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RESEARCH ON THE EVOLUTION OF INNOVATION BEHAVIOR OF NEW GENERATION ENTREPRENEURS IN DIFFERENT SCENARIOS

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Abstract. Innovation of new generation entrepreneurs is crucial to the development of a country. Empirical research method can analyze the history and current situation, but it is difficult to reflect the dynamic process and evolution trend under different scenarios. In this paper, we adopt computational experiment method to model the decision-making process of new generation entrepreneurs. Multi-agent evolution model is constructed to simulate individual behavior of different types of new generation entrepreneurs under different scenarios. By the comparison of different results, it analyses the evolutionary rules of innovation behaviors and explores guidance policies to promote entrepreneurs' innovation behavior and achieve better innovation performance. The experimental results show that although internal elements such as individual's innovative spirit, innovative ability and cognition of social capital determine the innovation intention, the capital, technology and talent conditions are also very important for innovation implementation. New generation entrepreneurs with different risk preferences should objectively evaluate and treat innovation risks according to their own characteristics. This helps to reduce the negative impact of innovation risk on continuous innovation. Meanwhile, government should pay attention to establishing risk guarantee mechanism such as innovation insurance fund to promote the innovation of new generation entrepreneurs.

Keywords: new generation entrepreneur, innovation behavior, computational experiment, evolution, scenario.

JEL Classification: C63, D91, O31.

Introduction

Innovation is the fundamental power and source of economic growth. Innovation activities are promoted by entrepreneurs and ultimately transformed into productivity. Therefore, entrepreneurs are the main promoters of economic development. "New generation entrepreneur" is a new term put forward in recent years. The definition for new generation en-

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trepreneur is not unified, it is mainly from the intergenerational and group aspects, e.g., millennial entrepreneurs (Liu et al., 2019), "generation Y" (Strauss & Howe, 1991), etc. In china, new generation entrepreneurs refer to the groups which are usually born after 1980 and grew up in the Internet era, with the general characteristics of high-end academic level, international education background and specialized knowledge structure. Compared with the older generation, they can better accept advanced knowledge and technology, and have more active thinking and stronger innovation awareness. Therefore, in the era of innovation and development, the new generation of enterprises are placed high expectations.

Compared with the previous generation, new generation entrepreneurs have better material conditions and higher starting point, but they must face more complex market environment, more fierce competition, greater pressure and risk. When they make out an innovation decision, they inevitably need to face greater resistance and more constraints and challenges. Therefore, the study on the behavior of new generation entrepreneur should consider the complex context and their specific characteristics. This paper analyzes the multi mechanism and evolution rules of entrepreneurs' innovation behavior and innovation performance under different scenarios. It can provide reference for entrepreneurs' rational decision-making and government's innovation incentive policies.

1. Literature review

Researches on innovation rules of new generation entrepreneurs are very scarce. As new generation is a special group of general entrepreneurs, the research on innovation behavior of entrepreneurs can provide the basic theoretical framework for this study.

Innovation is the most important work for entrepreneurs. Entrepreneurs break the original market equilibrium by resource reorganization to obtain extra profits for the enterprises (Schumpeter & Nichol, 1934). Shane and Venkataranman (2000) believe that entrepreneurs' perception of innovation opportunities can be used to identify who can grasp opportunities in the market and lead enterprises in innovation. Cyert and March's entrepreneurial behavior theory and Kahneman and Kversky's prospect theory have become important theoretical foundations for studying the perception of innovation opportunities (Cyert & March, 1963; Kahneman & Kversky, 1979). Both of these theories believe that the basis of decision-makers' risk-taking behavior lies in the psychological gap between reality and expectation, which is a typical performance feedback model (Lant, 1992). Business decision makers often explore solutions and adjust rules based on the gap between actual performance and expectations (Audia & Greve, 2006; Baum & Dahlin, 2007). Dyer, Gregersen and Christensen (2008) proposed the theory of innovation opportunity perception, which assumes that innovative entrepreneurs adopt innovation behavior according to the perception of innovation opportunity, this model explains how the perception of innovation opportunities increases the possibility of innovation behavior. Perception has distinct subjective characteristics. This makes enterprises led by different entrepreneurs have different development modes under the same external environment, which forms the basis of the core competitiveness of enterprises (Amit & Schoemaker, 1993).

Based on the consistency of behavior and intention, researchers usually study behavior rule through the corresponding intention. For example, Wei and Ho (2019) verify that sup-

pliers' competence and reputation are influential signals for perceived service quality, which in turn affects perceived value and outsourcing intentions. Ivanaj, Nganmini, and Antoine (2019) measure the E-Learners' perceptions of service quality using five dimensions of the SERVQUAL scale in the e-learning context.

However, innovative attitude and innovation behavior are not always consistent (Guan et al., 2017). Kanter (1988) believes that innovation behavior is a series of processes that an individual seeks the support of the approver after understanding the problem and tries to make the supporters form an alliance until the innovation is practiced. Therefore, the perception of innovation opportunity or innovation intention is not equal to innovation behavior, and the implementation of innovation behavior also depends on the acquisition of innovation resources. Meanwhile, external factors such as social capital and policy environment affect the uncertainty and risk of innovation (Hiatt & Sine, 2014). Therefore, this paper studies the influencing factors of entrepreneur innovation behavior from two aspects: personal factors and external factors.

1.1. Personal factors affecting entrepreneur innovation

1.1.1. Innovative spirit

Entrepreneur innovative spirit means strong desire, motivation and intention for innovation. Entrepreneurs with high innovative spirit are devoted to developing new and different values or combining existing resources into a more productive form. Entrepreneur innovative spirit is the core of Schumpeter's "creative destruction" thought, including daring to take risks (Covin & Salvin, 1989), positive pioneering (Khandwalla, 1977), the spirit of combining adventure with exploration, and unwilling to stick to conventions. Baumol (1990) believes that entrepreneur innovative spirit is the key influencing factor of enterprises' continuous innovation.

1.1.2. Innovative ability

Jiao, Yang, Gao, Xie, and Wu (2016) found that guanxi ability, social responsibility ability, and strategic leadership ability have significantly positive effects on enterprise innovation. The success of an entrepreneur depends on his knowledge and ability, which can help the entrepreneur minimize the risk of innovation. Scholars generally believe that entrepreneurs play multiple roles and perform multiple functions in the process of running a business. The analysis by Rahim, Mohamed, and Amrin (2015) suggests that entrepreneurial ability, including knowledge, values and self-confidence, is crucial to the realization of entrepreneur innovation behavior and performance.

