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Determinants of Public Investment in Green Hospital Buildings in Vietnam: An Integrated Theoretical Approach

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Abstract

Green Hospital Buildings (GHBs) are pivotal for achieving sustainable development goals in the construction sector, yet their adoption in developing economies, particularly in the public sector, remains modest. This study investigates the critical determinants of public investment decisions for GHBs in Vietnam. The research is grounded in an integrated Technology-Organization-Environment (TOE) framework, synthesized with the Resource-Based View (RBV), Resource Dependence Theory (RDT), and Diffusion of Innovation (DOI) theory. Data collected from 172 experts and managers in the Vietnamese healthcare and construction sectors were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results reveal that institutional drivers—specifically legal frameworks, supportive government policies, and institutional leadership/capacity—along with construction industry readiness and perceived advantages, are the primary propellants of GHB investment. Interestingly, perceived disadvantages and broad socio-economic conditions were not found to be statistically significant barriers. These findings suggest that fostering GHB development in emerging markets requires a strategic shift from mitigating perceived drawbacks to strengthening institutional mandates and supply chain capabilities.

1. Introduction

The construction industry is widely recognized as a primary consumer of energy and natural resources, contributing significantly to greenhouse gas emissions and waste generation [1]. To mitigate these impacts, integrating circular economy principles and adopting Green Building (GB) practices have emerged as critical solutions [2]. While general GBs have demonstrated substantial benefits in resource conservation and waste reduction [3], the healthcare sector presents a unique frontier. Empirical evidence suggests that Green Hospital Buildings (GHBs), including hospital buildings, can significantly enhance energy and water efficiency [5], promote sustainable waste management [6-8], and improve therapeutic environments [4].

However, transitioning to GHBs is far more complex than in other sectors due to the distinct operational nature of hospital facilities. Unlike commercial properties, hospitals face a "performance paradox": strict mandates for infection control, pressure regimes, and indoor air quality often conflict with standard passive design strategies (e.g., natural ventilation) employed in general GBs. Furthermore, hospital buildings are among the most resource-intensive building typologies, characterized by 24/7 operations and complex technical systems. Research from the U.S. indicates that medical buildings emit three times more CO2 than typical office buildings [9] and consume up to ten times more energy per square meter [10]. Consequently, while the environmental adoption of GHBs is imperative, it faces formidable technical and operational barriers.

In the context of Vietnam, this urgency is amplified by recent policy shifts. The government's commitment to Net Zero emissions by 2050 at COP26, alongside the National Green Growth Strategy for 2021–2030 (Decision No. 1658/QD-TTg), has placed unprecedented pressure on public infrastructure to align with sustainable practices. Despite these high-level directives and global initiatives [11], the prevalence of GHBs in developing economies like Vietnam remains modest. To understand this stagnation, previous research has explored general barriers to GB adoption [13-17]. However, these inquiries largely focus on the commercial sector and fail to address the unique exigencies of the healthcare sector—such as critical service delivery mandates, stringent infection control protocols, and the intricate governance frameworks characteristic of public investment.

Currently, empirical studies focusing specifically on GHBs in developing nations remain conspicuously underrepresented. A clear knowledge gap exists regarding the determinants that drive public investment decisions in this specialized sector. This study addresses this gap by empirically investigating the critical factors influencing GHB development in Vietnam. By aligning general GB theories with the specific realities of healthcare infrastructure, this research provides theoretical insights and practical strategies to foster the green transformation of the Vietnamese public health sector.

2. A Theoretical Framework and Research Hypotheses

This study's integrated conceptual model (Fig. 1) is anchored in a synthesis of four established theoretical perspectives:

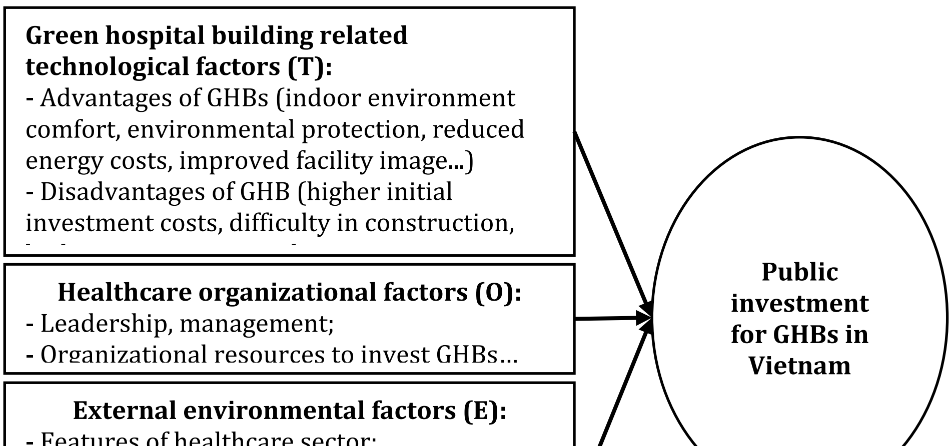

Fig. 1 *The integrated theoretical framework*

To provide a comprehensive analysis of GHB investment determinants in Vietnam, this study adopts the Technology-Organization-Environment (TOE) framework as the overarching structural scaffold. While TOE identifies where to look for factors (the three contexts), it does not explicitly explain the nature of the relationships within those contexts. Therefore, three complementary theories—Diffusion of Innovation (DOI) [20], Resource-Based View (RBV) [18], and Resource Dependence Theory (RDT) [19]— are integrated to deepen the explanatory power of each TOE dimension (see Figure 1).

First, the technological context and DOI: The technological context pertains to the perceived characteristics of the innovation itself. The study leverages DOI theory [20] to populate this dimension, focusing on attributes that significantly impact adoption rates. Specifically, this study examines "relative advantage" (perceived benefits such as operational savings and patient satisfaction) and "complexity" (perceived disadvantages or technical

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challenges). Additionally, "compatibility" acts as a bridge, ensuring green principles align with existing hospital protocols.

Secondly, the organizational context and RBV: The organizational context concerns the internal characteristics of the healthcare institution. Here, the Resource-Based View (RBV) [18] is employed to argue that unique internal resources are prerequisites for adopting complex innovations like GHBs. Within the empirical model, RBV justifies the inclusion of financial capacity, human capital (expertise), and leadership commitment (NLCS) as critical internal resources that determine whether a hospital can sustain the transition to green operations.

Finally, the environmental context and RDT: The environmental context addresses the external arena in which the hospital operates. We apply Resource Dependence Theory (RDT) [19] to explain how hospitals, as resource-constrained entities, must respond to external pressures and incentives to survive and thrive. This lens validates the inclusion of external determinants such as supportive government policies (CCCS), legal frameworks (VBPL), and industry/supply chain capacity (NLNHT), highlighting the institution's dependence on the broader construction and regulatory ecosystem.

Therefore, the integration of these theories offers a holistic understanding. Specifically, the resource-oriented perspectives of RBV and RDT enrich the DOI-based technological assessment by suggesting that even if GHBs are perceived as advantageous, their adoption is contingent upon the availability of internal resources and favorable external conditions. This multi-theoretical approach is particularly vital for the nascent green building market in developing economies like Vietnam, where resource constraints and institutional voids are prevalent.

