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Polycentric Collaborative Governance, Sustainable Development and the Ecological Resilience of Elevator Safety: Evidence from a Structural Equation Model

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Abstract: The goal of public security and safety under the concept of sustainable development has been transformed into the maximization of the comprehensive goal of economic, environmental, and social security and safety. The polycentric collaborative governance mode is a crucial approach for the reform of government regulation. Social–ecological resilience has become a typical paradigm in the field of risk governance. Polycentric collaborative governance and safety resilience are the foundation and booster of elevator safety governance. In this paper, we expound on the system elements and mechanisms of polycentric collaborative governance and ecological resilience of elevator safety under the guidance of sustainable development by using a conceptual framework method. On this basis, we explore the influence degree and mechanism of elevator safety polycentric collaborative governance on elevator safety ecological resilience under the guidance of sustainable development by constructing a structural equation model based on micro-survey data. The results show that (1) the polycentric collaborative governance subject composed of the government, business, society, and the public is the key force to enhancing the ecological resilience of elevator safety; (2) enhancing the ecological resilience of elevator safety has a significant direct promoting effect on improving the mitigation, recovery, learning, and coping ability of elevator safety; (3) improving the learning ability has a significant direct promoting effect on improving the mitigation, recovery, and coping ability of elevator safety; (4) improving the coping ability has a significant direct promoting effect on improving the mitigation and recovery ability of elevator safety; (5) improving the mitigation ability has a significant direct promoting effect on improving the recovery ability of elevator safety. Therefore, in the process of elevator safety governance under the guidance of sustainable development, we should not only adhere to the polycentric collaborative governance mode but also attach importance to the ecological resilience governance paradigm of elevator safety, which together can improve the elevator quality and safety level.

Keywords: sustainable development orientation; collaborative governance; polycentric collaborative governance mode; ecological resilience of elevator safety; structural equation model

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1. Introduction

With the rapid development of cities and the construction of high-rise and super high-rise facilities, elevators have become an essential mode of transport for the people [1]. China's elevator industry is undergoing rapid development. Moreover, China has become the world's largest elevator producer and user [2]. Relevant data [3] indicate that from 2005 to 2021, the number of elevators in use in China has increased by more than 7.2 million units, suggesting an increase of approximately 11 times. By the end of 2021, the number of elevators in use in China reached 8.7998 million units, accounting for more than 47% of overall special equipment in use. At the same time, China's elevator production constitutes more than 80% of the world's production, and the percentage of elevators in use constitutes more than 40% of the world's total use. Furthermore, the elevator safety level of China is close to that of developed countries in Europe and the United States. According to statistics, from 2010 to 2020, the number of people served per elevator in China has declined from 823 to 179, which is considerably lower than the global level of 388 and the North American level of 384. In addition, the mortality rate per 10,000 elevators and accident rate per 10,000 elevators decreased from 0.27 to 0.03, showing an 8-fold decrease, which is far lower than the death rate per 10,000 vehicles (1.8). However, frequent elevator faults and accidents, the serious aging problem of elevators, and the pressure on residents' safety guarantees continued to increase [4]. This is because, first, elevators in China generally operate with large passenger flow, long cycles, and high loads. In some large shopping malls or residential quarters, elevators, which are used frequently, can brake as many as 4500 times a day. Second, with the continuous growth of elevator ownership, the number of old elevators that have been in use for 20 years or more has increased yearly. Taking 2020 as an example, elevators with a service life of 10 years or more constituted more than 20%, and elevators with a service life of more than 5 years constituted more than 65%. Therefore, a certain gap exists between the current stage of elevator safety construction and the higher demands of the people for safety, convenience, and comfort. The public is becoming increasingly sensitive to elevator accidents, and the elevator safety situation is not optimistic. The traditional elevator safety supervision mode is facing increasing pressure. Public safety is a booster for national safety and social stability. China has always placed considerable focus on public safety. Since the 18th National Congress of the Communist Party of China, "establishing a sound public safety system" has been regarded as one of the core tasks of social governance [5]. Elevator safety involves the life safety and quality of life of the people. Therefore, the study of elevator safety governance has important theoretical and practical value.

In recent years, with the rapid increase in the number of elevators and the frequent occurrence of old elevator problems, elevator safety has become the focus of grassroots governance in China and a "key trivial matter" focused upon by the government. The Communist Party of China and the government have introduced many policies to effectively solve the problems and contradictions in elevator safety governance. In 2016, the multi-center governance idea of "streamlining administration, delegating power, delegating regulation, and optimizing services" was first proposed in the Key Points of the Reform of Promoting Streamlining administration, delegating power, combining regulation and Optimizing Services in 2016. In the Top Design Scheme of Special Equipment Safety Supervision Reform, the multi-center governance mode is clearly proposed, which requires the role of all relevant parties in special equipment safety to be played, and a multi-governance work pattern is formed. In 2019, the Fourth Plenary Session of the 19th CPC Central Committee indicated that co-construction, co-governance, and sharing are important social governance systems to promote the modernization of national governance capacity and governance system [6]. In 2021, the Outline of the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China mentioned that development and safety should be coordinated and that safety should be integrated into the process of national development and in all fields. Furthermore, the safety supervision of special equipment must be strengthened, and safety rectification must be further promoted. The 14th Five-Year Plan (2021–2025) for the Development of China's Special Equipment Safety and Energy Conservation Business indicated that adhering to systematic governance as well as joint management and social governance is imperative. Moreover, a multifaceted co-governance work pattern should be adopted wherein the government exercises a unified leadership, the regulatory authorities perform their duties in accordance with the law, the enterprise fulfills its responsibilities, the inspection agency provides technical support, the industry association provides self-discipline services, and the public participates in supervision. In 2022, The China Elevator Quality and Safety Improvement Action Plan (2022) reported that the goal of "elevator safety governance capacity should be significantly improved, the elevator quality and safety level should be significantly improved, and the safety of the people in the elevator must be effectively guaranteed". Based on these policies, the polycentric collaborative governance mode has been practiced in the process of elevator safety governance and has achieved certain results. In the process of social governance, the government is only one of the subjects that are required; it also needs the cooperation of the market, society, and the public. That is, the polycentric collaborative governance mode requires the interaction and negotiation among polycentric collaborative governance subjects [7]. The polycentric collaborative governance mode of elevator safety is a requirement for the development of supervision theory and promotion of the government co-governance work pattern, and for the driving force of economic and social development and stability, and is a crucial part of promoting the modernization of national governance [5].

With the rapid development of the economy, global resource depletion, energy consumption, and environmental destruction have become increasingly serious. How to realize the sustainable development of the human economy and society has aroused a common concern worldwide. The sustainable development strategy is one of China's economic development strategies. President Xi Jinping has stressed on many occasions that China should uphold the vision of innovative, coordinated, green, open, and shared development, promote high-quality economic development, completely implement the 2030 Agenda for Sustainable Development, and meet the "30 and 60" carbon goals(carbon peak and carbon neutral). Under the guidance of sustainable development, the goals and approaches of public security governance must be changed. The objective of elevator safety governance has been changed from one-dimensional safety accident governance to multi-dimensional "sustainable development" governance, including the material environment, the institutional system, and the social economy. In the existing studies on elevator safety governance, many scholars have established elevator safety risk identification, risk evaluation, and risk control systems based on risk management theory [8–12]. However, these studies have neither considered the sustainability of elevator safety governance and the active safety response ability of elevator safety governance objects nor distinguished the influencing factors of elevator safety governance subjects and objects. The paradigm of social–ecological resilience overcomes the limitations of structural functionalism, negative expression of social vulnerability, and difficult quantification of social constructivism in classical disaster social science and becomes a typical paradigm of social disaster, crisis, and risk management. The whole life cycle governance concept of social–ecological resilience is highly consistent with the concept of sustainable development. However, up to now, elevator safety ecological resilience governance has not been studied.

Under the guidance of sustainable development, the polycentric collaborative governance mode and social–ecological resilience paradigm play an important role in the process of elevator safety governance. Therefore, it is of great value to explore the following research problems, which can fill the gaps in relevant research. What are the governance subjects of the elevator safety polycentric collaborative governance model, and what are the system elements and mechanisms? What are the elements of elevator safety ecological resilience governance? Has the practice of polycentric collaborative governance mode improved the level of elevator safety governance? Does the influence of the subject of polycentric collaborative governance on the level of elevator safety governance differ? Do the system elements of elevator safety and ecological resilience influence each other? In order to answer these questions, this paper uses the conceptual framework method and structural equation model to analyze the system elements and mechanism of elevator safety polycentric collaborative governance and elevator safety ecological resilience and analyzes the impact of polycentric collaborative governance mode on elevator safety ecological resilience. The aim is to provide a quantitative basis and decision support for government departments to carry out elevator safety supervision and governance.

The main contributions of this paper are as follows: First, at the theoretical level. Based on the concept of sustainable development, we place the polycentric collaborative governance mode and the elevator safety ecological resilience governance paradigm in the same research framework and analyze its system elements and mechanisms. We constructed a framework of polycentric collaborative governance mode and elevator safety ecological resilience and enriched the literature on polycentric collaborative governance and resilience theory. Second, at the method level. This paper establishes a structural equation model, constructs the index system of polycentric collaborative governance and elevator safety ecological resilience, and designs a questionnaire and structural equation model scale. Third, at the empirical level. Based on the micro-survey data, the measurement model and structural models are used to verify the impact of the polycentric collaborative governance mode on the ecological resilience of elevator safety. It further verifies the influence of enhancing elevator safety ecological resilience on its constituent elements and the interaction relationship among the constituent elements of elevator safety ecological resilience. Under the guidance of sustainable development, the paper provides the basis for government departments to formulate elevator safety governance policies suitable for the polycentric collaborative governance mode and optimize the elevator safety governance mode.

The remainder of this paper is arranged as follows. Section 2 is devoted to a literature review. Section 3 is the theoretical mechanism and research hypothesis. Section 4 constructs the structural equation model, explains the meaning of variables, and designs the questionnaire and the structural equation model scale. Section 5 conducts an empirical analysis of the structural equation model. Section 6 presents research conclusions, policy recommendations, and limitations of the research.

2. Literature Review

2.1. Polycentric Collaborative Governance

Polycentric governance. British scholar Michael Polanyi first proposed the concept of "multi-center" in the book logic of freedom. Later, Elinor Ostrom and Vincent A. Ostrom introduced the concept of "multi-center" into the field of public affairs governance in the 1970s and emphasized the combination of polycentric and autonomous governance. China's research on 'multi-center' also started in the same period and gradually made some achievements in the fields of public crisis, public service, social governance, and regional collaboration [13–15]. Polycentric governance aims to construct a comprehensive governance system that includes the state, market, society, and citizens. For the framework of polycentric governance, western academicians mainly hold the view of rejecting the leading role of the government, while Chinese academic circles hold a neutral attitude towards polycentric governance and recognize the indispensable role of government governance.

Collaborative governance. Since the 1990s, the rapid rise of the wave of globalization has generated new challenges to the management-oriented new public management theory. The imbalance between public affairs governance needs and governance capabilities promotes the development of governance theory. Hermann Haken, a professor at the University of Stuttgart, Germany, is the founder of Synergetics. He claimed that "order and disorder generally exist in various things in nature and human society, and under certain conditions, the two transform into each other" [16]. The collaborative governance theory is the product of the cross-integration of the collaborative and governance theories. Coordination implies that subsystems cooperate with each other under the control of order parameters and form new structures and characteristics that do not exist in subsystems. Governance is a process in which government and nongovernment organizations use public rights to jointly manage public affairs through competition and cooperation [17]. The collaborative governance theory emphasizes the dominance of order parameters, self-organization of subsystems, diversity of governance subjects, coordination of governance subjects, and contingency of governance methods. The collaborative governance theory has achieved successful practice in politics, economics, management, sociology, and so on [18–21]. Cases such as the NOCR community pension model in the United States, the effective rescue of the Wenchuan earthquake in China, and the effective prevention and control of COVID-19 are the results of the collaborative participation of multiple forces. In terms of theoretical research, Western scholars' research on collaborative governance theory started relatively early and achieved more success. Numerous scholars have conducted research on collaborative governance from the perspectives of model interpretation [22–25] and application research [26–31]. As the Third Plenary Session of the 18th CPC Central Committee clearly proposed the relevant concepts of social governance, the collaborative governance theory provides new perspectives and ideas for China's social governance innovation. Moreover, the collaborative governance theory has become a hot spot of academic research in recent years [32–34]. Several scholars have conducted research on collaborative governance based on its purpose [35–39], characteristics [40–42], and paths [43–48].

