power, explaining 77.2% of the variance in financial sustainability and 69.2% in green innovation. This demonstrates that dimensional expansion captures contemporary knowledge assets more comprehensively than classical formulations, supporting arguments for theoretical evolution beyond established boundaries.

Second, the study reveals unexpected hierarchies in intellectual capital effectiveness, with green capital ($\beta = 0.275$) and cultural capital ($\beta = 0.243$) substantially outperforming digital capital ($\beta = 0.158$) in driving innovation outcomes. This pattern fundamentally challenges prevailing assumptions positioning digital capabilities as primary competitive advantage drivers in contemporary business environments. Whether this reflects genuine resource value patterns or context-specific conditions remains theoretically ambiguous, requiring cross-cultural validation before broader generalization.

Third, the research establishes green innovation as a critical mediating mechanism through which intellectual capital influences financial sustainability, accounting for 21.46% to 28.72% of total effects. This positions environmental innovation as strategically essential rather than optional for SMEs navigating contemporary business complexities, while demonstrating that knowledge assets operate through multiple pathways requiring integrated management approaches.

Practically, findings suggest SME managers should prioritize green and cultural capital development alongside digital transformation initiatives, recognizing that environmental knowledge and organizational culture generate substantial innovation outcomes in contexts characterized by evolving sustainability requirements. Policymakers should reconsider frameworks emphasizing digital-only approaches, developing integrated programs supporting environmental knowledge acquisition, organizational culture strengthening, and digital-green technology adoption. However, moderate effect sizes and geographic specificity constrain confident prescription, requiring contextual adaptation and continued validation.

Critical limitations fundamentally constrain interpretation. The cross-sectional design prevents causal inference, geographic focus on a single Indonesian regency limits generalizability, and measurement reliance on self-reported data introduces potential bias despite statistical controls. The unexpected finding that digital capital demonstrates modest effects raises questions about measurement adequacy and contextual factors that require systematic investigation. Future research should prioritize longitudinal validation, establishing temporal relationships, cross-cultural replication, determining boundary conditions, and mechanism exploration, revealing why green and cultural capital outperform digital capabilities in specific contexts.

The 6-Go Digital Intellectual Capital framework advances intellectual capital theory through dimensional expansion while exposing contextual sensitivities in resource value hierarchies. The study provides insights into knowledge asset dynamics within Indonesian SMEs while highlighting substantial validation requirements before broader theoretical or practical application. The unexpected patterns observed warrant continued investigation rather than premature generalization, ultimately contributing to a more nuanced understanding of how intellectual capital functions across diverse institutional environments.

Acknowledgements

The authors gratefully acknowledge the financial support provided by the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia, through the Directorate General of Higher Education, Research and Technology, under the following grant agreements: Main Contract No. 122/C3/DT.05.00/PL/2025 and Derivative Contracts Nos. 34/SPK/LL1/AL.04.03/PL/2025 and 020/04/LPPM/VI/2025.

The authors also extend their appreciation to LLDIKTI Region I, North Sumatra, and Universitas Battuta for institutional support. Sincere thanks are conveyed to the community stakeholders and research assistants whose contributions were instrumental in the completion of this study.

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