Factors Affecting Green Transformation in Industrial Clusters in Hanoi, Vietnam

Trung Son Nguyen

VNU University of Economics and Business, 144 Xuan Thuy, Cau Giay, Ha Noi, Vietnam

ABSTRACT	Published Online: March 19, 2026

Although previous studies on green transformation mainly emphasize macro-level policies and environmental management, empirical analyses focusing on industrial clusters in Vietnam remain limited. This paper investigates the factors affecting green transformation in industrial clusters in Hanoi, Vietnam. Based on the theoretical framework of institutional theory and resource-based view, a structural equation modeling (SEM) approach was applied to identify and measure the effects of key determinants, including institutional framework, human resources, financial resources, innovation capacity, and environmental regulation. Data were collected from 300 valid responses across 8 industrial clusters in Hanoi. The measurement model was validated using Cronbach's Alpha, EFA, and CFA, with good reliability and fit indices (GFI = 0.917, CFI = 0.959, RMSEA = 0.043). SEM results indicate that financial resources exert the most substantial positive influence on the effectiveness of green transformation policies, followed by human resources. The study contributes empirical evidence to the understanding of micro-level dynamics driving green transformation within Vietnam's industrial clusters and offers managerial and policy implications for promoting sustainable industrial development.

KEYWORDS: *Green transformation; industrial clusters; SEM; Policy; Hanoi; Vietnam.*

1. INTRODUCTION

Green transformation has become an inevitable global development trend driven by increasing climate change pressures, the imperative of sustainable growth, and significant shifts in international trade standards. Many countries, including Vietnam, have pledged to achieve net-zero emissions at COP26, reflecting a strong commitment to transitioning toward a green economy (OECD, 2024; World Bank, 2025). In this context, the management and development of industrial clusters toward greening are considered critical, given their capacity to accelerate technological innovation, optimize resource use, and establish industrial symbiosis relationships that reduce emissions and enhance international competitiveness (Chertow, 2007; World Economic Forum, 2023).

According to OECD (2024), industrial clusters account for over 60 percent of total industrial emissions in many OECD and G20 member countries. Therefore,

promoting green transformation within industrial clusters is a prerequisite for realizing climate commitments and maintaining national positions in global supply chains (UNIDO, 2023). However, green transformation in industrial clusters cannot occur spontaneously or rely solely on market mechanisms. It requires the proactive and directive role of state governance. Kemp and Never (2017) and Altenburg and Assmann (2017) emphasize that the state must lead, regulate, and facilitate the creation of policy frameworks, environmental standards, intersectoral coordination mechanisms, mobilization of green financial resources, and digitalizing ecological monitoring systems.

Recent studies on state management of green transformation in industrial clusters have concentrated on several main themes: the development of evaluation criteria for green industrial cluster governance; the establishment of intersectoral coordination models, particularly the *"one-stop governance unit"* (UNIDO, 2023); the application of digital tools for environmental monitoring (OECD, 2024); and the assessment of green finance and technological innovation policies in promoting transformation (World Economic Forum, 2023). In Vietnam, however, existing studies mainly focus on individual large clusters or localized assessments

within specific provinces, without adequately addressing the distinctive characteristics of industrial clusters. Research on integrated state management models, measurable performance indicators, and intersectoral coordination mechanisms remains limited, especially in major urban areas with high industrial density such as Hanoi.

Industrial clusters play a vital role in local economic growth, job creation, investment attraction, and innovation for a developing country like Vietnam. Nevertheless, their current development still faces multiple challenges. Most clusters originate from the relocation of traditional craft villages or have evolved spontaneously, resulting in weak infrastructure, outdated production technologies, and limited compliance with environmental standards. In Hanoi, the city with the highest concentration of industrial clusters in the country, environmental pollution has become increasingly severe. According to IQAir, Hanoi consistently ranks among the world's most polluted cities. Many clusters lack centralized wastewater treatment systems or operate them ineffectively, directly affecting public health and the city's capacity to attract green investment.