Polycentric collaborative governance. The polycentric collaborative governance mode is the organic combination of polycentric governance mode and collaborative governance mode. In the early stage, the polycentric collaborative governance mode focuses on the application of public crisis management, non-profit organization management, and other fields. Since 2015, the polycentric collaborative governance mode has been mainly applied in aspects such as poverty management, environmental governance, urban agglomeration and urban community governance, network society governance, and corruption governance. Through the literature review of polycentric collaborative governance, this paper considers polycentric collaborative governance to be a multidimensional concept with rich connotations. The first connotation is the diversification of governance subjects. Numerous scholars have summarized the ruling party, the government, the National People's Congress, the Chinese People's Political Consultative Conference, the judiciary, people's organizations, social organizations, corporate organizations, mass media, and the public into three categories: government, market, and society. The second is the diversification of governance methods. Dialogue, negotiation, collective action, competition, and cooperation, among many subjects under multi-centered governance, are the main aspects of co-governance. Public–private partnerships are the main form of co-governance. The third is the diversification of governance objects. In the process of macro governance, such as politics, economy, culture, and society, one-sided economic governance may lead to a disconnect between economic governance and political governance, cultural governance, and social governance. The same is true for the micro-governance process; that is, the diversity of co-governance objects emphasizes the importance of collaboration and collaborative governance. The fourth is the diversification of governance structure. The governance structure reflects the essential connotation of multi-governance. Any organizational structure such as the state, society, and family needs governance, and governance varies from structure to structure. The vertical structure focuses on system governance, and the horizontal structure focuses on regional governance [49].

2.2. Elevator Safety Governance

Studies on elevator safety and elevator safety risk management in developed countries have been relatively mature. Countries, including the United States, the European Union, and Japan, have thoroughly studied aspects, such as comprehensive risk evaluation, elevator safety inspection, elevator safety maintenance, and other contents on the basis of elevator laws and standards practice [50–54]. Moreover, relevant international organizations have also carried out theoretical research on elevator safety risk assessment and have developed more than 20 types of elevator safety assessment methods, such as safety checklist and hazard index method [55–57]. In China, the research on elevator safety started late but developed rapidly. First, at the practical level. This research is guided by intelligent governance and intelligent supervision. For example, the China Special Equipment Inspection and Research Institute has built an elevator quality and safety traceability information platform to encourage enterprises to record the information related to the manufacturing, installation, maintenance, and inspection process of elevator products. Information technology is actively used to improve the efficiency of elevator safety supervision and governance. In recent years, with the goal of the intelligent supervision of elevator safety, various provinces have also carried out a lot of practical work on elevator safety risk governance [58,59]. For example, Nanjing Special Equipment Testing and Research Institute has developed an elevator intelligent management platform for the emergency treatment and analysis of elevator safety accidents. Fujian Special Equipment Inspection and Research Institute has developed a special equipment inspection integrated management system and a special equipment dynamic supervision information system for elevator inspection and supervision data management and data analysis practice. Second, at the theoretical level. Numerous studies by many scholars have theoretically studied the elevator safety risk evaluation system, risk evaluation method, and risk influencing factors [58,60–65]. For example, Niu Donghai used AHP to evaluate the safety of elevators utilized. The evaluation factors are divided into the first and second level factors, the evaluation factor judgment matrix is constructed, the weight vector is solved, and the evaluation content refined by the second level factors is scored on site, and then the safety evaluation score is calculated. Based on the fault tree method, Sun Yong analyzed a case of an elevator shearing accident caused by elevator operators entering the top of the elevator car. Du Zihao proposed an elevator safety evaluation method based on modified variable fuzzy sets.

According to the literature review, it can be found that the theoretical research and practical work of elevator safety governance are mainly based on risk theory. Moreover, the existing studies have mainly focused on micro research, and few studies have reported elevator safety governance at the macro level. Safety and security risk theory provides strong support for the optimization of elevator safety supervision and the governance mode, especially for the improvement of elevator safety risk evaluation methods, and promotes the elevator safety governance system to be more scientific and perfect. However, the safety and security risk theory presents some disadvantages in solving the macroscopic and global safety and security governance problems. Therefore, this paper constructs the polycentric collaborative governance mode of elevator safety, introduces the social resilience theory in the field of elevator safety governance for the first time, and further analyzes the relationship between them, which provides a macro perspective for better solving the problem of elevator safety governance.

2.3. Social Resilience Governance

With the increasing risks in economic growth, social development, urban management, and environmental protection, many scholars have studied resilience construction and governance in numerous studies [66–68]. For example, a study explored organizational resilience through KPIs. A study used the fuzzy Delphi method to verify the social sustainability indicators of green buildings in China. Resilience theory has evolved beyond the early engineering paradigm and ecological paradigm and has been developed into a social–ecological paradigm, which has been widely applied in disaster, crisis, and risk management in economic and social development. The connotation of social resilience refers to the ability of a social system to adjust, recover, and adapt when facing uncertainty and disturbance factors for maintaining the overall equilibrium state of the social system. Social resilience provides a new perspective for the operation and sustainable development of complex systems. It also lays a strong social foundation for the governance of Chinese-style risk societies, which are perfectly suitable for the "compound governance" structure formed through three mechanisms of the state, market, and society in risk governance [69]. Studies on social resilience have focused on various fields, and the current consensus can be summarized as follows: Social resilience belongs to the category of the social governance mechanism, which emphasizes the ability of social systems to adjust, recover, and adapt while facing external uncertainties and disturbances for maintaining the overall balance of the social structure. Social resilience can be analyzed from the perspectives of stability, redundancy, adaptability, and timeliness. However, social resilience has not been introduced in elevator safety governance, and research on the relationship between polycentric collaborative and social resilience governance is limited. The analysis of the factors that influence social resilience is not comprehensive and reasonable. In particular, the theoretical model and quantitative analysis of social resilience must be further expanded. Therefore, on the basis of field investigation and literature, combined with the actual situation of elevator safety governance, this study introduced social resilience theory in elevator safety governance for the first time and selected the comprehensive evaluation indicators of elevator safety resilience governance, which established a foundation for quantitative research.

3. Theoretical Mechanisms and Theoretical Hypotheses

The theoretical mechanism and research hypothesis were discussed mainly on the basis of field investigation and work experience. First, the system elements and mechanisms of the polycentric collaborative governance of elevator safety were discussed in detail, and then, the ecological resilience elements of elevator safety oriented by sustainable development were elaborated. Second, according to the system elements and mechanisms, the frame structure of the polycentric collaborative governance mode that affected the ecological resilience of elevator safety was established. Finally, the influence path was explained according to the framework structure, and then the research hypothesis was proposed.

3.1. Theoretical Mechanisms

3.1.1. System Elements of Elevator Safety Polycentric Collaborative Governance

By investigating elevator safety institutions such as Nanjing Special Equipment Inspection and Research Institute, Fuzhou Special Equipment Inspection and Research Institute, and Quanzhou Special Equipment Inspection and Research Institute, we find the root cause of elevator safety problems is the responsibility implementation of elevator-safety-governance-related subjects. However, in reality, elevator production units do not manage elevators, and elevator management units do not use elevators. There is a phenomenon of fuzzy responsibility between elevator-safety-related units, which causes the imperfect responsibility chain of elevator safety governance. Some scholars summarize the subject of elevator safety governance as government, elevator users, elevator maintenance units, elevator inspection, testing institutions, and insurance institutions, and put forward the concept of government, enterprises, and society-collaborative governance. Some scholars summarize the main body of elevator safety management as elevator manufacturing unit, elevator installation unit, elevator maintenance unit, and elevator inspection and testing unit. According to existing literature on the subject of elevator safety governance, it mainly includes government, business, and society. With the optimization of the social governance structure and the improvement of the governance mode, under the polycentric collaborative governance mode, the public has more ways to participate in social governance and can play a decisive role. For example, when an elevator accident occurs, what the public says and does has a significant impact on accident disposal [3,70,71].

Therefore, the public should also be one of the subjects of elevator safety governance. From a macro perspective, the polycentric collaborative governance system structure for elevator safety is divided into four subsystems. The first is the government subsystem. In the process of elevator safety governance, the government performs its duties in accordance with the law, promotes intelligent supervision and credit supervision, regulates and guides the orderly operation of the market, and leads the business, society, and public. The second is the business subsystem. In the process of elevator safety governance, the business abides by the law, provides high-quality elevator products, develops an elevator quality and safety guarantee system, and cultivates elevator operators with "high quality, high level, and high skills". In addition, it ensures the safety of the public in the process of taking the elevator and promotes the orderly development of the industry. The third is the society subsystem. In the process of elevator safety governance, the society provides technical support, inspection and testing, industry training and examinations, and industry self-discipline services. Furthermore, it empowers the government to conduct safety supervision work. The fourth is the public subsystem. In the process of elevator safety governance, through the mechanism of supervision and reporting complaints, the public can supervise the production, manufacturing, and operation of the business as well as report and complain about the illegal acts of the business.

The government subject subsystem, business subject subsystem, society subject subsystem, and public subject subsystem jointly constitute the framework of the polycentric collaborative governance mode. According to the elevator-safety-related policies and regulations and practical work experience, the subsystem elements of elevator safety polycentric collaborative governance can be analyzed from a micro perspective. The first is the government subsystem that includes the elements of governments and supervision departments at all levels. According to the Opinions of the Central Committee of the Communist Party of China and the State Council on Promoting the Reform and Development of Safety Production, governments at all levels should improve the implementation of the responsibility system for production safety, reform the safety supervision and supervision system, promote governance according to the law, establish a safety prevention and control system, and strengthen the building of basic safety guarantee capabilities. According to the Special Equipment Safety Law of the People's Republic of China, governments at all levels should establish coordination mechanisms to strengthen the leadership and supervision of elevator safety work. Based on the safety and security supervision principle of "managing the industry must manage safety, managing business must manage safety, and managing production and operation must manage safety", special equipment safety supervision, safety production supervision, housing and urban-rural development, transportation, health, and other departments should implement grading, classification, and whole-process safety supervision of elevators. The second is the business subsystem, which includes the elements of elevator manufacturers, elevator operation units, elevator users, elevator maintenance units, insurance institutions, and real estate developers. On the premise of obtaining business qualifications, the business of elevator manufacturers encompasses all aspects of the entire life cycle of elevator design, manufacturing, installation, transformation, and repair. The elevator manufacturing unit is responsible for the safety performance of elevator products. The elevator business unit is responsible for elevator sales, leasing, import, and export. According to the Product Quality Law of the People's Republic of China and the Civil Code of the People's Republic of China, the responsibilities of elevator manufacturers and elevator operation units are linked to each other, aiming to protect the rights and interests of elevator consumers. Elevator owners and property service units have management rights and obligations over the use of elevators. Moreover, different types of elevators have different use units. The newly installed elevators that have not been handed over to the elevator owner shall be used by the project construction unit. For the elevator entrusted to the property service unit for management, the user unit is the property service unit. For the elevator managed by the property unit itself, the use unit is the property unit. Elevator safety follows the rule of "three points depend on manufacturing, seven points depend on maintenance". The elevator manufacturing unit or the unit that has obtained the maintenance qualification is responsible for the daily safety performance and emergency rescue of the elevator. Through elevator safety liability insurance, professional liability insurance, and other insurance types, the insurance unit acts as an insurer to settle claims for elevator safety accidents that occur to the insured. The real estate developer is responsible for the quality of the elevator machine room, shaft, pit, and other engineering construction, as well as elevator selection and configuration during the procurement process, which are the basis of elevator quality and safety. The third is the society subsystem, which includes the elements of elevator inspection and testing institutions, elevator industry associations, and mainstream media. The elevator safety inspection and testing institution are responsible for statutory inspection, technical identification, and safety risk assessment of elevator safety. China Elevator Association, China Promotion Association for Special Equipment Safety and Energy-Saving, and China Association of Special Equipment Inspection are responsible for elevator safety publicity and consultation, examination training, technical identification, and standard formulation. Relevant mainstream media popularize industry safety knowledge and achievements through publicity and guidance, as well as supervise and warn by reporting and analyzing elevator accidents. The fourth is the public subsystem, which includes the elements of social public and industry self-media. In public places, the public has the dual identity of free residence elevator co-owner and elevator users. The unsafe behavior of the public is a potential hazard to elevator safety, which directly results in elevator accidents. With the continuous development of Internet technology, the public can participate in and exercise the right to the information and supervision of elevator safety governance through industry we-media. The public can also interact with the mainstream media and influence the progress of elevator safety accident treatment.

3.1.2. System Mechanisms of Elevator Safety Polycentric Collaborative Governance

System elements are the basis of the elevator safety polycentric collaborative governance system, and system mechanisms are the driving force of the polycentric collaborative governance mode that affects the elevator safety governance level.

(1) Mechanisms of the government subsystem

The operation mechanisms of the government subsystem encompass responsibility implementation, policy guarantee, administrative licensing, supervision and inspection, emergency rescue, punishment, departmental linkage, information disclosure, government assistance, and publicity and education.

