

Research on the Whole-Chain Governance System of Green Building

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Abstract

Under the background of vigorously promoting green building throughout the country, in order to improve the quality and efficiency of green building management, taking the whole-chain governance system of green building as the research object, summarize and analyze the domestic and foreign research results, drawing on the theory of system dynamics, build the SD model of the quality and efficiency improvement factor of green building management composed of three subsystems with the enterprises and the public as the main driving force, To deduce the key factors affecting the development of green buildings, This paper puts forward practical countermeasures and suggestions from the aspects of optimizing the guiding path of green building project governance system, improving the technology-driven strategy of green building industry development, and enhancing the public participation of green building project governance.

Keywords

Green Building, Whole-Chain Governance System, System Dynamics

1. Research Background

The escalating threat of global climate change has propelled the pursuit of carbon neutrality and peak carbon emissions to the forefront of international agendas. In this context, the construction industry, as a predominant contributor to global energy consumption and carbon emissions, bears immense responsibility in the transition towards a low-carbon future. Green buildings, characterized by their emphasis on energy efficiency, resource conservation, and environmental friendliness throughout their lifecycle, have emerged as a pivotal solution to mitigate the sector's environmental impact (The Ministry of Housing and Urban-Rural Development, 2022).

However, the widespread adoption and effective implementation of green building practices on a global scale are hindered by fragmented governance approaches. Current governance frameworks often focus on isolated stages of the building lifecycle, such as design or construction, neglecting the interconnectedness of planning, material production, operation, maintenance, and eventual demolition. This lack of a holistic, full-chain perspective results in inefficiencies, inconsistencies in standards, and difficulties in achieving synergistic effects across different phases and regions.

This study, titled “Research on the Full-Chain Governance System of Green Buildings”, aims to explore the establishment and optimization of such a global governance system. By analyzing existing international policies, standards, and collaborative mechanisms, it seeks to identify the key elements, stakeholders, and operational dynamics required for an effective full-chain governance framework. The ultimate goal is to provide insights and recommendations that can enhance the coordination and effectiveness of global efforts in promoting green buildings, thereby accelerating the transition to a low-carbon economy and society.

At present, domestic and foreign scholars have carried out relevant research on the improvement of the quality and efficiency of green building management. Since the 1970s, the international community has generally paid more attention to improving the quality and efficiency of green building management, and increased the theoretical exploration and practical application of this aspect (*The National Development and Reform Commission, 2019*). As early as 1975, the United States issued the ASHRAE standard for the first time, forcing the construction industry to implement energy-saving standards, which are used to reduce the energy consumption of building air conditioning and build energy-saving and environmentally friendly buildings (*General Office of the State Council, 2017*). In 1993, the Green Building Association (USGBC) was established in the United States, followed by the comprehensive green building evaluation standard—LEED, which promoted the development of green building in the building industry in the United States (*Li, Zhang, & Yu, 2018*). Relatively speaking, the domestic research on improving the quality and efficiency of green building management started relatively late. *Wang (2021)* established a management model combining cloud manufacturing BIM and construction engineering BIM, and improved the management efficiency of new prefabricated green buildings through simulation verification. *Zhang (2021)* analyzed the problems existing in the management of green building projects, and proposed to improve the management level of green building projects by establishing a sound policy and regulation guarantee system for green building construction, enhancing the awareness of green environmental construction, and strengthening the management of green construction technology. *Jiu Miao et al. (2024)* analyzed the climate zoning and environmental characteristics of “Belt and Road” countries, sorted out the key technologies and applications of green building, and built a green building technology system. *Wu Jindong et al. (2021)* conducted in-depth research on the incremental cost of green building technology from different aspects such as the distribution area, building

properties and types, discussed the close relationship between the application of green building technology, the difficulty of technology and the adaptability of building types, and put forward the theory of improving the utilization rate and balanced development of green building technology. Liu et al. (2023) sorted out the problems in the development process of green building design standard system, proposed to strengthen the research on the basic science of green building design, improve green building design standard system, revised the architectural professional teaching material system, and solved the root cause of the unsatisfactory effect in the implementation process of green building.

