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Research Article

Digital Innovation Model for Eco-Friendly Business: SMEs Strategy to Face Market Disruption

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ABSTRACT

Small and medium enterprises (SMEs) face increasing pressure to remain competitive amid digital transformation and growing environmental concerns. Digital green innovation has become a strategic pathway for SMEs to achieve both sustainability and resilience in disruptive markets. This study investigates how government support and green absorptive capacity (GAC) influence digital green innovation performance (DGI) in SMEs. It further examines the mediating role of efficient and integrated business model innovation in strengthening this relationship. The study focuses on SMEs in the culinary and fashion sectors in Bandung and Cirebon, Indonesia, given their significant contributions to the regional economy and their ongoing challenges in digital and green transformation. A quantitative, exploratory design was employed. Data were collected through structured surveys and interviews with 200 SME owners and managers. The data were analyzed using Structural Equation Modeling (SEM) with a Partial Least Squares (PLS) approach. Both government support and GAC significantly enhance DGI performance. GAC demonstrates a stronger direct effect compared to government support. In addition, efficient and integrated business model innovations partially mediate these relationships. It highlights that external and internal resources must be translated into concrete business practices to generate substantial impact. The combination of government support, green absorptive capacity, and business model innovation provides an effective strategy for SMEs to sustain competitiveness in dynamic markets.

Keywords: Government support; green absorptive capacity; digital green innovation performance; business model innovation, Indonesia SMEs

1. Introduction

Hart[1] predicted that future business would be rooted in environmentally sustainable capabilities. To achieve competitive advantage, business model innovation has become increasingly vital in responding to dynamic markets and customer demands [2,3]. Organizations must act proactively to generate customer value and adapt to change [4], which requires the integration of technology and environmental awareness as part of their competitive strategies [5].

The rapid advancement of digital technologies has transformed how organizations operate. Many SMEs

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have shifted to digital platforms for transactions, customer interaction, and marketing, which creates new opportunities for efficiency and competitiveness [6], [7]. According to Utami and Sitanggang[8], this transformation enhances operational efficiency, expands market reach, and strengthens long-term competitive advantage. Nevertheless, innovation adoption in SMEs remains uneven. Limited resources, weak knowledge transfer, and minimal access to information often hinder their ability to sustain performance [9], [10]. [11] therefore emphasize the importance of developing business innovation models tailored to current market needs and technological trends.

The Natural Resource-Based View (NRBV) provides a useful perspective for explaining how firms can leverage digital innovation to achieve environmental and economic benefits simultaneously [1]. Environmentally friendly digital innovation not only reduces waste and resource consumption but also supports circular economy practices [12]. Digital transformation thus acts as both a driver of competitiveness and a mechanism to achieve sustainability goals [13]. Previous studies have explored innovations in organizational structure, value creation, and differentiation [14], [15], [16]. However, there remains a call to further investigate the role of external stakeholders, such as government, in fostering eco-friendly digital innovation for SMEs [17], [18].

In Indonesia, SMEs are widely recognized as vital contributors to national economies [19]. However, they often face challenges in maintaining competitiveness in the global market [20]. Barriers such as limited financing, insufficient human resource capabilities, and weak access to technology are persistent. In this context, government support, through policy initiatives, financial incentives, and digitalization programs, can play a decisive role in accelerating SME development [21]. At the same time, growing environmental concerns reinforce the urgency of integrating sustainability principles into business models [22], [23], [24]. Concerns about environmental disasters and the various negative impacts arising from business processes have become a hot topic. According to Elkington[25] triple bottom line, successful businesses must balance financial, environmental, and social objectives. Thus, eco-friendly technology adoption and green business practices are essential for building competitive and sustainable SMEs [26]. However, the mechanisms through which government support and absorptive capacity affect SMEs' digital green innovation performance remain insufficiently understood [27], especially for SMEs in Indonesia.

This study addresses this gap by examining the influence of government support (external factor) and green absorptive capacity (internal factor) on digital green innovation performance, mediated by efficient and integrated business model innovation. By focusing on SMEs in Indonesia, the research seeks to explain how both external and internal enablers interact to strengthen sustainable competitiveness in resource-constrained environments. The study makes three contributions. First, it conceptualizes how eco-friendly digital innovation performance can be enhanced by government support, green absorptive capacity, and business model innovation. Second, it integrates the perspectives of the NRBV [1] and stakeholder theory [28], which are often applied separately in prior research. Third, it provides practical insights into how SMEs can adopt environmentally friendly digital business innovations to improve competitiveness and long-term sustainability.

The structure of this paper consists of an introduction, which explains the phenomenon and gaps in previous research. The second section explains and develops a framework consisting of a literature review and the results of previous studies. The third section explains the method, sample selection, and analytical tools used. The fourth section explains the results of the analysis and discussion. Conclusions and recommendations for further research are presented in the final section.

2. Literature review

2.1. Natural resource-based view

This study uses the NRBV to investigate the role of efficient business model innovation, business model innovation integration, and government support in enhancing digital green innovation performance of SMEs. Theoretically, the NRBV approach was introduced by Hart[1] which is a development of the Resource-Based View (RBV). It emphasizes that a company's long-term competitive advantage can be achieved through a sustainable natural resource-based strategy. The NRBV highlights the importance of environmentally friendly business innovation and efficient resource management as key factors in creating a sustainable business [29]. The NRBV concept argues that there are three main strategic capabilities that an organization can carry out, namely pollution prevention, product management, and sustainable development [30]. Each capability has a different driving force to survive in a changing business environment [29]. This framework underscores that business strategy and competitive advantage can depends on an organization's attention to the environment under consideration. The NRBV underscores the importance of organizations continually innovating and seeking new capabilities to develop environmental solutions to enhance their capacity to adapt to ever-increasing environmental demands [12], [31]. Such efforts lead to the development of valuable, rare, and difficult-to-imitate organizational capabilities, which drive significant competitive advantage and superior performance outcomes.