2.1 H1: Perceived Advantages

Within the Technological context of the TOE framework, the DOI theory posits that relative advantage—the degree to which an innovation is perceived as being better than the idea it supersedes—is a critical predictor of adoption rates [20]. In the context of GHBs, this relative advantage is multifaceted. Functionally, multiple studies confirm that green design improves the indoor environment, which in turn enhances therapeutic outcomes for patients [21, 22]. Economically, the relative advantage is evidenced by enhanced energy efficiency [23] and significant long-term savings on operational costs [24]. This financial argument aligns with DOI principles, where research has identified financial returns and enhanced reputation as primary drivers, with energy cost savings often acting as the single most influential factor [12]. Indeed, without such tangible advantages coupled with government support, investors are unlikely to pursue green buildings for purely ecological reasons [25]. Consistent with DOI's postulate that high relative advantage fosters innovation adoption, it can be argued that these functional and economic benefits will drive investment decisions in Vietnam's healthcare sector. Accordingly, the following hypothesis is proposed:

H1: The perceived advantages (UD) of green hospital buildings positively influence the development of this type of buildings in Vietnam.

2.2 H2: Perceived Disadvantages

Conversely, within the technological context, DOI theory suggests that complexity—the degree to which an innovation is perceived as relatively difficult to understand and use—negatively affects adoption rates [20]. In the case of GHBs, this complexity is manifested primarily through financial and technical hurdles.

Financially, the complexity is evidenced by the 'green premium.' Green projects frequently entail a substantial initial cost increase, ranging from 1-20% depending on certification standards and location [26], alongside construction timelines that can extend by up to 20% [25]. Perhaps more critical than the explicit cost is the perceived risk associated with financial complexity; an unclear return on investment (ROI) and ambiguous payback periods are consistently cited as primary deterrents that foster a passive, risk-averse stance among healthcare investors [9, 27]. Operationally, DOI's concept of compatibility is also relevant. The adoption of GHBs is often impeded by conflicts with existing organizational routines. These challenges include complex maintenance requirements, the scarcity of specialized personnel, and the difficulty of aligning green initiatives with established institutional cultures and user behaviors [28]. A major industry survey corroborated this, identifying budget shortfalls and the prioritization of core medical service delivery over sustainability as top barriers, indicating a perceived incompatibility between green goals and immediate medical mandates [29].

This theoretical alignment is visible in the Vietnamese context as well. Tran and Nazir [30] employed SEM to confirm that investors' decisions are significantly shaped by the perceived drawbacks of green technology. Consistent with the theoretical prediction that high complexity and low compatibility deter innovation diffusion, it can be argued that these barriers create a negative feedback loop for GHB investment. Thus, the following hypothesis is proposed:

H2: The perceived disadvantages (ND) of green hospital buildings negatively influence the development of this kind of buildings in Vietnam.

2.3 H3: Institutional Leadership and Management

Moving to the organizational context of the TOE framework, the Resource-Based View (RBV) is applied to analyze internal drivers. RBV postulates that a firm's competitive advantage and ability to innovate rely not only on tangible assets but significantly on intangible resources, such as human capital and managerial capabilities [18]. In this study, the commitment and cognitive disposition of senior leadership are conceptualized as critical intangible resources that define the organization's readiness for change.

Literature consistently identifies this managerial resource as a determinant of technology adoption. General studies demonstrate that top management support is a prerequisite for successful implementation [12], often stemming from a strategic orientation towards social and environmental responsibility [31]. This principle is particularly salient in the healthcare sector, where the "green" transformation depends heavily on the supportive psychological disposition of the entire management hierarchy [32]. Conversely, the lack of this internal resource—manifested as risk-averse attitudes or a lack of awareness—acts as a significant barrier [8, 25]. In the specific context of Vietnam, leadership commitment has been empirically verified as a pivotal internal factor shaping investment decisions [30]. From an RBV perspective, visionary leaders who prioritize patient well-being and operational efficiency represent a high-value organizational resource that facilitates the mobilization of other assets for GHB projects. Therefore, it is hypothesized that the quality of this internal leadership resource directly impacts development outcomes:

H3: The perceptions and attitudes of the healthcare institutions' leaders and managers (LDQL) significantly affect the development of public GHBs in Vietnam.

2.4 H4: Institutional Resources (Financial and Human Capital)

Remaining within the organizational context, the RBV provides the theoretical justification for evaluating the institution's material capacity. RBV dictates that for an organization to capitalize on an innovation, it must possess specific resource configurations that are valuable, rare, and non-substitutable [18]. In the context of GHB adoption, these resources are categorized into tangible and intangible assets.

Regarding tangible resources, financial capacity is paramount. The literature consistently highlights that green projects require significant upfront capital for advanced technologies and longer payback periods [8, 12]. Consequently, a deficiency in financial resources acts as a primary binding constraint, rendering the adoption of green standards unfeasible regardless of intent. Regarding intangible resources, human capital and organizational culture are identified as critical determinants. RBV suggests that possessing physical assets is insufficient without the absorptive capacity—the ability of employees to recognize the value of new information, assimilate it, and apply it [33]. Studies indicate that a shortage of qualified personnel with the technical skills to operate green buildings serves as a major deterrent [25]. Furthermore, organizational culture—specifically the alignment of staff habits and stakeholder readiness with sustainable practices—functions as an internal regulator that can either accelerate or obstruct implementation [32]. In the Vietnamese public healthcare sector, which is characterized by constrained budgets and traditional operational models, the availability of these specific resources (NLCS) becomes the deciding factor for project feasibility. Therefore, based on the RBV premise that internal resource abundance drives strategic action, the following hypothesis is proposed:

H4: The related resources of healthcare institutions (NLCS) positively influence the development of public GHBs in Vietnam.

2.5 H5: Healthcare Sector-Specific Characteristics (Industry Constraints)

Shifting the focus to the environmental context of the TOE framework, the specific characteristics of the healthcare industry represent a critical external determinant. While the RDT typically emphasizes how organizations adapt to acquire resources, it also highlights how structural constraints within an industry can dictate organizational behavior [19]. A fundamental structural challenge identified in healthcare is the "split incentive" problem [34]. This phenomenon represents a misalignment of resource dependency: the party bearing the immediate financial burden and construction risks (the hospital) is distinct from the party receiving the primary benefits (patients and society). Consequently, the returns on investment are deferred or externalized, creating a powerful structural disincentive for resource-constrained organizations to invest.

In the context of the Vietnamese public health system, this industry-specific constraint is amplified by the sector's core mandate. Tasked with providing universal basic care under significant fiscal pressure, public hospitals are compelled to prioritize immediate clinical needs (e.g., medical equipment, medicines) over long-term investments in high-performance building infrastructure. The pursuit of green facilities, therefore, is often relegated to a secondary concern due to these systemic pressures. This confluence of industry-specific barriers informs the following hypothesis:

H5: The healthcare sector-specific characteristics (DTNY) significantly influence the development of public GHBs in Vietnam.