To sum up, most of the research mainly focuses on the green building construction, design standards, technology application, etc., but the chain of green building governance factors related research is very few, the existing literature in the study of green building chain governance way, the conduction path, influencing factors, internal logic research is constrained by questionnaire survey, combined with qualitative quantitative analysis, comprehensive evaluation method of screening factors (Atmaca & Atmaca, 2022). The complexity, systematization and integrity of the whole chain of green building governance are not considered enough, and there is no comprehensive analysis and in-depth study on the causal relationship and circular logic of the influencing factors of the whole chain of green building governance.

From the literature and the data of field practice investigation, under the background of two-carbon, strengthening the whole chain governance of green building governance is of great practical significance for improving the management efficiency, and the effect of green building governance directly affects the sustainable development process of the construction industry in the future. This paper from the influencing factors of green building chain governance, on the basis of the existing academic research, theoretical results, through the comprehensive analysis of the data collected, establish a system dynamics model, and analyze the causal loop of the feedback model, explore the system, technology, supervision, triple logic, functional department, enterprises, the public perspective put forward the opinions of the green building chain governance, to improve the green building management quality, promote the development of green transformation.

2. The Whole-Chain Governance System of Green Building

2.1. Determine the System Boundary

Green building the whole chain governance has the characteristics of complexity, global, integrity, can be regarded as a complex system, including system, technology, supervision, triple logic, involving functional department guidance, industry implementation, public participation, and other subsystems, the subsystem and its internal elements between each other, mutual correlation, mutual interaction, jointly build a multi-dimensional, multi-level, multi-directional complex relationship network. On the basis of the research on scholars, we will explore a new path: it is difficult to improve the quality and efficiency of green building management

effectively, which, to some extent, is due to the influence of the driving mechanism of complex systems. Therefore, it is the key way to solve the difficult problem to analyze the causality, logical relationship and influencing factors among the sub-systems.

2.2. Main Body Analysis of the Whole Chain of Green Building Governance System

In the comprehensive study of domestic and foreign academic multidimensional analysis of green building governance, on the basis of green building governance methods, summarize and promote the whole chain governance model, involving the main body mainly include functional department, enterprises, the public and other stakeholders, functional department policy system, enterprise executive power, consumer choice tendency and social public supervision and common is the main driving force of green building management quality effect (Xu, 2024).

2.2.1. Guidance of the Functional Department System

At present, the development of green buildings is in its initial stage. The incentive policies and mandatory norms issued by the functional department can directly or indirectly enhance the quality and efficiency of green building management and promote the long-term development of green buildings. Incentive policy is the functional departments' certain degree of incentives, subsidies and preferences to green building development enterprises. Through this move, it aims to increase the additional economic benefits of development enterprises, reduce the incremental cost of green buildings, stimulate the willingness of enterprises to develop green buildings, and expand the research and development and investment in green technology. Compulsory norms lead from top to bottom. The functional department plays multiple roles of guidance, supervision and management, issues mandatory laws and regulations to promote the development of green buildings, and guides enterprises to make investment decisions.

2.2.2. Enterprise Technology-Driven

The driving role of enterprises in the whole chain of green building governance is mainly reflected in the adaptability, maturity and cost-effectiveness of green building technology. In order to in energy saving, water saving, environmental protection play the natural advantage of green building, enterprise in promoting green building management quality effect is bound to promote relatively mature and widely used of high and new technology, therefore, the adaptability and maturity of green building technology for green building management quality effect plays a crucial supporting role (Tang et al., 2023). Compared with traditional buildings, due to the wide application of a large number of green technologies, the technical cost input of green buildings has been significantly increased. By adopting efficient technology, intelligent management technology and renewable energy technology, companies can not only reduce costs but also improve the overall performance of green buildings.