Specifically, the root of elevator safety is in the responsibility implementation mechanism. The responsibility implementation mechanism indicates that during polycentric collaborative governance for elevator safety, the party committee and government undertake leadership responsibility, relevant businesses undertake entity responsibility, and relevant departments undertake the supervisory responsibility. The government and regulatory departments supervise the technical service responsibilities of the elevator manufacturers, supervise and urge the maintenance units to provide satisfactory maintenance and emergency rescue work and supervise the daily inspection work of the elevator owners. The legal supervision system, policies, as well as regulations, technical safety specifications, and national standards provide the basis and guarantee of elevator safety governance. The policy guarantee mechanism refers to the fact that government entities conduct elevator safety supervision in accordance with the laws and technical regulations. The levels of active safety and intrinsic safety are improved by establishing a legal supervision system, improving policies and regulations, and optimizing technical specifications and standards for elevator safety. The administrative licensing mechanism includes the production license of the elevator production unit, approval and registration of the elevator user unit, business license of the elevator operating unit, qualification assessment of the elevator operators, and elevator elimination and scrapping mechanism. The supervision department shall supervise and inspect the life cycle of elevator design, manufacturing, operation, use, maintenance, inspection, and testing. The supervision and inspection mechanism implies that the supervision department supervises and inspects elevator quality and safety issues as well as violations of laws and regulations based on compulsory inspection, on-site inspection, administrative law enforcement, and accident investigation and handling systems. The emergency rescue mechanism means that local governments at all levels coordinate the elevator intelligent emergency rescue work through the "96333" elevator emergency rescue platform, rescue public service platform, and elevator safety intelligent supervision system to improve emergency rescue efficiency, reduce safety accident losses and improve elevator safety emergency rescue system. In the process of elevator safety governance, the mechanism of punishment refers to the measures taken by the government based on the Special Equipment Safety Law of the People's Republic of China and Regulations on Safety Supervision of Special Equipment (Decree No. 549 of The State Council of the People's Republic of China) to stop elevator safety violations, to stop illegal activities, confiscate illegal gains, impose fines, and other measures. The departmental linkage mechanism emphasizes that the relevant departments of elevator safety governance should strengthen work coordination. Through the overall linkage of the market supervision department, the housing construction department, and the public security department, as well as the overall linkage of the property management department, the owner, and the maintenance unit, the human, financial and material resources are concentrated to jointly improve the level of elevator safety management. The information disclosure mechanism refers to the timely disclosure of elevator laws and regulations, policy standards, and industry market information based on the annual government bulletin, official website, academic literature, and new media channels. Furthermore, through this mechanism, information supply channels should be broadened, and the public's right to elevator safety information should be protected. The government rescue mechanism means that the government solves the problem of insufficient funds for the renovation of elevators in old communities by establishing a subsidy and relief mechanism in a timely manner and opening up a dedicated channel for maintenance funds. The mechanism of publicity and education means that the regulatory authorities increase the efforts to popularize elevator safety laws through various media and channels, create an atmosphere of understanding the law, abide by the law, use it in the society, and popularize the knowledge of safe elevator rides.

(2) Mechanisms of the business subsystem

The operation mechanisms of the business subsystem encompass quality, procurement, salary mechanism, craftsman, credit, price, and insurance.

Specifically, the quality mechanism means that based on the scrap and recall system, the elevator production unit and the user unit optimize the elevator quality and safety guarantee system, improve the product quality level and provide high-quality services. The procurement mechanism means that the maximum level of safety in the entire life cycle of the elevator is improved through the procurement and maintenance modes based on "equipment + maintenance", "Internet of things (IoT) + maintenance", "full cycle maintenance", and so on. The salary mechanism means that more high-quality elevator operators are attracted by increasing compensation and benefits, improving the salary structure, and increasing incentives for employees. The craftsman mechanism means that the ability evaluation and assessment method of elevator employees is optimized. Moreover, the improvement of theoretical knowledge and practical operation ability of elevator employees is strengthened based on the personnel training mechanism of "high quality, high ability, and high level". The credit mechanism means that a long-term supervision mechanism for elevator safety is established, an elevator IoT safety service platform is created, and elevator safety credit supervision is promoted [72]. A safety evaluation model is constructed to form a credit evaluation index system for elevator maintenance units, manufacturing units, users, inspection units, and maintenance personnel by collecting, summarizing, and analyzing information and data on daily elevator operation, maintenance, and emergency rescue. The price mechanism refers to breaking market information asymmetry by establishing a fair price mechanism for elevator products and services. The transparency of price information is improved through the horizontal and vertical evaluation of product quality and price inside and outside the industry. The insurance mechanism refers to the "insurance + service" mode of elevator safety governance to encourage and guide elevator maintenance units, users, and other parties to participate in elevator safety governance. The insurance institution shall be liable for compensation for personal injury and property loss of the third party as well as personal injury or property loss of the elevator operator. Further, the participation of insurance institutions in the investigation and disposal of elevator emergencies can provide full play to their advantages as a third party and promote the efficient development of investigation and disposal work [73].

(3) Mechanisms of the society subsystem

The operation mechanisms of the society subsystem include technical support, training and education, industry self-discipline, and news publicity.

Specifically, the technical support mechanism is based on the safety supervision mode of the "dual-track system" of elevator safety supervision and inspection. The social inspection force is gradually introduced to improve the technical support ability of elevator safety inspection by optimizing the elevator safety inspection mode, inspection items, and inspection cycle. The training and education mechanism means that the training and education of elevator safety laws and regulations, elevator safety policies and awareness, and elevator emergency rescue knowledge, are carried out by elevator safety industry associations. The industry self-discipline mechanism means that the elevator industry association regulates the behavior of the elevator industry by regularly organizing moral integrity and vocational skills training, increasing the publicity and implementation of elevator safety regulations and standards, regularly organizing enterprise exchanges in the elevator industry, and exposing elevator safety faults and hidden dangers. The news mechanism means that the mainstream media regularly publicize elevator safety knowledge and achievements, promptly expose elevator property units, maintenance units, and user units with high complaint rates, and track, report, and analyze elevator safety incidents in a timely manner.

(4) Mechanisms of the public subsystem

The operation mechanisms of the public subsystem encompass supervision and participation, speech, complaints, and reporting.

Specifically, the supervision and participation mechanism refers to improving the mechanism of public opinions, suggestions, complaints, and reporting, as well as strengthening the benign interaction between the public and regulatory authorities. Furthermore, through the post-evaluation of elevator safety laws, regulations, and industry policies, the public should be motivated, and the government should be assisted in addressing elevator safety issues. The mechanism of speech means that the public focuses on the progress of elevator safety accidents through legal network platforms such as new media and self-media, expresses personal opinions, and participates in discussions. The regulatory authorities take timely measures to avoid the negative effect of elevator safety accidents through a statistical analysis of public speech and online public opinion information. The complaint-reporting mechanism refers to the public reporting illegal behaviors observed in the process of elevator safety governance through means such as the complaint hotline, complaint website, complaint mailbox, Weibo, and WeChat. The government departments deal with public comments and suggestions in a timely and effective manner.

3.1.3. Ecological Resilience Governance of Elevator Safety from the Perspective of Sustainable Development

(1) Sustainable development and elevator safety governance

The World Commission on Environment and Development defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Sustainability science focuses on solving systemic problems such as the manner in which natural and social dimensions intersect, social changes affect the natural environment, and changes in the natural environment shape social states. Sustainable development is a concept, form, process, way of life, and revolution [74]. The survival, environmental, development, security, and energy crisis under the community with a shared future for mankind are no longer a single, isolated crisis but a systemic crisis. In practice, the Sustainable Development Goals (SDGs) Agenda was signed at the United Nations Sustainable Development Summit in 2015, and a package of SDGs including 17 goals, 169 sub-goals, and 232 indicators was formally proposed. SDGs emphasize the coordinated development of the three dimensions of economy, society, and environment and are more systematic and extensive in goal setting, thereby proposing the direction for the development of countries worldwide in the next 15 years [75]. If we understand elevator safety from the perspective of sustainable development, we should focus on the comprehensiveness of elevator safety governance. First, elevator safety governance should prioritize people’s security and focus on people’s life security, mental health, and happiness index [76]. Second, elevator safety governance should establish an ecological resilience mechanism for elevator safety, integrate social resources, enhance learning ability and adaptability, and realize self-organization management of the safety governance system. Third, the process of elevator safety governance "before, during and after the event" as well as the governance concept of "economy, society and environment" should be established to improve the elevator safety risk prevention and resistance ability. Fourth, the focus should be placed on elevator safety accident prevention and normalized management of safety incidents to realize the change from focusing on reducing accident losses to focusing on reducing safety risks and from passive safety governance to active safety governance. At the same time, the investigation and management of elevator safety risks and safety risk prevention measures should be strengthened.

(2) Social resilience and elevator safety governance

As the focus on social governance continues to sink, the complexity, vulnerability, and sensitivity of elevator safety governance continue to increase. Improving the mechanism for dealing with elevator safety risk governance under the concept of sustainable development is essential to cope with the complex and diverse risks of elevator safety governance, improve the elevator safety governance system, and enhance the efficiency of elevator safety management. At the same time, the awareness of "full life cycle governance" and "safety ecological resilience governance" should be established. The concept of "resilience" first appeared in the fields of engineering, physics, and ecology. It refers to the ability of a material to absorb energy during plastic deformation and rupture and its response to external environmental stress. Since the 1990s, the concept of resilience has been introduced into the field of social governance, and concepts such as "resilient city" and "resilient organization" have emerged. It was then introduced into complex social–ecological systems, representing a "change-adapt-change" ability inspired by the system's response to pressures and constraints. At this stage, resilience governance based on the perspective of disaster management is a type of "stability-recovery-adaptation" ability. Resilience theory has also gradually expanded from the field of ecology to the field of social ecology. Socio-ecological resilience comes from the paradigms of sustainable development, social fragility, ecological balance, and structural functionalism [77–79]. It satisfies prevention, emergency response, and reconstruction and reflects the ability to actively respond to, digest disasters, and self-recovery. From a macro perspective, the theoretical basis for the components of social–ecological resilience includes community capacity, resilience, adaptive capacity, coping capacity, learning capacity, 4R capacity (robustness, redundancy, resourcefulness, rapidity), and broad and narrow sense capacity theories. Accordingly, the connotation of social–ecological resilience can be summarized as follows: a system, community, or society exposed to disasters or risks has the ability to maintain its original state or a better new state through confrontation or adjustment [79]. From a micro perspective, social–ecological resilience is the ability of society to predict, prepare, and respond, emphasizing the ability to absorb disturbances and recover after disasters as well as the ability to rebuild, learn, and innovate social systems [80–82].

(3) Elements of elevator safety ecological resilience from the perspective of sustainable development

The socio-ecological resilience system is a closed-loop system that, over time, is divided into four links: mitigation, recovery, learning, and coping. Corresponding to it are the elements of mitigation, recovery, learning, and coping abilities. From a natural perspective, mitigation ability refers to the ability of system objects to maintain the state before being disturbed, the ability to prepare before disasters, and automatically adjust after disasters. Recovery ability is the ability of system objects to return to work and recover from disturbances and pre-disaster conditions. From a humanistic perspective, learning ability refers to the ability of system subjects to actively accumulate experience in response to disturbances and disasters to the system to reduce risks. Coping ability is the reconstruction and recovery work of the system subject to the disaster-stricken state of the system on the basis of learning ability. At the same time, the system's mitigation, recovery, learning, and coping abilities are closely linked. The original functions of a social system with strong buffering and recovery abilities can be quickly restored, even if it is affected by external disturbances and disasters. Moreover, social systems require active mitigation and recovery and should actively learn from disasters and risks. Better learning and coping abilities enable social systems to effectively withstand the effects of future or potential disasters and risks [79,83,84].

Hence, the elements of social–ecological resilience should be introduced into the field of elevator safety governance, and elevator safety governance should be executed on the basis of resilience. At the macro level, the relevant subjects of elevator safety governance should be clarified. Moreover, the life cycle safety supervision concept of elevator design, manufacturing, installation, transformation, repair, use, operation, and inspection should be optimized from the perspective of government supervision. The ecological resilience of elevator safety should cover natural and social factors. This paper develops the natural factors of elevator safety ecological resilience from mitigation and recovery abilities and develops the social factors of elevator safety ecological resilience from learning and coping abilities. Specifically, the elements of elevator production, operation, and use for the ecological resilience of elevator safety are constructed from the perspective of businesses and users. From the perspective of inspection agencies, the elements of elevator inspection and testing are constructed. From the perspective of government and supervision, the elements of elevator safety supervision, accident emergency rescue, accident investigation, and accident handling are developed. In addition, based on some special aspects of elevator equipment, such as selection and configuration, the elements of ecological resilience for elevator safety are analyzed separately.