2.6 H6: Legal Framework Quality

Within the environmental context, the legal framework constitutes the most significant external determinant for public sector projects. The RDT suggests that organizations, especially public ones, depend heavily on the external regulatory environment for legitimacy and operational sanction [19]. Consequently, the government's authority to establish and enforce mandates acts as a primary coercive force driving adoption.

The literature posits that a robust legal framework serves as a critical enabler. Without clear mandates for energy efficiency, the market lacks the necessary coercive pressure to shift away from conventional practices [26, 35]. However, the existence of regulations is insufficient; their enforcement quality is paramount. Deficiencies in the enforcement mechanism can jeopardize the entire strategy [35]. Specifically, barriers often arise from limited administrative capacity. When regulatory bodies lack the specific expertise to evaluate green technologies, or when approval processes are opaque, projects suffer from significant procedural inefficiencies. Empirical evidence from Australia [36] and China [34] confirms that prolonged planning and approval timelines create substantial transaction costs and uncertainty, effectively deterring investment. Therefore, the clarity, consistency, and administrative efficiency of the legal system are viewed as decisive factors. Hence, the following hypothesis is proposed:

H6: The quality of the legal framework (VBPL) has a significant impact on the development of public GHBs in Vietnam.

2.7 H7: Supportive Government Policies (Incentive Mechanisms)

Complementing the regulatory framework within the environmental context, the RDT is further employed to examine the role of supportive government mechanisms. While regulations represent the coercive 'stick', supportive policies function as the 'carrot', representing the provision of critical external resources necessary to reduce environmental uncertainty and dependence [19]. These mechanisms are multifaceted, targeting the supply side (investors), the demand side (society), and intermediaries (manufacturers/training bodies). Theoretically, they function by lowering adoption barriers through two primary channels:

(1) Economic resources: Financial incentives (e.g., tax breaks, subsidies, loans) directly offset the high initial costs and 'split incentive' risks discussed previously.

(2) Technical and cognitive resources: Non-financial support—such as developing technical standards, providing training guidelines, and funding scientific research—reduces the knowledge gap and enhances the industry's technical readiness.

Empirical research strongly corroborates the RDT perspective. International studies consistently indicate that in the absence of such resource infusions, the green market remains stagnant [37, 38]. Notably, Deng and Yang [25] identified the lack of incentive mechanisms as the single most influential impediment to green construction in China. In the Vietnamese public sector, where internal resources are scarce, external government support acts not merely as a bonus but as a prerequisite for viability. Thus, it is hypothesized:

H7: Supportive policies by government (CCCS) have a significant impact on the development of public GHBs in Vietnam.

2.8 H8: Industry and Supply Chain Capacity (External Support Ecosystem)

Moreover, within the environmental context, the RDT highlights the critical role of the external support ecosystem. RDT posits that organizational success is contingent upon the stability and capability of the supply chain partners that provide essential inputs [19]. In the construction of complex facilities like GHBs, this dependence extends across the entire project lifecycle.

The literature identifies technical resource scarcity within the industry as a formidable barrier. This encompasses a chronic shortage of specialized human capital (experts for design, simulation, operation, and maintenance) and informational deficits regarding green materials and technologies [34, 39]. Without proven reliability and technical competence from external service providers, the perceived risk of innovation failure increases significantly, deterring adoption. Beyond individual expertise, the maturity of the broader construction supply chain is pivotal. Research on supply chain readiness indicates that a fragmented or immature ecosystem—characterized by a scarcity of green products, inconsistent technical standards, and poor coordination among stakeholders—severely impedes development [25, 40]. In developing markets like Vietnam, this challenge is often exacerbated by limited industrialization and the complexity of managing multi-stakeholder interactions [41]. Consequently, the readiness of this entire ecosystem—from material availability to professional collaboration—determines the feasibility of GHB projects. It is argued that a robust industry capacity reduces external dependency constraints, thereby facilitating adoption. Thus, the following hypothesis is proposed:

H8: The GB-related capacity of the construction industry and other supportive industries (NLNHT) significantly influences the development of public GHBs in Vietnam.

2.9 H9: Macro-Environmental Context (Natural and Socio-Economic Conditions)

Concluding the environmental context analysis, the broader macro-environmental conditions—encompassing natural, economic, and social dimensions—are examined. While previous hypotheses focused on specific institutional pressures, this hypothesis addresses the fundamental boundary conditions that dictate the feasibility of green investments.

First, regarding natural conditions, the compatibility between green technologies and the local physical environment is paramount. Adverse or highly specific climatic conditions can render standardized green solutions ineffective or prohibitively expensive, thereby increasing the technical risk and deterring investment decisions. Second, regarding socio-economic conditions, the RDT emphasizes the critical influence of the demand side (patients, staff, and society). A hospital's strategic choices are essentially responses to external market demands. A positive societal perception of sustainability creates normative pressure and market demand, which serves as a signal for construction suppliers and investors to adapt [38, 42]. Conversely, as demonstrated by Deng and Yang [25] in China, when the societal recognition of green benefits is low—meaning patients and staff do not actively prioritize a high-quality, sustainable healing environment—the market lacks the necessary 'pull' mechanism. In such a context, the incentive for healthcare facilities to pursue green projects is severely diminished. Therefore, these macro-factors collectively define the landscape in which investment decisions are made. The following hypothesis is proposed:

H9: Contextual factors (natural, economic, and social) (TNKTXH) significantly influence the development of public GHBs in Vietnam.

3. Research Methodology

3.1 Instrument Development and Measurement Scale

This study employed a mixed-methods approach to investigate factors influencing public Green Healthcare Building (GHB) investment in Vietnam. Initially, an extensive literature review and preliminary qualitative research (e.g., expert interviews) identified potential barriers and driving factors for GHB project development. This foundational work yielded an initial set of 5 measurement items for the dependent variable—Development of GHB Projects—and 37 potential influencing factors.

A focus group discussion was conducted with academic experts to: (1) validate that the identified influencing factors accurately reflected the conditions of public GHB investment in Vietnam; and (2) review and assess the content, phrasing, and interconnectivity of the survey statements (items) to ensure clarity, consistency, and minimize ambiguity, thereby finalizing the survey questionnaire and its measurement scales. The finalized questionnaire utilized a five-point Likert scale (1 – Strongly disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly agree) for all observed variables, which were presented as positively framed statements.

The research model incorporates one latent dependent variable: "Development of GHB investment in Vietnam" (referred to as PT-CTYTX). PT-CTYTX is conceptualized as "the increase in terms of project quantity, diversity of building and project types (e.g., new construction, minor/major renovations), degree of greenness, diversity and scale of funding sources, and geographical distribution of projects." This construct was measured using five observed variables: (1) PT-CTYTX1: The healthcare institution has constructed or is currently constructing certified GHBs or buildings incorporating green solutions; (2) PT-CTYTX2: The healthcare institution intends to invest in constructing GHBs in the near future; (3) PT-CTYTX3: The healthcare institution intends to construct new buildings and/or renovate existing facilities to meet specific green criteria in the near future; (4) PT-CTYTX4: The healthcare institution intends to increase its investment allocation for green building projects in the near future; (5) PT-CTYTX5: The healthcare institution intends to progressively enhance the 'green' efficiency of its buildings in the near future. Given that the indicators (PT-CTYTX1 to PT-CTYTX5) represent manifestations of the underlying organizational strategy and are expected to highly covary, this construct was modeled reflectively. Regarding the independent variables, two constructs—UD and LDQL that related to psychological perceptions and attitudes —were modeled reflectively. The remaining seven independent variables—ND, NLCS, DTNY, VBPL, CCCS, NLNHT, and TNKTXH - representing composite external or resource-based factors were operationalized using a formative measurement model (refer to Appendix 1 for detailed model specification).