2.2.3. Public Supervision

In today's society, with the rapid development of economy, the public's demand for housing, office buildings and public buildings is no longer limited to the use of residential functions, with more focus on air pollution index, energy utilization efficiency and environmental protection degree. Public participation can promote the functional department and enterprises to attach importance to the development of green buildings, and formulate stricter regulations and systems. At the same time, it can form social pressure, promote enterprises to improve their social responsibility, strictly implement green building-related design standards, construction regulations and environmental protection systems, and reduce the negative impact on the environment (Xu, Zhou, & Chen, 2024). Therefore, the participation of the public and supervision are the key driving factors of the whole chain of green building governance system, and play an irreplaceable role in the improvement of governance efficiency.

3. Construction of the Driving Factor Model of the Green Building Whole-Chain Governance System

3.1. Causal Relationship Diagram

There is a causal relationship between multiple mechanisms of action, forming a closed loop, interacting, head-to-end causal chain, also known as a feedback loop. With the help of Vensim PLE, this paper constructs three subsystems of mechanism of action from the three aspects of system, technology and society, screen the key variables, analyze the linkage effect between variables, and draw the causal diagram (Figure 1).

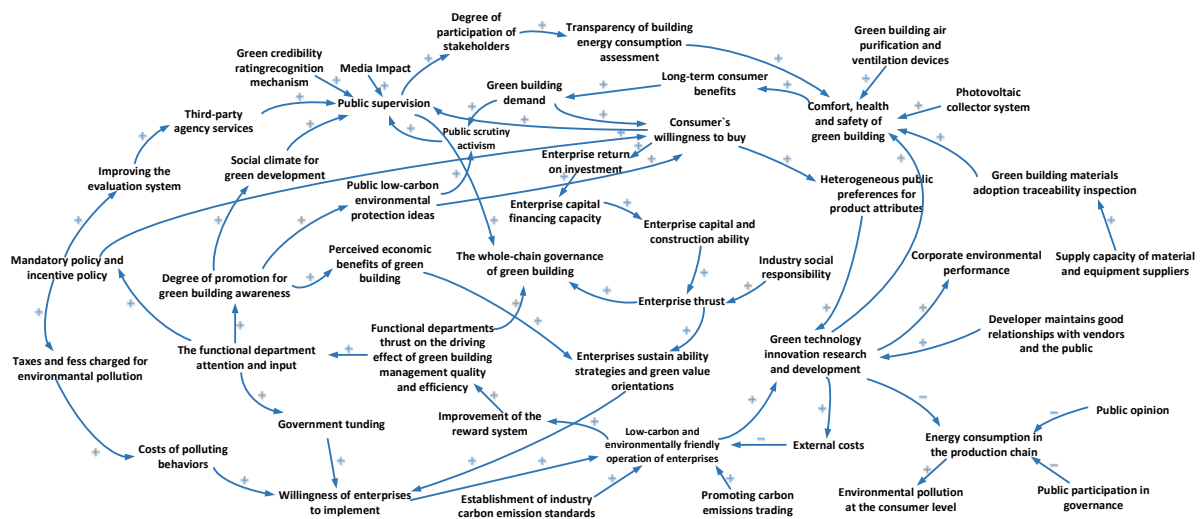


Figure 1. Causal relationship diagram of the whole-chain governance system of green building.

3.2. The Causal Feedback Model Analysis

By sorting out the causal diagram, the main factors affect the governance mechanism of the whole chain of green building which feeds back into the loop for analysis.

3.2.1. Functional Department Guidance Subsystem Loop

The driving role of government thrust on the management quality and efficiency of green buildings (+) the functional department attaches great importance to the degree and investment (+) mandatory policy and incentive policy (+) environmental pollution tax (+) pollution behavior cost (+) the intention of the enterprise (+) enterprise low carbon environmental protection operation (+) the improvement of the reward system (+) functional department thrust of green building management quality effect.