From the perspective of natural science, based on the three dimensions of the material environment, institutional system, and social economy under the direction of sustainable development, the mitigating ability is analyzed from factors such as material resources, climate environment, selection and configuration, elimination and scrap, technology, and use management. Recovery ability is analyzed from factors such as monitoring of resources, internal management, multi-governance, population, regulations, standards, economic development, and other factors. From the perspective of social science, based on the three dimensions of the material environment, institutional system, and social economy under the direction of sustainable development, learning ability is analyzed from factors such as inspection and testing, maintenance, risk early warning, safety investment, and emergency rescue. Recovery ability is analyzed from factors such as publicity, insurance compensation, safety acceptance, and safety restoration. These factors together constitute the factors determining the ecological resilience of elevator safety.

3.2. Theoretical Hypotheses

According to the theoretical mechanism, the elevator safety polycentric collaborative governance is a composite governance mode including the government, society, business, and the public. Elevator safety ecological resilience is a composite governance paradigm that includes multiple subsystems of mitigation ability, recovery ability, learning ability, and coping ability. Based on the system elements and mechanisms of the two, the framework structure of the polycentric collaborative governance mode affecting elevator safety and ecological resilience is constructed as shown in Figure 1. The subject of polycentric collaborative governance affects each dimension of elevator safety ecological resilience based on system mechanisms.

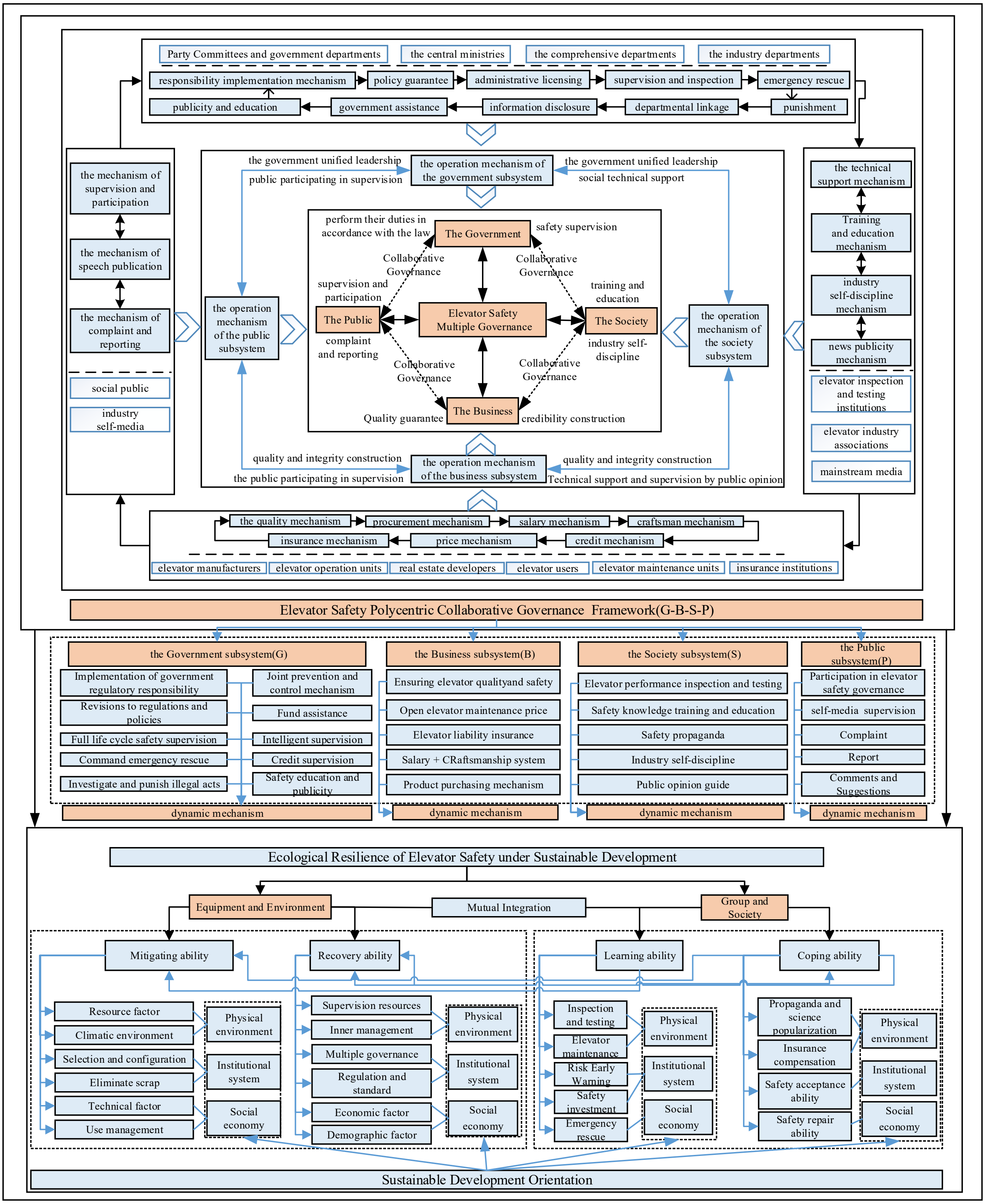

Figure 1. The conceptual framework of polycentric collaborative governance mode affecting ecological resilience of elevator safety.

Under the polycentric collaborative governance mode, the government, business, society, and the public constitute the elevator safety collaborative governance system based on mutual contact, mutual cooperation, mutual restraint, and mutual game. The core of the elevator safety polycentric collaborative governance mode is to form a system structure of "the enterprises taking primary responsibility, local governments exercising unified leadership, supervision departments performing their duties according to law, inspection institutions offering technical support, industry associations providing self-regulatory services, and the public participating in supervision" through cooperation among various subjects. By providing play to the role of all relevant subjects in elevator safety governance, the work pattern of multiple governances is gradually formed. In the process of polycentric collaborative governance of elevator safety, the government subject performs its duties according to law, carries out elevator safety supervision, guides the market order, and uniformly leads the subject of enterprises, society, and the public. The business subject shall abide by laws and regulations, operate in good faith, establish the elevator quality and safety traceability and guarantee system, train high-quality and competent elevator operators, and ensure the safety of the social public. The society subject provides elevator technical support and quality services. Improve the elevator safety level through detection and inspection, training and education, self-discipline services, and other measures, and empower the government to supervise the relevant behaviors of enterprises. By participating in supervision and reporting complaints, the public subject actively supervises the production, manufacturing, operation, and other behaviors of the business, reports, and complaints about illegal behaviors of the business. All in all, the mechanisms in the polycentric collaborative governance of elevator safety are not one-to-one correspondence with each subject. It is led by one party, and other relevant parties participate in, perform their duties, and jointly act on elevator safety governance.

Under the concept of sustainable development, from the physical environment, institutional system, and social economy, elevator safety ecological resilience includes mitigation ability, recovery ability, learning ability, and coping ability. Among them, the elements of mitigation ability include resource and climate factors in the physical environment dimension, elevator selection, elimination and scrapping factors in the institutional system dimension, the technical dimension, and using management factors in the social economy dimension. The elements of recovery ability include supervision resources and internal management factors in the physical environment dimension, multiple co-governance, laws, regulations, and standards in the institutional system dimension, and economic and population factors in the social economy dimension. The elements of learning ability include inspection, testing, and maintenance factors in the physical environment dimension, risk warning and safety input factors in the institutional system dimension, and emergency rescue factors in the social economy dimension. The elements of coping ability include the publicity and popularization of science and insurance compensation in the physical environment dimension, safety acceptance factors in the institutional system dimension, and safety repairing factors in the social economy dimension. The elements of mitigation ability and recovery ability mainly affect the equipment and environment, while the elements of learning ability and coping ability mainly affect the group and society.

Hence, it can be said that the elevator safety ecological resilience framework overcomes the main problems existing in the elevator safety risk theory. The elevator safety resilience framework distinguishes mitigation ability, recovery ability, learning ability, and coping ability and comprehensively analyzes the factors before, during, and after accidents. The importance of learning ability and coping ability in dealing with elevator safety accidents is highlighted, and the possible damage caused by elevator accidents is considered more comprehensively. Mitigation ability and recovery ability are mainly from the perspective of natural physics while learning ability and coping ability are mainly from the perspective of humanity and society, both of which belong to the research ideas from the macro perspective. This method breaks through the previous elevator safety evaluation method, which is limited to the micro perspective, and improves the scientific and rational evaluation method.

In the process of enhancing the ecological resilience of elevator safety, more targeted measures of elevator safety governance can be put forward from a macro perspective.

According to the frame structure, in order to enhance the ecological resilience of safety elevators, it is necessary to find the key driving point first. The subject of polycentric collaborative governance for elevator safety includes the government, business, society, and the public. The government exercises the responsibility of normative guidance and safety supervision in elevator safety governance. The business is responsible for elevator quality safety and integrity construction. Society plays the functions of elevator safety publicity, training and examination, and inspection and testing. The public participates in elevator safety supervision. Therefore, the four subjects in the polycentric collaborative governance mode are the key driving points for enhancing the ecological resilience of elevator safety. Accordingly, Hypotheses 1-1 to 1-4 are proposed in this paper.

Hypothesis 1-1 (H1-1). *The government subject is the key element that enhances the ecological resilience of elevator safety.*

Hypothesis 1-2 (H1-2). *The business subject is the key element that enhances the ecological resilience of elevator safety.*

Hypothesis 1-3 (H1-3). *The society subject is the key element that enhances the ecological resilience of elevator safety.*

Hypothesis 1-4 (H1-4). *The public subject is the key element that enhances the ecological resilience of elevator safety.*

According to the frame structure, the ecological resilience of elevator safety is determined by the four dimensions of mitigation, recovery, learning, and coping abilities. Based on the 4R theory of ecological resilience, mitigation ability is the embodiment of resilience maintenance and resilience restoring ability. Recovery ability is the embodiment of resilience restarting ability. Learning ability refers to the resilience ability of the social system to adapt to the disturbance state and the ability to learn and deal with and reduce risks. Coping ability refers to the ability of the system to learn, change, recover, and rebuild after disturbance. Therefore, the four elements of elevator safety ecological resilience are a closed loop system, which is also related to enhancing elevator safety ecological resilience. According to this, Hypothesis 2-1 to Hypothesis 2-4 are proposed in this paper.

Hypothesis 2-1 (H2-1). *Strengthening the ecological resilience of elevator safety can improve mitigation ability.*

Hypothesis 2-2 (H2-2). *Strengthening the ecological resilience of elevator safety can improve recovery ability.*

Hypothesis 2-3 (H2-3). *Strengthening the ecological resilience of elevator safety can improve learning ability.*

Hypothesis 2-4 (H2-4). *Strengthening the ecological resilience of elevator safety can improve coping ability.*

As mentioned above, the ecological resilience system of safety is dynamic, complex, and nonlinear. The factors between the natural and social environment in the system are cross-integrated; that is, the components of social–ecological resilience are mutually influenced. Similarly, there may be mutual influence among the components of elevator safety and ecological resilience. Based on the conceptual framework, when learning ability is enhanced, mitigation ability, recovery ability, and coping ability are also likely to be enhanced. There may be situations where learning ability affects mitigation ability, recovery ability, and coping ability; coping ability affects mitigation ability and recovery capacity; mitigation ability affects recovery ability.

According to this, Hypothesis 3 to Hypothesis 5 are proposed in this paper.

Hypothesis 3-1 (H3-1). *Improving learning ability will improve mitigation ability;*

Hypothesis 3-2 (H3-2). *Improving learning ability will improve recovery ability;*

Hypothesis 3-3 (H3-3). *Improving learning ability will improve coping ability;*

Hypothesis 4-1 (H4-1). *Improving coping ability will improve mitigation ability;*

Hypothesis 4-2 (H4-2). *Improving coping ability will improve recovery ability;*

Hypothesis 5 (H5). *Improving mitigation ability will improve recovery ability.*

To sum up, this paper considers that the following theoretical situations exist in the process of elevator safety governance: (1) polycentric governance directly affects the ecological resilience of elevator safety; (2) enhances elevator safety and ecological resilience, which in turn will affect elevator safety mitigation ability, recovery ability, learning ability and coping ability; (3) the elements of elevator safety ecological resilience system interact with each other.

The path of polycentric collaborative governance affecting elevator safety and ecological resilience is presented in Figure 2.

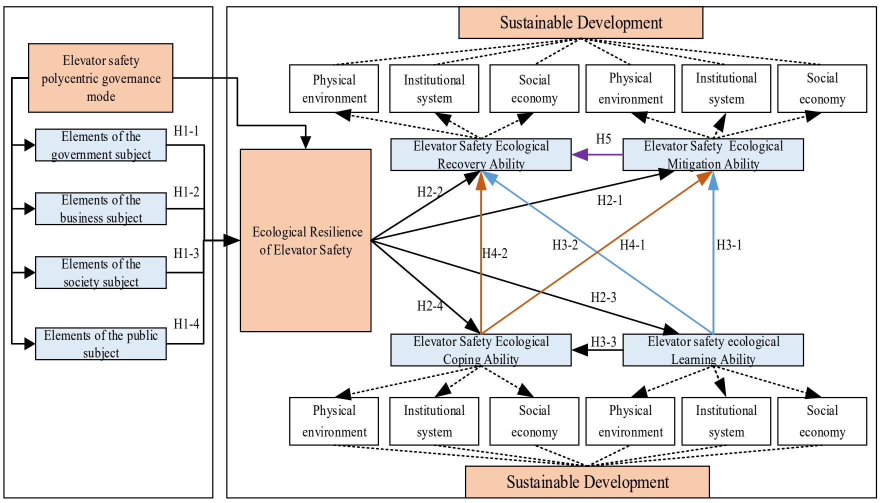

Figure 2. The path of polycentric collaborative governance affecting the ecological resilience of elevator safety.

