

Hypothesis

Innovative Resources, Promotion Focus and Responsible Innovation: The Moderating Roles of Adaptive Governance

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Abstract: This paper discusses the relationship between innovative resources, promotion focus, adaptive governance and responsible innovation. In accordance with the path of “demand—motivation—behavior”, this paper takes adaptive governance as the moderator, and constructs an influence relationship model of “innovative resources—promotion focus (adaptive governance)—responsible innovation”. Then this paper takes 361 managers from above the middle management level and the technical personnel of enterprises as the investigation objects, and conducts empirical research by using the structural equation model. The results show that: (1) innovative resources have a significant positive impact on responsible innovation; (2) promotion focus partially mediates the effect of innovative resources on responsible innovation; (3) adaptive governance has a positive moderating effect on the relationship between innovative resources and responsible innovation. The results enrich the quantitative research of responsible innovation, reveal the internal mechanism of innovative resources affecting responsible innovation, provide a new way for technological innovation governance and provide a new way of thinking for the transformation from the traditional innovation paradigm into a sustainable innovation paradigm.

Keywords: innovative resources; promotion focus; adaptive governance; responsible innovation

1. 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, causing research and policy concerns regarding the social control of technology, ethical security and other aspects [1]. The traditional paradigm of innovation is concerned with the advancement of technology and the enhancement of economic effects, while addressing the social crisis that may arise from innovation activities, and the problems of social ethics and social desirability arising from the innovation itself [2]. As a new management paradigm, responsible innovation means the change in the existing innovation paradigm, and explores the future of innovation to make innovation meet social needs as well as moral and ethical constraints, which is an inevitable decision made by society to achieve sustainable development [3]. However, whether to embrace responsible innovation is an important question for an enterprise that would need to give up “high efficiency” and “low cost” procedures to then be able to carry out this type of innovation.

According to resource-based theory, the performance of corporate responsibility behavior depends on whether an enterprise has available abundant resources [4]. At present, some scholars have discussed the relationship between innovative resources and responsible innovation. Zhang took the big data industry as the research object, constructed a theoretical framework based on inclusion, anticipation,

responsiveness and reflexivity, and discussed the relationship between innovative resources and the development efficiency of technology (privacy security technology, data acquisition, data utilization and data regulation) [5]. Antel took the field of fetal surgery as the research object and explored the relationship between innovative resources and the technical ethics of fetal surgery using case study methods [6]. Lukovics compared the innovation environment of Hungary and the Netherlands using the social technology integration research method, and explored the impact of R & D costs and the number of R & D personnel on responsible innovation [7]. However, the above research only uses qualitative research methods to explore the impact of innovative resources on responsible innovation; the research ignores the internal mechanism of the impact of innovative resources on responsible innovation. Therefore, this article attempts to verify the research results of previous scholars by using qualitative research methods, and then further explores the mechanism of innovative resources affecting responsible innovation. Relevant research have shown that the resources of enterprises determine the needs of enterprises, and the needs of enterprises lead to behavioral motivation [8]. Some studies confirmed that there is a significant relationship between resources and behavioral motivation [9–11]. Brekke and Girard also demonstrated the relationship between motivation and responsible behavior [12,13]. Therefore, this article attempts to introduce motivation into the research model to explore what kind of motivation plays an intermediary role between innovative resources and responsible innovation. In addition, the regulation focus theory has important applications in the study of corporate behavior motivation [14]. The regulatory focus theory divides the basic motivation of enterprises into two types: the promotion focus and the prevention focus. The promotion focus means that enterprises tend to pursue more efficient behavior patterns and pay attention to the growth of other enterprises, while the prevention focus means that enterprises are more willing to maintain the status quo and pay attention to the stability and safety of other enterprises [15]. Companies that focus on growth and development will also take their social responsibilities into account to ensure their long-term development [16]. Scholars verified the relationship between corporate growth and corporate social responsibility behavior using empirical methods [17,18]. It can be concluded that the demand of enterprises caused by innovative resources will affect the behavioral motivation of enterprises and further promote the emergence of corporate responsibility behavior. According to the hierarchy of needs theory and the corporate behavior theory, we can know that behavior is driven by motivation, and motivation is stimulated by demand, which promotes enterprise behavior intended to meet demand [19]. Many scholars have applied the demand-motivation-behavior framework to the category of business management. Liang followed the research path of enterprise demand-motivation-behavior, and discussed the requirements of innovative resources at different stages of enterprise development impact on corporate goals and behaviors. Finally, Liang found the consistency of enterprise needs and cooperative relationship behaviors [20]. Huang studied the motivation of enterprises to join a brand alliance by examining the path of corporate demand-motivation-behavior [21]. Therefore, based on the path of “demand-motivation-behavior”, this article takes innovative resources as the starting point, and explores the impact of corporate demand caused by different innovative resources on promotion focus and responsible innovation behavior. We inferred from this examination that the impact of innovative resources on responsible innovation is likely to be achieved by a promotion focus.