1.1.3. Personality and risk preference

Entrepreneurs' personality has been regarded as an important variable influencing entrepreneur innovative spirit and innovative ability (Chan et al., 2012; Arthur, 1994; Luria & Berson, 2013; Chan et al., 2015). Personality traits that affect entrepreneur innovation include psychological and behavioral characteristics such as risk preference, which refers to a personality or tendency of individuals to express themselves in a consistent mode of action under differ-

ent situations, which is the key factor that determines individual behavioral characteristics and results (Pervin, 1994). According to Graham and David (2015), entrepreneurs who play a dominant role in decision-making have obvious differences in risk preference, so that companies of the same size, in the same industry and facing the same innovation opportunities might finally make completely different decision choices. According to individual differences, risk preference can be divided into three categories: risk pursuit, risk neutrality and risk aversion. Most scholars believe that individual risk preference is stable and persistent, but the change of psychological factors such as emotion will also have an impact on the risk attitude and cognition, leading to the instability of risk preference (Martínez et al., 2017).

1.1.4. Cognitive social capital

Entrepreneurs' social capital refers to entrepreneurs' capacity to work their way into relationship networks which provide them with essential resources. Hernandez and Camarero (2017) analyze the network of personal, professional, social and institutional relationships of entrepreneurs, and propose that the social capital resources of entrepreneurs are the decisive factor determining the economic benefits. Hernandez-Carrion, Camarero-Izquierdo, and Gutierrez-Cillan (2019) suggest the existence of two different mechanisms which may explain the enrichment and entrepreneurial exploitation processes of social capital's resources: (1) the resource mechanism, based on a network's size and diversity, providing quantity and variety of social capital resources, and (2) the exchange mechanism, based on a network's cohesion and relational quality. The former is called structural social capital and the later cognitive social capital. Cognitive social capital can be divided into common language, common vision, shared values and similar cultural level among members within the innovation network (Stam et al., 2014). The accumulation of cognitive social capital can help entrepreneurs obtain the recognition of innovation strategy from their team members, partners, relatives and friends, so as to lay a foundation for the development of innovation activities; at the same time, the improvement of cognitive social capital is conducive to the formation of irreplaceable common values for all parties concerned, slowing down the impact of organizational culture, improving the efficiency of knowledge integration and cooperation, and facilitating all parties involved in the cooperation to accept new knowledge.

1.2. External factors affecting entrepreneur innovation

1.2.1. Institutional factors

Dai and Si (2018) take Chinese private enterprises as samples and find that institutional changes affect the allocation of entrepreneurship. Under uncertain environment, institutional factors will affect the size of transaction cost, and then affect the behavior mode of entrepreneurs. Entrepreneurs expect good institutional environment, cultural environment, and financial environment that encourage innovation and tolerate failure, so as to promote a loose external environment for innovation. Promoting entrepreneurship through policy tools is a common practice in various countries (Feldman et al., 2013; Lanahan & Feldman, 2015).

1.2.2. Structural social sapital

As a special resource, entrepreneurs' structural social capital plays an important role in promoting the innovation performance of enterprises (Batjargal, 2007; Anderson, 2002). Innovation performance is realized in terms of the process of entrepreneurs' expansion and deepening of specific structured social capital (Vissa, 2011). As organization's network and innovation process becomes more and more complex, enterprises embedded in social network can achieve favorable resources for enterprises' innovation. Resources contained in entrepreneurs' social network relations provide an opportunity for enterprises to win innovation performance, while entrepreneurs obtain the information, resources, services and substantial support needed for the development of innovation opportunities and the operation of enterprises (Hernandez-Carrion et al., 2019).

Existing studies have studied the relevant influencing factors of entrepreneur innovation behavior from different perspectives, which provides a useful reference for this study. However, the existing researches lack of further research on the consistency and causes between behavioral intention, behavior and performance, and also lack of in-depth discussion on the particularity of new generation entrepreneurs and the differences between the new generation and their older generation in terms of cognitive social capital. In this study, computational experiment method in social science is adopted to explore the dynamic innovation process with multi-factor interaction and feedback. It combines micro motivation of innovation behavior with the dynamic process of realizing innovation performance of enterprises. Based on the constructed multi-agent evolution model, this paper simulates the evolution process of innovation intention, innovation behavior and innovation performance of different types of new generation entrepreneurs under different scenarios, analyzes the evolutionary rules of new generation entrepreneurs' innovation, and explores the policy strategies promoting new generation entrepreneurs' innovation and achieving enterprise innovation performance.

The remaining sections of this study are organized as follows. The context model abstracted from real world about new generation entrepreneur innovation is introduced in Section 2. Then we develop a multi-agent model and describe its agent attributes, workflow, decision rules, evolutionary rules in Section 3 and parameters are discussed in Section 4. In Section 5, we simulate the innovation process of new generation entrepreneurs under different scenarios and deeply analyze the results. And conclusions and discussions are drawn in the last Section.

2. Context and behavior model

In order to observe the dynamic process of innovative behavior of new generation entrepreneurs under complex influence of internal and external factors and analyze the evolutionary rules of their innovation behavior and enterprise innovation performance under different scenarios, this paper integrates the complex environment, individual micro-level factors (risk preference, innovation spirit, innovation ability, cognitive social capital, structural social capital, etc.) and macro-level factors (Government Innovation Support Policies, etc.) into the research frame work, and constructs a multi-agent computational experimental model to verify some empirical conclusions.

New generation entrepreneurs are usually young, promising, ambitious and high-quality elites. Innovation is often regarded as an important means to realize the value of life rather than just to seek the improvement of economic benefits of enterprises. Therefore, compared with policy incentive factors, the most direct motivation of their innovation behavior is the innovative spirit and innovative ability. However, new generation entrepreneurs are usually inexperienced, and their decision-making power in enterprises is often restricted by various parties. Therefore, consistent cognition and support of relatives, friends, partners for innovation (i.e. cognitive social capital) are also important prerequisites for them to implement innovation. Meanwhile, although the incentive of innovation system environment is no longer the direct factor that affects its innovation behavior, innovation related policies can provide entrepreneurs with the support of talents, technology, capital and other aspects needed for innovation, and create conditions and guarantees for the success of innovation and the realization of enterprise innovation performance, so these external factors also play an important role in the innovation process. Historical innovation performance can improve the cognitive social capital of entrepreneurs, help new generation entrepreneurs obtain higher support rate in the continuous innovation, and improve the enthusiasm for further innovation, while the experience of innovation failure would have a negative impact on the sustainable innovation behavior. Therefore, the innovation of new generation entrepreneurs is a nonlinear dynamic process under the interaction of complex internal and external environments. The process can be abstracted as shown in Figure 1.