One fundamental cause of these issues lies in state management's fragmented and non-integrated nature over green transformation in industrial clusters. UNIDO (2023) and OECD (2024) highlight that the absence of integrated management models and effective intersectoral coordination mechanisms poses a significant barrier to green transformation, particularly in developing economies. In Hanoi, industrial cluster planning remains inconsistent and weakly linked to environmental and clean technology policies. Intersectoral coordination is limited, environmental monitoring tools are underdeveloped, and managerial capacity and green financial resources remain insufficient. These shortcomings hinder industrial clusters from meeting new international market requirements and undermine the city's competitiveness and sustainable development trajectory.

Given this context, the study "*Factors Affecting Green Transformation in Industrial Clusters in Hanoi, Vietnam*" must be timely. It aims to fill the theoretical gap in the governance of green industrial clusters in Vietnam and propose an integrated model of state management tailored to local conditions. The research also seeks to develop an evaluation framework for the effectiveness of state management in promoting green transformation within industrial clusters, thereby enhancing Hanoi's competitiveness and contributing to Vietnam's international commitments to sustainable and green development.

2. THEORETICAL FRAMEWORK AND RESEARCH MODEL

2.1. Theoretical framework

Green transformation refers to the transition from an economic growth model dependent on fossil fuels and environmentally harmful production toward an environmentally friendly, low-carbon, and renewable energy-based growth model. OECD (2011) emphasized that green transformation is not merely a technological shift but also involves structural adjustments in the economy, institutional arrangements, and human behavior to ensure long-term sustainable development. Recent studies by UNEP (2022), OECD (2024), and EY (2023) identify three fundamental characteristics of green transformation:

1. It is a comprehensive, cross-sectoral, and long-term process that requires simultaneous change across institutional systems, technologies, and social behavior.
2. It is closely associated with technological innovation, particularly in renewable energy, resource recycling, and industrial symbiosis.
3. It requires active leadership and coordination from state management through clear, transparent, and feasible policies.

Green transformation has thus become an inevitable trend due to the urgent need to address climate change, mitigate the environmental impacts of economic growth, and sustain competitiveness in the context of global integration (World Bank, 2020). Recent research by Lamperti et al. (2020) and Samper et al. (2021) confirms that failure to implement timely green transformation may lead nations to technological stagnation, loss of competitiveness, and significant economic losses as they risk exclusion from emerging global supply chains.

According to UNIDO (2017), an industrial cluster is a concentration of small and medium-sized enterprises within a defined geographical area that shares infrastructure, technology, human resources, and economic benefits. This concept emphasizes the advantages of industrial symbiosis, reduced production costs, and enhanced innovation capacity through interaction and cooperation among enterprises within the cluster (Chertow, 2007; OECD, 2024). Recent global research trends have advanced industrial clusters toward the eco-industrial park (EIP) model. EIPs aim to improve production efficiency and prioritize environmental protection, emission reduction, and sustainable development (World Bank et al., 2021; World Economic Forum, 2024). Adopting clean technologies, modern environmental management systems, and industrial symbiosis models has become common in transforming industrial clusters worldwide.

2.2. Research model

Green transformation fundamentally represents the balanced development between a green economy and a green ecology. This process requires governments to design appropriate transition policies and depends on enabling factors such as eco-innovation, green knowledge, and financial investment (Speck & Zoboli, 2017). In addition, governmental behavior, investment policies, climate change, environmental concern, and public green awareness influence the overall development capacity of a green economy (Frank, 2013; Kar et al., 2015). Similarly, these same determinants shape green transformation within the manufacturing sector (Cheong & Wu, 2014). From internal and external

environmental perspectives, green transformation comprises endogenous factors such as R&D investment, technological innovation, high-quality human resources, capital mobilization capacity, and exogenous factors, including the transition context, government policies, and financial conditions (Qi & Li, 2011). As manufacturing remains one of the world's largest carbon-emitting sectors, its future trajectory must prioritize ecological considerations (Yi & Liu, 2015). Based on these foundations, this study classifies the factors influencing the effectiveness of state management in green transformation into five main groups:

2.2.1. Financial resources

Financial resources within industrial clusters reflect the capacity to mobilize, allocate, and effectively utilize capital for green technology investment, circular infrastructure, and environmental services (Blackburn et al., 2001). This capacity depends on firm size, internal profit accumulation, operational efficiency, liquidity, the quality of relationships between banks and enterprises, and the value of collateral assets (Timmons & Bygrave, 1986). Existing research rarely explores the relationship between financial capability and the effectiveness of state management in industrial green transformation. Most studies focus instead on the role of economic capacity in enterprise restructuring and transition processes (Cao et al., 2009). These studies consistently indicate a positive relationship between financial strength and transformation performance.