In addition, government is an important external stakeholder for an enterprise, whose regulatory approach will greatly affect the implementation of responsible innovation [22]. Faced with ethical safety issues in innovation activities, governments of various countries have promulgated a series of policies and measures to promote responsible innovation. These policy measures include the European Union’s “Horizon 2020” 8th R & D framework plan [23], the American “National Nano Plan Environmental, Health and Safety Strategic Research Plan” [24] and the Chinese “13th five-year plan for scientific and technological innovation” [25]. It can see that the government governance method plays an important role in discussing the social issues of technological innovation. But at present, scholars have not reached a unified conclusion on the topic of the relationship between government governance and responsible innovation. Chen and Hofmann thought that public policies for innovation issued by the government

would urge enterprises to consider moral and ethical issues during the process of innovation and create a positive external environment for enterprises to implement responsible innovation [26,27]; Roeser, Xue and other scholars thought that the government's technology governance policies distort the information symmetry among stakeholders and hinder the implementation of responsible innovation strategies [28,29]. The inconsistency of previous research conclusions may be due to the fact that scholars regard enterprises and government as if they are two independent individuals, and ignore the interactions between government and enterprise during the process of policy formulation and implementation. Adaptive governance by contrast emphasizes that during the process of policy formulation and implementation, the government and enterprises maintain communication, share resources and learn from each other to ensure the sustainability and accuracy of the government's policy [30]. In the existing literature, scholars mostly applied adaptive governance to environmental governance [31], shared economy supervision [32] and local project management [33]. Few scholars explored the regulatory role of adaptive governance in the process of responsible innovation activities. Therefore, this paper introduces the concept of adaptive governance to explore whether adaptive governance creates a favorable environment for responsible innovation and promotes the smooth development of responsible innovation.

This paper makes up for the shortcomings of previous studies and constructs a conceptual model of “innovative resources—promotion focus (adaptive governance)—responsible innovation” with promotion focus as the mediator variable and adaptive governance as the moderator variable. In addition, we analyze the internal mechanism of the impact of innovative resources on responsible innovation and the moderating effect of adaptive governance between innovative resources and responsible innovation, reveal the driving of the development of responsible innovation and provide a way to realize the sustainable development of technology and society.

2. Theoretical Background and Hypothesis Development

2.1. Definition of Related Concepts

2.1.1. Innovative Resources

Halme believed that the available innovative resources underpinning responsible innovation activities include the number of shares issued, assets and liabilities, the amount of professional knowledge stored, the amount of intellectual property owned, the extent of R & D cooperation and corporate reputation [34]. Petraite divided resources into four categories: financial support, researchers and developers, corporate reputation and social relations [35]. Chou believed that corporate capital, the relationship between enterprises, society and stakeholders, has an impact on responsible innovation [36]. Based on the research of the above scholars, it can see that the innovative resources required for responsible innovation include not only the resources that directly affect enterprises' innovation (money, knowledge, technology), but also the external relationship capital that indirectly affects enterprises' innovation activities. Since people can be carriers of knowledge and technology [37], we divide innovative resources into three categories: financial capital, human capital and social capital.

2.1.2. 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 focused 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 [38]. 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 [39]. 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 [40]. 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 properly embedded in social development [41]. Combined with the existing research, this paper defines responsible innovation in this way: in the early stage of innovation, enterprises include many stakeholders participating in decision-making and predicting 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, to achieve scientific and technological progress and finally to make scientific and technological progress properly embedded in social development. Compared with the traditional innovation paradigm, the characteristics of responsible innovation mainly embody the following four aspects: inclusion, anticipation, responsiveness and reflexivity. Among them, inclusion is reflected in the participation of a wider range of stakeholders in innovation activities; anticipation is reflected in the forward-looking analysis of innovation activities; responsiveness is reflected in the recognition and retrial of the innovation process and structure by the innovation subject; reflexivity is reflected in the establishment of a continuous adaptive process between the innovation subject and the external, so as to rectify the deviation of innovation activities [42].

2.1.3. Promotion Focus

In order to achieve a specific goal, an individual or organization will try to change or control their own thoughts or methods. This process is called self-regulation. In the process of self-regulation, an individual or organization shows a specific inclination or tendency, which is called regulatory focus [43]. Based on the different motivations of individuals or organizations to pursue goals, they are generally divided into having a promotion focus or a prevention focus [44]. Enterprises with a promotion focus will show the pursuit of “self value”. Such enterprises are not constrained by specific goals and tasks, actively face risks and use new ideas and methods to achieve an ideal state beyond the tasks and goals [45]. In contrast with the prevention focus, a promotion focus can guide an enterprise to proactively establish contact with customers, experts and other external related groups and to obtain various information, knowledge, experience and methods related to creative task objectives through relationship construction and information seeking [46]. Therefore, this paper attempts to introduce the promotion focus into the influence relationship of “innovative resources–responsible innovation”, and reveals the role of promotion focus.