2.2. Stakeholder theory

Freeman[28] suggested that how a business operates is largely based on stakeholder theory. This theory emphasizes that a company's long-term success depends not only on financial profits but also on its ability to meet the expectations and interests of various stakeholders, such as customers, employees, suppliers, communities, and governments. The essence of this approach is how an organization manages relationships with all stakeholders to create shared value [32]. In this context, SMEs are often faced with situations where stakeholder involvement is required. According to Freeman[28], stakeholders can have a significant influence on an organization's actions. Responsibility for environmental sustainability and minimizing pollution has become a major concern, especially for the government [33]. Thus, as a stakeholder, government must be able to provide favorable regulations, incentives, and access, serving as catalysts so that it becomes a catalyst for SMEs to develop business models that are not only operationally efficient, but also aligned with the principles of sustainability and environmental responsibility.

2.3. Government support and digital green innovation performance

Government support in the business context is defined as steps taken by public authorities to assist and facilitate the development and sustainability of businesses [27]. In the transition toward digital and environmentally friendly practices, the government, as a key stakeholder, plays an important role in supporting innovation. From a stakeholder theory perspective, governments represent a dominant external stakeholder whose expectations, regulations, and incentives shape firms' strategic priorities and innovation behavior [28], [32]. According to Feranita et al.[21], government support, both financial and non-financial, can facilitate the development of environmentally friendly business model innovation. Previous studies have shown that the ability to use digital technology enables rapid absorption of information, particularly with regard to environmental changes [34]. Government support in the form of regulations, incentives, and facilities can create an ecosystem that allows organizations to pursue innovation aimed not only at efficiency but also at environmental performance [35]. By signaling sustainability priorities and reducing uncertainty, government support provides legitimacy for firms to invest in digital green innovation in response to stakeholder expectations. As [36] noted, today's business practices affect society as a whole, and organizations are therefore responsible for protecting the environment as part of their commitment to future generations. In this regard, the government's role extends beyond providing encouragement to improve technical capabilities. It also involves fostering a broader understanding of technological development in the field of environmentally friendly digital innovation [37]. By promoting the use of green business technology and knowledge, governments can help organizations recognize development trends and improve their performance in volatile environments.

H1. Government support positively influences digital green innovation performance.

2.4. Green absorptive capacity and digital green innovation performance

The challenges faced by SMEs in Indonesia often stem from their limited ability to absorb and apply new knowledge or information from the external environment. Cohen and Levinthal[38] argued that the success of business innovation depends not only on the availability of resources or technology but also on an organization's capacity to continuously learn from external sources. This absorptive capacity is not static; rather, it varies across contexts and over time [19], with the ultimate goal of generating meaningful organizational outcomes. In the innovation process, the ability to absorb knowledge can differ greatly. When an organization is in a growth phase, has adequate resources, and is supported by a strong knowledge infrastructure, innovation tends to accelerate [39]. Conversely, this capability may decline during periods of resource scarcity, personnel turnover, or strategic shifts. Fosfuri and Tribó[40] and Wang et al.[41] noted that innovation is a complex activity in which new knowledge must be applied for commercial purposes, making the ability to exploit external knowledge a critical determinant of innovation performance.

Building on this, green absorptive capacity extends the concept by focusing on the ability to recognize, assimilate, and apply environmental knowledge for sustainable innovation. Hurtado-Palomino et al.[42] identify green absorptive capacity as a crucial dynamic capability in knowledge-based competition and eco-innovation. Empirical evidence shows that absorptive capacity significantly enhances innovation performance in SMEs by enabling the effective integration of external knowledge into innovation activities [43]. More recent studies further demonstrate that absorptive capacity plays a critical role in supporting green and digital innovation by linking environmental knowledge with digital technologies and organizational learning processes [39], [41], [44]. However, existing research largely emphasizes absorptive capacity as a general organizational capability, with limited attention to how green-specific absorptive processes directly translate environmental knowledge into digital green innovation outcomes, particularly in resource-constrained SMEs [26], [45].

In this context, green absorptive capacity becomes essential for enabling SMEs to internalize externally sourced environmental knowledge and convert it into digitally enabled green innovations that improve both environmental and competitive performance [18], [46]. Accordingly, this study posits that green absorptive capacity serves as a direct driver of digital green innovation performance by enabling SMEs to internalize external environmental knowledge and convert it into digitally enabled green innovations.

H2. Green absorptive capacity positively influences digital green innovation performance.

2.5. The mediating role of efficient business model innovation and integrated business model innovation

Several studies have found that a critical step for organizations to achieve superior performance is adopting innovation models that create value, adapt to dynamic environments, and integrate technology with market needs in a sustainable manner [40], [42]. For companies, the realization of strategic goals is inseparable from external support and the ability to absorb information. In the era of digital transformation and increasing environmental awareness, the performance of environmentally friendly digital innovations is essential for achieving sustainability and competitiveness [46]. Government support plays a crucial role in encouraging this innovation through conducive policies, such as tax incentives, knowledge transfer, and regulations for environmentally friendly businesses. Such support creates an ecosystem that enables organizations to adopt digital technologies for sustainable solutions. Doh and Kim[37] stated that the government's role can also extend to acting as an information channel.

From a stakeholder theory perspective, government support represents a key external stakeholder influence that shapes firms' strategic priorities and innovation behavior. Governments signal environmental expectations, reduce uncertainty, and provide legitimacy for sustainability-oriented investments, thereby motivating firms to redesign their business models in response to stakeholder pressures [28], [31], [32]. In this context, government support does not directly generate innovation outcomes, but operates by enabling firms to reconfigure how value is created, delivered, and captured through business model innovation.

Efficient business model innovations, such as environmentally friendly products, processes, and supply chains, serve as a bridge that strengthens the relationship between government support and green innovation performance [41], [47], [48]. With this support, companies can increase efficiency, reduce environmental impact, and achieve a competitive advantage in the global market. Efficiency-oriented business model innovation allows firms to internalize government incentives by optimizing resource use, lowering operational costs, and improving environmental compliance.