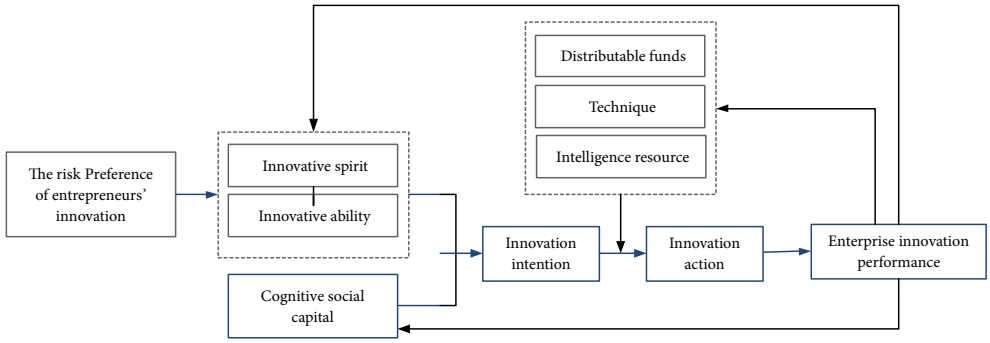

Figure 1. Context and behavior model of new generation entrepreneur innovation

3. Computational model

3.1. Agent attributes and workflow

Assume that there are m new generation entrepreneurs in the system, with entrepreneur subject number $i\left(i=1,2,\ldots,m\right)$ as their unique identity. Entrepreneurs have different attributes and the initial settings of their main attributes are as follows:

1) Risk preference: There are three types of entrepreneurs' risk preference: risk pursuit, risk neutrality and risk aversion. The number of entrepreneurs in each category is m/3.
2) Innovative spirit: The innovative spirit of the three types of entrepreneurs presents a normal distribution.

3) Innovative ability: Innovative ability refers to the innovative ability after the adjustment of decision-making power. The initial settings of the three types of entrepreneurs' innovative ability show a normal distribution.
4) Cognitive social capital, disposable capital, technological level and intelligence resource: The initial values of entrepreneurs' attributes are randomly distributed, and there is no significant difference in the average values of entrepreneurs.

According to the hypothesis, in each simulation iteration cycle, the innovative spirit, innovative ability and cognitive social capital of each new generation entrepreneur determine their innovative intention. When the innovation intention is not less than the threshold of innovation implementation, the main body begins to prepare for innovation in the early stage. If the enterprise has the conditions for innovation (with the funds, technology and intelligence needed for innovation), the entrepreneur formally implements innovation. Because innovation itself has certain risks and uncertainties, the actual performance brought by innovation is uncertain, which is related to the technological level and intelligence resource of enterprises. Enterprise innovation performance in turn will affect entrepreneurs' innovative spirit, innovative ability, cognitive social capital, disposable capital, technology level and intelligence resource. The workflow of innovation behavior of new generation entrepreneurs is shown in Figure 2.

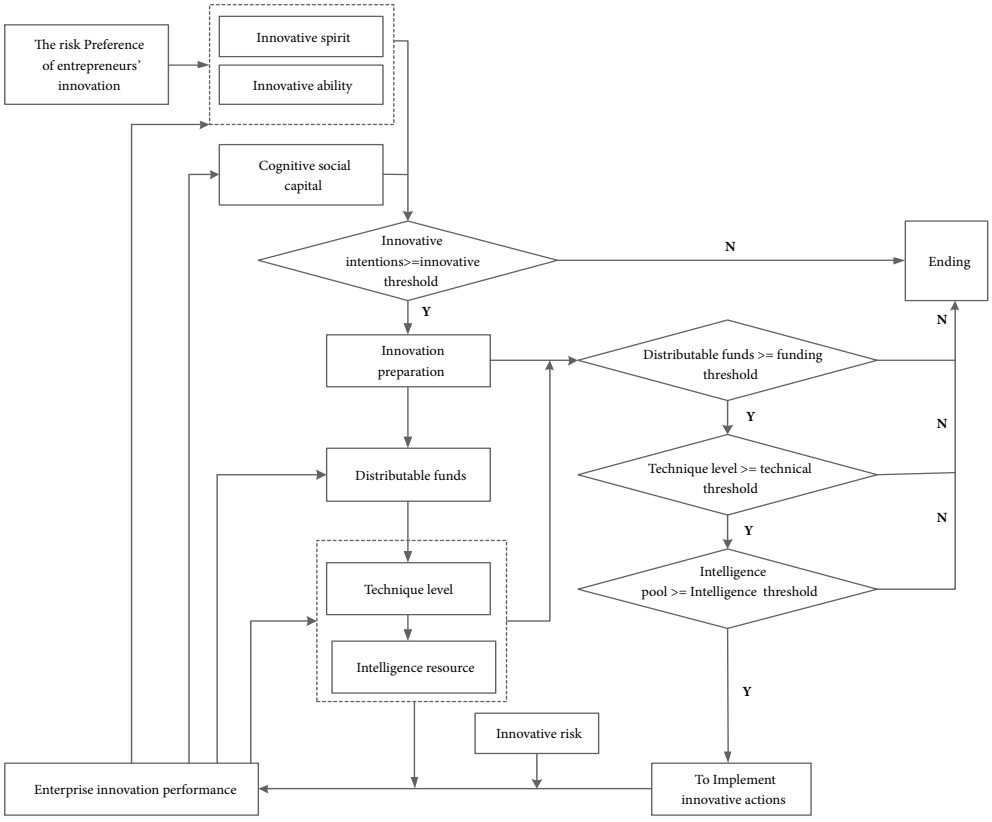

Figure 2. The workflow of innovation behavior of new generation entrepreneurs

3.2. Agent decision rules

(1) Innovative Intention Decision Rules. The new generation entrepreneurs first make the decision whether to innovate or not according to their innovative spirit, innovative ability and cognitive social capital. According to the regression analysis results of empirical research and the mathematical modeling method, referring to the consumer decision-making rules of Guan, Zhao, and Du (2017), the relationship between the related factors of the main innovation intention is set as follows:

$$INO\_will_i^j = \left(\frac{1}{e^{(1-sp_i^j)}}\right)^{\alpha_1} \times \left(\frac{1}{e^{(1-ab_i^j)}}\right)^{\alpha_2} \times \left(\frac{1}{e^{(1-co_i^j)}}\right)^{\alpha_3}. \quad (1)$$

Among them, $INO\_threshold_i^j$ is the innovative intention of entrepreneur subject i in j iteration cycle, and α_1, α_2, α_3 are respectively the influence coefficients of innovative spirit, innovative ability and cognitive social capital on innovative intention, while sp_i^j, ab_i^j, co_i^j are respectively the innovative spirit, innovative ability and cognitive social capital of entrepreneur i in j iteration cycle.