2.1.4. 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 [47]. With the continuous development of adaptive management in the field of public management, the original dimension of learning and change has been added to the dimension of cross level communication, forming the concept of adaptive governance [48]. 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, facilitates coordination to reduce conflicts between the government and enterprises in the short term and makes weak government intervention have stronger

effects [49]. Therefore, compared with traditional regulation, the characteristic of adaptive governance can encourage enterprises to participate in the policy-making process and share public and private resources in the process of policy development, meaning the government can formulate sustainable and inclusive policies in line with the current market environment and social environment based on the current situation for industry.

2.2. *The Effect of Innovative Resources on Responsible Innovation*

The demand level of enterprises includes survival demand, development demand and self realization demand [50]. When survival needs promote the development of enterprises, enterprises mainly focus on meeting their economic and legal responsibilities to achieve profits and accumulate funds [51]; when the demand of enterprises rises to encompass demand for development, enterprises increasingly consider assuming ethical responsibilities. At this time, enterprises need to meet the interest demands of their stakeholders [52]; when the demand rises to become self realization demand, enterprises are more willing to take the initiative to assume social responsibility roles. This means the survival needs of enterprises are the long-term basis of development needs and self realization needs [53]. Enterprises will only consider assuming ethical responsibilities after they have achieved sufficient fund accumulation [7]. Therefore, in the early stage of innovation, enterprises with sufficient funds often have remaining capacity to slow down their innovation efficiency properly; they can use forward-looking analysis to explore and evaluate the possible consequences of innovation, and improve their ability to control and predict the risks of innovation activities, finally enabling them to promote the implementation of responsible innovation. In addition, abundant human capital often coexists with heterogeneous knowledge and interdisciplinary knowledge within the enterprise, which is conducive to a comprehensive understanding and in-depth understanding of the problems in the process of scientific and technological innovation, forming an effective “early warning mechanism” [3]. Under such a mechanism, on the one hand, enterprises can adjust their behavior patterns in time when they feel that they lack knowledge and control of innovation, and they can correct their own behaviors so that their technological innovation activities and the external environment are dynamically matched, so as to develop a response supporting their social values [54]; in addition, this mechanism can encourage enterprises to reflect on the premise assumption, requirements, objectives, implementation process and results of innovation itself, thereby enabling them to re-examine the innovation problem [55]. Finally, the increase of social capital means there is also an increase of enterprise stakeholders. In order to survive and develop, the behavior of an enterprise should conform to a series of explicit or implicit behavior norms, and address the interests or emotional needs of all stakeholders to the maximum extent [56]. Therefore, with the continuous increase of social capital during the process of innovation, there are discussions on the scope of authority, role, division of labor and interdisciplinary cooperation involving innovation subjects (sociologists, philosophers, educators, etc.) in a wider range [57]. Enterprises listen to the demands of different stakeholders for innovation, coordinate the conflicts among stakeholders and achieve the compatibility of scientific and technological innovation activities to promote the implementation of responsible innovation [58]. Based on the above analysis, this paper proposes the following hypothesis:

Hypothesis 1. *Innovative resources have a direct positive impact on responsible innovation.*

2.3. *The Intermediary Role of Promotion Focus between Innovative Resources and Responsible Innovation*

(1) The effect of innovative resources on promotion focus

On the one hand, abundant financial capital can prevent capital competition between internal departments and teams, reduce internal restrictions and maintain stable financial performance [59]. Enterprises with stable cash flow can effectively alleviate managers’ concerns about the survival and safety of their enterprises, meaning these enterprises could then pay attention to their development and self realization, stimulate their demand for self realization, become more willing and able to participate

in new projects, pursue challenging tasks to realize “self value” and form a promotion focus [60]. On the other hand, abundant social capital and human capital mean that enterprises’ ability to acquire and absorb information increases [61]. With the continuous absorption and integration of external heterogeneous knowledge, enterprises will present a diversified state of information, which will help enterprises to form a sensitive perception mechanism, find potential risks ahead of competitors and conduct timely control actions [62]. With the continuous enhancement of risk tolerance, enterprises are more willing to adjust their own technology, methods, products and services according to the continuous changes of the external environment, so that they can show their competitive advantages in a dynamic market environment, transform a stability strategy into an expansion strategy, and promote the formation of a promotion focus [63].