3.2 Sample Size and Data Collection Procedure

The target population for this study comprised top managers, specifically senior leaders and facility managers responsible for infrastructure investment within healthcare institutions and hospitals across Vietnam. To ensure the adequacy of the sample for Partial Least Squares Structural Equation Modeling (PLS-SEM), a minimum of 90 responses was targeted, consistent with the "10-times rule" guidelines proposed by Hair et al. (2017) for achieving sufficient statistical power.

Data were collected between May and July 2024. A non-probability sampling strategy combining purposive and snowball techniques was employed to effectively identify and reach eligible participants. Initially, 211 managers and leaders from various healthcare institutions were invited to participate. Of these, 180 responses were received across 74 distinct healthcare institutions, representing an initial response rate of 85.3%. Following a rigorous screening process to exclude incomplete surveys or those exhibiting unengaged response patterns (e.g., straight-lining), 172 valid responses were retained for the final analysis. This final sample size substantially exceeded the minimum requirement for PLS-SEM application, thereby providing a robust basis for the subsequent statistical analyses.

4. Results of Data Analysis

4.1 Analysis of respondent profiles

The quantitative analysis is based on survey data collected from a total of 172 respondents, who are managers and leaders at public healthcare facilities across Vietnam. The demographic and professional characteristics of the sample are shown in the fig. 2.

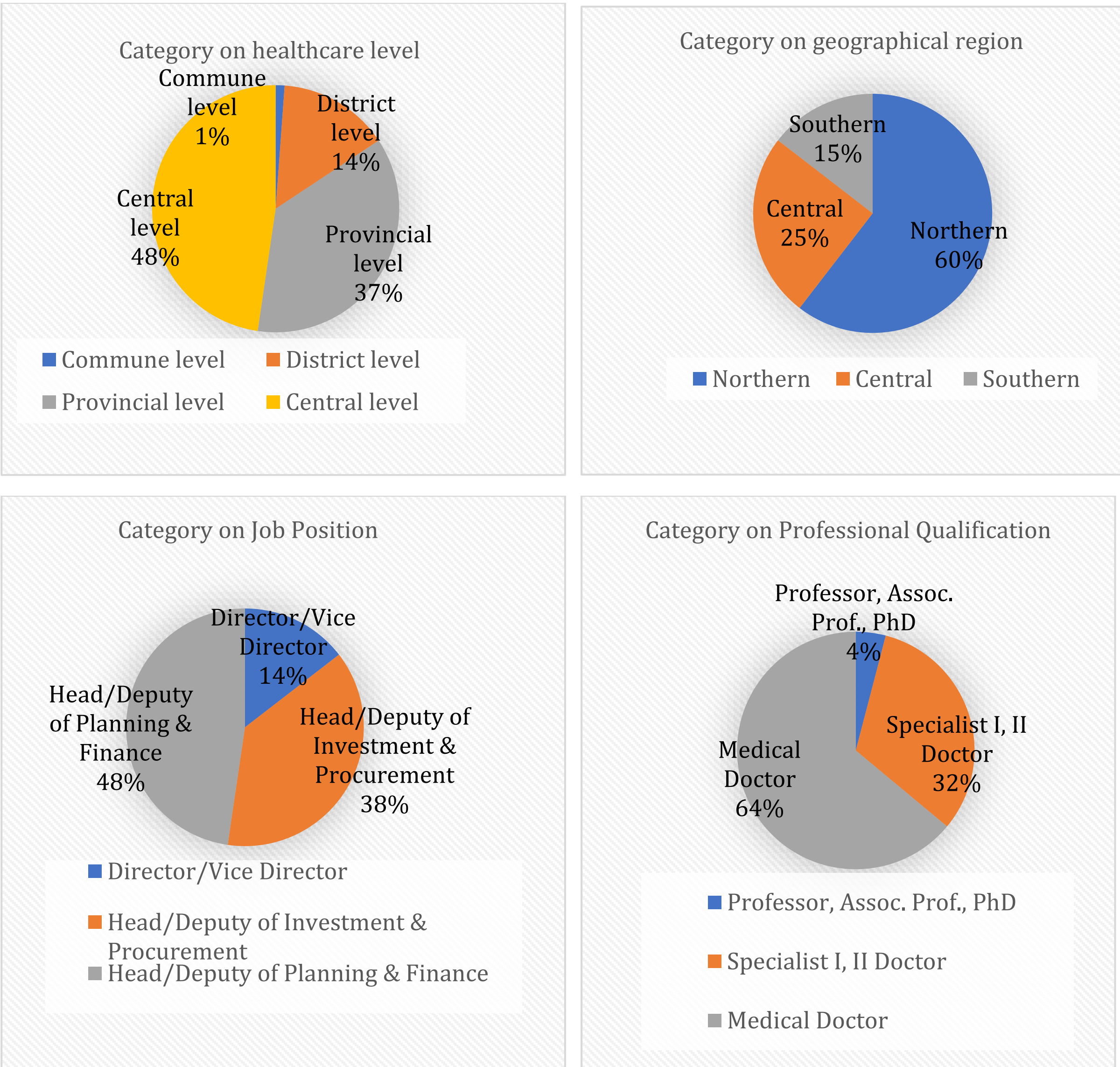

Fig. 2 *Respondent profiles*

The sample is predominantly concentrated in upper-level healthcare facilities. Respondents from provincial-level (36.6%) and central-level (47.7%) institutions collectively account for 84.3% of the total sample. The representation from district-level (14.5%) and commune-level (1.2%) facilities is considerably smaller. This distribution is strategically appropriate for the research objective. Major investment decisions concerning large-scale construction projects, particularly green-certified buildings, are primarily made and have the most significant impact at provincial and central-level hospitals. Therefore, focusing data collection on these two tiers ensures the high relevance and applicability of the research findings to key healthcare infrastructure investments.

The sample is well-profiled, comprising key decision-makers. The majority of respondents are heads or deputy heads of the department of planning & finance (47.7%) and the department of investment & procurement (37.8%). Top-level management, including directors and vice directors, constitutes 14.5% of the sample. This is a significant strength of the study as the respondents are individuals directly involved in the decision-making, planning, resource allocation, and management of construction investment projects within their institutions. Their perspectives are therefore highly credible and practically valuable, offering an accurate reflection of influencing factors from an insider's point of view.

The majority of respondents possess a medical background, including Medical Doctors (64.0%) and Specialist Doctors (Level I & II) (32.0%). A small fraction (4.1%) holds advanced academic titles such as Professor, Associate Professor, or PhD. This characteristic indicates that key decision-makers for construction investments in the healthcare sector have a strong foundation in medical science. This ensures that investment decisions are thoughtfully considered from the perspective of the functional and operational needs of a healthcare facility. However, it may also imply that deep expertise in green building technology is not the primary strength of the respondent pool, which underscores the importance of factors such as consultancy and the capacity of supporting industries, as explored in this research.