Furthermore, integrated business model innovation enables companies to embed environmental, social, and economic considerations into their core value logic rather than treating sustainability as a peripheral activity. Integrated business model innovation facilitates collaboration with external stakeholders—such as suppliers, digital platforms, and communities—allowing firms to align government support with broader value networks and sustainability goals [5], [9], [49]. By reconfiguring inter-organizational relationships and governance structures, integrated business model innovation enhances firms' ability to leverage government support for digitally enabled green innovation that spans the entire value chain [50], [51]. Accordingly, this study argues that government support influences digital green innovation performance indirectly through both efficiency-oriented and integrated business model innovation, with the latter playing a critical role in translating external stakeholder support into systemic and scalable green digital innovation outcomes.

H3. Government support influences digital green innovation performance through efficient business model innovation.

H4. Government support influences digital green innovation performance through integrated business model innovation.

This study also examines the role of integrated business model innovation as a mediator between green absorptive capacity and digital green innovation performance. SMEs with high levels of green absorptive capacity are able to learn from training, understand market trends, and incorporate new technologies into their operations [40]. This capability allows firms to embed environmental knowledge into digital green innovation processes, thereby improving their chances of developing efficiencies and integrating business model innovations [10], [42]. Efficient business model innovation and integrated business model innovation function as mechanisms that connect government support and green absorptive capacity with the performance of digital green innovation [26]. Efficient business model innovation emphasizes resource optimization, cost reduction, and the effective use of technology to create sustainable value [26]. In contrast, integrated business model innovation highlights cross-sector collaboration, the interconnectedness of actors within the innovation ecosystem, and the organization's ability to orchestrate diverse external resources [10].

H5. Green absorptive capacity influences digital green innovation performance through efficient business model innovation.

H6. Green absorptive capacity influences digital green innovation performance through integrated business model innovation.

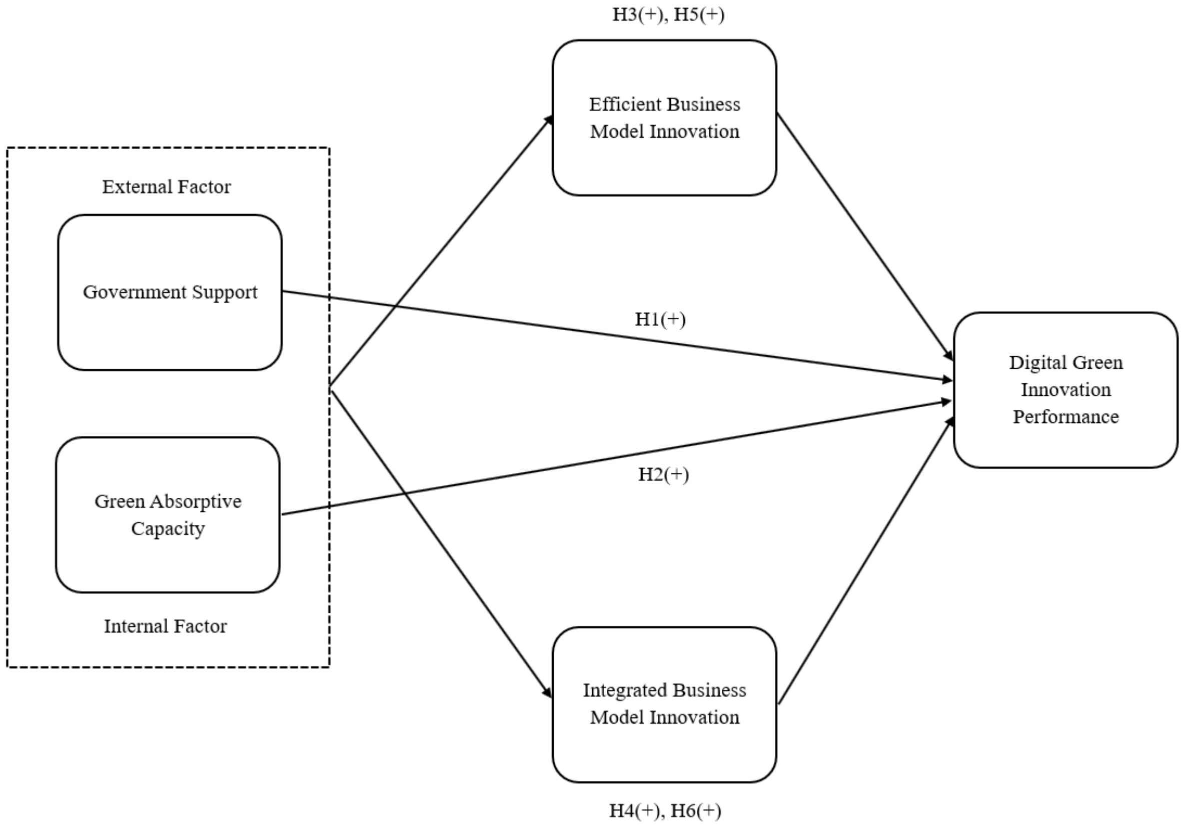

Figure 1. Conceptual Framework

3. Materials and methods

3.1. Research design

This research uses a quantitative method with an exploratory approach to identify patterns, trends, and relationships between government support and green absorptive capacity on digital green innovation performance, while examining the mediating roles of efficient business model innovation and integrated business model innovation. Data were collected through surveys, structured interviews, and secondary data analysis to provide a deeper understanding of the factors influencing the integration of digital aspects into sustainable business models. The results of this study are expected to provide strategic recommendations for industry practitioners, policymakers, and academics in designing innovative solutions that support sustainability-oriented digital transformation.

3.2. Data collection

The data for this study were obtained from small and medium enterprises (SMEs) located in the cities of Bandung and Cirebon, selected due to the large number of SMEs and their significant role in the regional economy. Two data collection techniques were employed: (1) a quantitative survey using a structured questionnaire distributed to SME owners or managers across various industrial sectors; and (2) structured interviews with selected SME owners who had adopted digital technologies and implemented sustainability practices.

