

Received November 30, 2020, accepted December 16, 2020, date of publication December 21, 2020, date of current version December 31, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3046095

# Adaptive Governance, Loose Coupling, Forward-Looking Strategies and Responsible Innovation

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**ABSTRACT** This paper discusses the relationship among adaptive governance, loose coupling, forward-looking strategies and responsible innovation, and constructs the influence relationship model of "adaptive governance- loosely coupling- forward looking strategies- responsible innovation". Then we take 366 managers from middle management and above as well as the technical personnel of enterprises as the investigation objects, and conduct empirical research by using the structural equation model (SEM). The results show that: (1) adaptive governance has a significant positive impact on responsible innovation; (2) loosely coupling partially mediates the effect of adaptive governance on responsible innovation; (3) forward looking strategy partially mediates the effect of adaptive governance on responsible innovation; (4) Loose coupling and forward-looking strategies play a chain mediating role in the relationship between adaptive governance and responsible innovation.

**INDEX TERMS** Adaptive governance, loose coupling, forward-looking strategies, responsible innovation.

## I. INTRODUCTION

Emerging technologies represented by nanotechnology, transgenic technology, stem cell research, biomedical technology, nuclear energy, robotics and military security technology are regarded as controversial examples of technological innovation, which not only promotes industrial development and social change but also cause concerns about social control of technology and ethical safety among research and policy levels[1]. Faced with the problems of technological social control, ethical safety, etc. that have arisen in innovation activities, governments of various countries have successively promulgated a series of policy measures to promote technological innovation. The EU has referred the responsible innovation strategy in "Horizon 2020" 8th R & D framework plan", which discusses ethical, legal and social factors in natural science and engineering research [2]. The American government specially released the "National Nano Plan Environmental, Health and Safety Strategic Research Plan", emphasizing that the nanoscience research projects must integrate environmental, social, ethical and other factors [3]. Chinese "13th five-year plan for scientific and technological innovation" advocates responsible research and innovation, and urges enterprises

to pay attention to social responsibilities such as ecological protection and security in technological innovation activities [4]. Davis considered that big data is an emerging technology. While on the one hand, it provides convenience for our lives, on the other hand, there will be information security issues such as privacy leakage. Eden proposed that in the development of information and communication technology, attention should be paid to the risk of privacy leakage, research and innovation should be carried out responsibly, and the acceptance of social ethics should be fully considered [5]. Xia pointed out that genetic engineering and stem cell technology are the emerging fields, which most likely to generate ethical risks [6]. Ding pointed out that human embryonic stem cell technology brings unavoidable ethical risks, and scientific experts must carry out responsible innovation to reduce the negative problems caused by innovation [7]. Therefore, we must find a balance between innovation and ethical risks, and impose ethical constraints on emerging technologies technology [8]. As a new management paradigm, responsible innovation means to change the existing innovation mode and explore the future of innovation to make innovation meet the social needs and ethical constraints, which is the inevitable choice for society to achieve sustainable development [9].

However, companies need to pay more time and economic costs to implement responsible innovation. Enterprises lack the internal motivation to implement responsible innovation.

The associate editor coordinating the review of this manuscript and approving it for publication was Davide Aloini.

Therefore, the government, an important external stakeholder of a company, can promote the implementation of responsible innovation. Developed countries put forward the idea of adaptive governance very early. In 1960, American scholar Arnold Kaufman first proposed the concept of "participatory democracy", marking the formation of adaptive governance. The theory advocates solving public affairs issues through joint discussion and negotiation of citizens. Citizens are not only voters, but also managers of public affairs [10]. The Skefton report in the United Kingdom pointed out that the participation of the private sector in public policy making can make policies more flexible and sustainable [11]. After the idea of adaptive governance was put forward, the conceptual framework, "adaptive governance" has been applied in resource commons management and other complex socioecological systems by developed countries, and achieved great success [12]. As a product in the context of a Western developed country (mainly the United States and the European Union), few scholars discuss responsible innovation in the context of other countries. The theoretical reviews of adaptive governance are mostly limited to developed countries, ignoring its discussion in the context of developing countries. While in most developing countries, governance failures are the main impediment to sustained economic development [13]. The traditional governance mechanisms rely on intergovernmental negotiation and rigid implementation. However, government may have difficulties in combating the new global challenges that the international community must confront. New governance mechanisms must be explored and developed for policy coordination within and across government boundaries [14]. For example, during the COVID-19 pandemic, the government faces huge challenges and risks. At this time, the government should strengthen cooperation with the private sector. The government should discuss with the private sector and face unknown risks and challenges together. Therefore, we explore adaptive governance in the context of China, establish a research framework for responsible innovation based on adaptive governance, and discuss the effectiveness of adaptive governance on responsible innovation.

Adaptive governance emphasizes that the right of policy-making should be shared by the government and all stakeholders. Enterprises, the main body of responsible innovation, provide relevant technical knowledge for the government in the process of policy-making [15]. However, due to the different social functions of the government and the enterprise, they will follow different principles in the process of innovation governance. The government advocates social interests as the main concern and tends to follow the "prevention principle", which means that unless there is sufficient evidence to prove that technological innovation is safe, it should be assumed that it is dangerous; enterprises tend to advocate economic interest as the main concern and follow the "precautionary principle", which emphasizes that unless there is sufficient evidence to prove that technological innovation is dangerous, it should be assumed that it is safe [16]. Therefore, how to coordinate the conflict of principles

and objectives in adaptive governance between government and corporate has become the key to the impact of adaptive governance on responsible innovation.

Loose coupling is a system based on trust. The elements which have common goals and respective interests in the system are independent units with external relations. In order to achieve the goal of the system, each element should be differentiated between the whole and the part. We should not only pay attention to the internal efficiency of the elements, but also focus on to the coordination and cooperation among the elements, so as to keep the stable relationship among the elements [17]. It can be concluded that the loose coupling relationship between government and enterprises can coordinate the differences of principles and objectives between them in adaptive governance, so that they could reach an agreement on the governance of science and technology ethics, and promote the implementation of responsible innovation.

In addition, the change of government's innovation regulation behavior, one of the fundamental factors, affect the strategic choice of enterprises [18]. Adaptive governance not pursuits the efficiency of traditional governance, and highlights the use of boosting policies to alleviate the short-term contradictions between the government and enterprises, so that both sides can reach an agreement on the sustainable development strategy [15]. In order to achieve the long-term strategic goal of sustainable development, enterprises need to improve the prediction ability of future market demand and social demand to meet their sustainable development. Thence, this paper explores whether the effectiveness of adaptive governance can affect the implementation of responsible innovation by changing the strategic choice of enterprises.

Therefore, this paper takes loose coupling and forward-looking strategies as intermediary variables to construct a conceptual model of "adaptive governance-loose coupling-forward looking strategies-responsible innovation". Then we analyze the impact of adaptive governance on responsible innovation and the mediating role of loose coupling and forward-looking strategies.