Finally, regarding geographical distribution, the sample reflects a concentration in Northern Vietnam (60.5%), followed by Central (25.0%) and Southern Vietnam (14.5%). We acknowledge this geographical imbalance as a limitation of the study. While the findings offer robust insights into the Northern context, generalizations to the national level should be approached with caution. Future research should aim for a more spatially balanced sampling strategy to enhance external validity.

4.2 Measurement Model Validation

4.2.1 Assessment of Reflective Constructs

The measurement model was evaluated using SmartPLS 3.0. The reflective constructs (LDQL, UD, PT-CTYTX) were assessed for internal consistency, convergent validity, and discriminant validity. As shown in Table 1, all Composite Reliability (CR) values exceeded the threshold of 0.7, and Cronbach's Alpha values ranged from 0.746 to 0.784, confirming internal consistency. Although items LDQL1 and PT-CTYTX2 exhibited outer loadings between 0.4 and 0.7, they were retained because their removal did not significantly improve the Average Variance Extracted (AVE). All AVE values exceeded 0.5, supporting convergent validity.

Table 1 *Cronbach's alpha, CR, AVE, and the square root of AVE of the reflective constructs*

	LDQL	UD	PT-CTYTX	Alpha	CR	AVE
LDQL	**0.755**	0.000	0.000	0.746	0.839	0.570
UD	0.690	**0.779**	0.000	0.784	0.860	0.607
PT-CTYTX	0.730	0.744	**0.737**	0.784	0.854	0.542

Hint: The bold diagonal values are the square root of average variance extracted of each construct.

To ensure a rigorous evaluation of discriminant validity—establishing that each construct is empirically distinct from others—this study adopted a multi-faceted approach employing three criteria: Cross-loadings, the Fornell-Larcker criterion, and the Heterotrait-Monotrait ratio (HTMT). First, Cross-loadings were examined. As presented in Table 2, the outer loading of each indicator on its associated construct was consistently higher than its cross-loadings on any other construct. This provides initial evidence that the indicators are properly assigned and that the constructs are distinct at the indicator level. Second, the Fornell-Larcker criterion was applied. As shown in Table 1, the square root of the Average Variance Extracted (AVE) for each construct (represented by the bold values on the diagonal) is greater than the highest correlation between that construct and any other construct in the model. This satisfies the traditional requirement for discriminant validity.

Finally, and most importantly, HTMT was assessed. Recent methodological literature argues that the Fornell-Larcker criterion may lack sensitivity in detecting discriminant validity issues (Henseler et al., 2015). Therefore, the HTMT ratio serves as the decisive metric. As displayed in Table 3, all HTMT values were found to be below the conservative threshold of 0.85. This result definitively confirms that discriminant validity is established for all constructs in the structural model."

Table 2 *Cross loadings of the reflective constructs*

	LDQL	UD	PT-CTYTX
LDQL1	**0.570**	-0.217	0.212
LDQL2	**0.832**	0.166	0.023
LDQL3	**0.781**	-0.111	0.218
LDQL4	**0.809**	0.016	0.251
UD1	0.260	**0.735**	-0.305
UD2	0.219	**0.792**	0.111
UD3	-0.215	**0.874**	0.313
UD4	-0.208	**0.704**	0.209
PT-CTYTX1	0.109	-0.339	**0.750**
PT-CTYTX2	0.025	0.328	**0.603**
PT-CTYTX3	0.303	0.145	**0.862**
PT-CTYTX4	0.301	-0.275	**0.728**
PT-CTYTX5	0.413	0.147	**0.715**

Table 3 *Heterotrait-Monotrait (HTMT) ratio*

	LDQL	UD	PT-CTYTX
LDQL	0.000	0.000	0.000
UD	0.855	0.000	0.724
PT-CTYTX	0.713	0.000	0.000

4.2.2 Assessment of Formative Constructs

For the formative constructs (NLCL, DTNY, VBPL, TNKTXH, ND, NLNHT, CCCS), the evaluation focused on collinearity and the significance of weights. From Table 4, Variance Inflation Factor (VIF) values for all indicators were below 5 (ranging from 1.01 to 1.24, indicating no critical multicollinearity issues (see Table 4). Bootstrapping (5,000 subsamples) was performed to test the significance of outer weights. Indicators with non-significant weights ($p > 0.05$) were further examined for their outer loadings. Based on this procedure, items CCCS4, NLCS3, and NLNHT3 were removed as they showed both insignificant weights and low loadings (< 0.5). The remaining indicators were retained to preserve the content validity of the formative constructs.

Table 4 *VIF, outer weights, P-values of outer weights and outer loadings*

	Outer weights					Outer loadings	VIF
	Orig. Sam.	Sam. Mean	St. Dev.	T Stas.	P		
CCCS1 -> CCCS	0.06	0.06	0.12	0.50	**0.62**	0.60	1.08
CCCS2 -> CCCS	0.36	0.35	0.12	3.03	0.00	0.68	1.01
CCCS3 -> CCCS	0.92	0.90	0.06	15.28	0.00	0.92	1.05
CCCS4 -> CCCS	-0.05	-0.04	0.11	0.45	**0.65**	0.04	1.01
CCCS5 -> CCCS	0.17	0.17	0.10	1.63	**0.10**	0.58	1.09
DTNY1 -> DTNY	0.28	0.27	0.11	2.57	0.01	0.63	1.24
DTNY2 -> DTNY	0.39	0.40	0.11	3.69	0.00	0.72	1.23
DTNY3 -> DTNY	0.32	0.32	0.12	2.73	0.00	0.66	1.23
DTNY4 -> DTNY	0.47	0.46	0.09	4.99	0.00	0.72	1.13
ND1 -> ND	0.06	0.10	0.30	0.20	**0.84**	0.53	1.01
ND2 -> ND	0.45	0.21	0.42	1.07	**0.29**	0.56	1.04
ND3 -> ND	0.64	0.21	0.52	1.25	**0.21**	0.60	1.14
ND4 -> ND	-0.54	0.00	0.50	1.09	**0.28**	0.58	1.11