In the system for the positive feedback cycle, the functional department increases the role of green building management, improves the importance of green building, expands investment, promotes incentive policy to enhance the enterprise of green building project management, and at the same time adopts mandatory policy to increase the cost of environmental pollution, providing legal support for the development of green building. For market competitiveness, enterprises reduce the cost of operation and maintenance management, and actively implement various policies and systems of low carbon, environmental protection, energy saving and carbon reduction (Luo et al., 2023). In order to promote the functional department to improve the reward and punishment system, enhance the driving role of the functional department thrust, thus forming a virtuous cycle, and jointly promote the continuous improvement of the quality and efficiency of green building management.

3.2.2. Enterprise Implementation Subsystem Loop

Enterprise thrust (+) enterprise sustainable development strategy and green value orientation (+) enterprises to carry out the will (+) enterprise low carbon environmental protection operation (+) green technology innovation research and development (+) green building comfort and health and safety (+) consumer long-term interests (+) green building demand (+) (+) enterprise return on investment (+) enterprise capital financing ability (+) enterprise capital and construction ability (+) thrust.

Enterprise thrust is the starting point of the positive feedback cycle, promoting enterprises to follow the sustainable development strategy and green value orientation, and then enhancing the willingness of enterprises to implement environmental protection measures and implement the low-carbon environmental protection operation mode. In the process of operation, enterprises have increased their investment in green technology innovation and research and development, and the comfort level and health and safety level of green buildings have been improved, which directly affects the long-term interests of consumers. After experiencing the advantages brought by green buildings, consumers will increase their demand for green buildings, and then increase their purchase intention. Then it will affect the return on investment of the enterprise, enhance the ability of enterprise capital financing, further enhance the capital and construction ability of the enterprise, and finally form a positive cycle to strengthen the thrust of the enterprise again, so as to continuously promote the operation of the whole loop.

3.2.3. Public Participation Subsystem Loop

Public supervision (+) Participation of stakeholders (+) transparency of building energy consumption assessment (+) Green building comfort and health safety (+) long-term interests of consumers (+) Green building demand (+) enthusiasm of public supervision (+) public supervision.

In the positive feedback loop of the public participation subsystem, the role of public supervision can improve the participation of stakeholders, and the transparency of building energy consumption assessment will be improved accordingly. Increased transparency will help improve the comfort, health and safety of green buildings, thus protecting the long-term interests of consumers. Consumers' demand for green buildings will increase accordingly, which will stimulate the public to participate in supervision and give full play to the role of public participation. (Figure 2)