## II. THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

### A. THEORETICAL BACKGROUND

#### 1) ADAPTIVE GOVERNANCE

At the end of the 20th century, Holling *et al.* criticized the top-down and efficiency oriented rigid management mode. At the same time, they proposed adaptive management and hypothesized that policies should be tested, learned and improved according to the changing environment [19]. With the continuous development of adaptive management in the field of public management, the dimension of cross level communication has been added to the original dimensions of learning and changing, and forming the concept of adaptive governance [20]. Adaptive governance means that both the government and stakeholders play an important role in the policy-making process, which contributes

to the formulation of adaptive, inclusive, people-oriented and sustainable policies to ensure the clarity and accuracy of legal policies [21]. Therefore, compared with traditional regulation, the characteristic of adaptive governance can encourage enterprises, suppliers and other stakeholders to participate in the policy-making process and share public and private resources in the process of policy development. Under this circumstance, government can formulate sustainable and inclusive policy which is consistent with current market environment and social environment based on the current situation for industry.

Scholars have carried out research on adaptive governance based on the negative externality of technology. Xue considered that adaptive governance has broken people's perception of traditional government supervision. It can respond to the social risks and negative externalities caused by industrial development [22]. Mark believed that adaptive governance can effectively alleviate environmental pollution during the innovation process [23]. Xue analyzed the effectiveness of adaptive governance on responsible innovation from the perspectives of governance principles, governance relationships and governance tools [24].

## 2) RESPONSIBLE INNOVATION

The United States first proposed the concept of "responsible development" in the *"Law on the research and development of nanotechnology in the 21st century"*, which focus on maximizing the positive significance of nanotechnology to promote social progress while reducing the negative impact of technological innovation in order to address the most urgent social needs of the country [25]. Afterwards, the discussion about "responsible innovation" increased gradually. Scholars defined the concept of responsible innovation from different perspectives. Van den Hoven focused on the description of the concept of responsible innovation itself by defining it as an activity or process, which leads to the extension of unknown elements related to the physical world, the conceptual world and the institutional world in the process of innovation, so as to expand the set of cognition and action selection [26]. Cavally paid attention to the internal attributes and evaluation criteria of responsible innovation, and believed that responsible innovation is a future oriented, uncertain, complex and collective behavior, and that the results of innovation need to effectively meet social, moral and ethical needs [27]. Mei paid attention to the governance and communication structure of responsible innovation, and believed that responsible innovation is a transparent and interactive process, in which social actors and innovators take responsibility for each other, so as to realize the moral acceptability, sustainability and social satisfaction of the innovation process, making scientific and technological progress embedded in social development [28]. Combined with the existing research, this paper defines responsible innovation in this way: in the early stage of innovation, enterprises and other stakeholders participate in decision-making and predict the impact of innovation on society. During the process of

innovation, based on the progress of R&D activities and the goals set in the early stage, enterprises should reflect on their own behavior to make sure that the innovation process and results meet moral and social expectations, gradually achieve scientific and technological progress and finally make scientific and technological progress properly embedded in social development.

In this paper, conceptual dimensions mean the general framework for responsible innovation. Also, they help us understand the depth of the concept. the term "dimension" (also refer to as feature, approach, key principle or aspect) was used by several authors in the articles that were taken into consideration for this review.

Various dimensions of RRI were found in the literature. The European Commission describe six distinct dimensions as follow: engagement, gender equality, science education, ethics, open access and governance. Carsten concentrated on the practical implementation of dimensions bringing on actors, norms and activities [29]. Various researchers have referred to previous dimensions, which were originally not associated with RRI, e.g., the ones offered by Pellizzoni (2004): liability, accountability, care and responsiveness [30]. Stilgoe listed four dimensions that had emerged during public debates: anticipation, inclusion, reflexivity and responsiveness [9]. These dimensions were also included in the current analysis. The literature review concentrated on both how the dimensions were termed and described and how they emerged and evolved in the academic discussion. The dimensions were grouped: for example, the dimension "actors" by Carsten [29] was grouped under "inclusion", or "transparency" by Forsberg [31] was grouped under "responsiveness". Some dimensions, e.g., gender equality and science education were not analyzed in the current review because of little or almost no discussion in the reviewed literature. At the end of the analysis, four different conceptual dimensions were selected: anticipation, inclusion, responsiveness, and reflexivity. The four conceptual dimensions were chosen, as they appeared clearly in the reviewed articles and were discussed and elaborated on further [9].

### a: INCLUSION

Responsible innovation regards innovation as a future-oriented, uncertain and complex collective behavior. Inclusion means that a larger scope of innovation subjects other than scientists can discuss the scope of power, roles, division of labor, and interdisciplinary collaboration [9]. In addition, innovation subjects listen to the demands of stakeholders in innovation activities, and realize the openness of innovation activities. Studies have shown that the stakeholders of responsible innovation mainly include governments and policy makers at various levels, universities, research institutions and education groups, business organizations, non-governmental organizations, civil organizations, innovative users, and independent researchers [5]. In general, the basic classification of stakeholders in responsible innovation activities is experts (including innovative planners, universities,

research institutions and other innovative R&D executive organizations), the public (including innovative users, innovative social participants and Potential service targets, etc.), policy makers (including various levels of government and policy institutions, science and technology committees and other innovative investment institutions, etc.)

#### b: ANTICIPATION

The anticipation of responsible innovation requires that the moral and social satisfaction of new technologies needs to be paid attention to in the early stages of technology development [32]. Anticipation focus on describing and analyzing potential unknown effects in order to build a flexible and adaptive system. Under the consideration of social, environmental, and ethical factors, innovation entities can effectively deal with the unexpected results of research and innovation, and form innovative "forward-looking governance" [33]. Under such a mechanism, technological innovators themselves need to drive problem-solving discussions based on the results of the problem, and they are more concerned about the conditions under which harm occurs or reoccurs. The first condition for anticipation is to trigger technical and social discussions in the early stages of innovation.

#### c: REFLEXIVITY

The reflexivity of responsible innovation means that there is no standard path to follow for innovation and development. It is necessary to recognize the cognitive limitations of individuals and organizations, and form a mirror image of the behaviors, commitments, assumptions and capabilities of individuals and organizations [34]. Therefore, scientists who are the subject of scientific and technological innovation need to examine themselves as a part of a larger society and understand the impact of their actions on social development. Starting from the responsible innovation paradigm, the reflexivity and cognitive framework of stakeholders is the premise. reflexivity helps to achieve effective responses to occasional negative events of technological innovation and control the innovation process [35].