4. Research Methods and Data Sources

4.1. Research Methods

4.1.1. Construction of the Structural Equation Model

On the basis of theoretical mechanism analysis, an SEM model is constructed to empirically test the proposed research Hypotheses 1 to 5. Structural equation model, also known as latent variable model, is a kind of excellent multivariate data analysis method, and its essence is simultaneous econometric model. Compared with the general linear model, the structural equation model has the following advantages: First, the structural equation model is divided into measurement model and structural model, which can be used to integrate data measurement and data analysis. This model is an extension of the general linear model. Second, the structural equation model can be simultaneously used to deal with complex multi-variable research data and the measurement errors of latent and observed variables. The variance-covariance model can be used to estimate the parameters and reflect the real relationship among multiple variables. Third, the structural equation model can be utilized to identify, estimate, and test various causal models based on causal theory and to express the relationship among variables in the form of the path graph and causal pattern. The study of the relationship among observed variables to investigate the relationship among latent variables, which are difficult to be quantified, can effectively solve the problem of inability to directly measure latent variables.

The measurement model comprises latent and observed variables, reflecting the relationship between the two. Latent variables are unobservable variables, which are divided into intrinsic and extrinsic latent variables. It is mainly reflected by the data content measured by the observed variables. The intrinsic latent variable is the dependent variable in the path analysis, and the extrinsic latent variable is the independent variable in the path analysis. Based on the analysis of the ways in which polycentric collaborative governance mode affects elevator safety and ecological resilience, the proposed measurement model is shown in Formulas (1) and (2).

$$X = \Lambda_X \xi + \delta \quad (1)$$

$$Y = \Lambda_Y \eta + \varepsilon \quad (2)$$

In Formula (1), the extrinsic latent variable ξ includes element of the government subject ξ_1, element of the business subject ξ_2, element of the society subject ξ_3, and element of the public subject ξ_4. X is the observed variable matrix corresponding to the extrinsic latent variable ξ, which is composed of the mechanism content of elevator safety polycentric collaborative governance mode. Λ_X is the factor load coefficient matrix of the observed variable corresponding to the extrinsic latent variable ξ. δ is the measurement error matrix. In Formula (2), the intrinsic latent variable η includes mitigation ability η_1, recovery ability η_2, learning ability η_3, coping ability η_4, and ecological resilience of elevator safety η_5. Y is the observed variable matrix corresponding to the intrinsic latent variable η, which is composed of the content of the ecological resilience evaluation index system of elevator safety. Λ_Y is the factor loading coefficient matrix of the observed variable corresponding to the intrinsic latent variable η. ε is the measurement error matrix. Furthermore, ξ is independent of δ, η is independent of ε, $E(\xi) = 0$, $E(\delta) = 0$, $E(\eta) = 0$, $E(\varepsilon) = 0$.

The structural model presents the causal relation between latent variables, reflecting the relationship between latent variables and latent variables. The structural model constructed in this paper is presented in Formulas (3) to (7).

$$\eta_1 = \beta_{11}\eta_3 + \beta_{12}\eta_4 + \beta_{13}\eta_5 + \zeta_1 \quad (3)$$

$$\eta_2 = \beta_{21}\eta_1 + \beta_{22}\eta_3 + \beta_{23}\eta_4 + \beta_{24}\eta_5 + \zeta_2 \quad (4)$$

$$\eta_3 = \beta_{31}\eta_5 + \zeta_3 \quad (5)$$

$$\eta_4 = \beta_{41}\eta_3 + \beta_{42}\eta_5 + \zeta_4 \quad (6)$$

$$\eta_5 = \gamma_{51}\xi_1 + \gamma_{52}\xi_2 + \gamma_{53}\xi_3 + \gamma_{54}\xi_4 + \zeta_5 \quad (7)$$

In Formula (3) to formula (7), γ is the influence of the extrinsic latent variable ξ on the intrinsic latent variable η, β is the influence of the intrinsic latent variable η on the intrinsic latent variable η, ζ is the residual term or error term, it is the error value that cannot be predicted or explained in the structural model and there is no correlation between ζ_1 to ζ_5, $E(\zeta) = 0$.

4.1.2. Index Selection of Structural Equation Model

The SEM model constructed in this paper contains 4 extrinsic latent variables $(\xi_1, \xi_2, \xi_3, \xi_4)$, 5 intrinsic latent variables $(\eta_1, \eta_2, \eta_3, \eta_4, \eta_5)$ and 52 observed variables $(X_1, X_2, \ldots, X_{23}, X_{24}; Y_1, Y_2, \ldots, Y_{27}, Y_{28})$. Specifically, it includes 9 dimensions: government subject, business subject, social subject, public subject, elevator safety ecological resilience, elevator safety mitigation ability, recovery ability, learning ability, and coping ability, and that is the first-level index of structural equation model. The 9 first-level indexes are decomposed into 52 second-level indexes. The indicator system of the elevator safety ecological resilience influenced by polycentric collaborative governance mode is formed, as shown in Table 1.

Table 1. Indicator system of polycentric collaborative governance mode affecting elevator safety ecological resilience.

Extrinsic Latent Variable	**Observed Variable**		**Intrinsic Latent Variable**	**Observed Variable**	
First Level Indicator	**Second Level Indicator**	**Symbol**	**First Level Indicator**	**Second Level Indicator**	**Symbol**
Government Subject ξ_1	Responsibility implementation mechanism	X_1	Elevator Safety Ecological Mitigation Ability η_1	Elevator density	Y_1
	policy guarantee mechanism	X_2		Climate conditions	Y_2
	administrative licensing mechanism	X_3		Gathering situation of elevators in public places	Y_3
	supervision and inspection mechanism	X_4		Old elevator condition	Y_4
	emergency rescue mechanism	X_5		Casualties of elevator passengers	Y_5
	punishment mechanism	X_6		Qualified situation of elevator inspection and testing	Y_6
	departmental linkage mechanism	X_7		Elevator safety hidden danger situation	Y_7
	information disclosure mechanism	X_8	Elevator safety Ecological Recovery Ability η_2	Staffing of elevator safety supervisors	Y_8
	government assistance mechanism	X_9		Elevator safety inspection situation	Y_9
	publicity and education mechanism	X_{10}		Work level of elevator safety government departments	Y_{10}
Business Subject ξ_2	quality mechanism	X_{11}		Public awareness of elevator safety	Y_{11}
	procurement mechanism	X_{12}		The state of judicial development	Y_{12}
	salary mechanism	X_{13}		Economic development	Y_{13}
	craftsman mechanism	X_{14}		Density of population	Y_{14}
	credit mechanism	X_{15}	Elevator Safety Ecological Learning Ability η_3	Elevator safety inspection personnel allocation	Y_{15}
	price mechanism	X_{16}		Regular inspection of elevator safety	Y_{16}
	insurance mechanism	X_{17}		Elevator safety operation personnel allocation	Y_{17}

Table 1. *Cont.*

Extrinsic Latent Variable	Observed Variable		Intrinsic Latent Variable	Observed Variable	
First Level Indicator	**Second Level Indicator**	**Symbol**	**First Level Indicator**	**Second Level Indicator**	**Symbol**
Society Subject ξ_3	technical support mechanism	X_{18}	Elevator Safety Ecological Learning Ability η_3	Elevator safety maintenance personnel allocation	Y_{18}
	training and education mechanism	X_{19}		Funds of elevator safety inspection institutions	Y_{19}
	industry self-discipline mechanism	X_{20}		Elevator safety informatization construction	Y_{20}
	news publicity mechanism	X_{21}		Elevator safety emergency rescue timeliness situation	Y_{21}
Public Subject ξ_4	supervision and participation mechanism	X_{22}		Elevator safety emergency rescue level	Y_{22}
	speech publication mechanism	X_{23}	Elevator Safety Ecological Coping Ability η_4	Attention situation of elevator safety network public opinion	Y_{23}
	complaint and reporting mechanism	X_{24}		Elevator safety mainstream media attention	Y_{24}
				Public satisfaction of elevator safety accident handling	Y_{25}
				Owner satisfaction of elevator safety management	Y_{26}
				Government assistance for old elevators	Y_{27}
				Development of elevator safety insurance	Y_{28}
	Ecological Resilience of Elevator Safety η_5				

According to the theoretical mechanism and frame structure, and combined with the conclusion of field research, the second level indicators are selected. The secondary indicators for the government subject are selected from 10 dimensions such as responsibility implementation, policy guarantee, and administrative license. The secondary indicators for the business subject are selected from 10 dimensions such as the quality mechanism, procurement mechanism, and salary mechanism. The secondary indicators for the society subject are selected from 4 dimensions such as technical support, training and education, industry self-discipline, and news propaganda mechanism. The secondary indicators for the public subject are selected from 3 dimensions such as supervision participation, speech publication, and complaint reporting.

In order to measure the elevator safety mitigation ability, seven secondary indicators, such as elevator density, are selected from three dimensions of physical environment, institutional system, and social economy. In order to measure the elevator safety recovery ability, seven secondary indicators, such as the staffing of elevator safety supervisors, are selected from the three dimensions of physical environment, institutional system, and social economy. In order to measure the elevator safety learning ability, eight secondary indicators such as elevator safety periodic inspection were selected from three dimensions of physical environment, institutional system, and social economy. In order to measure the coping ability of elevator safety, six secondary indicators, such as the attention of online public opinion on elevator safety, are selected from three dimensions of physical environment, institutional system, and social economy.

4.1.3. Questionnaire Design of Structural Equation Model

The data used in this paper are all from the survey questionnaire. According to the research hypothesis and index system, the questionnaire was designed to obtain the SEM model empirical data. The questionnaire includes two parts: basic information and question survey. Among them, the first part of the questionnaire is basic personal information, including age, education background, working time, and unit attributes. The second part of the questionnaire is question survey. The polycentric governance mode of elevator safety includes 24 questions, and the ecological resilience of elevator safety includes 28 questions. It is known that the latent variables of SEM model need to be measured by observation variables (or indexes). The measurement indexes of structural equation model are mostly discontinuous, continuous, and category indexes, which are usually subjective assigned data [85]. Therefore, the observed variables were measured using a 5-point Likert Scale of semantic difference. Based on this, the original data of subjective assignment are obtained. Specific questions and assignment criteria of observed variables are shown in Tables 2 and 3.

Take the assignment of variable X_1, for example. Assign values according to the results of the questionnaire. The question item is set as: "The main body of the government fails to implement the responsibility implementation mechanism well". When the surveyed think: the actual situation is very inconsistent with the problem item, then $X_1 = 5$; the actual situation is inconsistent with the problem item, then $X_1 = 4$; the actual situation is generally consistent with the problem item, then $X_1 = 3$; the actual situation is consistent with the problem item, then $X_1 = 2$; the actual situation is very consistent with the problem item, then $X_1 = 1$.

Meanwhile, according to the theoretical mechanism and SEM model variables, the SEM path diagram is drawn, as shown in Figure 3. Based on the path empirical analysis, load coefficient and influence coefficient are obtained.

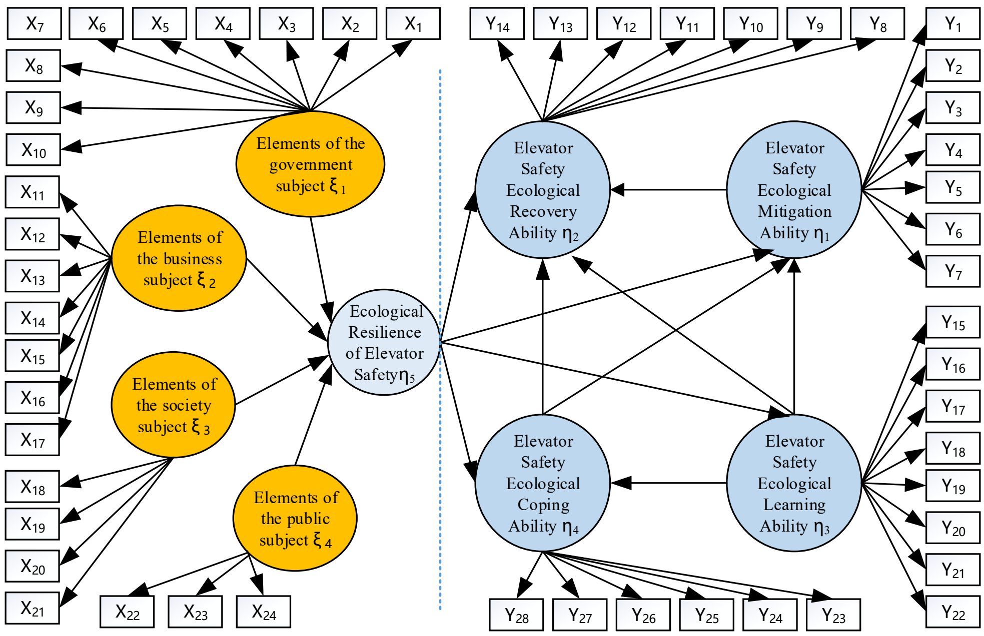

Figure 3. The SEM path of polycentric collaborative governance affecting the ecological resilience of elevator safety.