H1: *Financial resources positively impact state management's effectiveness in green transformation within industrial clusters in Hanoi.*

2.2.2. Human resources

Human resources encompass individuals' collective knowledge, skills, innovative capacity, and implementation ability who contribute to achieving organizational and societal objectives. As a structural component of economic growth, human resources determine development speed and quality. Numerous studies use human capital as an explanatory variable for GDP growth, showing its positive influence on productivity and economic expansion (Tamura, 2006; Fleisher et al., 2010; Campbell & Agbiokoro, 2014).

First, highly qualified officials in local management agencies such as Departments of Industry and Trade or Industrial Cluster Management Boards ensure that environmental policies are formulated, evaluated, and adjusted to fit the specific characteristics of each cluster, thereby improving feasibility and enforcement. UNESCO-UNEVOC emphasizes that systematic investment in green skills and professional capacities enables administrators and workers to understand green building standards, material circularity, and cleaner production processes, establishing a solid foundation for sustainable industrial transition.

Second, a high-quality workforce with expertise in clean technologies and environmental management tools accelerates the ability of enterprises within clusters to adapt to carbon pricing mechanisms, emission trading systems, and

state-issued green finance policies. Reports by BCG indicate that industrial clusters with a highly skilled workforce can more readily restructure production models, shorten the adoption period of green technologies, and enhance overall operational efficiency. Moreover, research by Likun Ni (2023) identifies "*green human capital*" as integrating environmental expertise and soft skills such as project management and policy communication, which strengthen emission control and energy efficiency. Finally, the World Bank (2023) affirms that systematic investment in training and reskilling workers in carbon-intensive sectors improves green transition capacity and ensures economic continuity and sustainable income for local communities.

H2: *Human resources positively impact state management's effectiveness in green transformation within industrial clusters in Hanoi.*

2.2.3. Coordination mechanism and technological innovation

The coordination mechanism among stakeholders plays a decisive role in improving the effectiveness of green transformation within industrial clusters. The World Economic Forum identifies four governance models suitable for different cluster contexts, ranging from centralized command to flexible network structures, ensuring balanced participation of government, enterprises, and local communities in setting, monitoring, and assessing Net Zero objectives. Similarly, PwC highlights catalytic cooperation between government and the private sector, in which the state not only formulates policies but also designs internal processes, convenes intersectoral forums, and facilitates data sharing to advance green innovation initiatives systematically. BCG recommends that governments evolve existing economic clusters to sustain competitiveness while creating new opportunities through green investment incentives, inter-ministerial steering committees, and integrating public and private investment funds to minimize disruption and accelerate transformation.

Technological innovation is recognized as an exogenous driver of economic growth, promoting development through knowledge accumulation and diffusion (Sirilli & Evangelista, 1998). Empirical studies confirm a significant positive correlation between technological innovation and green economic development (Kazi et al., 2015). Kazi and colleagues show that technological innovation enhances value-added in manufacturing, shifts production toward high-tech labor, and directs R&D toward energy-saving, low-emission, and low-carbon technologies (Masso & Vahter, 2008).

H3: Coordination mechanism and technological innovation positively impact state management's effectiveness in green transformation within industrial clusters in Hanoi.

2.2.4. Institutional framework

The institutional framework of state agencies serves as a critical driver for green transformation in the manufacturing sector. The state directs the reallocation of

resources and industrial spatial planning through transition policies, strengthens market supervision, develops service platforms supporting transformation, and fosters a favorable environment for green growth (Grossman, 1988). Accordingly, the government functions simultaneously as a designer, an arbiter, and a facilitator. Empirical studies on public administrative behavior and industrial upgrading have confirmed that management functions, industrial policy, and public investment can promote green industrial upgrading and transformation (Loizides & Vamvoukas, 2005).