#### d: RESPONSIVENESS

The responsiveness of responsible innovation is the basic ability of responsible innovation, which involves adjusting behavior patterns when they feel insufficient knowledge about innovation [36]. The responsiveness of responsible innovation emphasizes that the subjects and governance of innovation activities need to be established in an interactive, continuous, and adaptive process, in order to achieve correct guidance and real-time correction of innovation activities [9].

The responsible innovation framework is shown in Figure 1.

### 3) LOOSE COUPLING

The term "coupling" was proposed in the field of physics. It refers to the phenomenon of mutual influence and even union in the dynamic relationship of interdependence, coordination and mutual promotion under the positive interaction of various elements [37]. After the coupling theory was put

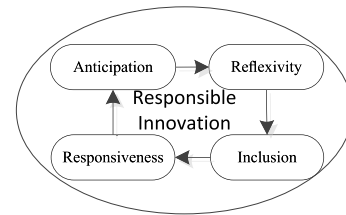


FIGURE 1. Framework of responsible innovation.

forward in the field of physics, its connotation has been extended. In the field of management, coupling refers organizations (two or more) or departments (two or more) make each unit develop cooperatively through mutual penetration, promotion and restriction under a certain rule, and realize the overall strategic goal [38]. Loose coupling means that the elements in the system not only keep consistent in the macro strategic objectives through the relationship of mutual promotion and mutual restriction, but also maintain the inheritance and independence of the elements themselves at the micro level, and retain the conflicts between the elements, so that the system has both independence and responsiveness [39]. Independence refers to whether the dependency relationship among the parameters within each element can be adjusted without being restricted by the dependency relationship between elements; responsiveness refers to that other elements need to make adjustment according to the change of any element in the system [40]. Loose coupling will appear in the following four scenarios [41]: (1) There is a low frequency of interaction between elements. If the interaction between the elements is irregular and occasional, then loose coupling is likely to occur. (2) There is an indirect relationship between the elements. If the two organizations communicate not directly, but through a third party. Then it will reduce the ability to directly respond to each other's activities and form a loose coupling relationship. (3) There are different explanations for the same causal link. Different individuals and organizations will focus on different parts of the environment and make different interpretations to similar external stimuli, and then produce different responses. (4) The existence of non-immediate effects, which means that one element cannot respond while another element changes. Compared with closely coupled, loose coupling has more flexibility and diversity, which can better meet the dynamic needs of context change and improve the stability of the system [42].

Scholars have carried out research from the perspective of employee level, enterprise level, and external enterprise. Frandsen's research found that a loosely coupling system in an organization can enable employees to continue to dialogue and intervene in the implementation of strategies [43]. Lukka believed that the loose coupling between rules and conventions is the reason for the management accounting system to maintain change and stability in the organization [44]. Newton proposed that using loosely coupled systems to establish a framework to resolve conflicts between internal and external stakeholders [45]. Then, scholars also discussed

the relationship between loose coupling and responsible innovation. Hofman believed that the degree of coupling of technology innovation network members significantly affects the business performance, and loose coupling has a positive impact on responsible innovation [39]. Sahaym believed that organizations can form alliances and hire temporary workers to achieve a higher degree of loose coupling and increase the responsible innovation performance of enterprises [46].

#### 4) FORWARD-LOOKING STRATEGIES

Forward-looking strategies mean the ability to predict future market demand and social demand. This ability can lead the same industry to launch new products or services, introduce or improve new technologies, strategically withdraw from mature or declining industries [47]. In the process of responsible innovation, forward-looking strategies can be reflected in two parts: anticipation and inclusion. Anticipation refers to the early assessment of the subject value, social needs and risk level of research in order to ensure that new products and services can meet the future market demand and social demand; inclusion means that research should attract research objects, users, experts and other stakeholders participate widely, listen to the views of different stakeholders on technological innovation activities, improve the perception ability of enterprises, and make the innovation process or innovative products meet the social needs and ethical expectations in the dynamic environment [48].

Some scholars focus on the relationship between forward-looking strategies and innovation. Shoham's research on 193 export companies found that the forward-looking strategies companies is positively correlated with their innovation performance [49]. Miles found that forward-looking strategies enable companies to maintain high flexibility for a long time, and forward-looking strategies can promote the implementation innovation [50]. Jin believed that forward-looking strategies will achieve breakthrough innovations by improving flexible, decentralized, and flat organizational structures. And the implementation of innovation needs to be based on this organizational structure [51]. With the rise of the concept of responsible innovation, some scholars began to study the relationship between forward-looking strategy and responsible innovation. Aragon believed that SMEs that implement forward-looking strategies have higher practical flexibility, organizational structure development, organizational consistency, and promote the implementation of responsible innovation [52]. Song pointed out that forward-looking strategic can improve technical and IT capabilities, which can help companies to achieve responsible innovation [53].

Previous studies have shown that adaptive governance, loose coupling and forward-looking strategies are related to responsible innovation. We infer that adaptive governance, loose coupling and forward-looking strategies are also related. But few scholars put adaptive governance, loose coupling, forward-looking strategies and responsible innovation into a research framework. Therefore, we put adaptive governance, loose coupling, forward-looking strategies and

responsible innovation into one research framework based on previous scholars' research. Then we verify the relationship between adaptive governance and responsible innovation, and reveal the role of loose coupling and forward-looking strategies between adaptive governance and responsible innovation.

### B. HYPOTHESES

#### 1) THE EFFECT OF ADAPTIVE GOVERNANCE ON RESPONSIBLE INNOVATION

Polanyi scientific community proposed that enterprises often lack self-examination of ethics and morality in innovation activities, and the adaptive governance can keep eyes on this issue to promote implementation of responsible innovation [35]. Firstly, adaptive governance encourages enterprises to participate in policy-making, so as to realize the transformation from almighty government to governance government [54]. Enterprises' participation in policy-making means that both sides will share information on a certain technology. After integrating government information, enterprises can realize the government's demand for social sustainable development and technological ethics. Therefore, for the purpose of pursuing legitimacy, companies will take economic goals and social goals into consideration. When evaluating technological innovation efficiency, companies will not only use technological advancement and economic growth as evaluation criteria, but also consider the acceptability of ethics and social needs [55]. That urges enterprises to think moral and ethical issues over in the innovation process, and promotes the implementation of responsible innovation. Secondly, in the process of policy implementation, adaptive governance accentuates that the government adopts boost policies to accept the market behavior of enterprises. Under these circumstances, policies can match the market environment of the industry in which the enterprise is located, and coordinates the economic interests of the enterprise and the government's demand for public value [56]. It alleviates the conflict between the government and the enterprise's goals, and weakens the enterprise's worries about government intervention to undermine the value of the enterprise [57]. In this case, the goals of the enterprise and the government are very consistent. The enterprise will take the initiative to implement the science and technology ethics policies that have been promulgated, fulfill the ethical and moral responsibilities emphasized by the government, ensure the public value of technological innovation, and promote the implementation of responsible innovation [58]. Finally, for the sake of keeping up with the exponentially changing technological development trend, the government needs to monitor and evaluate the implementation effect after the policy implemented [59]. Adaptive governance underlines that the government and enterprises should establish an interactive, continuous and flexible adaptive learning process. When government lacks professional knowledge, government will communicate and negotiate with the enterprise to adjust the government's governance model, revise and improve the existing

policies, and realize the institutional coupling of innovation evolution process and social value response, and form a virtuous circle and incentive mechanism for responsible innovation. Then government will create a scientific and friendly policy environment for responsible innovation, promotes the implementation of responsible innovation [60]. Based on the above analysis, this paper proposes the following hypothesis:

*Hypothesis 1:* Adaptive governance has a significant positive impact on responsible innovation.