(2) The effect of a promotion focus on responsible innovation

First of all, a promotion focus will drive enterprises to actively establish contact with customers, experts, other teams and other external related groups, and enterprises could then seek external information, knowledge, experience and methods that are conducive to their growth [64]. After understanding the heterogeneous knowledge, background and values of their stakeholders, enterprises can then effectively deal with unexpected results generated by innovation under the premise of widely considering social, environmental, moral and other factors, and form “forward-looking governance” to guide technological innovation activities towards the direction of moral and ethical acceptability and social expectation satisfaction [65]. In addition, a promotion focus drives enterprises to constantly obtain new and useful information from the outside world and implement feedback, which helps them to form a mirror image of their own behavior, commitment and ability [66]. A feedback mirror helps enterprises to recognize their own cognitive deficiencies, formulate innovation goals, adopt research methods, establish research models and establish research management systems, meaning it can help enterprises to re-examine their scientific principles and principles; in addition, a feedback mirror is conducive to the effective response to and control of technological innovation incidents, the correct guidance and real-time correction of innovation activities, and the development of a response adapting the innovation evolution process to social values and then promoting the implementation of responsible innovation [67]. Finally, a promotion focus drives enterprises to try new ideas by combining their own knowledge, carrying out organizational change to seek the realization of self-worth and showing strong perseverance in this process, while corporate responsibility behavior is one of the main ways to achieve self-worth [68]. Therefore, a promotion focus will encourage enterprises to change their traditional innovation paradigm, regard innovation activities as a collective behavior involving enterprises, policy makers and the public, coordinate the emotional conflicts among the main bodies of technological innovation activities, improve the inclusiveness of innovation activities, embed technological innovation activities in social development and realize responsible innovation [69]. Based on the above analysis, this paper proposes the following hypothesis:

Hypothesis 2. *Promotion focus plays an intermediary role between innovative resources and responsible innovation.*

2.4. The Regulatory Role of Adaptive Governance between Innovative Resources and Responsible Innovation

The “Polanyi science community” suggested that enterprises often lack self-examination of ethics and morality in their innovation activities, and lack the ability to predict the future based on their innovation practices [70]. Therefore, government intervention affects the relationship between innovative resources and responsible innovation to a certain extent. This study discusses the moderating role of adaptive governance covering three aspects: corporate participation in policy formulation, corporate resource sharing during policy formulation and weak government intervention in policy implementation. First of all, adaptive governance encourages enterprises to participate in policy-making so enterprises can realize their role as social citizens, consciously avoid the negative impacts of science and technology and assume responsibility for predicting and evaluating the consequences of science

and technology [71]. However, the main aims of corporate financial capital are to pursue “high efficiency” and “low costs”, bringing constant capital flow to the enterprise [72]. In an adaptive governance environment, the sense of responsibility of an enterprise as a social citizen will promote it to give up its one-sided pursuit of “efficiency” and “cost”, and change the goal of using financial capital to pursue short-term financial performance into a use of sufficient finance capital that slows down the innovation process, constantly tests and evaluates during the innovation process and changes or even interrupts the work immediately in case of any malpractice or danger, so as to achieve the institutional coupling of an innovation evolution process response to social value [73]. In addition, in the adaptive governance environment, in addition to participating in policy-making, enterprises will also share public and private resources with the government in the process of policy-making to ensure the accuracy of policy-making [74]. The integration of government resources and enterprise resources enables enterprise resources to have public value and tends to transform their business objectives from purely economic ones into a combination of economic and social goals [71]. It not only encourages enterprises to use technological advancement and economic growth as evaluation criteria, but also integrate the acceptability of moral ethics and the satisfaction of social needs and expectations into the evaluation criteria of innovation performance, so as to realize the public value of science and technology [75]. Finally, in the process of policy implementation, the policies formulated by adaptive governance not only alleviate the target conflict between the government and the enterprise, but also conform to the market environment of the industry where the enterprise is located, and weakens the concern of the enterprise about government intervention damaging the value of enterprise [76]. In this case, the goal consistency between the enterprise and the government becomes stronger, which not only ensures the interests of the enterprise, but also addresses the government’s demand for public value, reduces the risk associated with the enterprise’s implementation of the policy and encourages the enterprise to make use of their existing innovative resources, actively implement the issued policies and regulations, fulfill the ethical responsibility emphasized by the government and ensure there is a public value of technological innovation [77]. Based on the above analysis, this paper proposes the following hypothesis:

Hypothesis 3. *Adaptive governance plays a regulatory role between innovative resources and responsible innovation.*

The conceptual model of this study is shown in Figure 1.

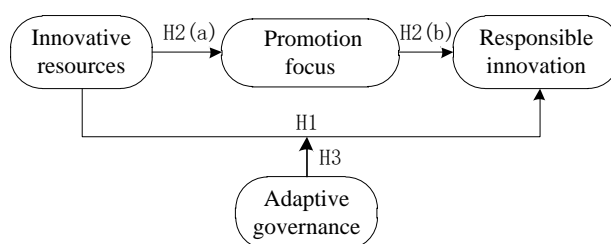


Figure 1. The conceptual model.