The state and public authorities are decisive in promoting and implementing green transformation, especially in developing countries (Lederer et al., 2018). In Vietnam, under a centralized and proactive administrative model, the government has initiated a national green transformation strategy extending beyond the energy sector to include agriculture and forestry. This approach aims to restructure the economy, enhance energy security, and mobilize new financial and technological resources amid the decline of traditional development aid. Tax incentives and land-lease exemptions for renewable energy projects demonstrate the Government's commitment to positioning green energy as a national priority.

H4: *The Institutional framework positively impacts state management's effectiveness in green transformation within industrial clusters in Hanoi.*

2.2.5. Environmental regulation

Environmental regulation represents a core component of the state's social governance framework, critical in promoting green transformation and environmental protection in the manufacturing sector. These regulations provide incentives for cleaner industries to gradually replace polluting ones, directly influencing the process of industrial green transformation (Jaffe et al., 1995). Furthermore, enforcing environmental management policies enhances awareness of pollution and green transformation among human resources, directs capital toward sustainable enterprises, and stimulates R&D in energy-saving, emission-reducing, and low-carbon technologies (Yang et al., 2012; Zhao et al., 2015). Environmental regulation thus affects human resources, financial capacity, technological innovation, and public administrative behavior and is a moderating force in industrial upgrading and transformation.

H5: *Environmental regulation positively impacts state management's effectiveness in green transformation within industrial clusters in Hanoi.*

3. METHODOLOGY

The research employed a quantitative approach using a structured questionnaire designed to evaluate the effectiveness of state management in green transformation across industrial clusters in Hanoi. The analysis focused on five independent constructs: institutional framework, human resources, financial resources, coordination mechanism, technological innovation, and environmental regulation. It also focused on one dependent construct representing the effectiveness of state management in green transformation. Each construct was operationalized into measurable indicators adapted from international frameworks and contextualized for Vietnam's industrial cluster system. Responses were measured on a five-point Likert scale ranging from strongly disagree to strongly agree, ensuring consistency across all variables used in the exploratory and confirmatory stages.

Data collection took place between March and June 2025, covering eight industrial clusters in Hanoi, including Bắc Thăng Long, Quang Minh, Ngọc Hồi, Sài Đồng B, Đài Tư, Thạch Thất, Quốc Oai, and Phú Nghĩa. The study targeted both cluster management boards and enterprises operating within these clusters, particularly those engaged in environmental management, production technology, and administrative oversight. 300 valid responses were obtained out of 320 distributed questionnaires, achieving a response rate of 93.7%. Each cluster contributed approximately 15 to 20 responses, ensuring representative coverage across different industrial sectors such as food processing, electronics, mechanical manufacturing, and construction materials.

According to methodological recommendations by Hair, Black, Babin, and Anderson (2019), a minimum of five observations per variable is required for Exploratory Factor Analysis. Similarly, Gorsuch (1983) and MacCallum et al. (1999) recommend at least 200 observations for Confirmatory Factor Analysis to ensure robust statistical validity. Therefore, the final sample size of 300 met and exceeded these requirements, allowing for the reliable application of CFA and SEM techniques. Data analysis was carried out using SPSS 20 and AMOS 24 software.

4. RESULT AND DISCUSSION
4.1. Preliminary assessment of the scale

To ensure the reliability of the measurement scale and assess internal consistency, the research team conducted Cronbach's Alpha testing on all components of the hypothesized model. The results showed that the Cronbach's Alpha values of all latent variables exceeded 0.6, indicating high internal consistency among the items (Table 1). Therefore, the scale was considered reliable and suitable for subsequent analyses. The detailed results of Cronbach's Alpha reliability testing are presented below.