## 2) THE INTERMEDIARY ROLE OF LOOSE COUPLING BETWEEN ADAPTIVE GOVERNANCE AND RESPONSIBLE INNOVATION

On the one hand, adaptive governance emphasizes that the dynamic interaction between government and enterprises is an important way to ensure the matching of governance and innovation [24]. Adaptive governance enables the government and enterprises to interact and learn in the policy formulation process. The government provides policy support and public resources for enterprises to ensure the smooth progress of enterprise innovation activities; enterprises provide the government with market information and professional technical knowledge to ensure that the government understands technological risks and the probability of occurrence of the risk, and help the government to set the regulatory threshold [22]. It can be seen that both the government and enterprises will respond appropriately to each other's needs in order to maintain the responsiveness between them, and promote the formation of a loose coupling relationship between the both sides. On the other hand, adaptive governance does not blindly emphasize the control of risks, nor does it one-sidedly pursue the optimization of efficiency and cost. More importantly, adaptive governance emphasizes diversity and win-win, and incorporates two opposing independent goals at the same governance state [61]. Adaptive governance incorporates the government and enterprises into a system to jointly conduct policy-making discussions on scientific and technological ethics issues. Adaptive governance protects not only the interests of enterprises and governments, respectively, but also the interests of the whole [62]. Then loose coupling relationship between the government and enterprises is formed. Based on the above analysis, this paper proposes the following hypothesis:

*Hypothesis 2a:* Adaptive governance has a significant positive impact on loose coupling.

Loose coupling relationships are conducive to the government's delivery of fresh or heterogeneous information and knowledge to enterprises [63]. The implementation of responsible innovation requires companies to integrate a variety of heterogeneous knowledge, form a multidisciplinary knowledge system, break disciplinary barriers, strengthen the integration of social sciences and natural sciences, break through the separation of subjects in the innovation process and the Colingridge's dilemma, achieve forward-looking governance, ensure the controllability of

technological development, and finally achieve responsible innovation [64]. In addition, the loose coupling isolation mechanism enables the government and enterprises to perceive the external environment according to their own logic. The government focuses on understanding public needs and the sustainable development of society, and enterprises focus on perceiving market demand and the economic benefits brought by technological innovation activities [17]. Different cognitive methods in the system help companies to consider social, economic, environmental and moral factors in technological innovation activities, analyze potential dangers in technological innovation activities, deal with unexpected results in the innovation process effectively, and promote implementation of responsible innovation [65]. Based on the above analysis, this paper proposes the following hypotheses:

*Hypothesis H2b:* Loose coupling has a significant positive impact on responsible innovation.

*Hypothesis H2:* Loose coupling plays an intermediary role between adaptive governance and responsible innovation.

## 3) THE INTERMEDIARY ROLE OF FORWARD-LOOKING STRATEGIES BETWEEN ADAPTIVE GOVERNANCE AND RESPONSIBLE INNOVATION

Adaptive governance regards policy formulation as a process of continuous learning and experimentation by the government. In this process, the government continuously revises and evaluates policy objectives and practices, ensures policies can be continuously improved with the development of science and technology, and forms dynamic policy environment [66]. Changes of the policy environment, a kind of objective facts, that companies must face and adapt to, are driving forces that force companies to take effective actions. Therefore, in order to grab market share with competitors under a dynamic policy environment, or to prevent new potential competitors from entering the market [67], companies should learn from the outside, predict market demand and social needs, promote the enterprise's ability to resist risks and forward-looking strategies by taking the lead in improving technological processes, develop new products, and change the business strategy to cater to future policy trends [42]. In addition, the weak intervention of adaptive governance on enterprises means that the government's governance behavior is tentative and directional. Companies can quickly learn about the government's attitude, and the government can leave room for operation of the company, so that the company and the government can reach agreement on strategic goals, and coordinate the short-term conflicts between the government and the company [68]. In order to keep in line with the long-term goals of the government, companies tend to give up the short-term benefits brought by "low cost", predict market demand, environmental changes and technological changes that may arise in the future, then adopt appropriate and advanced business methods, pay attention to the sustainable development of the company and form a forward-looking strategies [69]. Based on the above analysis, this paper proposes the following hypothesis:

*Hypothesis 3a:* Adaptive governance has a significant positive impact on forward-looking strategies.

Forward-looking strategies often encourage companies to attract stakeholders such as customers, suppliers, policy makers, and domain experts to participate in forecasting activities, and avoid emotional bias and technical limitations improve their predictability of the external environment [70]. Players gathered by the enterprise help the enterprise obtain various information, knowledge, experience and methods related to the goal, and understand the heterogeneous knowledge, background and values of the stakeholders, then they coordinate the legality of knowledge and participation in technological innovation activities, and promote the implementation of responsible innovation [71]. In addition, the forward-looking strategies often push companies to predict market demand and social needs to make companies become industry leaders [47]. After enterprises predict market demand and social demand, they will use existing information to predict the unknown impact and consequences of the current enterprise research results, and then pre-evaluate the disciplinary value, social needs, and risk level of innovative activities to ensure innovation activities are under control. After that, enterprises can guide scientific research activities in the direction of moral acceptance and social expectations, and promote the implementation of responsible innovation. Based on the above analysis, this paper proposes the following hypotheses:

*Hypothesis H3b:* Forward-looking strategies has a significant positive impact on responsible innovation.

*Hypothesis H3:* The forward-looking strategies plays an intermediary role between adaptive governance and responsible innovation.