3. Research Method and Data Survey

3.1. Source and Process of Questionnaire Survey

In this paper, the data are collected by means of questionnaires. The respondents are middle-level and above managers as well as technical R&D personnel, both of which have a better understanding of innovative resources, responsible innovation, regulatory focus 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 have a certain understanding of the amount of innovative resources available 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; 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 focuses on 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, 361 valid questionnaires were collected from 187 companies, and the effective recovery rate was 72.2%. Among the 361 respondents, there are more males, accounting for 61.43% of the total; the education level of the respondents was mainly possessing a master's degree, which accounted for 55.17% of the total respondents; the working tenure of the respondents was predominately 1–5 years, accounting for 61.54% of the total; the industries of the respondents were mainly concentrated in biomedicine, artificial intelligence, nanotechnology, nuclear energy, accounting for 83.33% of the total. In addition, among the 187 enterprises, large enterprises accounted for 13.5%, while medium and small enterprises accounted for 86.5%.

3.2. Variable Measurement

The measurement of variables involved using a Likert 5-scale to compare the four aspects of enterprise innovative resources, promotion focus, responsible innovation and adaptive governance 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.

Table 1. The design of the variable scale.

Variable	Item	References
Innovative resources	IR1. Compared with the same industry, enterprises have good profitability and can provide sufficient financial support for innovation activities.	Halme [34]
	IR2. Compared with the same industry, the enterprise has a strong R & D team, and team members can communicate with other members according to their own knowledge accumulation to maximize the use of team knowledge.	
	IR3. Compared with the same industry, the R & D personnel of enterprises have higher scientific research quality, and can usually complete innovation projects with high quality.	
	IR4. Compared with the same industry, enterprises are closely related to external stakeholders such as suppliers, distributors and governments.	
	IR5. Compared with the same industry, enterprises tend to cooperate with external R & D teams to jointly develop new technologies.	
Promotion focus	PRO1. Enterprises are willing to try high-risk, high return projects.	Neubert [78], Chen [79]
	PRO2. The key point of an enterprise is to complete the task of expansion, and at the same time, to think about how to realize the self realization needs of the enterprise under the condition of ensuring profits.	
	PRO3. Enterprises tend to actively establish contact with customers, experts and other external related groups and obtain the required information.	
	PRO4. Enterprises will use new ideas and methods to achieve the ideal state beyond tasks and goals.	
Responsible innovation	IRR1. Enterprises have a wider range of stakeholders in innovation activities, whose basic actors include innovators, people and policy makers.	Mei [2], Stilgoe [3]
	IRR2. 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.	
	IRR3. In the process of innovation, enterprises repeatedly reflect on the assumptions, requirements, objectives, implementation process and results of innovation itself.	
	IRR4. 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.	
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 [30]
	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 making decisions.	

4. Results

4.1. The Results of the Measurement Model

4.1.1. Analysis 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 0.805, 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.

4.1.2. Reliability and Validity Test Results

In this paper, Cronbach's α coefficient was used to test the reliability of the questionnaire. The Cronbach's α coefficients of all variables were between 0.894–0.914, 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 [80]; the factor load was greater than 0.6, variance interpretation was greater than 60% 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.

Table 2. The reliability and validity test of the scale.

Variable	Item	Factor Loading	Cronbach's α	CITC	Cronbach's α Deleted	Variance Interpretation %	KMO
Innovative resources	IR1	0.845	0.909	0.756	0.893	73.509	0.881
	IR2	0.857		0.769	0.890		
	IR3	0.881		0.806	0.882		
	IR4	0.868		0.785	0.886		
	IR5	0.836		0.743	0.895		
Promotion focus	PRO1	0.906	0.914	0.826	0.874	79.528	0.848
	PRO2	0.900		0.817	0.877		
	PRO3	0.893		0.766	0.896		
	PRO4	0.867		0.807	0.891		
Responsible innovation	IRR1	0.876	0.894	0.774	0.860	75.948	0.845
	IRR2	0.879		0.778	0.859		
	IRR3	0.865		0.756	0.866		
	IRR4	0.866		0.758	0.866		
Adaptive governance	AG1	0.860	0.898	0.750	0.877	76.610	0.835
	AG2	0.877		0.776	0.867		
	AG3	0.879		0.778	0.866		
	AG4	0.885		0.788	0.863		

4.2. Test Results of Structural Equation Model

This paper used AMOS 17.0 to measure “innovative resources–promotion focus (adaptive governance)–responsible innovation”, and the results are shown in Figure 2. The model fitting index all met the requirements and indicated that the model has good fitness.

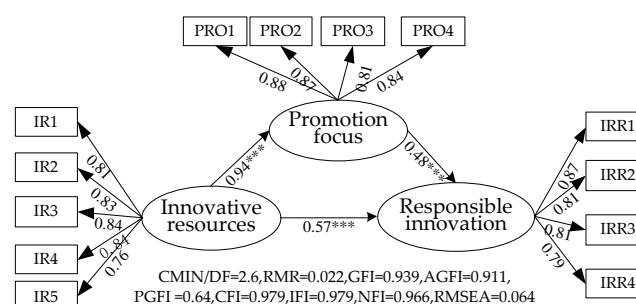


Figure 2. The influence relationship model of innovative resources, promotion focus and responsible innovation.