Table 1. Reliability testing results of the measurement scale

No.	Code		Item-Total Correlation	Cronbach's Alpha if Item Deleted
(1) Institutional Framework Cronbach's Alpha = 0.824			
1	TT1	,674	,774
2	TT2	,703	,763
3	TT3	,829	,686
4	TT4	,449	,856
(2) Human Resources Cronbach's Alpha = 0.715			
5	NL2	,493	,678
6	NL3	,564	,589
7	NL4	,558	,597
(3) Financial Resources Cronbach's Alpha =0. 672			
8	TC1	,542	,502
9	TC2	,456	,617
10	TC3	,459	,610
(4) Coordination Mechanism and Technological Innovation Cronbach's Alpha = 0.879			
11	CN1	,642	,881
12	CN2	,757	,839
13	CN3	,840	,804
14	CN4	,730	,850
(5) Environmental Regulation Cronbach's Alpha = 0.845			
15	MT1	,643	,819
16	MT2	,661	,813
17	MT3	,744	,775
18	MT4	,681	,803
(6) Effectiveness of State Management Cronbach's Alpha = 0.744			
19	QL1	,675	,732

20	QL2	,636	,626
21	QL3	,667	,606
22	QL4	,596	,653
23	QL5	,579	,813

Source: Summary of the authors' analysis

4.2. Exploratory factor analysis (EFA)

The first exploratory factor analysis showed that the total cumulative variance explained reached 66.454%, exceeding the 50 percent threshold, confirming that the extracted factors accounted for a significant proportion of variance in the dataset. This indicates that the observed variables adequately represent the underlying constructs of the study. After conducting the KMO and Bartlett's tests, the results demonstrated that the dataset was suitable for factor analysis. Five variables that did not meet loading requirements were eliminated after two rounds of EFA using the Varimax rotation method. All remaining observed variables had factor loadings greater than 0.50, satisfying the requirement for convergent validity. The analysis identified six factors comprising a total of 23 observed variables (Table 2). This confirms that the measurement items consistently represent dimensions affecting the effectiveness of state management in green transformation among industrial clusters in Hanoi. The detailed results of the exploratory factor analysis are presented in the subsequent tables.

Table 2. Final Results of Exploratory Factor Analysis (EFA)

Rotated Component Matrix

	Component					
	1	2	3	4	5	6
CN3	,888					
CN2	,851					
CN4	,850					
CN1	,782					
MT3		,864				
MT2		,811				
MT4		,811				
MT1		,798				
TT3			,878			
TT1			,822			
TT2			,813			
TT4			,665			
QL2				,843		
QL1				,821		
QL3				,774		
QL5				,784		