The questionnaire was designed to measure the level of digital technology adoption, the implementation of environmentally friendly business practices, and the challenges and opportunities faced in integrating both. The interviews complemented the survey findings by exploring participants' motivations, challenges, and strategies in dealing with digital transformation and sustainability. A total of 200 respondents were purposively selected to ensure that the sample reflected the diversity and specific characteristics of the targeted SME sector. The collected data were analyzed using Structural Equation Modeling (SEM) with a Partial Least Squares (PLS) approach. Information about the respondents is presented in Table 1.

Table 1. Respondent Profile

Respondents	Frequency	Percentage
City of Origin		
Bandung	108	54%
Cirebon	92	46%
Types of SME's		
Fashion	93	47%
Culinary	107	54%
Gender		
Male	103	52%
Female	97	49%
Age		
25 – 34 years	34	17%
35 – 44 years	81	41%
45 – 54 years	41	21%
55 – 65 years	44	22%
Education		
Junior High School	5	3%
High School/Vocational High School	77	39%
Bachelor's	104	52%
Master's	14	7%
Position		
Owner	64	32%
Manager	49	25%
Owner and Manager	87	44%
Number of Employees		
Less than 5 people	15	8%
5 – 15 people	68	34%
16 – 30 people	77	39%
More than 30 people	40	20%
Annual Turnover		
Less than 150 million	4	2%
150 – 250 million	12	6%
250 – 350 million	64	32%
350 – 450 million	78	39%
More than 450 million	42	21%

Based on the distribution of respondents, the SMEs in this study came from two main regions, namely Bandung City (54%) and Cirebon City (46%). In terms of business sectors, the majority of respondents were engaged in the culinary sector (54%), while the remainder were in the fashion sector (47%). Demographically, the majority of respondents were male (52%), with the largest age range being 35–44 years (41%), and most were born between 1981–1990 (41%). The educational level was dominated by bachelor's degree graduates (52%), with the most common position being owner and manager of the business

(44%). The number of employees in the majority of SME's was in the range of 16–30 people (39%), while the largest annual turnover was in the range of IDR 350–450 million (39%). These data indicate that the majority of respondents were active entrepreneurs with medium-sized business capacities and relatively good educational backgrounds.

3.3. Measurement

Green absorptive capacity is measured using 11 items across four dimensions: acquisition, assimilation, transformation, and exploitation. The measurement items for this variable were adapted from [52], [53]. Digital green innovation performance is measured by 9 items included in 4 dimensions, namely green product development, green production, energy efficiency, and sustainable corporate image [45], [54]. Government support is measured by 8 items included in 4 dimensions, namely financial incentives, capacity building, infrastructure access, and green innovation policy [55]. Efficient business model innovation is measured by 7 items adapted from 4 dimensions, namely operational efficiency, cost reduction, productivity & quality, and process automation [49], [51]. Integrated business model innovation is measured with 8 items adapted from 4 dimensions, namely digital integration, tech-based product development, external collaboration, and sustainable business model [50], [56].

4. Results

4.1. Convergent validity and reliability

Based on the results of convergent validity and reliability tests, all constructs in this study were declared to meet the required criteria. The loading factor values for the majority of indicators were above 0.70, indicating that each item was able to reflect the construct well, although there were several indicators whose values were close to the minimum limit but were still acceptable. The Cronbach's Alpha value for all variables was greater than 0.90, indicating very strong internal consistency between items. This was reinforced by the composite reliability (CR) value which was also above 0.90, confirming that the research instrument had a very high level of reliability. Furthermore, the Average Variance Extracted (AVE) value for all variables ranged from 0.589 to 0.716, indicating that each construct was able to explain more than 50% of the variance in its indicators. Thus, this research instrument was declared valid and reliable, so it can be used for further structural analysis to examine the relationships between variables.

Table 2. Convergent Validity and Reliability Test

Variables	Item	Loading Factor	Cronbach's Alpha	CR	AVE
Green Absorptive Capacity	GAC1	0.792	0.937	0.946	0.617
	GAC2	0.742			
	GAC3	0.823			
	GAC4	0.834			
	GAC5	0.843			
	GAC6	0.876			
	GAC7	0.715			
	GAC8	0.793			
	GAC9	0.717			
	GAC10	0.762			
	GAC11	0.727			

Variables	Item	Loading Factor	Cronbach's Alpha	CR	AVE
Digital Green Innovation Performance	DGI1	0.932	0.942	0.951	0.684
	DGI2	0.764			
	DGI3	0.860			
	DGI4	0.808			
	DGI5	0.830			
	DGI6	0.771			
	DGI7	0.822			
	DGI8	0.820			
	DGI9	0.826			
Government Support	GS1	0.735	0.900	0.920	0.589
	GS2	0.780			
	GS3	0.712			
	GS4	0.822			
	GS5	0.774			
	GS6	0.743			
	GS7	0.798			
	GS8	0.769			
Efficient Business Model Innovation	EBM1	0.809	0.993	0.946	0.716
	EBM2	0.779			
	EBM3	0.803			
	EBM4	0.845			
	EBM5	0.914			
	EBM6	0.874			
	EBM7	0.892			
Integrated Business Model Innovation	IBM1	0.837	0.933	0.945	0.684
	IBM2	0.769			
	IBM3	0.818			
	IBM4	0.887			
	IBM5	0.899			
	IBM6	0.846			
	IBM7	0.746			
	IBM8	0.802			

Table 2. (*Continued*)

4.2. Discriminant validity

Based on the results of the discriminant validity test through cross-loading analysis, all indicators showed higher loading values for the constructs they measured compared to other constructs. For example, indicators AC1–AC11 had consistently higher loading values for the green absorptive capacity variable compared to other variables. The same thing was also seen for the construct of digital green innovation performance, government support, efficient business model innovation, and integrated business model innovation, where each indicator had the highest loading value for its original construct. This indicates that each indicator is able to clearly distinguish the construct it represents from other constructs in the research model. The cross-loading test is used to test discriminant validity because the principle is to compare the indicator's correlation value with the construct it measures (main loading) with the correlation with other constructs (cross loading). If the main loading value is significantly higher than the cross loading, it can be concluded that the indicator better represents the original construct than other constructs. Thus, these results confirm that all constructs in this study have good discriminant validity, so that the model built can be trusted for testing structural relationships between variables.