#### 4) THE EFFECT OF LOOSE COUPLING ON FORWARD-LOOKING STRATEGIES

The loose coupling relationship between the government and the enterprise provides an opportunity for enterprises to learn from the government [72]. There are two types of corporate learning, one is error-correcting single-loop learning, and the other is double-loop learning that corrects original goals. The double-loop learning enables companies to learn the government's way of thinking, understand the government's next regulatory direction, and help companies reflect on the status quo, so that companies can predict future market and social needs based on the government's regulatory direction, modify original objectives enable companies to seize potential opportunities in a dynamic environment and form forward-looking strategies [73]. In addition, the dominant logic of the government and the enterprise in the loose coupling relationship is different, and their processing mode will also be different, so the system will show a diversified state of information [16]. The diversification of information provides enterprises with a sensitive perception mechanism, enabling them to play a proactive role in market competition, and making them discover potential risks in the market and society before competitor [74]. Forward-looking strategies

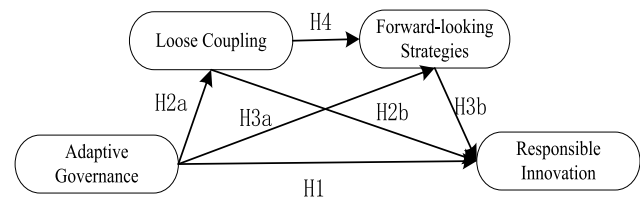


FIGURE 2. The conceptual model.

often require large capital, material and manpower investment due to product development and market expansion, and the returns are often uncertain, hence, companies that implement forward-looking strategies will face greater risks [75]. Therefore, the sensitive perception mechanism of the enterprise in the loose coupling relationship improves the enterprise's ability to deal with risks in the implementation of the forward-looking strategies, and promotes the formation of the enterprise's forward-looking strategies. Based on the above analysis, this paper proposes the following hypothesis:

*Hypothesis 4:* Loose coupling has a significant positive impact on the forward-looking strategies.

The conceptual model of this article is shown in Figure 2.

### III. RESEARCH METHOD AND DATA SURVEY

#### A. SOURCE AND PROCESS OF QUESTIONNAIRE SURVEY

In this paper, questionnaire survey was used to collect data. The respondents are middle-level and above managers as well as technical R&D personnel, both of which have a better understanding of loose coupling, forward-looking strategies and responsible innovation of enterprise and adaptive governance of the region where the enterprise is located. There are two reasons for choosing middle-level and above managers and technical R & D personnel. First, the innovation activities of enterprises are mainly completed by technical R & D personnel, who has a certain understanding of innovation process and the establishment of management systems in technological innovation. Secondly, the middle-level and above managers of an enterprise often have a better understanding of the operation process of the enterprise; in order to ensure the legitimacy of the organization, they will continue to pay attention to the relevant policies on technological innovation. In addition, we mainly sent questionnaires to biomedicine, artificial intelligence, nanotechnology, nuclear energy and other industries. We chose these rapidly innovating industries because emerging technologies have become the driving force of social development, while moral issues such as food safety, environmental pollution and social ethics gradually emerged as well. People are beginning to recognize the two sides of technological innovation.

This survey was conducted with two main preliminary steps. First of all, with the assistance of companies that cooperate with the research group and the university (mainly concentrated in Heilongjiang, Jilin, Liaoning and other northern regions of China), the companies participating in the survey were determined. Second, we got in touch with the presidents of alumni associations in Beijing, Hebei, Henan,

Shandong, Shanghai, Zhejiang, Chongqing and obtained their support. We selected the appropriate research company and then contacted the target company to obtain their support for the survey. The survey response method mainly involved on-the-spot responses. Before conducting the survey, we explained the relevant terms involved in the questionnaire, then the respondents began to fill out the questionnaire when they fully understood its relevant terms. For a small number of people who found on-the-spot surveys inconvenient, we sent the prepared questionnaire to the respondents by email, explained the terms appearing in the questionnaire through telephone communication and provided for the questionnaire to be submitted within two weeks (for those who did not submit on time, we urged them to submit twice, and for those who did not submit afterwards, we gave up).

This survey started from October 2018 to May 2019. After eight months, the data of middle-level and above managers and technical R & D personnel from 187 enterprises were finally collected. The industry includes pharmaceutical biology, artificial intelligence, nanotechnology, nuclear energy and other industries. A total of 500 questionnaires were distributed in this survey. We removed two types of invalid samples: first, the questionnaire was not completed, which meant more than half of the items in a single variable were not answered; second, the questionnaire that was suspected to not be answered seriously, which mainly manifested in obviously regular answers. Finally, 366 valid questionnaires were collected from 187 companies, and the effective recovery rate was 73.2%. Refer to the appendix for statistical information of valid samples.

## B. VARIABLE MEASUREMENT

The measurement of variables involved using a Likert 5-scale to compare the four aspects of enterprise adaptive governance, loose coupling, forward-looking strategies and responsible innovation with the same industry. Scoring from 1 to 5, where “1” means “very disagree”, “5” means “very agree”, and so on. The interviewees evaluated the current situation of their enterprises according to their subjective perceptions. The scale design is shown in Table 1.

## IV. RESULTS

### A. THE RESULTS OF THE MEASUREMENT MODEL

#### 1) RELIABILITY AND VALIDITY TEST RESULTS

In this paper, Cronbach's  $\alpha$  coefficient was used to test the reliability of the questionnaire. The Cronbach's  $\alpha$  coefficients of all variables were between 0.755–0.842, all of which were greater than 0.7. The CITC (Corrected Item-Total Correlation) was greater than 0.4, indicating that the reliability of the questionnaire was good [78]; the factor load was greater than 0.6, variance interpretation was greater than 50% and the KMO (Kaiser-Meyer-Olkin) value was greater than 0.7, all of which indicated that the validity of the questionnaire was good. The reliability and validity test results of specific items are shown in Table 2.

#### 2) VARIABLE DESCRIPTIVE STATISTICS AND RESULTS OF HOMOLOGOUS VARIANCE

Since all variables involved in this study were reported by a senior manager, the relationship between variables may be affected by homologous bias. Therefore, in this study, the correlation coefficient between test variables was used to test the homologous deviation of data. The largest correlation coefficient between variables was 0.707, obviously less than 0.9, which indicates that there was no obvious homologous deviation in the survey data, which can be used for further data analysis and hypothesis testing. Specific statistics are shown in Table 3.

### B. TEST RESULTS OF SEM

This paper used AMOS 17.0 to measure “adaptive governance–loose coupling (forward-looking strategies)–responsible innovation”, and the results are shown in Figure 3. The model fitting index all met the requirements and indicated that the model has good fitness.

From Figure 3, we can see that  $CMIN / DF$  is  $1.595 < 5$ ;  $GFI$ ,  $AGFI$ ,  $CFI$  are all greater than 0.9;  $PGFI$  is  $0.686 > 0.5$ ;  $RMSEA$  is  $0.04 < 0.08$ ;  $RMR$  is  $0.03 < 0.05$ . The results show that the fitting degree of the model is good [79].