When the innovation intention is not less than the entrepreneur's innovation threshold $INO\_threshold_i^j$, the main body makes the decision of innovation preparation; otherwise, the entrepreneur chooses not to innovate in the iteration cycle.

(2) Innovative implementation rules. For the new generation entrepreneurs entering the preparatory stage of innovation, the main body further examines their innovative capital, technology level and intelligence resource. Only when the three are not less than the threshold requirements of capital, technology and intelligence resource for innovation can entrepreneurs really implement innovation. The capital, technology and intelligence that entrepreneurs can use for innovation not only come from the internal resources of enterprises, but also from the resources that entrepreneurs can obtain through social networks, i.e. the structural social capital from the government, banks and research institutes. In addition, the disposable funds also include the innovation funds in the government's innovation support policies.

(3) Enterprise innovation performance output rules. The performance output of enterprises is related to innovation-related innovation risk, technology level and intelligence resource. Successful innovation needs to meet the conditions:

$$1 - e^{-\gamma \times (tech_i^j)^{\theta_1} \times (pers_i^j)^{\theta_2}} \geq u(0,1). \quad (2)$$

Among them, γ, θ_1, θ_2 are model parameters, which determine the accumulative speed of technology level and intelligence resource. $u(0,1)$ represents the random number between [0,1], reflecting the uncertainty of innovation activities in the real world (Guan et al., 2017), $tech_i^j$, $pers_i^j$ are respectively the technology level and intelligence resource that entrepreneurs i have in j iteration cycle. If the conditions are met, the innovation will be successful and the enterprise will achieve positive performance output:

$$PERF\_ent_i^j = \left(\frac{1}{e^{(1-tech_i^j)}}\right)^{w_1} \times \left(\frac{1}{e^{(1-pers_i^j)}}\right)^{w_2} \times u(0,1)^{w_3}. \quad (3)$$

Among them, w_1, w_2, w_3 are the influence coefficients of technological level, intelligence resource and innovation risk on enterprise innovation performance. Random number reflects the uncertainty of innovation performance.

If the condition of Formula (2) is not satisfied, the failure of innovation will bring loss to the enterprise, that is, the innovation performance of the enterprise is negative.

$$PERF\_ent_i^j = 0 - u(0,1). \tag{4}$$

Because the reasons for failure are uncertain, this model uses random numbers less than zero between 0 and 1 to represent the loss of enterprises caused by innovation failure.

3.3. Agent evolutionary rules

The initial innovation threshold of entrepreneurs is related to their risk preference.

$$INO\_threshold_i^0 = 1 - risk_i, \tag{5}$$

$risk_i$ is the risk preference of entrepreneur i. It can be seen that entrepreneurs pursuing risk have lower innovation threshold and are more likely to participate in innovation.

The entrepreneurs have the ability of self-adaptation and self-learning. The innovation performance of other entrepreneurs will affect their innovation thresholds.

$$INO\_threshold_i^{j+1} = (1-\sigma) \times INO\_threshold_i^j + \sigma \times \sum_{k=1}^{m} (PERF_{ent\,k}^{\ j}) . \tag{6}$$

Among them, α is the model parameter of the main learning ability.

In addition, the innovative performance of entrepreneurs produced by their innovation behavior has a certain impact on entrepreneurs' innovative spirit, innovative ability, disposable capital, technological level and intelligence resource.

(1) Innovative spirit. As a descriptive model of risk decision-making, prospect theory (Kahneman & Tversky, 1979) can better describe the behavioral characteristics of decision-makers, such as reference dependence, loss avoidance and probability judgment distortion, and explain the different impacts of income and loss on decision-makers. Based on the idea of prospect theory, this model expresses the influence function of enterprise innovation performance on entrepreneurs' innovative spirit as follows:

$$\begin{cases} \Delta sp_i^j = -\lambda\left(-PERF_{enti}^{\ j}\right)^{\rho_1}, \ PERF_{enti}^{\ j} \le 0 \\ \Delta sp_i^j = \left(PERF_{enti}^{\ j}\right)^{\rho_2}, \ PERF_{enti}^{\ j} > 0 \end{cases}. \tag{7}$$

Among them, ρ_1 and ρ_2 $(0 \le \rho_1, \rho_2 \le 1)$ respectively indicate the convexity degree of value function when the innovation performance of enterprises is "revenue" and "loss". The larger the ρ_1 and ρ_2, the greater the convexity degree of value function of entrepreneurs is. This reflects the psychological and behavioral characteristics of entrepreneurs' diminishing sensitivity to income. The parameter $\lambda > 1$ reflects the psychological and behavioral characteristics of decision-makers who are more sensitive to the loss than the gain of enterprise performance. The greater λ is, the greater the degree of loss avoiding tendency of entrepreneurs is. Ac-

cording to references Langer and Weber (2001) and Bleichrodt, Schmidt, and Zank (2009), we usually take $\rho_1 = 0.89$, $\rho_2 = 0.92$ and $\lambda = 2.25$.

The innovative spirit of entrepreneurs in the next cycle is:

$$sp_i^{j+1} = sp_i^j + \Delta sp_i^j. \tag{8}$$

(2) Innovative ability. The entrepreneurs can accumulate innovation experience and knowledge and improve innovative ability by implementing innovation. The improvement of innovative ability is related to the individual's existing innovative ability and uncertainties.

$$ab_i^{j+1} = \delta_1 \times ab_i^j + \delta_2 \times u(0,1) + \delta_3 \times (1 - ab_i^j). \tag{9}$$

Among them, the mode parameters are δ_1, δ_2, δ_3, and $\delta_1 + \delta_2 + \delta_3 = 1$.

(3) Disposable funds. Enterprise innovation performance has an impact on disposable capital:

$$Fi_i^{j+1} = Fi_i^j + PERF_{enti}^{\ j}. \tag{10}$$

Among them, Fi_i^j is the disposable capital owned by entrepreneur i in iteration cycle j.