Table 3. Discriminant Validity with Cross Loadings

	Green Absorptive Capacity	**Digital Green Innovation Performance**	**Efficient Business Model Innovation**	**Government Support**	**Integrated Business Model Innovation**
GAC1	**0.792**	0.463	0.438	0.320	0.450
GAC2	**0.742**	0.388	0.400	0.316	0.452
GAC3	**0.823**	0.433	0.506	0.267	0.496
GAC4	**0.834**	0.395	0.520	0.288	0.539
GAC5	**0.843**	0.450	0.546	0.305	0.507
GAC6	**0.876**	0.405	0.494	0.339	0.414
GAC7	**0.715**	0.378	0.462	0.366	0.303
GAC8	**0.793**	0.344	0.482	0.245	0.445
GAC9	**0.717**	0.405	0.470	0.341	0.235
GAC10	**0.762**	0.434	0.552	0.293	0.391
GAC11	**0.727**	0.380	0.543	0.260	0.358
DGI1	0.527	**0.932**	0.456	0.376	0.340
DGI2	0.357	**0.764**	0.341	0.362	0.314
DGI3	0.377	**0.860**	0.394	0.312	0.284
DGI4	0.439	**0.808**	0.397	0.333	0.300
DGI5	0.387	**0.830**	0.383	0.370	0.243
DGI6	0.454	**0.771**	0.455	0.260	0.278
DGI7	0.456	**0.822**	0.476	0.256	0.392
DGI8	0.408	**0.820**	0.285	0.283	0.298
DGI9	0.427	**0.826**	0.347	0.369	0.266
GS1	0.236	0.311	0.236	**0.735**	0.217
GS2	0.277	0.278	0.337	**0.780**	0.284
GS3	0.351	0.252	0.344	**0.712**	0.240
GS4	0.330	0.360	0.265	**0.822**	0.260
GS5	0.252	0.353	0.194	**0.774**	0.181
GS6	0.228	0.253	0.276	**0.743**	0.209
GS7	0.401	0.320	0.280	**0.798**	0.290

	Green Absorptive Capacity	Digital Green Innovation Performance	Efficient Business Model Innovation	Government Support	Integrated Business Model Innovation
GS8	0.249	0.282	0.209	**0.769**	0.184
EBM1	0.515	0.360	**0.809**	0.319	0.508
EBM2	0.474	0.489	**0.779**	0.423	0.452
EBM3	0.459	0.399	**0.803**	0.311	0.513
EBM4	0.538	0.373	**0.845**	0.236	0.597
EBM5	0.568	0.409	**0.914**	0.297	0.607
EBM6	0.564	0.383	**0.874**	0.255	0.633
EBM7	0.593	0.416	**0.892**	0.247	0.698
IBM1	0.451	0.324	0.560	0.302	**0.837**
IBM2	0.464	0.322	0.544	0.253	**0.769**
IBM3	0.467	0.267	0.581	0.262	**0.818**
IBM4	0.446	0.332	0.597	0.280	**0.887**
IBM5	0.468	0.393	0.627	0.293	**0.899**
IBM6	0.409	0.279	0.596	0.227	**0.846**
IBM7	0.415	0.270	0.479	0.253	**0.746**
IBM8	0.434	0.200	0.484	0.143	**0.802**

Table 3. (*Continued*)

After testing the discriminant validity using cross-loading, the next step is to test the discriminant validity with the Fornell-Larcker Criterion and HTMT Ratio to ensure the consistency of the results. Based on the results of the Fornell-Larcker Criterion, the square root of the AVE (Average Variance Extracted) value for each construct (bold diagonal value) is higher than the correlation between constructs in the same row and column. For example, the square root of the AVE value for green absorptive capacity (0.786) is greater than its correlation with other constructs such as digital green innovation performance (0.519), efficient business model innovation (0.628), and integrated business model innovation (0.538). The same thing is seen in other constructs such as digital green innovation performance (0.827) and efficient business model innovation (0.846) which are also higher than the cross-correlation value with other constructs. This indicates that each construct in the model has good discriminant validity because it is able to differentiate itself from other constructs.

Meanwhile, the results of the HTMT Ratio test also support these findings. All HTMT values between constructs are below the threshold of 0.85, for example the relationship between green absorptive capacity and digital green innovation performance (0.548), and between efficient business model innovation and integrated business model innovation (0.723). Since all HTMT values are below the threshold, it can be concluded that there is no multicollinearity problem between constructs and discriminant validity has been met. Thus, testing through cross loading, Fornell-Larcker Criterion, and HTMT Ratio consistently shows that all constructs in this research model have adequate discriminant validity, so that the model can be used for further analysis at the structural hypothesis testing stage.