Table 2. Index system and survey questionnaire scale of elevator safety polycentric collaborative governance mode.

Latent Variable	Observed Variable		
Symbol and Variable Name	Variable Name	Symbol	Variable Assignment
Government Subject ξ_1	responsibility implementation mechanism	X_1	Assuming that the government subject fails to effectively implement the relevant mechanism: the actual situation is very inconsistent with the assumption, then X = 5; the actual situation is inconsistent with the assumption, then X = 4; the actual situation is generally consistent with the assumption, then X = 3; the actual situation is consistent with the assumption, then X = 2; the actual situation is very consistent with the assumption, then X = 1.
	policy guarantee mechanism	X_2	
	administrative licensing mechanism	X_3	
	supervision and inspection mechanism	X_4	
	emergency rescue mechanism	X_5	
	punishment mechanism	X_6	
	departmental linkage mechanism	X_7	
	information disclosure mechanism	X_8	
	government assistance mechanism	X_9	
	publicity and education mechanism	X_{10}	
Business Subject ξ_2	quality mechanism	X_{11}	Assuming that the business subject fails to effectively implement the relevant mechanism: the actual situation is very inconsistent with the assumption, then X = 5; the actual situation is inconsistent with the assumption, then X = 4; the actual situation is generally consistent with the assumption, then X = 3; the actual situation is consistent with the assumption, then X = 2; the actual situation is very consistent with the assumption, then X = 1.
	procurement mechanism	X_{12}	
	salary mechanism	X_{13}	
	craftsman mechanism	X_{14}	
	credit mechanism	X_{15}	
	price mechanism	X_{16}	
	insurance mechanism	X_{17}	
Society Subject ξ_3	technical support mechanism	X_{18}	Assuming that the society subject fails to effectively implement the relevant mechanism: the actual situation is very inconsistent with the assumption, then X = 5; the actual situation is inconsistent with the assumption, then X = 4; the actual situation is generally consistent with the assumption, then X = 3; the actual situation is consistent with the assumption, then X = 2; the actual situation is very consistent with the assumption, then X = 1.
	training and education mechanism	X_{19}	
	industry self-discipline mechanism,	X_{20}	
	news publicity mechanism	X_{21}	
Public Subject ξ_4	supervision and participation mechanism	X_{22}	Assuming that the public subject fails to effectively implement the relevant mechanism: the actual situation is very inconsistent with the assumption, then X = 5; the actual situation is inconsistent with the assumption, then X = 4; the actual situation is generally consistent with the assumption, then X = 3; the actual situation is consistent with the assumption, then X = 2; the actual situation is very consistent with the assumption, then X = 1.
	speech publication mechanism	X_{23}	
	complaint and reporting mechanism	X_{24}	

Table 3. Index system and survey questionnaire scale of the ecological resilience of elevator safety.

Latent Variable	**Observed Variable**				
Symbol and Variable Name	**Sustainable Development**		**Variable Name**	**Symbol**	**Variable Assignment**
Elevator Safety Ecological Mitigation Ability η_1	Physical environment system	Resource factor	Elevator density	Y_1	Assuming that there is a negative phenomenon in the indicator layer: the actual situation is very inconsistent with the assumption, then $Y = 5$; the actual situation is inconsistent with the assumption, then $Y = 4$; the actual situation is generally consistent with the assumption, then $Y = 3$; the actual situation is consistent with the assumption, then $Y = 2$; the actual situation is very consistent with the assumption, then $Y = 1$.
		Climatic environment	Climate conditions	Y_2	
	Institutional system	Selection and configuration	Gathering situation of elevators in public places	Y_3	
		Eliminate scrap	Old elevator condition	Y_4	
	Socioeconomic system	Technical factor	Casualties of elevator passengers	Y_5	
		Use management	Qualified situation of elevator inspection and testing	Y_6	
			Elevator safety hidden danger situation	Y_7	
Elevator safety Ecological Recovery Ability η_2	Physical environment system	Supervision resources	Staffing of elevator safety supervisors	Y_8	Assuming that there is a negative phenomenon in the indicator layer: the actual situation is very inconsistent with the assumption, then $Y = 5$; the actual situation is inconsistent with the assumption, then $Y = 4$; the actual situation is generally consistent with the assumption, then $Y = 3$; the actual situation is consistent with the assumption, then $Y = 2$; the actual situation is very consistent with the assumption, then $Y = 1$.
			Elevator safety inspection situation	Y_9	
	Institutional system	Inner management	Work level of elevator safety government departments	Y_{10}	
		Multiple governance	Public awareness of elevator safety	Y_{11}	
		Regulation and standard	The state of judicial development	Y_{12}	
	Socioeconomic system	Economic factor	Economic development	Y_{13}	
		Demographic factor	Density of population	Y_{14}	
Elevator Safety Ecological Learning Ability η_3	Physical environment system	Inspection and testing	Elevator safety inspection personnel allocation	Y_{15}	Assuming that there is a negative phenomenon in the indicator layer: the actual situation is very inconsistent with the assumption, then $Y = 5$; the actual situation is inconsistent with the assumption, then $Y = 4$; the actual situation is generally consistent with the assumption, then $Y = 3$; the actual situation is consistent with the assumption, then $Y = 2$; the actual situation is very consistent with the assumption, then $Y = 1$.
			Regular inspection of elevator safety	Y_{16}	
		Elevator maintenance	Elevator safety operation personnel allocation	Y_{17}	
			Elevator safety maintenance personnel allocation	Y_{18}	
	Institutional system	Risk Early Warning	Funds of elevator safety inspection institutions	Y_{19}	
	Socioeconomic system	Safety investment	Elevator safety informatization construction	Y_{20}	
		Emergency rescue	Elevator safety emergency rescue timeliness situation	Y_{21}	
			Elevator safety emergency rescue level	Y_{22}	

Table 3. *Cont.*

Latent Variable	Observed Variable				
Symbol and Variable Name	**Sustainable Development**		**Variable Name**	**Symbol**	**Variable Assignment**
Elevator Safety Ecological Coping Ability η_4	Physical environment system	Propaganda and science popularization	Attention situation of elevator safety network public opinion	Y_{23}	Assuming that there is a negative phenomenon in the indicator layer: the actual situation is very inconsistent with the assumption, then $Y = 5$; the actual situation is inconsistent with the assumption, then $Y = 4$; the actual situation is generally consistent with the assumption, then $Y = 3$; the actual situation is consistent with the assumption, then $Y = 2$; the actual situation is very consistent with the assumption, then $Y = 1$.
		Insurance compensation	Elevator safety mainstream media attention	Y_{24}	
	Institutional system	Safety acceptance ability	Public satisfaction of elevator safety accident handling	Y_{25}	
			Owner satisfaction of elevator safety management	Y_{26}	
	Socioeconomic system	Safety repair ability	Government assistance for old elevators	Y_{27}	
			Development of elevator safety insurance	Y_{28}	
Ecological Resilience of Elevator Safety η_5					

4.2. Data Sources

This paper studies the relationship between polycentric collaborative governance mode and elevator safety ecological resilience from a macro perspective. The data sources in this paper are: (1) micro-survey data obtained by the research group in 2020 and 2021 based on questionnaires; (2) the relevant text data in the work. Interview is an effective method to obtain empirical data and actual situation. Hence, first, according to the content of the polycentric collaborative governance mode and elevator ecological resilience index system, sample interviews were conducted among the leaders related to the safety of special equipment (elevator), inspectors related to special equipment (elevator), and relevant experts, and questionnaires were optimized to form a formal questionnaire. Second, combined with the questionnaire variable scale, visit Nanjing, Fuzhou, Wuhan, Quanzhou, and other places of special-equipment-related units. Based on the online and offline research method, questionnaire survey was conducted on the staff and stakeholders of 60 elevator safety-related units, including elevator manufacturing, installation and transformation, use, inspection and testing, and maintenance units. A total of 300 questionnaires were sent out, 186 were recovered, and 152 valid questionnaires were obtained after excluding missed, incorrect, and invalid questionnaires. Finally, according to the variable assignment results of the survey questionnaire, EXCEL was used to further organize statistics, and the data needed for empirical research were obtained.

5. Empirical Results and Analysis

5.1. Reliability and Validity Analysis

The calculation results of the correlation coefficient matrix, Cronbach's α, σ and R^2 among the variables of elevator safety and ecological resilience are presented in Table 4. According to the correlation coefficient between variables, it is less than 0.95, and the standard deviation (σ) is greater than 0; thus, it can be seen that the parameter estimates of the model are reasonable.

Table 4. Correlation coefficient, reliability and validity test results of the SEM model.

Correlation Coefficient Matrix						Reliability and Validity Test		
Variable	**Ecological Resilience of Elevator Safety**	**Mitigation Ability**	**Recovery Ability**	**Learning Ability**	**Coping Ability**	**Cronbach's α**	**Standard Deviation σ**	R^2
Ecological Resilience of Elevator Safety	1.000	0.873	0.645	0.801	0.597	0.860	1.324	-
Mitigation Ability	-	1.000	0.697	0.641	0.713	0.753	1.137	0.634
Recovery Ability	-	-	1.000	0.815	0.810	0.826	1.259	0.679
Learning Ability	-	-	-	1.000	0.823	0.912	1.573	0.524
Coping Ability	-	-	-	-	1.000	0.834	1.347	0.738

First is reliability analysis. The reliability test aims to test the reliability, consistency, and stability of the scale's test results. The most commonly used measurement method is Cronbach's α coefficient, the mean value of the split-half reliability coefficient obtained according to all possible item division methods of the scale. When Cronbach's $\alpha \in [0.65, 0.70]$, it represents the minimum acceptable reliability coefficient value. When Cronbach's $\alpha \in [0.70, 0.80]$, the reliability is quite good. When Cronbach's $\alpha \in [0.80, 0.90]$, the reliability is very good. In this paper, the SPSS software was used to test the reliability and validity of the scale, and the results are indicated in Table 4. Except for the Cronbach's α coefficient of elevator safety mitigation ability being less than 0.80, the Cronbach's α coefficient values of other measures are all more than 0.8. To sum up, according to the reliability test results, R^2 is greater than 0.5, and so it can be seen that the scale has good reliability, the variables have high internal reliability, and the questionnaire has high reliability.

Second is validity analysis. After the demonstration of experts inside and outside the elevator safety governance industry, and with reference to the opinions of many experts, it shows that this scale has good content validity. Confirmatory factor analysis results show that the absolute value of the combined reliability C.R. is greater than 1.96, indicating that the scale has good introverted validity. To sum up, the variable setting of the survey questionnaire and the selection of observation variable indexes in this paper have good reliability and validity, which can be used for the overall suitability test analysis and parameter estimation of the model.

5.2. Analysis of Structural Equation Model Results

5.2.1. Overall Suitability Test of Structural Equation Model

On the basis of reliability and validity analysis, this paper uses the maximum likelihood estimation method to calculate the overall fitting degree of the model. The results of the overall fitness test of the SEM model are indicated in Table 5. The SEM model fit index does not exceed the range of the standard value, indicating that the SEM is a good fit. It can be concluded that the model hypothesis fits well with the observed data. The covariance matrix derived from the observed data is equal to the covariance matrix of the hypothetical model. Further analysis, according to Fisher's theory, when the p value is less than 0.05, it is statistically significant.

Table 5. Overall fit test results of the SEM model.