	Outer weights					Outer loadings	VIF
	Orig. Sam.	Sam. Mean	St. Dev.	T Stas.	P		
ND5 -> ND	-0.34	0.06	0.43	0.79	**0.43**	-0.44	1.02
NLCS1 -> NLCS	0.24	0.25	0.10	2.33	0.02	0.45	1.06
NLCS2 -> NLCS	0.81	0.79	0.09	9.47	0.00	0.84	1.06
NLCS3 -> NLCS	0.13	0.12	0.11	1.12	**0.26**	0.26	1.03
NLCS4 -> NLCS	0.44	0.43	0.14	3.18	0.00	0.41	1.03
NLNHT1 -> NLNHT	0.25	0.25	0.08	3.28	0.00	0.54	1.13
NLNHT2 -> NLNHT	0.30	0.29	0.12	2.47	0.01	0.69	1.30
NLNHT3 -> NLNHT	0.00	0.01	0.10	0.08	**0.94**	0.17	1.04
NLNHT4 -> NLNHT	0.71	0.70	0.09	7.86	0.00	0.91	1.31
NLNHT5 -> NLNHT	0.14	0.14	0.08	1.71	**0.09**	0.57	1.02
TNKTXH1 -> TNKTXH	0.81	0.50	0.46	1.76	**0.08**	0.82	1.01
TNKTXH2 -> TNKTXH	0.34	0.24	0.44	0.79	**0.43**	0.58	1.01
TNKTXH3 -> TNKTXH	0.47	0.33	0.44	1.08	**0.28**	0.54	1.00
VBPL1 -> VBPL	0.49	0.49	0.07	6.92	0.00	0.79	1.28
VBPL2 -> VBPL	0.15	0.15	0.07	2.24	0.03	0.49	1.18
VBPL3 -> VBPL	0.50	0.49	0.07	6.71	0.00	0.77	1.21
VBPL4 -> VBPL	0.29	0.29	0.07	4.26	0.00	0.55	1.12

4.3 The Structural Model Analysis

4.3.1 Assessment of Structural Model Collinearity

Before assessing the path coefficients, the structural model was checked for lateral collinearity issues. The Inner VIF values for all predictor constructs ranged from 1.067 to 3.633; all values were below the threshold of 5.0 (Hair et al., 2019), confirming that multicollinearity is not a concern in the structural model.

4.3.2 Evaluation of Model Fit and Predictive Power

First, the overall quality of the structural model was assessed using the Standardized Root Mean Square Residual (SRMR). The analysis yielded an SRMR value of 0.072, which falls below the recommended threshold of 0.08 (Hu & Bentler, 1999), indicating a satisfactory model fit.

Next, the model's explanatory power and predictive relevance were examined. Figure 2 illustrates that the model accounts for 76.8% of the variance in the dependent variable PT-CTYTX (R^2=0.768). This substantial R^2 value indicates that the independent latent variables collectively explain a significant portion of the variation in the outcome variable. Complementing the R^2, the predictive relevance was assessed using the Stone-Geisser's Q^2 value obtained via the blindfolding procedure (omission distance D=7). The resulting Q^2 value for PT-CTYTX was 0.392; this confirms that the path model exhibits predictive relevance for the endogenous construct (Hair et al., 2019). Furthermore, the effect sizes (f^2) for the predictor variables ranged from 0.223 to 0.373. According to established thresholds (Cohen, 1988), these values indicate that each independent variable contributes a medium to large effect to the explained variance of PT-CTYTX.

4.3.3 Hypothesis Testing

Finally, the research hypotheses were tested by examining the sign, magnitude, and statistical significance of the path coefficients. The bootstrapping procedure in SmartPLS 3.0 (using 5,000 resamples) was employed to assess the significance of these paths. The analysis revealed that six of the eight hypothesized paths were statistically significant (see Table 5). Consequently, hypotheses H1, H3, H4, H6, H7, and H8 received empirical support, while the remaining hypotheses were not supported.

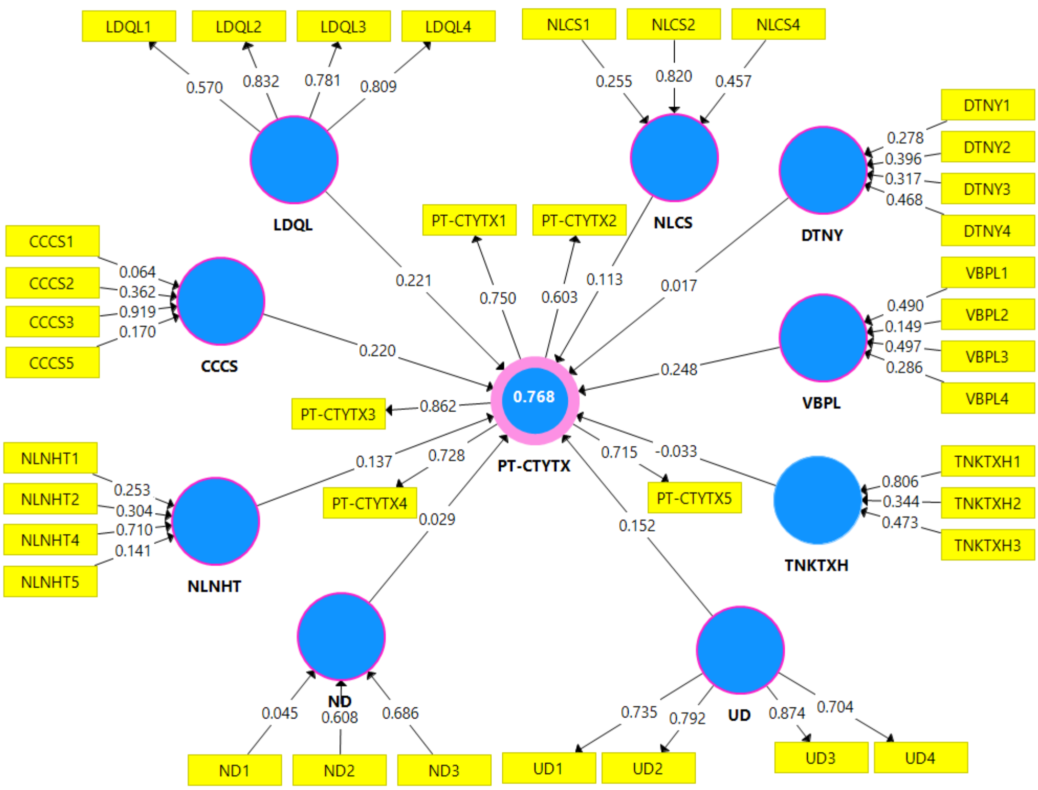

Fig. 2 *The result of research model re-analyzed by SmartPLS 3.0*

Table 5 *Path coefficients, T statistics and P values*

Hypotheses	Path Coeffs. (β)	Stard. Dev.	T Stat.	P Values	Inference
H1: UD -> PT-CTYTX	0.152	0.077	1.967	0.050*	Supported
H2: ND -> PT-CTYTX	0.029	0.054	0.541	0.589	Non-supported
H3: LDQL -> PT-CTYTX	0.221	0.075	2.963	0.003	Supported
H4: NLCS -> PT-CTYTX	0.113	0.050	2.279	0.023	Supported
H5: DTNY-> PT-CTYTX	0.017	0.058	0.287	0.774	Non-supported
H6: VBPL -> PT-CTYTX	0.248	0.084	2.967	0.003	Supported
H7: CCCS -> PT-CTYTX	0.220	0.061	3.584	0.000**	Supported
H8: NLNHT -> PT-CTYTX	0.137	0.067	2.047	0.041	Supported
H9: TNKTXH->PT-CTYTX	-0.033	0.049	0.683	0.495	Non-supported

***Highly significant; *Significant; critical t-value: 1.96, p <0.05 and 2.58; p <0.01.*

5. Discussions

5.1 Findings

Primarily, the legal framework (VBPL) demonstrated the most substantial positive influence on the development of public GHB investment in Vietnam (path coefficient = 0.248, p = 0.003). This aligns with previous research indicating that absent or inadequate government regulations on energy efficiency and green construction represent significant barriers to GB development [12, 43, 44]. Within the Vietnamese context, this finding can be attributed to the nascent stage of its green building sector, where the regulatory system is still evolving to meet practical realities. This ongoing maturation process potentially introduces risks such as compromised quality, project delays, cost overruns, and conflicts of interest. For instance, the current absence of specific regulations governing investment capital rates for green hospital buildings creates challenges in accurately determining total construction investment and managing costs during project preparation, thereby significantly influencing public GHB investment decisions.