(4) Technical level and intelligence resource. Whether the innovation is successful or not, the innovation behavior may affect the technological level and intelligence resource of enterprises. The extent of the impact is related to the structural social capital such as scientific research institutions and the government's intelligence policy in innovation.

$$tech_i^{j+1} = \varphi_1 \times tech_i^j + \varphi_2 \times u(0,1) + \varphi_3 \times \left(\frac{1}{e^{(1-stru_i^j)}}\right)^{\epsilon_1} \times \left(\frac{1}{e^{(1-poli_{pej})}}\right)^{\epsilon_2}; \tag{11}$$

$$pers_i^{j+1} = \varphi_1 \times tech_i^j + \varphi_2 \times u(0,1) + \varphi_3 \times \left(\frac{1}{e^{(1-stru_i^j)}}\right)^{\epsilon_1} \times \left(\frac{1}{e^{(1-poli_{pej})}}\right)^{\epsilon_2}. \tag{12}$$

Among them, φ_1, φ_2, φ_3, ϵ_1, ϵ_2 are the model parameters, $\varphi_1 + \varphi_2 + \varphi_3 = 1$, $stru_i^j$ is the structural social capital owned by entrepreneur i in the iteration cycle j, and $poli\_pe_j$ is the intelligence policy of government innovation in the j cycle.

4. Parameters setting and discussion

4.1. Parameters setting

In this study, public parameters and individual parameters of entrepreneurs for system simulation are set on the basis of empirical research. In specific applications, the values of each parameter are standardized first. For the parameters of innovative spirit, innovative ability and other indicators, the weight of different indicators are set firstly in data processing, and then the attribute values of samples are obtained by multi-index fuzzy decision method (Zadeh, 1965, 1968). The model parameters needed in the simulation refer to the relevant parameters in the regression analysis. At the same time, according to the comparison between the experimental results and the actual results, the particle swarm optimization algorithm is used to adjust through simulation training.

The main variables of the system and their initial assigning rules are shown in Table 1.

Table 1. Main variables and table of initial assignment rules

Variables / parameters	Implication	Assignment range	Assignment rules
m	Number of new generation entrepreneurs	150	Fixed value, including 50 risk-seeking entrepreneurs, 50 risk-averse entrepreneurs and 50 risk-neutral entrepreneurs
T	Simulation cycle	100	Fixed value
$risk_i$	Risk preference value of enterprise i	[0,1]	The three types of entrepreneurs accord with the normal distribution of N (0.3, 0.08), N (0.5, 0.08) and N (0.7, 0.08), respectively
sp_i^0	The initial innovative spirit of enterprise i	[0,1]	The three types of entrepreneurs accord with the normal distribution of N (0.3, 0.08), N (0.5, 0.08) and N (0.7, 0.08), respectively
ab_i^0	The initial innovative ability of enterprise i	[0,1]	The three types of entrepreneurs accord with the normal distribution of N (0.3, 0.08), N (0.5, 0.08) and N (0.7, 0.08), respectively
co_i^0	The initial cognitive social capital of enterprise i	[0,1]	Random
$stru_i^0$	The initial structural social capital of enterprise i	[0,1]	Random
Fi_i^0	The initial disposable funds owned by enterprise i	[0,1]	Random
$tech_i^0$	The initial technical level owned by enterprise i	[0,1]	Random
$pers_i^0$	The initial intelligence resource owned by enterprise i	[0,1]	Random
α_1	The model parameters of innovative spirit Influencing innovation intention	1.5	Simulation training
α_2	The model parameters of innovative ability influencing innovation intention	1.5	Simulation training
α_3	The model parameters of cognitive social capital influencing innovation Intention	1.5	Simulation training
γ	Technical level and the growth speed of intelligence resource	0.2	Simulation training
θ_1	The model parameters of technology influencing enterprise innovation performance	1.3	Simulation training
θ_2	The model parameters of intelligence affecting enterprise innovation performance	1.3	Simulation training

End of Table 1

Variables / parameters	Implication	Assignment range	Assignment rules
w_1, w_2, w_3	The influencing coefficient of technological level, intelligence resource and innovation risk on enterprise innovation performance	1.5, 1.5, 0.2	Simulation training
s	Mode parameters of entrepreneurs' learning ability	0.02	Simulation training
δ_1, δ_2, δ_3	The mode parameters of innovative ability learning	0.8, 0.05, 0.15	Simulation training
φ_1, φ_2, φ_3	The mode parameters of technical level learning	0.8, 0.05, 0.15	Simulation training
ϵ_1, ϵ_2	The mode parameters of structural social capital and talent policy influencing technological level	1.5, 1.3	Simulation training

4.2. Parameters discussion

Specific attribute parameter settings affect the simulation results of the system, therefore, in parameter settings, we try to consider the correspondence with the empirical results and consider the universality and representativeness. The total number of entrepreneurs M = 150 is set up in this study. The distribution of the initial parameters of the main attributes is shown in Figure 3.

(1) Innovative spirit: The initial settings of three types of entrepreneurship are shown in Figure 3(a). The vertical coordinate represents the quantitative value of entrepreneurship, and the horizontal coordinate represents the percentage of entrepreneurs. The same type of entrepreneurship has a normal distribution.

(2) Innovative ability: Innovative ability refers to the innovative ability after the adjustment of decision-making power. The initial setting of three types of entrepreneurs' innovative ability is shown in Figure 3(b). The vertical coordinate represents the quantitative value of entrepreneurs' innovative ability, and the horizontal coordinate represents the proportion of the total number of entrepreneurs. The innovative ability of the same type of entrepreneurs is approximately normal distribution.

(3) Cognitive social capital, disposable capital, technological level and intelligence resource: The initial distribution of entrepreneurs' attributes is shown in Figure 3(c), 3(d), 3(e) and 3(f), respectively. There is no significant difference in the average value of entrepreneurs, but there is a random distribution among individuals.