Classification of Statistical Tests	Test Statistics	Model Adaptation Criteria	Actual Value	Test Results
The multi-centered governance model from the perspective of collaborative governance effectively enhances the ecological resilience of elevator safety (p = 0.018)				
Absolute adaptation index	RMSEA	<0.05, Model adaptation is well; <0.08, Model adaptation is reasonable;	0.061	Reasonable adaptation
	SRMR	<0.05, Model adaptation is well; <0.08, Model adaptation is reasonable;	0.053	Reasonable adaptation
	NC	1 < NC < 3, Simple adaptation; NC > 5, Need to modify the model;	1.789	Well adaptation
Value-added adaptation index	CFI	>0.90	0.947	Well adaptation
	IFI	>0.90	0.952	Well adaptation
Simplified adaptation index	AGFI	>0.90	0.932	Well adaptation
	PGFI	>0.50	0.643	Well adaptation
	PNFI	>0.50	0.754	Well adaptation
Ecological resilience of Elevator safety under the direction of sustainable development (p = 0.021)				
Absolute adaptation index	RMSEA	<0.05, Model adaptation is well; <0.08, Model adaptation is reasonable;	0.058	Reasonable adaptation
	SRMR	<0.05, Model adaptation is well; <0.08, Model adaptation is reasonable;	0.054	Reasonable adaptation
	NC	1 < NC < 3, Simple adaptation; NC > 5, Need to modify the model;	2.211	Well adaptation
Value-added adaptation index	CFI	>0.90	0.981	Well adaptation
	IFI	>0.90	0.943	Well adaptation
Simplified adaptation index	AGFI	>0.90	0.981	Well adaptation
	PGFI	>0.50	0.778	Well adaptation
	PNFI	>0.50	0.873	Well adaptation

Note: RMSEA is the root of mean square and square of asymptotic residual; SRMR is the standard- ized root mean square residual; NC is the ratio of chi-square degree of freedom; CFI is the comparative fit index; IFI is the incremental fit index; AGFI is the fitness index; PGFI is the parsimony fit index; PNFI is the standard fit index after parsimony adjustment.

Therefore, the model hypotheses of the polycentric governance mode from the perspective of collaborative governance and the elevator safety ecological resilience from the perspective of sustainable development are well fitted to the observed data. The model is significant at the 5% level (p = 0.018). The hypotheses of the ecological resilience of the elevator safety model fit well with the observed data. Model is significant at the 5% level (p = 0.021). Hence, the model can be subjected to confirmatory factor analysis.

5.2.2. Analysis of Measurement Model Results

Further, this paper conducts confirmatory factor analysis. The first is to fit the correlation mode of the elevator safety polycentric collaborative governance mode with the actual data. That is, the 24 observed variables of the polycentric collaborative governance mode are fitted with extrinsic latent variables (government, business, social and public). The second is to fit the correlation mode between the elevator safety ecological resilience variables under the sustainable development and the actual data. That is, the 28 observed variables of the elevator safety ecological resilience are fitted with the intrinsic latent variables (the elevator safety mitigation ability, recovery ability, learning ability, and coping ability). The overall evaluation results of the measurement model are presented in Table 5.

Table 6 presents the load factors for the observed variables in the measurement model. The load factor of each observed variable is between 0.583 and 0.893, and each index has reached the acceptable standard of the model (reaching the 5% significant level). On the elevator safety polycentric collaborative governance model, the load factors of the four variables of department linkage mechanism, information disclosure mechanism, quality mechanism, and industry self-discipline mechanism are slightly lower than 0.7, and the load factors of other observed variables are all above 0.7. As for the elevator safety ecological resilience model, the load factors of the three variables (economic development, elevator safety emergency rescue level, and public satisfaction with elevator safety accident handling) are higher than 0.7, while the load coefficients of the other observed variables are higher than 0.7. This shows that the explanatory power of observed variables to latent variables is good.

Table 6. Parameter estimation results of SEM measurement model.

Elevator Safety Polycentric Collaborative Governance				Ecological Resilience of Elevator Safety				
Extrinsic Latent Variable	**Observed Variable**	**Load Factor**		**Intrinsic Latent Variable**	**Observed Variable**	**Load Factor**		**Sustainable Development**
Government Subject ξ_1	responsibility implementation mechanism	X_1	0.729 **	Elevator Safety Ecological Mitigation Ability η_1	Elevator density	Y_1	0.732 **	Physical environment system (0.779 **)
	policy guarantee mechanism	X_2	0.836 **		Climate conditions	Y_2	0.827 **	
	administrative licensing mechanism	X_3	0.745 **		Gathering situation of elevators in public places	Y_3	0.853 **	Institutional system (0.819 **)
	supervision and inspection mechanism	X_4	0.847 **		Old elevator condition	Y_4	0.784 **	
	emergency rescue mechanism	X_5	0.674 **		Casualties of elevator passengers	Y_5	0.893 **	Socioeconomic system (0.826)
	punishment mechanism	X_6	0.743 **		Qualified situation of elevator inspection and testing	Y_6	0.823 **	
	departmental linkage mechanism	X_7	0.692 **		Elevator safety hidden danger situation	Y_7	0.763 **	
	information disclosure mechanism	X_8	0.583 **	Elevator safety Ecological Recovery Ability η_2	Staffing of elevator safety supervisors	Y_8	0.872 **	Physical environment system (0.843 **)
	government assistance mechanism	X_9	0.836**		Elevator safety inspection situation	Y_9	0.814 **	
	publicity and education mechanism	X_{10}	0.754 **		Work level of elevator safety government departments	Y_{10}	0.845 **	Institutional system (0.797 **)

Table 6. *Cont.*

Elevator Safety Polycentric Collaborative Governance				Ecological Resilience of Elevator Safety				
Extrinsic Latent Variable	**Observed Variable**	**Load Factor**		**Intrinsic Latent Variable**	**Observed Variable**	**Load Factor**		**Sustainable Development**
Business Subject ξ_2	quality mechanism	X_{11}	0.689 **	Elevator safety Ecological Recovery Ability η_2	Public awareness of elevator safety	Y_{11}	0.794 **	
	procurement mechanism	X_{12}	0.739 **		The state of judicial development	Y_{12}	0.754 **	
	salary mechanism	X_{13}	0.843 **		Economic development	Y_{13}	0.631 **	Socioeconomic system (0.678 **)
	craftsman mechanism	X_{14}	0.853 **		Density of population	Y_{14}	0.724 **	
	credit mechanism	X_{15}	0.739 **	Elevator Safety Ecological Learning Ability η_3	Elevator safety inspection personnel allocation	Y_{15}	0.845 **	Physical environment system (0.831 **)
	price mechanism	X_{16}	0.862 **		Regular inspection of elevator safety	Y_{16}	0.831 **	
	insurance mechanism	X_{17}	0.641 **		Elevator safety operation personnel allocation	Y_{17}	0.784 **	
Society Subject ξ_3	technical support mechanism	X_{18}	0.874 **		Elevator safety maintenance personnel allocation	Y_{18}	0.863 **	
	training and education mechanism	X_{19}	0.763 **		Funds of elevator safety inspection institutions	Y_{19}	0.763 **	Institutional system (0.763 **)
	industry self-discipline mechanism,	X_{20}	0.649 **		Elevator safety informatization construction	Y_{20}	0.851 **	Socioeconomic system (0.756 **)
	news publicity mechanism	X_{21}	0.784 **		Elevator safety emergency rescue timeliness situation	Y_{21}	0.734 **	
Public Subject ξ_4					Elevator safety emergency rescue level	Y_{22}	0.683 **	
	supervision and participation mechanism	X_{22}	0.784 **	Elevator Safety Ecological Coping Ability η_4	Attention situation of elevator safety network public opinion	Y_{23}	0.865 **	Physical environment system (0.815 **)
					Elevator safety mainstream media attention	Y_{24}	0.765 **	
	speech publication mechanism	X_{23}	0.843 **		Public satisfaction of elevator safety accident handling	Y_{25}	0.654 **	Institutional system (0.759 **)
					Owner satisfaction of elevator safety management	Y_{26}	0.865 **	
	complaint and reporting mechanism	X_{24}	0.853 **		Government assistance for old elevators	Y_{27}	0.732 **	Socioeconomic system (0.788 **)
					Development of elevator safety insurance	Y_{28}	0.843 **	

Note: ** means significant correlation at 5% level.

The load factors of supervision and inspection, policy guarantee, and government assistance mechanism are 0.847, 0.836, and 0.836, respectively, which have the greatest explanatory power for the government subject. It shows that policy guarantee, supervision and inspection, and accident rescue are the main ways for the government to play a role in elevator safety polycentric collaborative governance. The load factors of salary mechanism, craftsman mechanism, and price mechanism are 0.843, 0.853, and 0.862, which have the greatest explanatory power for the business subject. This shows that the business mainly plays a role in elevator safety polycentric collaborative governance through salary mechanism, craftsman mechanism, and the price mechanism. The technical support mechanism has the greatest explanatory power to the society subject, indicating that the technical support provided by the elevator safety inspection organization is the main way for the society to play a role in elevator safety polycentric collaborative governance. The mechanism of supervision and participation, speech and complaints, and report show a high explanatory power to the public subject, indicating that the public subject plays a pivotal role in elevator safety polycentric collaborative governance.

The explanatory power of climate conditions, elevator agglomeration in public places, elevator passenger casualties, and elevator safety inspection on elevator safety mitigation capacity is higher than 0.8, which can be used to measure the elevator safety mitigation ability. The elevator safety supervision personnel, elevator safety supervision, and elevator safety government work level are the main variables employed to measure the elevator safety recovery ability. The elevator safety learning ability of 84.5%, 83.1%, 83.3%, and 85.1% can be explained by the elevator safety inspection personnel, elevator safety inspection, elevator safety maintenance personnel, and elevator safety informatization construction, respectively. This result explains the importance of elevator safety inspection, elevator maintenance, and intelligent safety management during elevator safety management. For the elevator-safety-response ability, the attention of network public opinion, owner satisfaction with elevator safety management, and the development of an elevator safety insurance are considerably more powerful than the attention of mainstream media, public satisfaction with accident handling, and government assistance for old elevators.

In addition, for elevator safety mitigation, recovery, learning, and coping abilities, under the guidance of sustainable development, differences occur in the influence coefficients of three dimensions, the physical environment, institutional system, and social economy. Except for the factor of socio-economic dimension in recovery ability, the values of all the other factors are higher than 0.7. Among them, in the mitigation ability, the order of the factors for each dimension of sustainable development is as follows: social economy > institutional system > physical environment. In recovery ability, the order of load factors is as follows: physical environment > institutional system > social economy. In learning ability, the order of load factors is as follows: physical environment > social economy > institutional system. In coping ability, the order of load factors is as follows: physical environment > social economy > institutional system. This result indicates that the physical environment is the main basis for improving elevator safety recovery, learning, and coping abilities, and the socioeconomic and institutional systems are the main driving force for improving the mitigation ability.

5.2.3. Analysis of Structural Model Results

Further, the structural model is empirically tested using the maximum likelihood estimation method. The evaluation indicators of the polycentric collaborative governance mode on the growth of the elevator safety ecological resilience level are all in line with the fitting criteria. This shows that the theoretical model of polycentric collaborative governance and elevator safety ecological resilience is consistent with the actual data. The influence coefficient reflects the significant influence of the independent variable on the dependent variable. The empirical test results are shown in Table 7.

Table 7. Model fitting index, path coefficient and hypothesis testing results.

Model Evaluation Index of Polycentric Collaborative Governance Affecting the Ecological Resilience of Elevator Safety					
Classification of Statistical Tests	**Test Statistics**	**Model Adaptation Criteria**	**Actual Value**	**Test Results**	
Absolute adaptation index	RMSEA	<0.05, Model adaptation is well; <0.08, Model adaptation is reasonable;	0.058	Reasonable adaptation	
	SRMR	<0.05, Model adaptation is well; <0.08, Model adaptation is reasonable;	0.043	Well adaptation	
	NC	1 < NC < 3, Simple adaptation; NC > 5, Need to modify the model;	2.032	Well adaptation	
Value-added adaptation index	CFI	>0.90	0.957	Well adaptation	
	IFI	>0.90	0.936	Well adaptation	
Value-added adaptation index	PGFI	>0.50	0.631	Well adaptation	
	PNFI	>0.50	0.751	Well adaptation	
Model Path Coefficient and Hypothesis Testing (p = 0.026)					
Model Independent Variable	**Path**	**Model Dependent Variable**	**Influence Coefficient**	**Corresponding Hypothesis**	**Hypothesis Test Results**
Government Subject ξ_1	→→	Ecological Resilience of Elevator Safety η_5	0.278 **	H1-1	Hypothesis test passed
Business Subject ξ_2	→→	Ecological Resilience of Elevator Safety η_5	0.394 **	H1-2	Hypothesis test passed
Society Subject ξ_3	→→	Ecological Resilience of Elevator Safety η_5	0.201 **	H1-3	Hypothesis test passed
Public Subject ξ_4	→→	Ecological Resilience of Elevator Safety η_5	0.094 **	H1-4	Hypothesis test passed
Ecological Resilience of Elevator Safety η_5	→→	Elevator Safety Ecological Mitigation Ability η_1	0.892 **	H2-1	Hypothesis test passed
Ecological Resilience of Elevator Safety η_5	→→	Elevator safety Ecological Recovery Ability η_2	0.741 **	H2-2	Hypothesis test passed
Ecological Resilience of Elevator Safety η_5	→→	Elevator Safety Ecological Learning Ability η_3	0.851 **	H2-3	Hypothesis test passed
Ecological Resilience of Elevator Safety η_5	→→	Elevator Safety Ecological Coping Ability η_4	0.534 **	H2-4	Hypothesis test passed
Elevator Safety Ecological Learning Ability η_3	→→	Elevator Safety Ecological Mitigation Ability η_1	0.814 **	H3-1	Hypothesis test passed
Elevator Safety Ecological Learning Ability η_3	→→	Elevator safety Ecological Recovery Ability η_2	0.613 **	H3-2	Hypothesis test passed
Elevator Safety Ecological Learning Ability η_3	→→	Elevator Safety Ecological Coping Ability η_4	0.512 **	H3-3	Hypothesis test passed
Elevator Safety Ecological Coping Ability η_4	→→	Elevator Safety Ecological Mitigation Ability η_1	0.571 **	H4-1	Hypothesis test passed
Elevator Safety Ecological Coping Ability η_4	→→	Elevator safety Ecological Recovery Ability η_2	0.851 **	H4-2	Hypothesis test passed
Elevator Safety Ecological Mitigation Ability η_1	→→	Elevator safety Ecological Recovery Ability η_2	0.600 **	H5	Hypothesis test passed

Note: ** means significant correlation at 5% level.