Subsequently, the “leadership and management of healthcare institutions” (LDQL) (path coefficient = 0.221, p = 0.003) and the “supportive government policies” (CCCS) (path coefficient = 0.220, p < 0.001) exhibited the next most considerable positive influences on the development of public GHB investment. These results concur with prior studies [12, 42], which generally affirm that top management support positively impacts organizational adoption of new technologies. Deng, Yang [25], for example, identified the lack of incentive and supportive mechanisms as a primary impediment to green building development in China. The current findings imply that healthcare institutions guided by leadership teams possessing long-term vision, innovative thinking, and a strong sense of responsibility towards stakeholders and the environment are more inclined to commit to GHB investments, a particularly pertinent observation within the public investment sphere. Furthermore, this highlights that financial, economic, and technical policy support mechanisms are crucial for promoting GHB projects, especially given Vietnam's constrained public health budget

Reflecting the distinct nature of GHB technology, the “perceived advantages of GHBs” (relative to conventional buildings) demonstrated a positive and statistically significant influence on the development of public GHB investment in Vietnam (path coefficient = 0.152, p = 0.050). This finding is congruent with existing empirical studies wherein experts concur that a clear awareness of GHB benefits enhances investors’ willingness to engage. Vietnam's improving economic conditions and heightened social awareness are driving demand for high-quality healthcare infrastructure that prioritizes human health, energy efficiency, resource conservation, and environmental sustainability. Moreover, competitive and innovation-driven pressures are prompting healthcare administrators to adopt more socially and environmentally responsible practices. Consequently, the perceived advantages of GHBs are gaining broader societal recognition, playing a pivotal role in attracting investment for public GHB initiatives.

Regarding external environmental factors, the “GB-related capacity of the construction industry and supporting sectors” demonstrated a positive and statistically significant influence on the development of public GHB investment (path coefficient = 0.137, p = 0.041). This aligns with numerous previous studies (e.g., [31, 37]) highlighting the criticality of a ready construction ecosystem for sustainable building project success. For instance, research in Australia has identified shortages of qualified experts and green materials as significant barriers [31]. Similarly, studies in China (e.g., [45]) underscore challenges such as technical complexity and insufficient experience in green design. Deng, Yang [25] further emphasized the detrimental effects of incomplete supply chains, inadequate technical standards, and a scarcity of GB specialists.

Among the six factors with a positive and statistically significant influence, the “healthcare institution’s capacity (NLCS)” exhibited the weakest, yet still significant, impact on the development of public GHB investment (path coefficient = 0.113, p = 0.023). This suggests that, beyond leadership commitment, when a healthcare institution possesses robust financial resources, a clear understanding of GHBs, appropriate human resources, and the operational capacity for such facilities, it is more likely to proactively and voluntarily engage in GHB investment

Finally, three of the nine research hypotheses lacked empirical support: “perceived disadvantages of GHBs,” “characteristics of the healthcare sector,” and “natural, economic, and social conditions.” First, perceived disadvantages of GHBs, including high initial investment costs and technical complexities, did not significantly influence the development of public GHB investment ($\beta = 0.029$, $p = 0.589$). This suggests that potential long-term benefits (e.g., energy savings, improved service revenue) may be perceived to outweigh these drawbacks, particularly when coupled with appropriate financial/policy incentives and enhanced sectoral implementation capacity. Second, “characteristics of the healthcare sector' (encompassing diverse ownership models, budget dependency, regulatory instability) demonstrated a negligible impact on the development of public GHB investment ($\beta = 0.017$, $p = 0.774$), indicating that factors like institutional leadership and specific policy support may exert more substantial influence. Finally, “natural, economic, and social conditions” were found to have no significant impact on the development of public GHB investment ($\beta = -0.033$, $p = 0.495$). The non-significances are not due to measurement errors, as the constructs for these hypotheses demonstrated high Composite Reliability (>0.7) and Convergent Validity (AVE > 0.5). Thus, the lack of statistical significance reflects a substantive finding regarding the Vietnamese context rather than a methodological flaw. This may suggest that healthcare facilities possessing robust strategic planning capabilities can effectively mitigate or navigate such external challenges. These non-significant results warrant further in-depth research to validate the role of these contextual factors and refine policy mechanisms influencing green healthcare infrastructure development in Vietnam.

5.2 Theoretical and Practical Implications

5.2.1 Theoretical Implications

This study offers significant theoretical contributions to the literature on green building adoption, particularly within the public healthcare sector of developing economies.

First, it advances the theoretical landscape by empirically validating an integrated framework that synthesizes the Resource-Based View (RBV), Resource Dependence Theory (RDT), and Diffusion of Innovation (DOI) within the Technology-Organization-Environment (TOE) structure. Unlike prior studies that often isolate these theories, our findings demonstrate their interconnectedness in explaining complex organizational behaviors. Specifically, the dominant impact of the Legal Framework and Government Support validates the core tenets of RDT in the public sector context, confirming that public institutions are highly responsive to coercive pressures and dependent on external resource channels for legitimacy and survival. Concurrently, the significance of Institutional Leadership and Capacity reinforces the RBV perspective, highlighting that external pressures alone are insufficient without the internal 'absorptive capacity' and managerial commitment to leverage those resources.

Second, the study refines the application of DOI theory in the context of public infrastructure. The strong influence of "perceived advantages" confirms that the relative advantage—manifested as long-term operational efficiency and therapeutic benefits—remains a primary driver. However, the non-significance of 'Perceived Disadvantages' (e.g., cost, complexity) offers a novel theoretical insight that challenges the traditional barrier-centric narrative. This suggests that in the specific context of public investment, institutional mandates and strategic necessity may override technical or financial concerns. This finding implies that the decision-making calculus in public healthcare is less sensitive to transactional costs compared to the private sector, thereby nuancedly expanding the boundaries of rational choice models in construction management.

Third, this research establishes a scientifically grounded analytical model for the nascent GHB market in Vietnam. By identifying the specific weight of drivers (legal framework, leadership, industry capacity), the study moves beyond generic lists of factors to provide a prioritized nomological network. This framework not only elucidates the specific determinants of GHB investment but also serves as a robust baseline for future comparative research in other emerging economies facing similar resource constraints and institutional voids.

5.2.2 Practical Implications

The findings of this study translate into actionable strategies for key stakeholders involved in the public healthcare infrastructure of Vietnam and similar emerging economies.