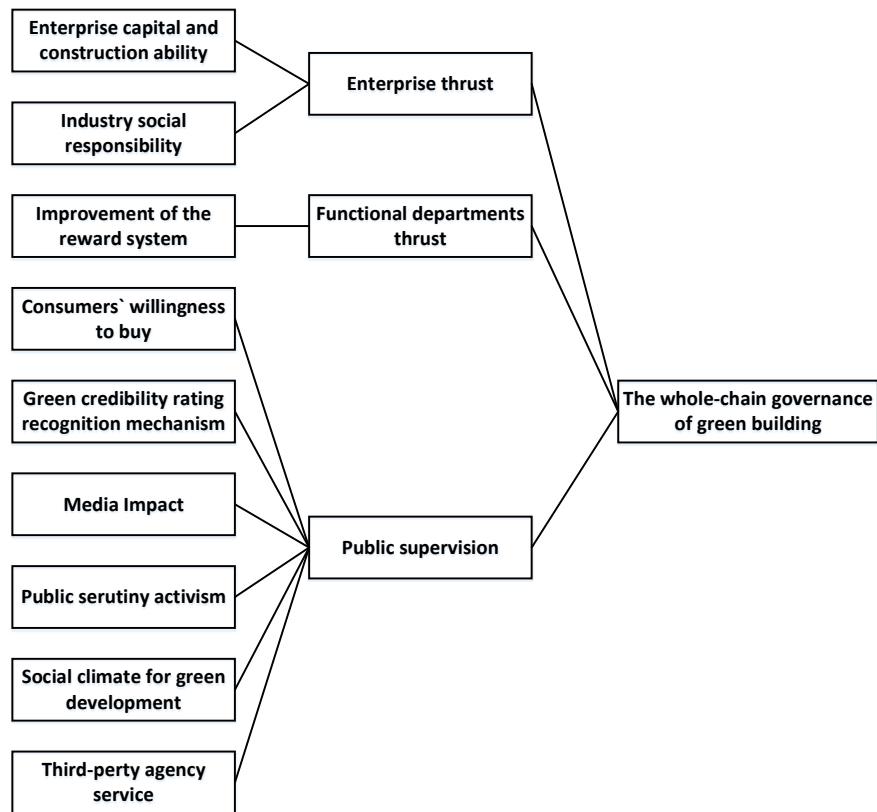


Figure 2. Reason tree of the whole chain of green building.

4. Countermeasures and Suggestions for Promoting the Whole Chain of Green Building Management

It can be analyzed from the causal relationship diagram of the whole chain of green building governance that there is an interaction between the three main systems, technology and supervision, and the functional department, enterprises and the public also influence and restrict each other. functional department support, institutional incentives, tax relief, and public recognition and purchase intention

of green building greatly affect the enthusiasm of the green building industry to improve the governance efficiency; the functional departments guidance and policy promotion, and the public to of high quality building products; industry implementation measures, governance effect and public supervision are also returned to the functional department departments to accelerate the improvement of relevant policies and systems.

4.1. Optimize the Guiding Path of the Green Building Project Governance System

4.1.1. Improve Policy Consistency

The development of green buildings started late. The relevant policies and systems on green building project management are formulated and introduced by various levels and multiple departments in a short period of time, which can solve the current contradictions and guide the governance practice of green building projects. Due to the different focus, foothold and starting points of different levels and departments, with the passage of time, the number of policies and systems issued gradually increases, and there will be contradictions and differences between each other, which will lead to the lack of long-term consistency of policies. The lack of consistent policy guidance will to some extent cause the stakeholders to face difficulties in strengthening the management of green building projects. According to the changes in the actual development trend of green buildings, jointly implement the consistency evaluation of the new policies and macro policy orientation, improve the consistency of the existing policies and regulations, and improve the consistency of all links from the decision-making and implementation to the use of green building projects, highlighting the guiding significance of the policies.

4.1.2. Enhance the Timeliness of Policies

The policies and systems issued by the functional department should have a long-term guiding role, reflecting the functional department's clear attitude and firm determination in the governance of green building projects. However, in the face of the unbalanced development of various provinces and cities, the timeliness of the policy system is difficult to be effectively guaranteed. In view of this situation, it is necessary to formulate more applicable flexibility standards within the framework of superior mandatory policies, and make corresponding adjustments according to local conditions. Some outdated policies or clauses have lost their guiding significance for the governance of green building projects at the present stage. On the one hand, policies in line with the current reality should be issued in time, and on the other hand, policies that are outdated or not applicable to the current and future should be abolished in time.

4.1.3. Overall Planning and Policy System

The systematic optimization of policies related to green building project governance plays an indispensable and key role in promoting the transformation and development of the construction industry in the direction of energy conservation

and carbon reduction. Policy formulation should not be separated in isolation, but should form a complete system to maintain policy coherence, cohesion and complementarity. To optimize the system of policies, we need to examine, integrate and improve the existing green building project governance policies from an overall perspective to ensure that they form an organic whole. The full life cycle impact of green buildings should be fully considered, including the stages of design, construction, operation and demolition, and a closed-loop system should be formed from the four links of policy introduction, implementation, evaluation and feedback. For example, the promotion policy of green building should be complementary to the design code of green building products, green building materials product evaluation standards, green building energy saving standards and other policies and systems (Agyekum et al., 2020).