NL3				,823	
NL4				,803	
NL2				,691	
TC1					,816
TC3					,716
TC2					,697

Source: Summary of the authors' analysis

4.3. Confirmatory factor analysis (CFA)

After completing the exploratory factor analysis, the confirmatory factor analysis (CFA) was conducted to verify the validity of the measurement model. The results showed that the Goodness of Fit Index (GFI = 0.917) and the Comparative Fit Index (CFI = 0.959) exceeded the minimum acceptable threshold of 0.85 (Figure 1). The Chi-square divided by degrees of freedom (CMIN/df = 1.508) was below 3, and the Root Mean Square Error of Approximation (RMSEA = 0.043) was less than 0.06. These values confirm that the model fits the market data well and maintains unidimensionality. From the initial six factors with 23 measurement items, after preliminary assessment, EFA, and CFA, the scale was refined to 22 observed variables. This final measurement model was then used for Structural Equation Modeling (SEM) to test the hypotheses related to factors influencing the effectiveness of state management in green transformation across industrial clusters in Hanoi.
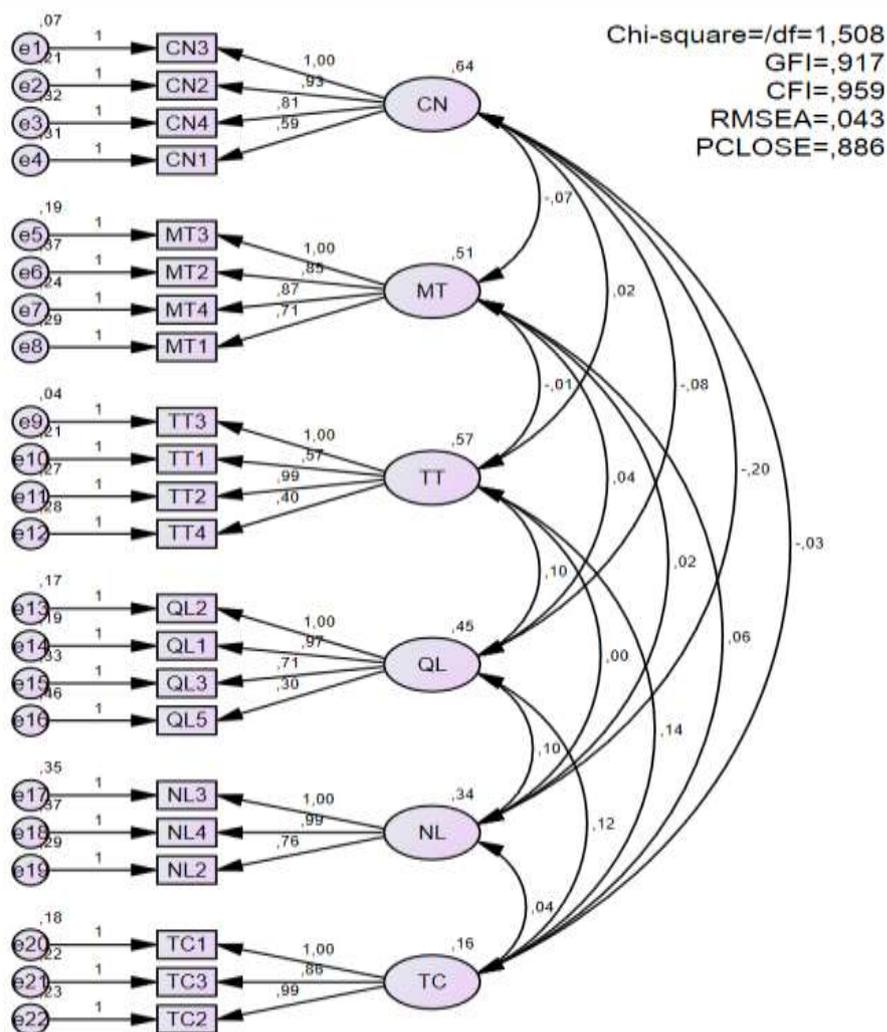

Figure 1. Confirmatory Factor Analysis (CFA) Model
Source: Summary of the authors' analysis

4.4. Hypothesis testing

After confirming the fit of the overall model, the study conducted Structural Equation Modeling (SEM) to examine the relationships among latent constructs. The final

SEM results achieved strong fit indices with CMIN/df = 1.508 (< 3), CFI = 0.959, GFI = 0.917 (both > 0.9), and RMSEA = 0.043 (< 0.05), indicating that the model was well-suited to the observed data (Figure 2).
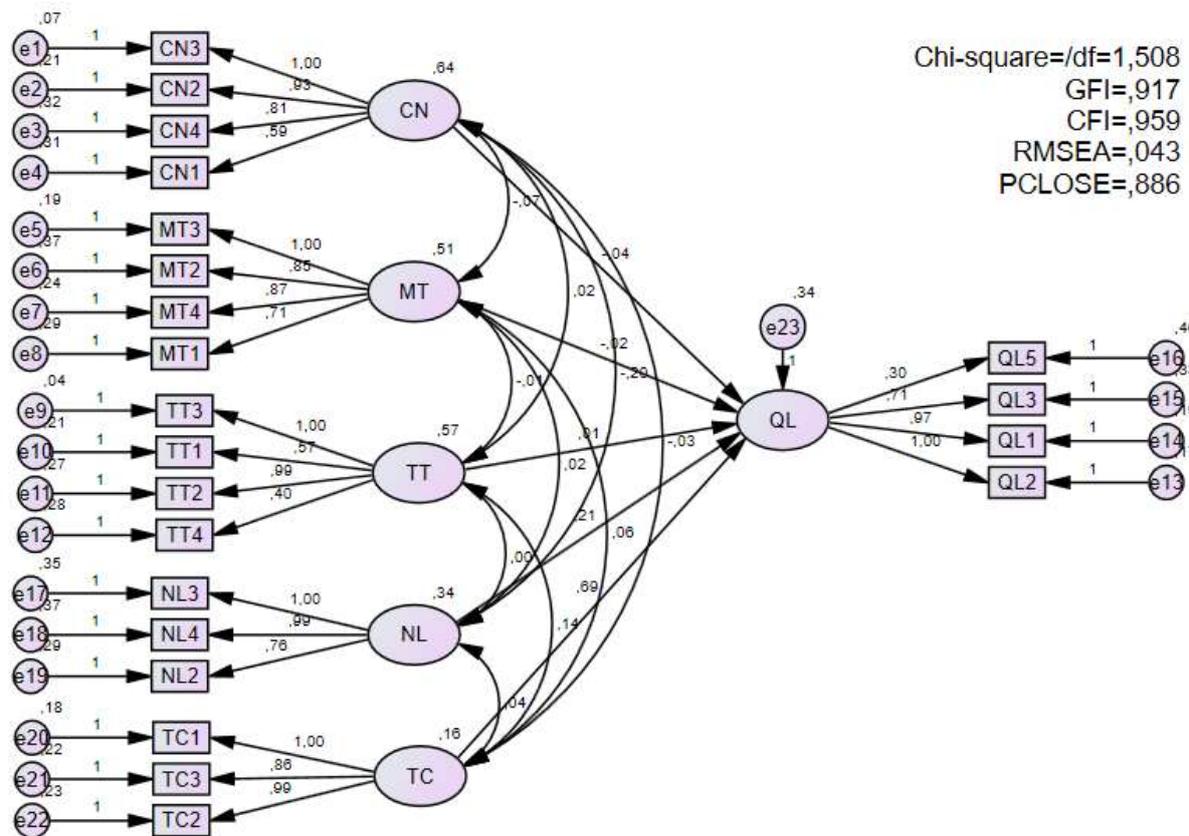