From Figure 2, we can see that CMIN/DF is $2.6 < 5$; GFI, AGFI, CFI, IFI and NFI are all greater than 0.9; PGFI is $0.64 > 0.5$; RMSEA is $0.064 < 0.08$; RMR is $0.022 < 0.05$. The results show that the fitting degree of the model is good [81].

From Table 3, we can see that the standardized path of the impact of innovative resources on responsible innovation is 0.567, and had a p -value greater than $p < 0.001$, indicating that innovative resources have a significant positive impact on responsible innovation, meaning hypothesis H1 is supported. In addition, the standardized impact of innovative resources on promotion focus is estimated to be 0.94, and had a p -value greater than $p < 0.001$, indicating that innovative resources have a significant positive impact on responsible innovation, while the standardized path of promotion focus on responsible innovation is 0.48, and had a p -value greater than $p < 0.001$, indicating that the promotion focus has a significant positive impact on responsible innovation. Based on the above analysis, innovative resources have a significant positive impact on the promotion focus, and promotion focus has a significant positive impact on responsible innovation, which provides the basis for the next step to test the mediation effect of a promotion focus.

Table 3. Structural Equation Model Standardized Path Coefficients and Significance.

	Standardized Estimates	S.E.	C.R.	p
Innovative resources → Responsible innovation	0.567	0.082	6.418	***
Innovative resources → Promotion focus	0.940	0.085	17.673	***
Promotion focus → Responsible innovation	0.478	0.051	5.490	***

*** denotes significant levels at 1%, respectively [82].

4.3. Test Results of Mediation Effect of Promotion Focus

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 4.

Table 4. The mediation effect test for facilitating focus.

Variable	Point Estimation	Product of Coefficients		Bootstrapping			
				Bias-Corrected 95% CI		Percentile 95% CI	
		S.E.	Z	Lower	Upper	Lower	Upper
Total Effect							
Innovative resources → Promotion focus → Responsible innovation	0.945	0.048	16.688	0.857	1.051	0.857	1.047
Indirect Effect							
Innovative resources → Promotion focus → Responsible innovation	0.417	0.197	2.177	0.100	0.894	0.091	0.869
Direct Effect							
Innovative resources → Responsible innovation	0.528	0.205	2.576	0.096	0.895	0.082	0.887

According to Table 4, the estimated point value of the total effect of “innovative resources–promotion focus–responsible innovation” is 0.945. Under a 95% confidence interval, the confidence interval of bias corrected is (0.857,1.051), the confidence interval of percentile is (0.857,1.047) and the confidence interval does not contain 0 [83], indicating that the total effect is significant; the indirect effect of “innovative resources–promotion focus–responsible innovation” is also significant. The estimated value of point is 0.417, under a 95% confidence interval, the confidence interval of bias corrected is (0.1,0.894), the confidence interval percentile is (0.091,0.869) and the confidence interval does not

contain 0, indicating that the indirect effect is significant; the estimated value of the point of direct effect of “innovative resources–promotion focus–responsible innovation” is 0.528 under a 95% confidence interval, while the corrected confidence interval of bias is (0.091,0.869). The confidence interval percentile is (0.082,0.887), and the confidence interval does not contain 0, indicating that the direct effect is significant. It can be concluded that promotion focus has an intermediary role between innovative resources and responsible innovation, assuming that H2 is supported.

4.4. Test Results of Moderating Effect of Adaptive Governance

The hierarchical regression results of the moderating effect of adaptive governance in the process of the impact of innovative resources on responsible innovation and the moderating effect of promotion focus on the impact of responsible innovation are shown in Table 5. Model 1 introduces responsible innovation as the dependent variable and innovative resources as the independent variable for regression analysis. The regression coefficient is 0.912, which is significant at the level of $p < 0.01$. This further proved that hypothesis H1 is supported. Afterwards, on the basis of model 1, adjustment variable adaptive governance was introduced to build model 2. The regression results show that the regression coefficient of adaptive governance is 0.625, which is significant at the level of $p < 0.01$, indicating that adaptive governance is suitable. Then, based on model 2, the cross product of innovative resources and adaptive governance was added. The regression coefficient for responsible innovation is 0.234, which is significant at the level of $p < 0.05$. At the same time, R^2 is increased from 0.831 to 0.897, and the explanatory power of the model is gradually enhanced, which showed that adaptive governance is related to the impact of innovative resources on responsible innovation, suggesting that H3 is valid. The corresponding regulatory effect is shown in Figure 3.

Table 5. The results of hierarchical regression analysis of adjustment effect of adaptive governance on accountability innovation.