Firstly, analyze the influence path of extrinsic variable elements (the polycentric collaborative governance mode) on enhancing the ecological resilience of elevator safety. It is not difficult to find from Table 7 that at a significance level of 5%, the influence coefficients of government subject, business subject, social subject, and public subject on enhancing the ecological resilience of elevator safety are significantly positive. The test results show that Hypotheses H1-1, H1-2, H1-3, and H1-4 pass the test. In other words, the government, business, society, and the public are the key points of elevator safety ecological resilience governance. At the same time, according to the size of the influence coefficient, it can be seen that the business subject has the greatest influence on enhancing the ecological resilience of elevator safety (0.394), followed by the government subject (0.278) and the society subject (0.201), and the public subject (0.094). Therefore, under the polycentric collaborative governance mode, the fundamental role of the market is affirmed, and the leading role of the government is not abandoned. Enterprises play a fundamental role in the process of safety governance based on product quality mechanism and procurement mechanism, elevator operator compensation mechanism and craftsman mechanism, elevator market credit mechanism, price mechanism, and insurance mechanism. The government performs its duties according to law, carries out elevator safety supervision, standardizes and guides the market order, leads enterprises, society, and the public in a unified manner, and plays a supporting role in elevator safety governance. Although the influence coefficient of society subject is lower than that of government and business subject, society subject provides elevator technical support and quality services. Through the elevator safety inspection, training and education, and self-discipline service to improve the level of elevator safety governance, support the government to supervise the relevant behavior of enterprises. The public subject, as an analysis factor separated from the social subject, has a relatively small coefficient but passes the test significantly. By participating in supervision and reporting complaints, the public subject actively supervises the production, manufacturing and operation behaviors of business subjects, and reports and complains about illegal behaviors of business subjects, which is also an important subject of polycentric collaborative governance.

Secondly, analyze the influence path of enhancing elevator safety ecological resilience on the intrinsic variable elements (elevator safety mitigation ability, recovery ability, learning ability, and coping ability). Enhancing elevator safety ecological resilience can improve elevator safety mitigation ability, recovery ability, learning ability, and coping ability, and then improve the level of elevator safety governance. At a significance level of 5%, the influence coefficients of enhancing elevator safety ecological resilience on improving the elevator safety mitigation ability and elevator safety recovery ability are significantly positive. In addition, the influence coefficients of enhancing the ecological resilience of elevator safety on improving elevator safety learning ability and elevator safety coping ability is significantly positive. The test results show that the Hypotheses H2-1, H2-2, H2-3, and H2-4 pass the test. This indicates that the elevator safety ecological resilience system is a closed-loop system, and the elements in the system are closely related to enhancing elevator safety ecological resilience, and the selection of elevator safety resilience elements is reasonable. According to the size of the influence coefficient, it can be seen that enhancing the ecological resilience of elevator safety has a greater influence on improving elevator safety mitigation ability (0.892), elevator safety recovery ability (0.741), and elevator safety learning ability (0.851), but has a relatively small influence on improving elevator safety coping ability (0.534).

Finally, analyze the influence path of the elements of the ecological resilience of elevator safety. At a significance level of 5%, the influence of improving elevator safety learning ability on improving elevator safety mitigation ability, elevator safety recovery ability, and elevator safety coping ability is significantly positive. The test results show that the Hypotheses H3-1, H3-2, and H3-3 pass the test. According to the size of the influence coefficient, it can be seen that improving elevator safety learning ability has the greatest influence on elevator safety mitigation ability (0.814), followed by elevator safety recovery ability (0.613) and elevator safety coping ability (0.512). At a significance level of 5%, the influence of improving elevator safety coping ability on improving elevator safety mitigation ability and elevator safety recovery ability is significantly positive. The test results show that Hypotheses H4-1 and H4-2 pass the test. According to the size of the influence coefficient, it can be seen that the influence of improving elevator safety coping ability on improving elevator safety recovery ability (0.851) is greater than the impact on elevator safety mitigation ability (0.571). At a significance level of 5%, the influence of improving elevator safety mitigation ability on improving elevator safety recovery ability is significantly positive. The test results show that Hypothesis 5 passes the test, and the influence coefficient reaches 0.6. There is a mutual influence among the components of elevator safety and ecological resilience. When the elevator safety learning ability is enhanced, the mitigation ability, recovery ability, and coping ability will also be improved to a certain extent. When the elevator-safety-response ability is improved, the relief ability and recovery ability will also be improved to a certain extent. When the elevator safety relief ability is improved, the recovery ability will also be improved to a certain extent.

6. Conclusions and Suggestions

6.1. Main Conclusions

Based on field investigation and practical work experience, the factors and mechanism of the multi-center cooperative governance mode and ecological resilience governance paradigm of elevator safety were analyzed. Based on the micro survey data of 60 elevator-safety-related units in China obtained in 2020 and 2021, the structural equation model was used to explore the impact degree and mechanism of the multi-center collaborative governance model on elevator safety ecological resilience under the guidance of sustainable development. Finally, the following conclusions are drawn.

(1) The social–ecological resilience theory from a macro perspective can make up for the limitations of risk theory in elevator governance research. Risk theory and resilience theory complement each other. Elevator safety ecological resilience can effectively evaluate the level of elevator safety governance.
(2) Under the polycentric collaborative governance mode, the government, business, society, and the public affected the elevator safety ecological resilience through 24 mechanisms, such as responsibility implementation, policy guarantee, quality, procurement, technical support, training and education, supervision and participation, and speech. The elevator safety mitigation ability, recovery ability, learning ability, and coping ability under the guidance of sustainable development can be effectively explained through 28 contents, such as elevator density, climate, elevator safety supervision personnel allocation, elevator safety inspection personnel allocation, and elevator safety mainstream media attention.
(3) The key points of enhancing elevator safety and ecological resilience were verified, and the government, business, society, and the public in the polycentric collaborative governance mode have a direct promoting effect on elevator safety and ecological resilience. The business subject has the greatest influence, followed by the government subject, the social subject, and the public subject.
(4) The relationship between enhancing the elevator safety ecological resilience and the ability of mitigation, recovery, learning, and coping, as well as the relationship among these four elements, were verified. Enhancing elevator safety and ecological resilience has a direct promotion effect on improving elevator safety mitigation, recovery, learning, and coping ability. There is a direct interaction between the components of elevator safety and ecological resilience. Under the guidance of sustainable development, material environment, institutional system, and social economy have a significant direct impact on all elements of elevator safety and ecological resilience.

6.2. Policy Implications

Under the background of promoting the modernization of the elevator safety governance capacity and governance system, the multi-center collaborative governance mode provides strong support for elevator intelligent governance. Based on the empirical results of the real structural equation model of elevator safety and ecological resilience under the multi-center governance model and sustainable development, the following policy suggestions are proposed to improve the level of elevator safety, ecological resilience, and elevator safety governance:

(1) During the period of the 14th five-year plan, in the elevator quality and safety level improvement action, we should continue to adhere to and improve the polycentric collaborative governance pattern of "enterprises to implement the main responsibility, the unified leadership of the local government, the supervision departments to perform their duties according to law, technical support of inspection institutions, self-discipline service of industry associations, and public participation in supervision". In particular, wisdom supervision should be highlighted, and supervision should be performed, supervision efficiency should be improved. Based on sustainable development, measures should be taken from the three dimensions of material resources, institutional system, and social economy to improve the elevator safety mitigation, recovery, learning, and coping abilities to enhance elevator safety ecological resilience and the elevator safety management level.

(2) In the polycentric collaborative governance mode, the elevator safety ecological resilience based on the government subject should be enhanced, and the meta-governance should be promoted. The meta-governance theory emphasizes the central position of the state and government in governance. The government is the maker of the polycentric collaborative governance rules and plays a leading role in the collaborative governance system. In the polycentric collaborative governance mode of elevator safety, we should fully respect the right of participation and expression of all parties and fully reflect the interests of all parties. We can not give up the leadership of the government by emphasizing polycentric collaborative governance. The government should play more roles in the top-level design and rule-making of elevator safety supervision, clarify the responsibility chain, and reshape the responsibility system of elevator safety governance.

(3) In the polycentric collaborative governance mode, the elevator safety ecological resilience based on the business subject should be enhanced, and autonomy–governance should be promoted. The theory of autonomy is self-governance and management, which is effectively guaranteed by law and restricted by the outside world. Using market forces rather than administrative forces to promote rational allocation of resources can better reduce transaction costs. The market subject is the product service provider in the process of elevator production and use. Based on the property rights theory and the principle of who benefits and who is responsible, the market subject parties should bear the corresponding responsibility. Therefore, we should promote the self-governance of market subjects, carry out the market survival of the fittest and self-improvement mechanism, and improve the elevator market credit mechanism, craftsman mechanism, and price mechanism.

(4) In the polycentric collaborative governance mode, the elevator safety and ecological resilience based on the society subject should be enhanced, and the good-governance should be promoted. With the development of society, the increasing number of social organizations, and the continuous advancement of social democracy, the theory of good governance was generated and implemented. The theory of good governance emphasizes the return of state power to society and embodies the idea of returning government to the people. The result of good governance is the maximum covenant to pursue public interest. While adhering to the government's dominant position in social governance, the theory of good governance also pays attention to the participation of social subjects. Any social organization representing public interests can

participate in public governance. Therefore, in the process of polycentric collaborative governance of elevator safety, the role of social organizations should be brought into play to stimulate the enthusiasm of industry associations and further promote the reform of elevator safety inspection and testing.

(5) In the polycentric collaborative governance mode, the elevator safety ecological resilience based on the public subject should be enhanced, and co-governance should be promoted. The theory of co-governance aims to solve the social governance problems most concerned by the public, and the main participant of co-governance is the public. Attaching importance to and strengthening public participation in social governance is conducive to fostering public awareness of responsibility and promoting the transformation of social governance. It is necessary to further improve public participation in elevator safety governance, improve public awareness of elevator safety, mobilize public enthusiasm for safety, and then improve the level of elevator safety governance.

(6) Finally, micro-level countermeasures and elevator safety management countermeasures should be optimized in production and design links by improving the elevator safety technical standards to enhance the elevator safety response capacity. The utilization and maintenance of the links should be achieved by raising the industry access threshold and standards to strengthen the long-term supervision mechanism. Third-party organizations, such as insurance companies, should be developed in the elevator safety management field to shift the risk cost function. The use system of elevator maintenance funds in old residential areas should be optimized. The data analysis of elevator safety intelligent supervision should be further explored, and the intelligent level of elevator safety governance should be improved.

6.3. Limitations and Future Work

This paper was subject to some limitations, which should be considered in further research. First, the transmission mechanism of the impact of polycentric collaborative governance mode on ecological resilience of elevator safety was tentatively analyzed, and the point-to-point path analysis was not performed. Therefore, the path study on the impact of polycentric collaborative governance on the ecological resilience of elevator safety should be further refined in the future. Second, the index of elevator safety ecological resilience we selected was relatively simple, and the data source is only the national overall data, which may cause some deviations in the overall research results. Therefore, it is necessary to add indicators related to intelligent supervision and credit supervision of elevator safety when studying the ecological resilience of elevator safety in the future. Meanwhile, micro data can be obtained from different regions and provinces in China to accurately measure the level of elevator safety and ecological resilience in different regions and provinces. Third, the data used in the structural equation model were obtained through questionnaires, which makes the research results subjective. Therefore, on the basis of optimizing the elevator safety ecological resilience index system, it is necessary to study the elevator safety resilience through the quantitative data in China's special equipment annual statistical report. In addition, we selected two core variables of polycentric collaborative governance and elevator safety ecological resilience under the guidance of sustainable development. In the future, it is necessary to set sustainable development as a core variable.

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