From Table 4, we can see that the standardized path of the impact of adaptive governance on responsible innovation is 0.197, and had a p-value greater than  $p < 0.05$ , indicating that adaptive governance has a significant positive impact on responsible innovation. In other words, hypothesis H1 is supported. In addition, the standardized impact of adaptive governance on loose coupling is estimated to be 0.629, and had  $p < 0.01$ , indicating that adaptive governance has a significant positive impact on loose coupling. In other words, hypothesis H2a is supported. While the standardized path of loose coupling on responsible innovation is 0.442, and had  $p < 0.01$ , indicating that the loose coupling has a significant positive impact on responsible innovation. In other words, hypothesis H2b is supported. Based on the above analysis, adaptive governance has a significant positive impact on the loose coupling, and loose coupling has a significant positive impact on responsible innovation, which provides the basis for the next step to test the mediation effect of loose coupling. The standardized impact of adaptive governance on forward-looking strategies is estimated to be 0.301, and had  $p < 0.01$ , indicating that adaptive governance has a significant positive impact on forward-looking strategies. In other words, hypothesis H3a is supported. While the standardized path of forward-looking strategies on responsible innovation is 0.206, and had  $p < 0.05$ , indicating that the forward-looking strategies has a significant positive impact on responsible innovation. In other words, hypothesis H3b is supported. Based on the above analysis, adaptive governance has a significant positive impact on the forward-looking strategies, and forward-looking strategies has a significant positive impact on responsible innovation, which provides the basis for the next step to test the mediation effect of forward-looking strategies. Furthermore, the standardized



**TABLE 1. The design of the variable scale**

Variable	Item	References
Adaptive Governance	AG1. There is a “bridge organization” in the industry where the enterprise is located, which can help the enterprise to establish a cooperative relationship with the government.	Clark[76]
	AG2. In the process of cooperation between the government and enterprises, the government constantly improves the existing policies according to the knowledge and technology provided by enterprises.	
	AG3.The government is willing to cross political boundaries and listen to the opinions of enterprises in the process of policy-making.	
	AG4. Enterprises participate in the whole process of government policy-making, including analyzing problems, making solutions and decisions.	
Responsible Innovation	RI1. Enterprises have a wider range of stakeholders in innovation activities, whose basic actors include innovators, people and policy maker.	Mei[77]、Stilgoe[9]
	RI2. In the early stage of innovation activities, enterprises can make forward-looking analysis on the future impact of activities, so as to guide innovation activities to the direction of moral acceptability and social satisfaction, and realize the controllable risk of innovation activities.	
	RI3. In the process of innovation, enterprises repeatedly reflect on the assumptions, requirements, objectives, implementation process and results of innovation itself.	
	RI4. The behavior subject and governance mode of innovation activities of enterprises are established in the process of interaction, sustainability and adaptability, so as to realize the correct guidance and real-time correction of innovation activities.	
Loose Coupling	LC1. Interaction with the government and other stakeholders is sporadic and not continuous.	Rasche [41]
	LC2. When communication with the government and other stakeholders is often achieved through third-party service agencies.	
	LC3. When government or stakeholders change certain measures or actions, enterprises can not make changes at the same time.	
	LC4. For the changes of market environment and social environment, enterprises, governments and stakeholders will give different explanations and responses.	
Forward-looking Strategies	FS1. In competition with peers, enterprises usually take actions first, and then competitors follow up or respond.	Yin[47]
	FS2. Enterprises often take the lead in launching new products, entering new markets or introducing new management modes and technologies	
	FS3. Enterprises often forecast the development trend of the market, take the lead in grasping the opportunities.	
	FS4. Enterprises often forecast the trend of social environment, and take the lead in sensing the change of social needs, then adjust themselves to adapt to this change.	

**TABLE 2. The reliability and validity test of the scale**

Variable	Item	Factor Loading	Cronbach’α	CITC	Cronbach’s α Deleted	Variance Interpretation%	KMO
Adaptive Governance	AG1	0.830	0.838	0.673	0.793	55.132	0.822
	AG2	0.823		0.649	0.804		
	AG3	0.816		0.689	0.787		
	AG4	0.797		0.673	0.795		
Loose Coupling	LC1	0.806	0.823	0.644	0.778	53.976	0.820
	LC2	0.803		0.642	0.779		
	LC3	0.802		0.654	0.774		
	LC4	0.795		0.647	0.777		
Forward-looking Strategies	FS1	0.842	0.811	0.579	0.785	51.686	0.776
	FS2	0.829		0.580	0.787		
	FS3	0.762		0.675	0.741		
	FS4	0.755		0.685	0.735		
Responsible Innovation	RI1	0.841	0.857	0.707	0.816	57.397	0.825
	RI2	0.838		0.714	0.813		
	RI3	0.825		0.691	0.822		
	RI4	0.825		0.694	0.820		

**TABLE 3. The mean, standard deviation of the variables and the correlation coefficient between the variables**

Variable	Mean	Standard Deviation	Adaptive Governance	Looe Coupling	Forward-looking Strategies	Responsible Innovation
Adaptive Governance	4.046	0.707	1			
Loose Coupling	3.968	0.739	0.521**	1		
Forward-looking Strategies	3.846	0.737	0.466**	0.479**	1	
Responsible Innovation	3.964	0.806	0.490**	0.567**	0.480**	1

path of the impact of loose coupling on forward-looking strategies is 0.393, and had  $p < 0.01$ , indicating that loose

coupling has a significant positive impact on forward-looking strategies, which provides the basis for the next step to test

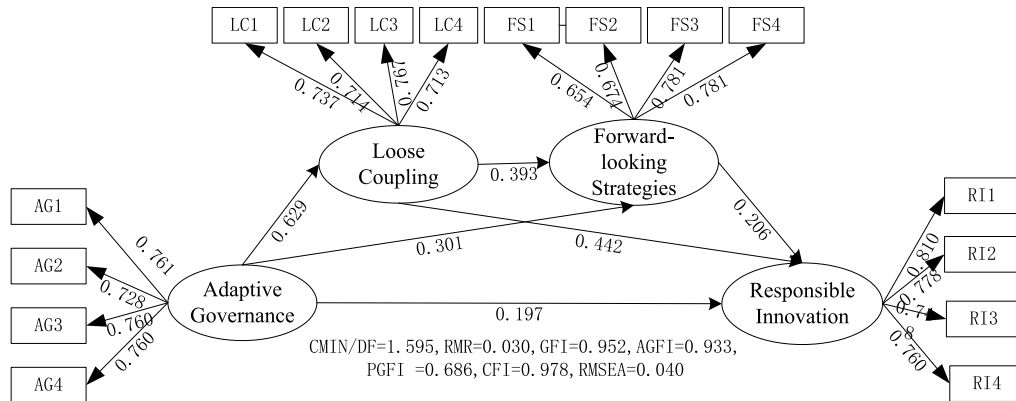


FIGURE 3. The influence relationship model of adaptive governance, loose coupling, forward-looking strategies and responsible innovation.