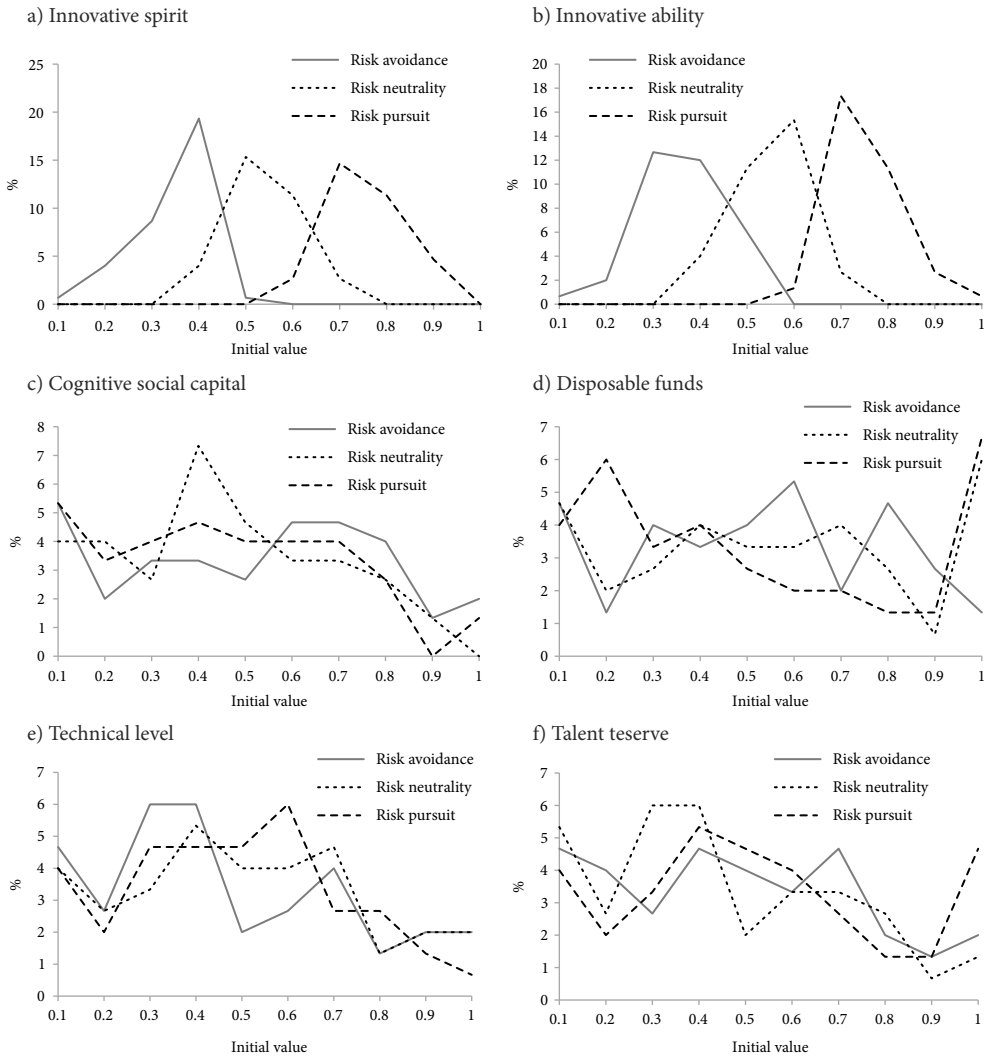

Figure 3. Initialization settings of entrepreneurs' agent attributes in the new generation

5. Evolution analysis

5.1. Evolution analysis of spontaneous innovation behaviour of new generation entrepreneurs

Spontaneous innovation is a need rather than being affected by external factors. Under the spontaneous innovation scenario, the new generation of entrepreneurs have no structural social capital and no innovation-related policy support. The entrepreneurs' innovation activities are based entirely on their innovative spirit and ability. The simulation experiment of spontaneous innovation can be used as a reference for different policy roles, and the possible policy scenarios can be explored through in-depth analysis of the bottlenecks in spontaneous

innovation. In order to reduce the deviation of experimental results caused by random factors in simulation, the average of simulation results is tested 50 times in each scenario. The evolution process of innovation intention and innovation implementation behavior of entrepreneurs with different risk preferences under spontaneous scenarios is shown in Figure 4.

As can be seen from Figure 4(a), Figure 4(b) and Figure 4(c), although the number of entrepreneurs with innovative intentions varies considerably under different risk preferences, their innovative implementation behavior basically falls to zero after 10 cycles without external support. Further analysis of innovation performance of entrepreneurs with different risk preferences shows that the overall innovation performance of entrepreneurs with different risk preferences is negative, and the loss of innovation performance of entrepreneurs with risk pursuit is more severe. Because of the declination of disposable capital caused by enterprise innovation performance, even if entrepreneurs have innovation intention, they would be unable to implement innovation. The evolution of entrepreneurship in spontaneous Innovation scenario is shown in Figure 5.

From Figure 5, we can see that in the spontaneous innovation scenario, entrepreneurship has not changed much because there are fewer entrepreneurs who really implement innovation, and the overall innovation has declined slightly.

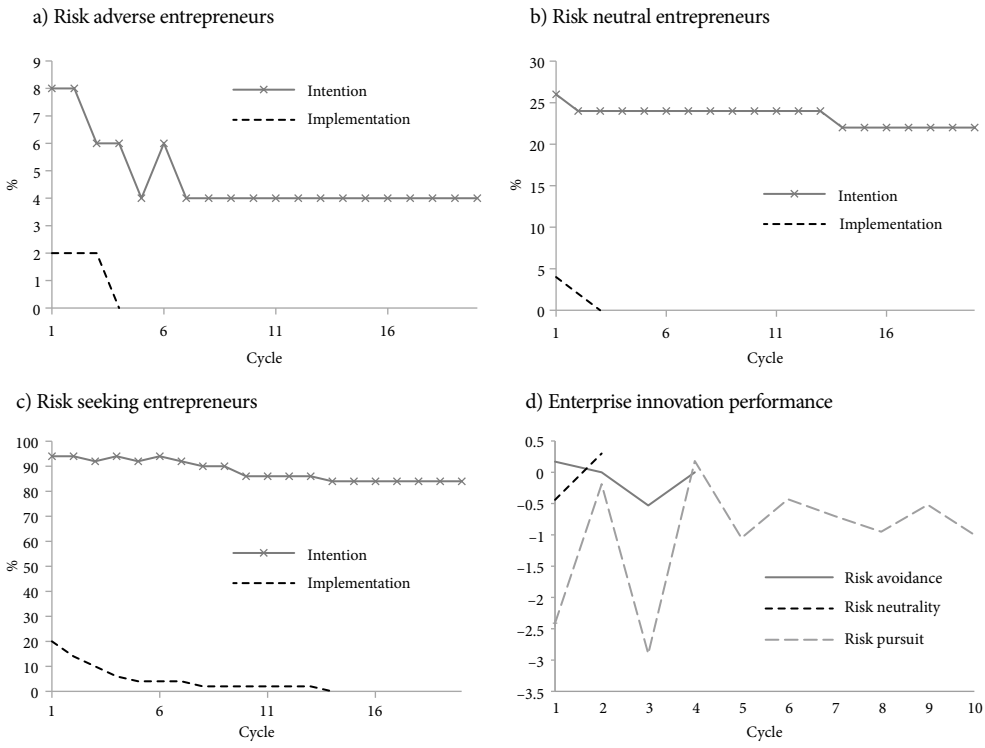

Figure 4. Evolution of spontaneous innovation behavior of new generation entrepreneurs