4.2. Improve the Technology-Driven Strategy of Green Building Industry Development

4.2.1. Improve Technology Pertinacy

Under the current background of sustainable development, green transformation has become the main development direction of the construction industry in the future. Green building project management technology is a solid cornerstone to ensure the smooth implementation of green building projects, the key factor to promote the implementation of the green concept in the construction industry, and also the power engine to improve the efficiency of green building governance. According to different building goals and demand, improve the pertinence of green building project management technology, provide customized solutions, pay attention to building energy efficiency and resource utilization efficiency, pay attention to the environmental protection of building materials, long-term sustainability of building, avoid excessive pursuit of technical blindness, to ensure that the construction project in the design, construction and operation of each stage in line with the standards and requirements of green building.

4.2.2. Promote the Cutting-Edge Nature of Technology

In the current rapidly developing green building industry, cutting-edge technology plays a crucial role in promoting the progress of the whole industry. We should pay attention to the research and development of green building project management technology, strengthen the innovation of traditional building technology, and promote the overall development of green technology through the introduction of new materials and new processes. In terms of technology research and development, pay attention to the introduction of big data, cloud computing, Internet of things, artificial intelligence and advanced information technology and intelligence means, speed up the green building project management technology upgrade, from project planning, design, construction to operation and maintenance and so on each link to strengthen supervision, improve the quality of construction project management, reduce the energy consumption rate of green building and environmental impact, realize the whole life cycle of green building pro-

ject precision management and control.

4.2.3. Expand Technical Relevance

The development of green building project governance technology is not isolated; it is closely connected with many fields, forming an interdependent and mutually reinforcing ecosystem. The development of green building project governance technology requires interdisciplinary and cross-industry cooperation and exchange, and forms a comprehensive green technology system by integrating knowledge and technology in different fields. Should be based on the functional departments' incentive support policy, strengthen scientific research institutions, colleges and enterprises and other power cooperation, set up special funds to support green technology innovation, further promote construction, environment, materials, energy and other multidisciplinary blend, professional integration, interdisciplinary, research production integration of research and development model (Song et al., 2021). Attention should also be paid to improving the level of green building design, improving the professional ability and technical level of the participants, improving the level of green building construction, improving the supply capacity of green building materials and equipment suppliers, and accelerating the transformation and application of green technology (Wu et al., 2019).

4.3. Enhance Public Participation in Green Building Project Governance

4.3.1. Maintain the Patency of the Participation Channels

In order to enable the green building project governance to truly serve the public, the public must actively participate in energy conservation and carbon reduction, and the channels of public participation, supervision and rights protection should be kept smooth and smooth. Build a diversified communication platform for the public interest to ensure the wide dissemination of policies and systems and the timely collection of public opinions. Regular green building policy consultation and opinion collection activities will be carried out, special feedback channels will be set up, hotlines, email addresses, WeChat public accounts and other contact information will be disclosed to facilitate the public to raise questions, complaints or suggestions on the supervision of green building projects, and ensure that these feedback can be dealt with in a timely and effective manner. By simplifying the procedures and procedures of public participation, the crux of the blockage of the communication channels between the functional department, the industry and the public can be opened, and the blockage of the communication between the upper and lower levels can be eliminated.

4.3.2. Encourage the Enthusiasm of Public Supervision

The functional department has introduced policies to implement incentives such as tax breaks and subsidies, encourage the public to actively participate in green building projects, and create official websites or applications, so that the public can easily access all kinds of information about green buildings. Through the reg-

ular release of case studies and typical demonstrations of green buildings, the environmental, economic and social benefits brought by the public participation in the supervision and governance of green building projects are displayed, and the public's sense of identity with the value of green buildings is enhanced, so as to promote the enthusiasm of the public to participate. Regular seminars and lectures will be held, and experts and environmental advocates in the field of green buildings will be invited to publicize the advantages and importance of green buildings. Through education and publicity activities, improve the public's awareness of the importance of green building project governance, stimulate the enthusiasm of public participation, and form a good situation in which the functional department, enterprises and the public jointly promote the development of green building.