For government agencies and policymakers: Given that the legal framework and government support were identified as the most critical determinants, a "top-down" intervention strategy is paramount. Policymakers should move beyond voluntary guidelines to establish mandatory green criteria within public procurement regulations for hospital projects. Furthermore, to address the financial dependence identified in the model, the government should institutionalize specific incentive mechanisms (e.g., fast-track approval processes, green bond access for public hospitals) to mitigate the perceived risks and initial cost premiums.

For healthcare leaders and administrators: The significance of "institutional leadership" suggests that the transition to GHBs is as much a managerial challenge as a technical one. Hospital directors must view green building adoption not merely as an infrastructure decision but as a strategic resource that enhances organizational reputation and operational efficiency. Consequently, investment planning should prioritize capacity building for internal management teams to improve their 'green readiness,' ensuring they can effectively oversee complex sustainable projects and collaborate with technical consultants.

For the construction industry and consultants: The study underscores the necessity of a holistic ecosystem approach. Since internal resources in public hospitals are often limited, the reliance on the "capacity of supporting industries" is high. Therefore, construction firms and consultants must proactively bridge the knowledge gap by providing integrated design-build solutions that simplify the technical complexity for hospital owners.

Finally, for the broader community: By empirically proving that "perceived advantages" drive adoption while "perceived disadvantages" are not significant barriers, this study serves as a powerful advocacy tool. It provides scientific evidence to shift the public narrative from focusing on the "cost of going green" to the "value of sustainable hospital," thereby building the necessary consensus for long-term public investment.

6. Conclusions

This study contributes to the advancement of sustainable infrastructure by empirically identifying the critical determinants of public investment in Green Hospital Buildings (GHBs) within the Vietnamese context. Grounded in an integrated TOE framework, the findings underscore that the transition to GHBs in the public sector is primarily driven by institutional forces rather than market dynamics. Specifically, the strong positive influence of the Legal Framework, Supportive Government Policies, and Institutional Leadership—alongside the Capacity of the Construction Industry—highlights that public investment decisions are shaped by a need for legitimacy and resource dependency.

Interestingly, the study reveals that traditional barriers such as perceived disadvantages (e.g., cost, complexity) and contextual constraints (socio-economic/natural conditions) do not significantly impede investment intentions. This suggests a unique characteristic of public hospital governance, where strategic mandates and long-term operational advantages override immediate transactional costs. By elucidating these factors, this research provides a vital evidence base for policymakers to shift from purely voluntary incentives to mandatory institutional frameworks, thereby effectively embedding circular economy principles into the healthcare built environment.

While this study offers robust insights, certain limitations delineate the boundaries of its findings and suggest avenues for future inquiry:

1. Although the sample (N=172) satisfies statistical power requirements for PLS-SEM, the respondents were predominantly drawn from Northern Vietnam. Furthermore, the focus was exclusively on public institutions. Future research should aim for a nationwide stratified sample and incorporate private hospital facilities to enable a comparative analysis between public and private investment behaviors.
2. This study specifically examined projects funded by public investment capital derived from the autonomous revenue of hospitals. Consequently, the findings may not fully apply to projects fully subsidized by the state budget or those utilizing ODA funds, which may operate under different regulatory constraints. Future studies should investigate how different funding structures moderate the adoption of green innovations.
3. The rejection of hypotheses concerning “perceived disadvantages” and 'sector-specific characteristics' warrants deeper investigation. It is plausible that these factors exert indirect or non-linear effects not captured by the current linear model. Future research could employ qualitative methods (e.g., in-depth interviews) or longitudinal designs to unpack the nuances of why these technical barriers are perceived as less critical by public decision-makers.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Tu-Hieu Nguyen, Mau-Banh Nguyen and Quangdung Tran;* ***data collection:*** *Tu-Hieu Nguyen;* ***analysis and interpretation of results:*** *Tu-Hieu Nguyen and Quangdung Tran;* ***draft manuscript preparation:*** *Tu-Hieu Nguyen and Quangdung Tran. All authors reviewed the results and approved the final version of the manuscript.*

Appendix *The measured variables of the research model*

Observed variables	Description
UD1	GHBs provide a much higher quality indoor environment.
UD2	GHBs help use energy more efficiently and economically
UD3	GHBs help protect the environment by promoting efficient energy use, conserving natural resources, and reducing greenhouse gas emissions
UD4	GHBs helps enhance the image and reputation of healthcare facilities
ND1	The higher initial construction cost
ND2	Risk of technical issues due to the use of green technologies, materials...
ND3	Risk of higher operating, maintenance, and repair costs
ND4	Risk of construction delays
ND5	GHBs is not yet aligned with the awareness, behaviors, and culture of staff, patients, and their families
LDQL1	An innovative and responsible approach to improve the quality of healthcare services

Observed variables	Description
LDQL 2	Commitments to reduce energy consumption costs and operating expenses, while also enhancing the quality of the working environment for staff and medical professionals
LDQL 3	Commitments to the goal of protecting the environment
LDQL 4	An understanding of the advantages and disadvantages of GHBs compared to conventional hospital facilities
NLCS1	Capital resource and the ability to repay loans for investing in GHBs
NLCS2	Capability of a management system to efficiently operate a GHB
NLCS3	A increasing demand for a more comfortable and healthier working environment
NLCS4	Active connection and collaboration with innovative organizations that are pioneering and responsible towards the environment and society
DTNY1	A growing focus across the sector on investing in GHBs and energy-efficient hospital buildings
DTNY2	The increasing competition among public hospital facilities across the sector
DTNY3	The societal demand for GHBs across the sector
DTNY4	Energy costs are increasingly taking up a larger share of the total operating expenses of hospital facilities
VBPL1	The quality of the system of legal documents and regulations on general green buildings
VBPL2	The alignment and applied feasibility of the system of legal documents and regulations on general green buildings within the context of Vietnam.
VBPL3	The alignment and applied feasibility of the system of legal documents and regulations on GHBs within the context of Vietnam.
CCCS1	The government's appropriate plans and action programs regarding the GBs sector
CCCS2	The availability and alignment of financial instruments—such as preferential loans, concessional credit, tax incentives, and green building insurance—to encourage and promote investment in GHBs
CCCS3	The availability and alignment of economic instruments—such as grant and revolving fund schemes, discounted loans, investment subsidies, and incentives like increased floor area allowances—to encourage and promote investment in GHBs
CCCS4	The availability and alignment of technical instruments—including technical standards, guidelines, and construction norms—related to investment in GHBs
CCCS5	The availability and alignment of advisory tools—such as training and awareness programs on GBs, GHBs, green building certification schemes, voluntary energy-efficient labeling for equipment, energy performance verification programs, energy audits, and initiatives supporting scientific research and international cooperation
NLNHT1	Numerous entities with strong capacities and specialized human resources experienced in implementing green building projects in general, and green hospital facilities in particular
NLNHT2	Availability and stability of market of green technologies in terms of supply, pricing and quality
NLNHT3	Availability and stability of renewable and sustainable energy solutions in terms of supply, pricing and quality
NLNHT4	Capital from the banking and financial system is readily available and sufficiently substantial to support and promote green activities, including green construction
NLNHT5	The market provides a range of solutions, software, and information technology systems that support the monitoring, management, and operation of green and sustainable buildings

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