	Responsible Innovation		
	Model 1	Model 2	Model 3
Independent variable			
Innovative resources	0.912 ***	0.234 ***	0.228 ***
Moderator variable			
Adaptive governance		0.625 ***	0.501 ***
Moderating effect			
Innovative resources \times Adaptive governance			0.234 **
R^2	0.831	0.896	0.897
ΔR^2		0.065	0.001

***, ** denotes significant levels at 1%, 5%, respectively [82].

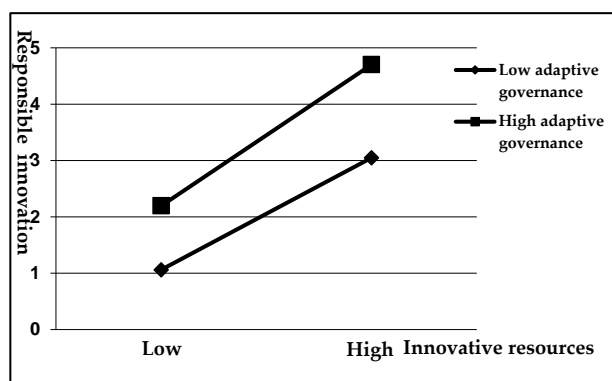


Figure 3. The regulatory role of adaptive governance in promoting the relationship between innovative resources and responsible innovation.

From the above discussion, we have come to the following conclusions: firstly, by testing the structural equation model consisting of three variables: innovative resources, promotion orientation and adaptive governance, we can see that hypothesis 1 is supported; secondly, we used bootstrap technology to repeatedly sample 2000 times and set a 95% confidence interval to test the mediation effect of a promotion focus, which showed that hypothesis 2 is supported; finally, the step by step regression method was used to test the moderating role of adaptive governance and indicated hypothesis 3 is supported. These results are shown in Table 6.

Table 6. The Summary of hypothesis test results.

Hypotheses	Supported or Not Supported
Hypothesis 1: Innovative resources have a positive impact on responsible innovation.	Supported
Hypothesis 2: Promotion focus plays a mediation role between innovative resources and responsible innovation.	Supported
Hypothesis 3: Adaptive governance plays a regulatory role between innovative resources and responsible innovation.	Supported

5. Discussion

This paper focuses on the ethical and moral issues of technological innovation. It explores the relationship between innovative resources, promotion focus, responsible innovation and the moderating role of adaptive governance from the perspective of needs, motivation and behavior. This article uses a survey of 187 companies in Heilongjiang, Jilin, Liaoning, Beijing and Shanghai to obtain 361 valid data. Then the data were analyzed by using the structural equation model, trust interval method and step by step regression method. The research results show that innovative resources have a significant positive impact on responsible innovation. Innovative resources (including financial capital, human capital and social capital) can improve enterprises' risk prediction ability, introspection ability, responsiveness to the external environment and inclusiveness towards promoting the implementation of responsible innovation. In addition, a promotion focus plays a partially mediating role between innovative resources and responsible innovation. When innovative resources are gradually abundant, the needs of the company will gradually transform from the needs of survival to the needs of self-realization, and the company's attention will expand towards sustainable development and self-realization. The company will then form a promotion focus. Promotion focus focuses on the growth and development of enterprises, and further promotes the implementation of responsible innovation, that is, promotion focus has a mediating role by encouraging innovative resources and responsible innovation. Finally, adaptive governance positively regulates the relationship between innovative resources and responsible innovation. Adaptive governance allows enterprises to participate in policy formulation, public-private resource sharing in the process of policy formulation and weak government intervention in enterprises during the implementation of policies, which increase the impact of innovative resources on responsible innovation. The theoretical contributions and implications for practice of this study, as well as the limitations of this research, are summarized below.

5.1. Theoretical Contributions

Responsible innovation is an important subject in the field of technological innovation. The focus of past research was to study the impact of existing enterprise innovative resources on responsible innovation through qualitative research [5,6]. The results of some of past research were also confirmed by employing the quantitative methods used in this paper. However, some studies have ignored the inherent mechanism of innovative resources affecting responsible innovation. Therefore, we further explored the impact of three types of innovative resources, financial capital, human capital and relational capital on responsible innovation, then we revealed the mechanism by which different types

of innovative resources affect responsible innovation. Finally, we enriched the quantitative research results of responsible innovation.

Moreover, the influence of the innovation resources on responsible innovation is further discussed. The current research focuses on the direct relationship between innovative resources and responsible innovation [7]. Our study also confirms the direct impact of innovative resources and responsible innovation, and further explores the role of promotion focus as a mediator between innovative resources and responsible innovation. In addition, the mediation effect produced by the promotion focus is the theoretical extension and application of the “demand–motivation–behavior” theoretical framework in the field of management.

Finally, the positive regulation effect of adaptive governance between innovative resources and responsible innovation reflects the significance of government governance for responsible innovation. Previous research has focused on whether government regulation is a catalyst for responsible innovation in enterprises, but these studies have not reached a uniform conclusion [27–30]. This article introduces adaptive governance into the research model and proves the positive role of adaptive governance in the implementation of responsible innovation in enterprises. It expands the theoretical framework of government regulation and provides new ideas for future research on government behavior.