Table 4. Fornell Larcker Criterion & Heterotrait Monotrait Ratio

	Fornell-Larcker Criterion					HTMT Ratio			
	GAC	**DGI**	**EBM**	**GS**	**IBM**	**GAC**	**DGI**	**EBM**	**GS**
Green Absorptive Capacity	**0.786**								
Digital Green Innovation Performance	**0.519**	**0.827**				0.548			
Efficient Business Model Innovation	0.628	0.479	**0.846**			0.670	0.506		
Government Support	0.384	0.393	0.353	**0.767**		0.416	0.426	0.381	
Integrated Business Model Innovation	0.538	0.366	0.678	0.308	**0.827**	0.568	0.385	0.723	0.328

4.3. Multicollinearity and common method bias test

Based on the results of multicollinearity and common method bias tests using the Variance Inflation Factor (VIF) values, it can be concluded that all constructs in the research model are in good condition. In general, the VIF value used to detect multicollinearity problems has a threshold of <5 or even stricter <3.3 to anticipate potential common method bias. The test results show that the VIF value for each construct is relatively low, ranging from 1.173 to 2.284. For example, the relationship between green absorptive capacity and other constructs produces VIF values of 1.795, 1.173, and 1.173, respectively; while efficient business model innovation has a VIF value of 2.284. Although this value is the highest, it is still far below the critical threshold, so it can be confirmed that there are no symptoms of serious multicollinearity. This indicates that each construct does not dominate each other in explaining the dependent variable and still contributes unique information. Furthermore, the use of a VIF value <3.3 as an additional indicator to test for common method bias also strengthens these results. All VIF values are below the 3.3 threshold, confirming that the model does not experience common method bias due to common source data. Therefore, both in terms of potential multicollinearity and common method bias, this research model meets the feasibility requirements and can proceed to the structural testing stage.

Table 5. Multicollinearity and Common Method Bias Test

	Digital Green Innovation Performance	**Efficient Business Model Innovation**	**Integrated Business Model Innovation**
Green Absorptive Capacity	1.795	1.173	1.173
Efficient Business Model Innovation	2.284		
Government Support	1.206	1.173	1.173
Integrated Business Model Innovation	1.933		

4.4. Predictive Relevance

Based on the results of the predictive relevance (Q^2) test using the blindfolding procedure, it can be seen that several constructs in the research model have quite good predictive ability for endogenous variables. The Q^2 value is calculated using the formula $Q^2 = 1 - (SSE/SSO)$, where SSO is the number of observations generated, while SSE is the number of prediction errors. Interpretation of the Q^2 value refers to the criterion that a value above zero indicates predictive relevance, while the greater the value, the higher the model's ability to explain endogenous variables. the test results show that digital green innovation performance (DGI) obtained a q^2 value of 0.227, efficient business model innovation (EBM) of 0.288, and integrated business model innovation (IBM) of 0.203. These values indicate that the model is able to explain significant variations in the data, with a moderate level of prediction ($0.15 < Q^2 < 0.35$). Among the three endogenous constructs, efficient business model innovation (EBM) has the highest Q^2 value, namely 0.288, which indicates that the exogenous variables in the model are relatively stronger in predicting EBM compared to other constructs.

Meanwhile, green absorptive capacity (GAC) and government support (GS) did not produce Q^2 values because they served as exogenous variables in the model. This is understandable, considering that exogenous variables are not predicted by other constructs, so their predictive relevance was not calculated. Overall, these results confirm that the research model has relevant and reliable predictive capabilities, particularly in explaining the dynamics of efficient business model innovation and the performance of digital green innovation. Therefore, the model can be considered to have good predictive quality and is suitable for testing causal relationships between variables.

Table 6. Predictive Relevance

	SSO	SSE	Q^2 (=1-SSE/SSO)
Green Absorptive Capacity	2200.000	2200.000	
Digital Green Innovation Performance	1800.000	1391.342	0.227
Efficient Business Model Innovation	1400.000	997.362	0.288
Government Support	1600.000	1600.000	
Integrated Business Model Innovation	1600.000	1275.216	0.203

4.5. Hypothesis test

The results of the path coefficient test indicate that government support (GS) has a positive and significant effect on the performance of digital green innovation (DGI) ($\beta=0.200$; $p<0.05$), as does green absorptive capacity (GAC) which has a stronger effect ($\beta=0.309$; $p<0.01$). In addition to the direct effect, both also work through the mediation path of business model innovation. In the paths GS → EBM → DGI ($\beta=0.229$; $p<0.001$) and GS → IBM → DGI ($\beta=0.202$; $p<0.01$), it appears that the effect of government support becomes more effective when mediated by efficient or integrated business model innovation, thus indicating a form of partial mediation (because the direct relationship GS→ DGI remains significant). Meanwhile, the mediation paths from GAC → EBM → DGI ($\beta=0.129$; $p<0.01$) and GAC → IBM → DGI ($\beta=0.207$; $p<0.001$) were also significant, with business model integration being the strongest path. This indicates that GAC not only has a direct effect but also further strengthens DGI through business model innovation, thus forming a partial-complementary mediation. Overall, these findings confirm that external support (GS) and internal capability (GAC) can drive digital green innovation in SMEs, but the strategic role of business model innovation is a crucial link to maximize this impact.

Table 7. Path Coefficient

	Original Sample	STDEV	T Statistics	P Values
GS → DGI (H1)	0.200	0.091	2.201	0.028
GAC → DGI (H2)	0.309	0.098	3.156	0.002
GS → EBM → DGI (H3)	0.229	0.055	4.173	0.000
GS → IBM → DGI (H4)	0.202	0.060	3.354	0.003
GAC → EBM → DGI (H5)	0.129	0.049	2.640	0.009
GAC → IBM → DGI (H6)	0.207	0.035	5.913	0.000