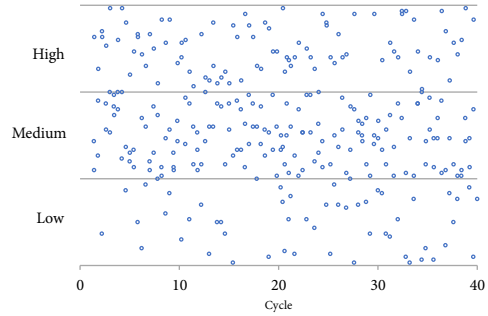

Figure 5. Evolution of the innovative spirit of the new generation entrepreneurs in the spontaneous innovation scenario

5.2. Evolution Analysis of Innovation Behavior of New Generation Entrepreneurs in the Structural Social Capital scenario

Under the spontaneous innovation scenario, the innovation behavior of the new generation entrepreneurs is limited by capital, technology and intelligence. Although they may have more innovative intentions, the actual implementation of innovation is insufficient. The structural social capital of entrepreneurs can provide financial, technical and intelligence support for entrepreneurs. In this part, we design four scenarios of structural social capital (see Table 2) to explore the evolution process of innovation behavior of new generation entrepreneurs under different scenarios.

The innovation intention and implementation of entrepreneurs with different risk preferences in four scenarios are shown in Figure 6.

Figure 6 shows that the innovation behavior of entrepreneurs under the structural social capital scenario has been improved to a certain extent than that of under the spontaneous innovation scenario; in contrast, venture-pursuit entrepreneurs have the highest innovative implementation behavior when they have sufficient structural social capital and there are still entrepreneurs implementing innovation after 20 cycles. However, entrepreneurs' innovative intentions and innovative implementation behavior are declining in the process of evolution

Table 2. Description of Structural Social Capital Scenario

Scenario number	Scenario name	Scenario description
SS_1	Low Structural social capital is more general	The entrepreneur can obtain a small amount of capital, technology and intelligence support from structural social capital
SS_2	Moderate structural social capital	The entrepreneur can obtain part of the capital, technology and intelligence support from structural social capital
SS_3	High Structural social capital	The entrepreneur can obtain most of the necessary funds, technology and intelligence support from structural social capital
SS_4	Adequate structural social capital	The entrepreneur is always possible to obtain all the necessary financial, technical and intelligence support from structural social capital

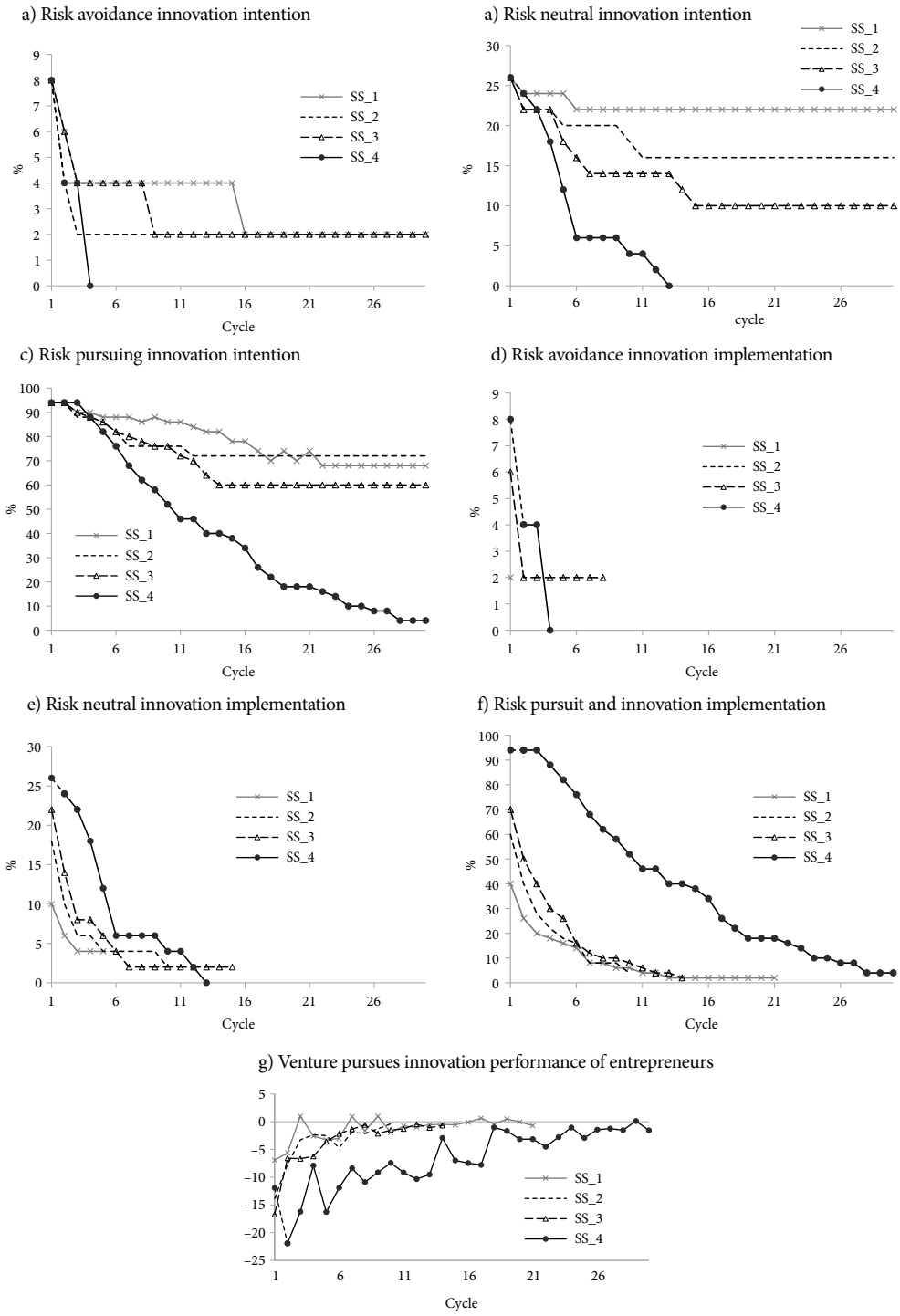

Figure 6. Evolution of entrepreneur innovation behavior with different risk preferences in the structural social capital scenario

and no entrepreneurs implement innovation after 30 cycles. The reasons for the decline in innovation implementation were shown from the innovation performance of venture-driven entrepreneurs, as in Figure 6(g). The reasons for the evolution of entrepreneurs' innovation intention in four scenarios can be further analyzed from the evolution process of entrepreneurs' innovative spirit, as shown in Figure 7.