TABLE 4. SEM standardized path coefficients and significance

	Standardized Estimates	S.E.	C.R.	P
Adaptive Governance → Responsible Innovation	0.197	0.080	2.752	**
Adaptive Governance → Loose Coupling	0.629	0.065	9.097	***
Loose Coupling → Responsible Innovation	0.442	0.095	5.544	***
Adaptive Governance → Forward-looking Strategies	0.301	0.069	3.788	***
Forward-looking Strategies → Responsible Innovation	0.206	0.088	3.007	**
Loose coupling → Forward-looking Strategies	0.393	0.077	4.736	***

\*\*\*, \*\*, \* denote significant levels at 1%, 5%, and 10%, respectively [80].

TABLE 5. comprehensive effect of adaptive governance and responsible innovation

Variable	Point Estimation	Product of coefficients		Bootstrapping			
		S.E.	Z	Bias-Corrected 95%CI		Percentile 95%CI	
				Lower	Upper	Lower	Upper
Adaptive Governance → Responsible Innovation				Total Effect			
	0.587	0.076	7.724	0.433	0.678	0.428	0.670
				Direct Effect			
	0.197	0.089	2.213	0.058	0.345	0.053	0.342
				Indirect Effect			
	0.391	0.077	5.078	0.285	0.537	0.243	0.501

chain mediating effect in the relationship between adaptive governance and responsible innovation.

C. TEST RESULTS OF MEDIATION EFFECT

Compared with the step-by-step test and Sobel test, the trust interval method using bootstrap technology is a more powerful test method. By using the trust interval method of bootstrap technology, it is easy to get the results of robustness analysis, which overcomes the problems of low ability and biased test results associated with the step-by-step test and Sobel test. Therefore, this paper used bootstrap technology to repeatedly sample 2000 times and set a 95% confidence interval to test the mediation effect of promotion focus. The inspection results are shown in Table 5.

First, we test whether there is a mediating effect between the two variables. The test results are shown in Table 5. The results show that the confidence interval of adaptive governance and responsible innovation does not contain 0, and the z value is greater than 1.960. Both the total effect and

indirect effect between adaptive governance and responsible innovation exist, and direct effect is significant. Therefore, we can conclude that there is a mediating effect between adaptive governance and responsible innovation.

Then, we verify the mediating effect of loose coupling and forward-looking strategies between adaptive governance and responsible innovation separately. According to the conceptual model, there are three intermediary paths between adaptive governance and responsible innovation. The first path is that adaptive governance influences responsible innovation through loose coupling; the second path is that adaptive governance influences responsible innovation through forward-looking strategies; the finally path is that adaptive governance influences responsible innovation through the chain mediating formed by forward-looking strategies and loose coupling.

The total indirect effect of adaptive governance on responsible innovation exists. Whether loose coupling and forward-looking strategies play the role of an intermediary, respectively, needs further verification.

**TABLE 6. Mediating effects of loose coupling and forward-looking strategies**

Variable	Point Estimation	Product of coefficients		Bootstrapping	
		S.E.	Z	Lower	Upper
Loose Coupling	0.230	0.061	3.77	0.108	0.351
Forward-looking Strategies	0.087	0.036	2.417	0.015	0.158

**TABLE 7. The mediating role of forward-looking strategies between adaptive governance and responsible innovation**

Variable	Point Estimation	Product of coefficients		Bootstrapping			
		S.E.	Z	Bias-Corrected 95%CI Lower	Upper	Percentile 95%CI Lower	Upper
Loose Coupling→ Responsible Innovation	0.522	0.074	7.054	0.401	0.642	0.400	0.635
	0.442	0.081	5.457	0.313	0.579	0.308	0.576
	0.081	0.036	2.250	0.037	0.163	0.032	0.152

According to the test method proposed by MACKINNON, the Proclin2 program is used to calculate the specific indirect effects of loose coupling and forward-looking strategies to test whether there are indirect effects. The results are shown in Table 6.

It can be seen from Table 6, the calculation results of Proclin2 show that when loose coupling and forward-looking strategies play the role of intermediary variable, their confidence intervals do not contain 0, indicating that both variables have indirect effects. That is, loose coupling and forward-looking strategies can play the mediating role between adaptive governance and responsible innovation respectively. Then hypothesis 2 and hypothesis 3 are supported.

Next, we test the chain mediation effect of loose coupling and forward-looking strategies. The test results are shown in Table 7.

Table 7 shows the results of Bootstrapping test. The confidence interval of loose coupling and responsible innovation does not contain 0, and the z value is greater than 1.960, indicating that the total effects, indirect effects and direct effects of the relationship between loose coupling and responsible innovation exist and the results are significant. Hence, we can conclude that the forward-looking strategies has a mediating effect between loose coupling and responsible innovation.

Based on these inferences, adaptive governance can affect responsible innovation not only through mediating effects of loose coupling and forward-looking strategies, respectively, but also through the intermediary chain formed by loose coupling and forward-looking strategies. Therefore hypothesis 4 is supported.

From the above discussion, we have come to the following conclusions: firstly, by testing the SEM consisting of four variables: adaptive governance, loose coupling, forward-looking strategies and responsible innovation, we can see that hypothesis 1, hypothesis 2a, hypothesis 2b, hypothesis 3a, hypothesis 3b is supported; secondly, we used

**TABLE 8. The summary of hypothesis test results**

Hypotheses	Supported or Not Supported
H1: Adaptive governance has a significant positive impact on responsible innovation.	Supported
H2: Loose coupling plays an intermediary	Supported
H2a: Adaptive governance has a significant positive impact on loose coupling.	Supported
H2b: Loose coupling has a significant positive impact on responsible innovation.	Supported
H3: The forward-looking strategies plays an intermediary role between adaptive governance and responsible innovation.	Supported
H3a: Adaptive governance has a significant positive impact on forward-looking strategies.	Supported
H3b: Forward-looking strategies has a significant positive impact on responsible innovation.	Supported
H4: Loose coupling has a significant positive impact on the forward-looking strategies.	Supported

bootstrap technology to repeatedly sample 2000 times and set a95% confidence interval to test the mediation effect of loose coupling and forward-looking strategies, which showed that hypothesis 2, hypothesis 3 and hypothesis 4 is supported. These results are shown in Table 8.