Figure 2. Structural Equation Modeling (SEM) Model
Source: Summary of the authors' analysis

The standardized regression results revealed that Financial Resources had the most potent positive effect (β=0.416) on the effectiveness of state management in promoting green transformation within Hanoi's industrial clusters (Table 3). This finding reflects current realities, as Hanoi has allocated hundreds of billions of VND to build and operate green-oriented clusters such as Mai Đình, Thường Tín, and Thạch Thất. However, this funding remains concentrated mainly on shared infrastructure like centralized wastewater treatment systems, which have not yet facilitated enterprises' deep investment in technological renovation and production modernization. This result is consistent with OECD (2021) and Chen & Xu (2020), who emphasized that adequate financial support from the government is a prerequisite for small and medium-sized enterprises to engage in green transformation and reduce industrial emissions proactively.

Human Resources ranked second in influence, with a standardized regression coefficient of β =0.187. Although Hanoi's Department of Industry and Trade has organized several environmental management training programs for enterprises within industrial clusters, the number of dedicated ecological officers remains insufficient. Only about one-third of clusters have separate environmental management staff,

limiting capacity for planning, monitoring, and implementing green transformation initiatives. This finding aligns with Ismail & King (2007), who demonstrated that personnel skills and expertise are essential for improving the quality of management information systems and environmental governance.

The Institutional Framework showed a weak positive influence (β=0.112), reflecting the fragmented management structure in Hanoi. Environmental and green transformation activities are divided among multiple agencies, primarily the Department of Natural Resources and Environment, the Department of Industry and Trade, and local authorities. This fragmentation causes inefficiency in licensing, inspection, and enforcement processes. The finding contrasts with Bai et al. (2022), who reported that centralized institutional governance in Suzhou Industrial Parks, China, significantly enhanced environmental regulation performance. Hence, Hanoi should establish a more unified governance model to strengthen state management capacity in the coming years.

Coordination mechanism and technological innovation exhibited a slight adverse effect (β=-0.044), suggesting that this element has not yet significantly promoted state management effectiveness. Most enterprises

within Hanoi's industrial clusters continue to rely on outdated equipment and low levels of technological modernization. Green technology investment remains fragmented and lacks a common data-sharing or innovation platform. This contrasts with Helo & Shamsuzzoha (2020), who demonstrated that advanced technology platforms such as IoT and Blockchain improved supply chain governance efficiency in European logistics enterprises. Hanoi should promote pilot projects that integrate government and enterprise cooperation in green technology adoption to address this gap.