4.3.3. Boost the Timeliness of Rectification Feedback

Establish rapid rectification and feedback mechanism, once found to identify problems, whether found problems in the process of project governance, or the public supervision reflect opinion suggestion, should quickly start the preset rapid response plan, appoint specialist team is responsible for, clear disposal process, responsibility distribution, rectification time limit and acceptance criteria, to ensure that the problem can be solved quickly, to avoid delay. Regular report to the public project implementation, to ensure that the public's right to know and participation in the effective guarantee, through a regular review process, collect different time feedback before and after the problem, continuous optimization rapid disposal solution, through clear objectives, depth communication, site office, monitoring, continuous improvement, to ensure that the problem is properly solved.

(Figure 3)

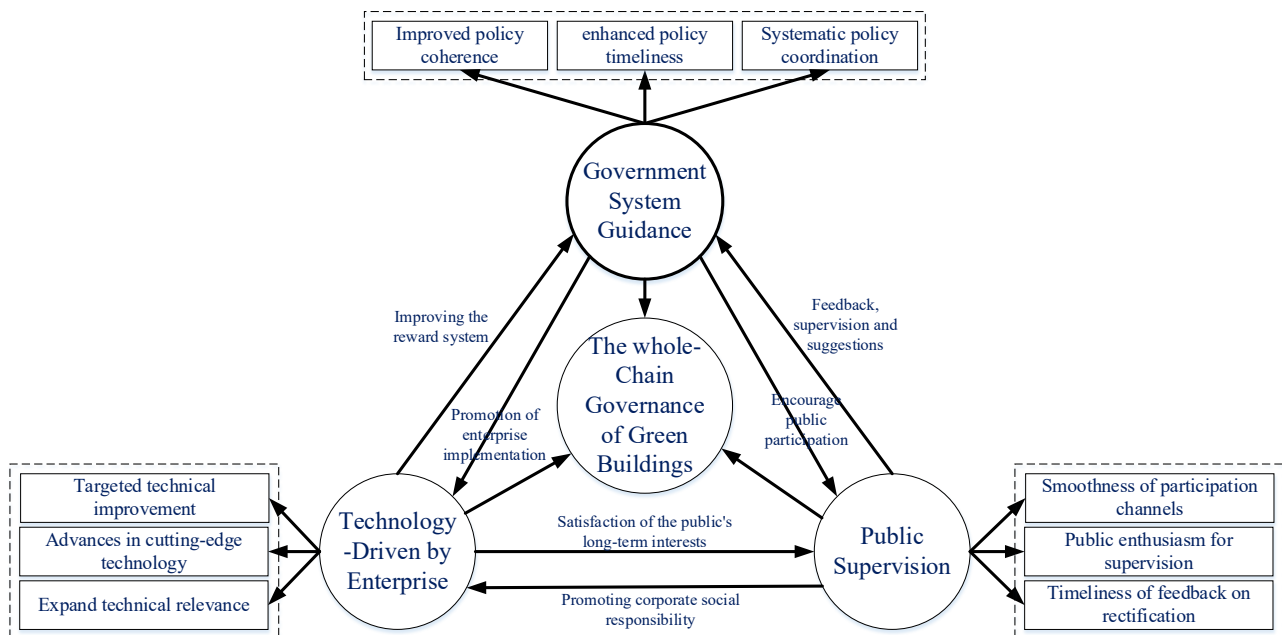


Figure 3. The function relationship of the whole chain governance system of green building.

5. Conclusion

This paper takes the whole chain governance system of green building as the research object, starts with the influencing factors of the whole chain governance of green building, and explores the mechanism of improving the quality and efficiency of the system, technology and supervision of green building management through the establishment of the system dynamic model. The study found that the policy guidance of the functional department, the technology drive of enterprises and the supervision and participation of the public are the key factors to promote the whole chain governance of green building. Through causality analysis, multiple positive feedback loops are constructed, the interaction logic between the functional department, enterprises and the public is analyzed, and countermeasures and suggestions are put forward to improve the green building promotion policy, optimize the technology-driven strategy and enhance the enthusiasm of public supervision. In order to provide a reference for improving the quality and efficiency of green building management, promoting the green and low-carbon transformation in the construction field, and realizing the Sustainable Development Goals.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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