5.2. Implications for Practice

As a concept of “sustainable development” in contemporary deepening and development, responsible innovation has important implications for China’s economic development, social progress and technological innovation. From a practical perspective, the theory and practice of “responsible innovation” could solve the problem of the disconnect between “responsibility” and “technical innovation” in some fields and departments in China. This could take full account of public value demands and address the public interests of all parties to the greatest extent. Such reflexivity could enable companies reflect on emerging or imminent value conflicts at any time and propose adjustments and solutions as quickly as possible. The inclusion of responsible innovation could involve building a platform that technical experts and the public could use to communicate with each other so that relevant engineering design information can be understood by the public, thereby reducing the possibility of value conflicts due to parties having incomplete information. A responsive company could observe the public’s specific attitudes to the implementation of technological innovation, appropriately adjust their pace of technological innovation and absorb the social factors surrounding technological innovation with an interactive, inclusive and open attitude, so as to truly provide a combined sense of “responsibility” and “innovation”.

The study explains the important role of innovative resources in implementing responsible innovation. First of all, companies should improve the repayment mechanism for corporate financing funds, make a comprehensive budget, predict and guard against all kinds of capital flow risks to ensure the stable cash flow of the enterprise; second, we should build a perfect incentive mechanism to prevent the loss of human capital from an enterprise by increasing the management’s shareholdings and base salary plus performance rates. At the same time, we should create an atmosphere of multi-disciplinary comprehensive research and encourage multi-disciplinary theoretical exchanges, cross disciplinary and interdisciplinary personnel exchanges and cooperation to attract multi-disciplinary talent; finally, by improving product quality, increasing charitable donations, ensuring the legitimacy of operation and employing other similar methods, companies should improve their reputation and corporate image, attract more stakeholders to establish contact with them, expand communication scope of their social network and enrich social capital.

Moreover, this study demonstrates the role of promotion focus in the implementation of responsible innovation. It shows that the promotion focus of an enterprise is also an important influencing factor that affects corporate responsible innovation. It creates an equal, transparent and innovative organizational atmosphere to provide resources and support collective learning, so as to enhance the self-efficacy of organizational innovation, guide enterprises to promote directional change and ensure the smooth

implementation of responsible innovation. It also consciously expands the innovative resources available to companies such as financial capital, human capital and social capital, and enhances an enterprise's operational risk capability, thereby encouraging enterprises towards a more proactive focus.

In addition, the study proves the important role of adaptive governance in implementing responsible innovation. First, the government can introduce the idea of crowdsourced policy-making, involve the public in legislative decision-making, improve the innovation governance policy by integrating public knowledge or information and increase the agility and transparency of technology innovation governance. Second, the government can share data with various stakeholders (especially enterprises), leading to these stakeholders establishing links between IT systems and guaranteeing the symmetry of information between the government and enterprises, meaning that government will be able to more easily understand the expertise and potential risks of a technology. This would make governance decisions more accurate and faster. Finally, the government should guide enterprises to conduct self-regulation. For example, in a certain industry, enterprises can set their own market entry conditions, technical standards, production safety regulations and social obligations to create a stable regulatory environment and help enterprises to internalize ethical behavior.

5.3. Limitations and Future Research

There are also some shortcomings in this study: on the one hand, the number of questionnaires collected in this paper is too small, and there was no research conducted on the relationship between innovative resources and responsible innovation according to the characteristics of different industries. Although the research results are universal, they do not have strong pertinence. Therefore, a large number of questionnaires can be conducted in the future, and the relevant theories of responsible innovation can be discussed according to the characteristics of different industries, so as to enhance the practical value of the theory of responsible innovation; on the other hand, this paper only examines the role of single intermediaries and regulation in the impact of innovative resources on responsible innovation, and the operation mechanism of this relationship is far more complex than that studied in this paper, as it can involve other factors such as corporate culture. There is also the question of whether there are any behavior and other factors in the R & D process that will affect the action path of this relationship, which we did not examine. These problems need to be further explored and improved.

6. Conclusions

This study explored the relationship between innovative resources, promotion focus, responsible innovation and adaptive governance, based on the theoretical framework of "demand–motivation–behavior". It analyzed the notable impact of innovative resources and responsible innovation. In addition to this, this research also demonstrated the intermediary effect produced by a promotion focus on the relationship between innovative resources and responsible innovation. The theoretical contributions of this study are as follows: (1) we took 361 middle-level and above managers and technical R & D personnel as survey objects, used the structural equation model, verified the positive impact of enterprise innovative resources on responsible innovation; (2) we made clear the impact mechanism of innovative resources on responsible innovation, which is of great significance to make clear how innovative resources affect responsible innovation; (3) While considering the effectiveness of government enterprise cooperation in the governance of science and technology ethics, we introduced adaptive governance into the model, and prove that compared with traditional government regulation, adaptive governance has more advantages in promoting the impact of innovative resources on responsible innovation.

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