Lastly, Environmental Regulation also showed a minor adverse effect ($\beta=-0.024$), indicating that current regulatory frameworks do not provide strong enough incentives for enterprises to adopt green transformation measures. Administrative penalties for environmental violations remain low, and inspection activities are not conducted frequently or thoroughly. As a result, many firms do not perceive regulatory pressure as a serious driver for behavioral change. This finding differs from Ismail & King (2009), who highlighted that a clear and stringent legal framework can positively influence environmental information management and compliance at the enterprise level. Therefore, Hanoi must strengthen inspection frequency and increase penalties to transform environmental regulations into more effective governance tools.

Overall, the SEM analysis confirms that most factors in the model positively influence the effectiveness of state management in green transformation across Hanoi's industrial clusters. Among them, Financial Resources exert the most substantial impact, followed by Human Resources, while Institutional Framework, Coordination Mechanism, Technological Innovation, and Environmental Regulation have weaker effects.

Table 3: Results of hypothesis testing

Hypothesis	Description	Standardized Estimate (β)	Result
H1	Financial Resources positively influence the effectiveness of state management in green transformation within Hanoi's industrial clusters	,416	Accepted
H2	Human Resources positively influences the effectiveness of state management in green transformation within Hanoi's industrial clusters	,187	Accepted
H3	Coordination mechanism and technological innovation positively influence the effectiveness of state management in green transformation within Hanoi's industrial clusters	-,044	Rejected
H4	Institutional Framework positively influences the effectiveness of state management in green transformation within Hanoi's industrial clusters	,112	Accepted
H5	Environmental Regulation positively influences the effectiveness of state management in green transformation within Hanoi's industrial clusters	-,024	Rejected

5. CONCLUSION

This study provides empirical evidence on the factors influencing the effectiveness of state management in green transformation within industrial clusters in Hanoi. Using the Structural Equation Modeling (SEM) approach, the research confirmed that financial resources, human resources, institutional framework, coordination mechanism, technological innovation, and environmental regulation jointly explain the variation in the effectiveness of state management toward green transformation.

The results highlight that financial resources exert the most substantial positive impact on state management effectiveness. This finding aligns with the practical context in Hanoi, where financial capacity determines the extent to which green transition policies can be implemented. Adequate funding enables the construction of shared infrastructure, investment in cleaner production technologies, and the maintenance of environmental services. However, the findings also reveal that public financial support has been concentrated primarily on infrastructure rather than technological upgrading. Thus, sustainable transformation requires expanding financial mechanisms that support enterprises directly in technology renewal and energy efficiency.

Human resources emerges as the second most influential factor. A competent and environmentally trained workforce contributes to the successful formulation and execution of green policies. The shortage of qualified environmental officers in cluster management boards underscores the need for capacity-building programs and specialized training. Investment in developing "green human capital" will improve operational efficiency, environmental compliance, and policy enforcement within clusters. The institutional framework shows a positive but limited impact,

indicating that the current management structure in Hanoi remains fragmented across departments. This fragmentation constrains coordination and leads to licensing, monitoring, and enforcement inefficiencies. To strengthen state management effectiveness, Hanoi should establish a more integrated and transparent institutional mechanism that promotes inter-agency collaboration and streamlined governance. Coordination mechanisms, technological innovation, and environmental regulation show weak or slightly negative relationships with management effectiveness. These results imply that the potential of collaborative innovation and regulatory enforcement has not been fully realized. The city's industrial clusters still rely on outdated production systems, with limited digital integration and low adoption of clean technologies. Likewise, environmental regulations are insufficiently stringent to drive proactive compliance. Strengthening regulatory enforcement, increasing penalties for violations, and creating incentives for green technology adoption would enhance the policy's effectiveness.

Financial and human resources are the primary drivers of state management effectiveness in green transformation within Hanoi's industrial clusters. Improving institutional coherence, promoting innovation and collaboration, and enhancing the rigor of environmental regulations are necessary to sustain green transformation. The findings offer policy implications for developing a comprehensive, resource-driven, and technology-oriented management model that supports Vietnam's commitment to sustainable industrial growth and green economic development.

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