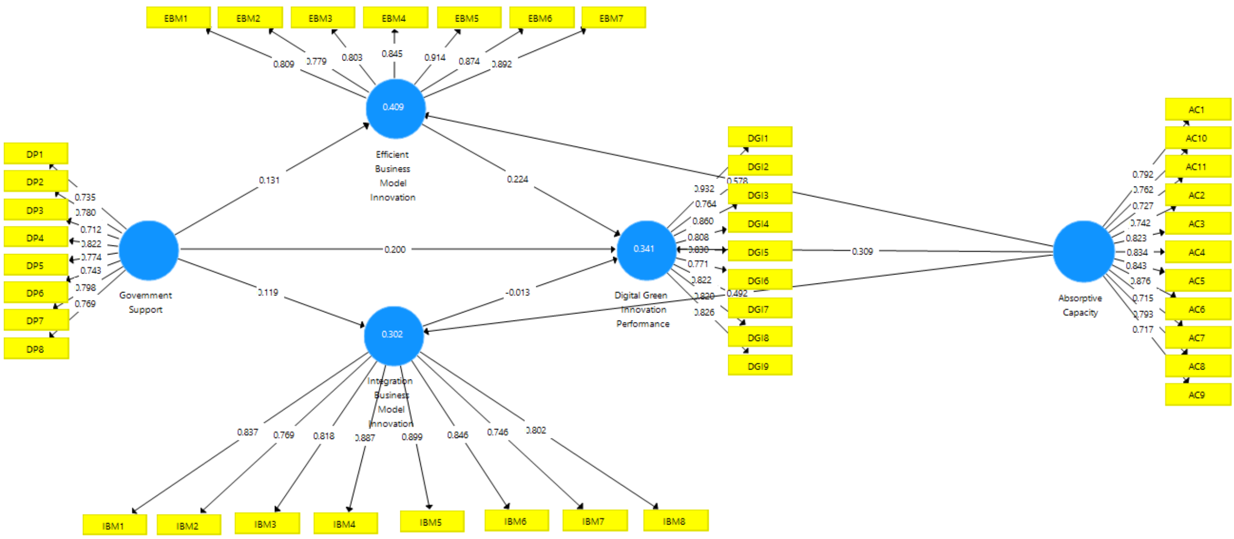

Figure 2. Output from SEM PLS

5. Discussion

The path analysis results show that government support (GS) and green absorptive capacity (GAC) are the two main factors driving increased digital green innovation performance (DGI) in SMEs. The significant influence of GS on DGI indicates that government incentives, regulations, and infrastructure access play a crucial role in creating a conducive innovation ecosystem. This aligns with previous findings that confirm that government intervention can reduce barriers to technology adoption and accelerate the transition to sustainable business models [35]. With this kind of support, SMEs have an additional incentive to strengthen their position when the market experiences disruption, for example due to changes in environmental regulations or the emergence of technology-based competitors [21].

In addition to external factors, the research also highlights the importance of green absorptive capacity (GAC), which is the ability of SMEs to absorb, internalize, and utilize external environmental knowledge. GAC has been shown to have a direct and significant impact on DGI, as well as an indirect impact through business model innovation. This suggests that SMEs that are able to learn quickly from technological changes, market trends, and environmentally friendly practices will be better prepared to adapt to market uncertainty [46]. In the context of disruption, green absorptive capacity can be an “adaptation engine” that enables SMEs not only to survive but also to create new opportunities.

Another interesting finding is the partial mediation of business model innovation, both through efficiency (EBM) and integration (IBM). Partial mediation in the government support (GS) → efficient business model innovation (EBM) and integrated business model innovation (IBM) → digital green innovation performance (DGI) pathways indicates that government support is more optimal if SMEs are able to transform the policies and incentives, they receive into efficient business models and integrate with various parties. As stated by [47] and [48], the innovation model must be interconnected across various elements to create new value and effectively resolve problems. In this regard, regulation or subsidy support alone is not enough; what matters is how SMEs internalize this support in their daily business practices. This is relevant in the context of market disruption, as only SMEs capable of restructuring their business models will be able to compete with new, more innovative players.

The mediation pathways of green absorptive capacity (GAC) → efficient business model innovation (EBM) and green absorptive capacity (GAC) → integrated business model innovation (IBM) → digital green innovation performance (DGI) emphasize that SMEs' internal capacity to absorb knowledge must be complemented by the willingness to innovate their business models. This mediation is partial-complementary, meaning that in addition to its direct influence, GAC strengthens its impact through business model innovation. Business model innovation even emerged as the strongest mediation pathway, indicating that integration across functions, partners, and technologies is crucial for sustaining digital green innovation. For SMEs, this translates into building cross-supply chain collaborations, for example with environmentally friendly suppliers, digital platforms, and green consumer communities. Such collaborations enhance SMEs' agility in responding to market pressures from multiple directions [39].

Overall, this discussion emphasizes that facing market disruption requires more than relying solely on external factors (such as government support). Internal strengths in the form of absorptive capacity and the ability to adapt business models are also required. The combination of these three aspects, namely policy support, learning capacity, and business model innovation, will determine the resilience and competitiveness of SMEs in an increasingly dynamic market era.

6. Conclusion and practical implications

6.1. Research conclusions

This study demonstrates that government support and green absorptive capacity (GAC) play significant roles in enhancing SMEs' digital green innovation performance. Among these factors, GAC exerts the stronger direct influence, underscoring the importance of SMEs' ability to absorb, adapt, and apply external environmental knowledge when facing market disruption. The findings also reveal that the effects of both government support and GAC are largely mediated by efficient and integrated business model innovation. This indicates that external support and internal capabilities are insufficient in isolation; they must be translated into concrete business model innovations to generate substantial impact. Overall, the study concludes that the configuration of external support, internal capabilities, and business model innovation provides an effective pathway for SMEs to strengthen digital green innovation performance and remain competitive in disruptive market environments.

6.2. Theoretical contributions

This study offers several theoretical contributions to the literature on digital green innovation and SME sustainability. First, it strengthens institutional and stakeholder-oriented perspectives by demonstrating that government support functions as a critical external driver shaping SMEs' strategic responses toward green digital innovation. Second, the findings enrich dynamic capabilities theory by confirming that green absorptive capacity not only directly enhances innovation performance but also operates through business model transformation mechanisms. Third, by identifying efficiency-oriented and integrative business model innovation as mediating mechanisms, this study advances understanding of how external institutional pressures and internal learning capabilities are translated into tangible innovation outcomes. Collectively, the study proposes an integrative framework that links policy support, absorptive capacity, and business model innovation to explain heterogeneity in SMEs' digital green innovation performance.