**V. DISCUSSION**

This paper focuses on the ethical and moral issues of technological innovation. We explore the relationship between adaptive governance, loose coupling, forward-looking strategies and responsible innovation. This article uses a survey of 187 companies in Heilongjiang, Jilin, Liaoning, Beijing and Shanghai to obtain 366 valid data. Then the data were analyzed by the SEM and trust interval method. The research results show that adaptive governance has a significant positive impact on responsible innovation. Adaptive governance guarantees the public value of technological innovation in the policy formulation stage, policy implementation stage and policy feedback stage to promote the implementation of responsible innovation. In addition, loose coupling and forward-looking strategies play a part of the mediating role between adaptive governance and responsible

innovation respectively. On the one hand, the characteristics of independence and responsiveness between the government and the enterprise in the adaptive governance process help to form a loose coupling relationship between the government and the enterprise. Then the loose coupling relationship is conducive to the delivery of fresh or heterogeneous information and knowledge by the government to enterprises, breaking through the separation of disciplines in the innovation process, and promoting the implementation of responsible innovation. Finally, loose coupling and forward-looking strategies play a chain intermediary role between adaptive governance and responsible innovation. Loose coupling relationships provide companies with an opportunity to learn from the government, enable them to understand the government's next regulatory direction, seize potential opportunities, discover market and social needs ahead of competitors, and form forward-looking strategies. The following summarizes the theoretical contribution and practical significance of this research, as well as the limitations of this research.

#### A. THEORETICAL CONTRIBUTIONS

Responsible innovation is an important subject in the field of technological innovation. In the past, scholars analyzed the practical applicability of adaptive governance to responsible innovation through theoretical analysis. However, they did not use objective actual data to verify the conclusion. On the basis of verifying the conclusions of Xue [22], [24], Mark [23], we use SEM to empirically verify the positive impact of adaptive governance on responsible innovation, and provide a theoretical basis for the government's choice of behavior.

In addition, this paper further explores the mechanism of adaptive governance affecting responsible innovation. In existing studies, scholars have verified the relationship between adaptive governance and responsible innovation [23], the relationship between loose coupling and responsible innovation [46], and the relationship between forward-looking strategies and responsible innovation [52], [53]. Through the "adaptive governance-loose coupling- forward looking strategies- responsible innovation" model, we also confirmed the conclusions of Mark, Hofman, Sahaym, Aragon, Song. We further explored the mediating role of loose coupling and forward-looking strategies between adaptive governance and responsible innovation, and revealed the specific path of adaptive governance acting on responsible innovation, enriching the theoretical basis of responsible innovation.

#### B. PRATICAL CONTRIBUTIONS

As the government they can introduce the idea of crowdsourcing legislation to allow the public to participate in legislative decision-making, improve the agility and transparency of technological innovation governance by integrating public knowledge or information. For example, the Finnish government has established a Kokeitun Paikka digital platform to connect the government and the public. The public can

not only provide opinions, but also propose draft legislation, examine the effects of policy implementation, and modify existing laws and policies. Secondly, the government and various stakeholders (especially enterprises) share data, establish connections between IT systems, and ensure the symmetry of information between the government and enterprises, so that the government can understand the expertise and potential risks of a certain technology, make governance decisions more accurately and faster. Finally, the government guides companies to conduct self-regulation. For example, in a certain industry, in order to create a stable regulatory environment, companies formulate market entry conditions, technical standards, production safety regulations and social obligations, etc. by themselves, so that companies will internalize ethical behaviors, and weak government interventions will produce stronger power.

As the companies, they try to use a certain technology as the core, and discuss with the government in formulating policies. In the process of discussion, the government and enterprises should establish standardized, strong interdependence and centralized management systems in their cooperation process, and realize the connection between them. At the same time enterprises should maintain their own logic to ensure the diversification of information in the system, and make science and technology ethics policies meet the needs of enterprises and society. After the policy is formulated, the enterprise should withdraw automatically; the government and the enterprise should terminate cooperation immediately, and finally the temporary "flexible community" is quickly dissolved.

What's more, the companies should form complex adaptive mechanisms such as self-organized learning, independent innovation and flexible collaboration to enhance the company's ability to predict market demand and form forward-looking strategies. Secondly, create a multi-disciplinary comprehensive corporate atmosphere, encourage multi-disciplinary theories, cross-disciplinary personnel exchanges and cooperation, attract the inflow of multi-disciplinary talents, make corporate knowledge diversified, and improve the company's ability to perceive market or social needs, and then promote the formation of forward-looking strategies.

#### C. LIMITATIONS AND FUTURE RESEARCH

This study also has some shortcomings: On the one hand, the data source of this article comes from Chinese companies. Therefore, the research conclusions are more universal to Chinese companies. In future research, we try our best to investigate companies in other countries, and conduct comparative studies according to the different circumstances of each country. On the other hand, the relationship between adaptive governance and responsible innovation is not studied separately for different industry characteristics. Therefore, a large number of questionnaire surveys can be conducted in the future, and related theories of responsible innovation can be explored according to the characteristics of different

TABLE 9. The Statistics of valid samples

		Number of Samples	Percentage			Number of Samples	Percentage
Gender	Male	203	55.46%	Working Years	1-5 Years	217	59.29%
	Female	163	44.54%		6-10Years	98	26.78%
Type of Ownership	Publicly Owned	251	68.58%	More than 10 Years	51	13.93%	
	Privately Owned	115	31.42%	Industry	Biomedicine	38	10.38%
Educational Background	Associate Degree	45	12.29%		Artificial Intelligence	109	29.785%
	Bachelor Degree	98	26.78%	Nanotechnology	58	15.85%	
	Master's Degree	187	51.09%	Nuclear Energy	96	26.23%	
	Doctoral Degree	36	9.84%	Others	65	17.76%	
Enterprise Size	Small Enterprise	153	41.81%	Years of Establishment	1-5 Years	161	43.99%
	Medium-sized Enterprise	134	36.61%		6-10Years	141	38.52%
	Large Enterprise	79	21.58%		More than 10 Years	64	17.49%

industries, and the practical value of the theory of responsible innovation can be enhanced.

## VI. CONCLUSION

This study explored the relationship between adaptive governance, loose coupling, forward-looking strategies and responsible innovation. It analyzed the notable impact of adaptive governance and responsible innovation. In addition to this, this research also demonstrated the intermediary effect produced by loose coupling and forward-looking strategies on the relationship between adaptive governance and responsible innovation. The conclusions of this study are as follows: (1) adaptive governance has a significant positive impact on responsible innovation; (2) loosely coupled partially mediates the effect of adaptive governance on responsible innovation; (3) forward looking strategy partially mediates the effect of adaptive governance on responsible innovation; (4) Loose coupling and forward-looking strategies play a chain mediating role in the relationship between adaptive governance and responsible innovation.

Funding: This work was supported by three funds: 1>National Natural Science Foundation of China: Evolution Mechanism, Model and Policy of Industry-University-Research Cooperation Innovation Network (71473055); 2>Heilongjiang Provincial Social Science Fund: Research on the path to promote the future industrial development of Heilongjiang Province under the background of new infrastructure. (20JYB042); 3> Fundamental Scientific Research Business Expense Project of Central Universities: Research on Responsible Innovation Mechanism and Governance of Artificial Intelligence Technology (3072020CFW0902).

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