6.3. Practical implications for SMEs

The findings provide several actionable implications for SME managers and practitioners. First, SMEs should prioritize the development of green absorptive capacity by investing in organizational learning, employee skill development, and continuous engagement with external knowledge sources such as suppliers, industry associations, and environmental programs. Strengthening these learning routines enables SMEs to more effectively identify and exploit digital green innovation opportunities. Second, SMEs are encouraged to actively pursue business model innovation as a strategic mechanism rather than a by-product of innovation activities. Efficiency-oriented business model innovation can help optimize resource utilization and reduce operational costs, while integrative business model innovation enables collaboration with eco-friendly suppliers, digital platforms, and local communities. Such integration enhances value creation while aligning business operations with sustainability objectives. Third, government support should be strategically internalized into business decisions rather than treated as short-term assistance. SMEs can leverage government programs related to digital training, green financing, and regulatory incentives to accelerate the adoption of environmentally friendly digital technologies. By aligning government support with internal capability development and business model redesign, SMEs can improve resilience and long-term competitiveness in sustainability-driven markets.

6.4. Limitations and future research directions

This study has several limitations that suggest avenues for future research. The focus on culinary and fashion SMEs in Bandung and Cirebon limits the generalizability of the findings to other sectors and regions. Future studies could examine SMEs operating in different industries or regulatory environments. The reliance on survey-based data introduces the possibility of common method bias, while the cross-sectional design restricts insights into long-term dynamics. Future research could adopt longitudinal or mixed-method approaches, incorporate in-depth case studies, and explore additional variables such as resilience capacity, digital ecosystem readiness, or collaborative innovation to provide a more comprehensive understanding of sustainable digital transformation among SMEs.

Author contributions

Conceptualization, S.L. Q., A.JU., and A.JO.; methodology, A.JO.; software, A.JO.; validation, A.JU. and Y.Y.; formal analysis, S.L.Q.; investigation, A.JU.; resources, A.JU.; data curation, S.L.Q. and A.JO.; writing—original draft preparation, S.L.Q. and A.JO.; writing—review and editing, S.L.Q. and A.JU.; visualization, A.JU.; supervision, A.JU.; project administration, S.L.Q.; funding acquisition, S.L.Q. and A.JO.. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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Appendix

Green Absorptive Capacity (GAC)

(Adapted from Flatten et al., 2011; Ma et al., 2021)

Acquisition

- GAC1. Our firm actively seeks information related to environmental technologies and practices.
- GAC2. Our firm regularly monitors external developments related to green and sustainable innovation.
- GAC3. Our firm maintains close relationships with external partners to acquire environmental knowledge.

Assimilation

- GAC4. Our firm effectively analyzes and understands externally acquired environmental knowledge.
- GAC5. Employees in our firm share and discuss new environmental knowledge internally.
- GAC6. Our firm is able to interpret environmental information in a way that supports decision-making.

Transformation

- GAC7. Our firm successfully combines new environmental knowledge with existing knowledge.
- GAC8. Our firm adapts existing processes based on newly acquired green knowledge.

Exploitation

- GAC9. Our firm applies environmental knowledge to improve products or services.
- GAC10. Our firm uses green knowledge to develop digital-based environmentally friendly innovations.
- GAC11. Environmental knowledge is effectively utilized to enhance our firm's innovation performance.

Digital Green Innovation Performance (DGIP)

(Adapted from George et al., 2021; Xie et al., 2023)

Green Product Development

- DGIP1. Our firm develops digital products that reduce environmental impact.
- DGIP2. Our firm introduces environmentally friendly features through digital innovation.

Green Production

- DGIP3. Digital technologies help our firm reduce waste and emissions in production.
- DGIP4. Our firm applies digital solutions to improve environmental performance in operations.

Energy Efficiency

- DGIP5. Digital technologies improve energy efficiency in our firm's activities.
- DGIP6. Our firm uses digital systems to monitor and reduce energy consumption.

Sustainable Corporate Image

- DGIP7. Digital green innovation enhances our firm's environmental reputation.
- DGIP8. Our firm is recognized as environmentally responsible due to digital innovation.
- DGIP9. Digital green initiatives improve stakeholder perceptions of our firm.

Government Support (GS)

(Adapted from Tinits & Fey, 2022)

Financial Incentives

- GS1. Our firm receives financial support for green or digital innovation initiatives.
- GS2. Government subsidies or tax incentives support our green innovation efforts.

Capacity Building

- GS3. Government programs enhance our firm's skills related to digital green innovation.
- GS4. Training or advisory services from government improve our innovation capability.

Infrastructure Access

- GS5. Government provides access to digital infrastructure supporting innovation.
- GS6. Public facilities or platforms support our firm's green innovation activities.

Green Innovation Policy

- GS7. Government regulations encourage our firm to adopt digital green innovation.
- GS8. Environmental policies motivate our firm to invest in sustainable digital technologies.

Efficient Business Model Innovation (EBMI)

(Adapted from Andreini et al., 2022; Müller, 2019)

Operational Efficiency

- EBMI1. Our business model improves operational efficiency through digital technologies.
- EBMI2. Digital innovation helps streamline our business processes.

Cost Reduction

- EBMI3. Our business model reduces operational costs through digital solutions.

- EBMI4. Digital innovation lowers resource and energy-related expenses.

Productivity & Quality

- EBMI5. Digital innovation improves productivity in our firm.
- EBMI6. Our business model enhances product or service quality through efficiency.

Process Automation

- EBMI7. Our firm automates key processes using digital technologies.

Integrated Business Model Innovation (IBMI)

(Adapted from Ancillai et al., 2022; Sultan & Riyadh, 2025)

Digital Integration

- IBMI1. Digital technologies are integrated across our core business activities.
- IBMI2. Our firm aligns digital systems with sustainability objectives.

Tech-Based Product Development

- IBMI3. Our firm develops products using advanced digital and green technologies.
- IBMI4. Digital innovation supports environmentally friendly product development.

External Collaboration

- IBMI5. Our business model encourages collaboration with external partners.
- IBMI6. Digital platforms support cooperation with suppliers or stakeholders.

Sustainable Business Model

- IBMI7. Sustainability is embedded in our firm's overall business model.
- IBMI8. Our business model balances economic, environmental, and social objectives.