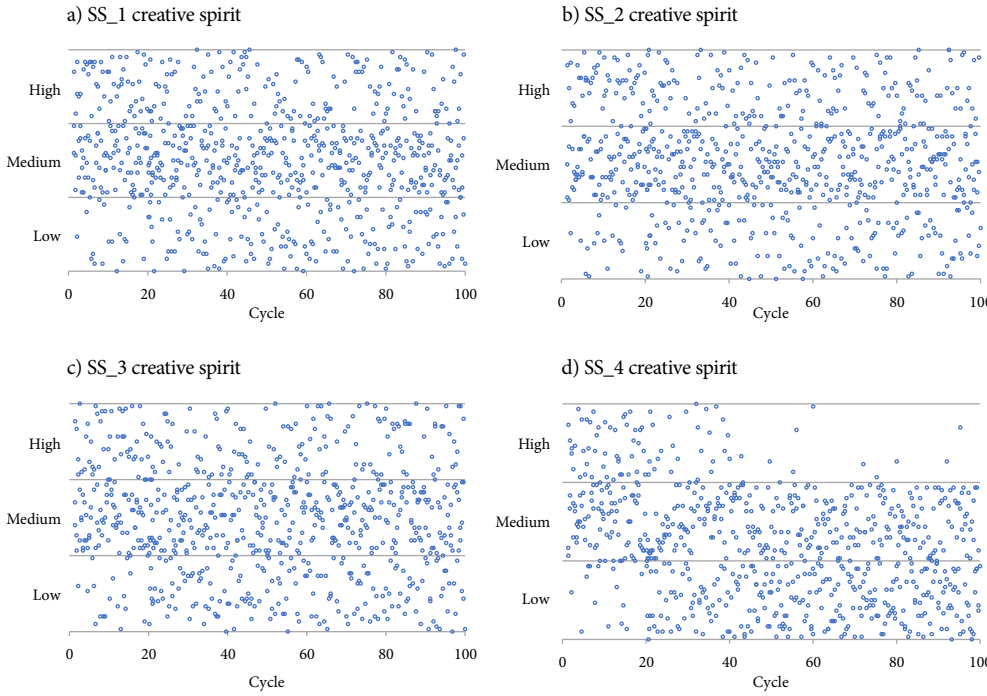

Figure 7. Evolution of entrepreneurs' innovative spirit in different social capital scenarios

From Figure 7, we can see that the evolution processes of entrepreneurship innovation under different social capital scenarios are basically similar. With the development of innovation implementation, entrepreneurship innovation is declining. Especially in the SS_4 scenario with the highest support, the spirit of innovation declines faster and there are only few risk-seeking individuals after 40 cycles. It can be seen that it is not enough to just implement innovation in a short time only with innovation support. When the risk of innovation is high, the guarantee of enterprise innovation performance is an important way to protect entrepreneurs' innovative spirit and encourage entrepreneurs to innovate continuously.

5.3. Evolution Analysis of Innovation Behavior of New Generation Entrepreneurs in the Innovation Policy scenario

Because of the externality and uncertainty of risk in the process of innovation, it is a common policy strategy adopted by countries implementing innovation to help innovative enterprises carry out innovative activities by means of R&D subsidies, financial loans, preferential land

rent, preferential tax returns and policies of technology and intelligence introduction. This section designs five policy scenarios (see Table 3) to explore the evolution process and law of innovation behavior of new generation entrepreneurs under different scenarios.

Table 3. Scenario Description of Innovation Policy

Scenario number	Scenario name	Scenario description
ST_1	Innovation insurance fund	The insurance fund of innovation risk would be established to compensate for the decline of enterprise performance caused by innovation.
ST_2	Innovative capital policy	Including financial loans and other pre-financing support, as well as tax incentives and other policies to reduce enterprise innovation costs.
ST_3	Innovation technology policy	Through R&D support and other means to encourage enterprises to improve technological level.
ST_4	Innovative intelligence policy	Through a series of talent policies, we can attract intelligence needed for innovation to resident locally and increase the intelligence resources needed for innovation.
ST_5	Comprehensive innovation policy	The combination of the first four policies.

5.3.1. Evolution Analysis in the Low Structure Social Capital scenario

When the structural social capital owned by entrepreneurs is low, it is difficult for entrepreneurs to obtain financial support through banks, technical cooperation with universities and scientific research institutes, also, the ability of the government to obtain resources is limited. Under the combination of this scenario and different innovation policy scenarios, the innovation willingness and implementation of entrepreneurs with different risk preferences are shown in Figure 8: LST_1, LST_1, LST_1 and LST_1 respectively represent the combination of the policy scenario of the Fifth Central Committee and the low-structure social capital scenario.

As shown in Figure 8(a), Figure 8(b) and Figure 8(c), under the policy scenario LST_1 of setting up innovation insurance fund, entrepreneurs with different risk preferences have 100% innovation intention, but few entrepreneurs really implement innovation due to the limitation of capital, technology and intelligence conditions. From Figure 8(d), Figure 8(e) and Figure 8(f), it can be seen that entrepreneurs with different risk preferences have a greater willingness to innovate under LST_2. This is because innovative capital ensures the realization of enterprise innovation performance and reduces innovation risk. However, although innovative capital policy solves the problem of capital, there are still few entrepreneurs who really implement innovation due to the restrictions of technology and intelligence conditions. In LST_3 scenario, as shown in Figure 8(g), Figure 8(h) and Figure 8(i), due to the lack of financial support, the decline in corporate performance caused by innovation risk has reduced the innovative intention of entrepreneurs with different risk preferences, meanwhile, few entrepreneurs have implemented innovation. LST_4 scenario is similar to LST_3 scenario, entrepreneurs' innovation intention is declining, and innovation implementation is rare. Unlike the four scenarios mentioned above, in the LST_5 scenario of the first four innovation

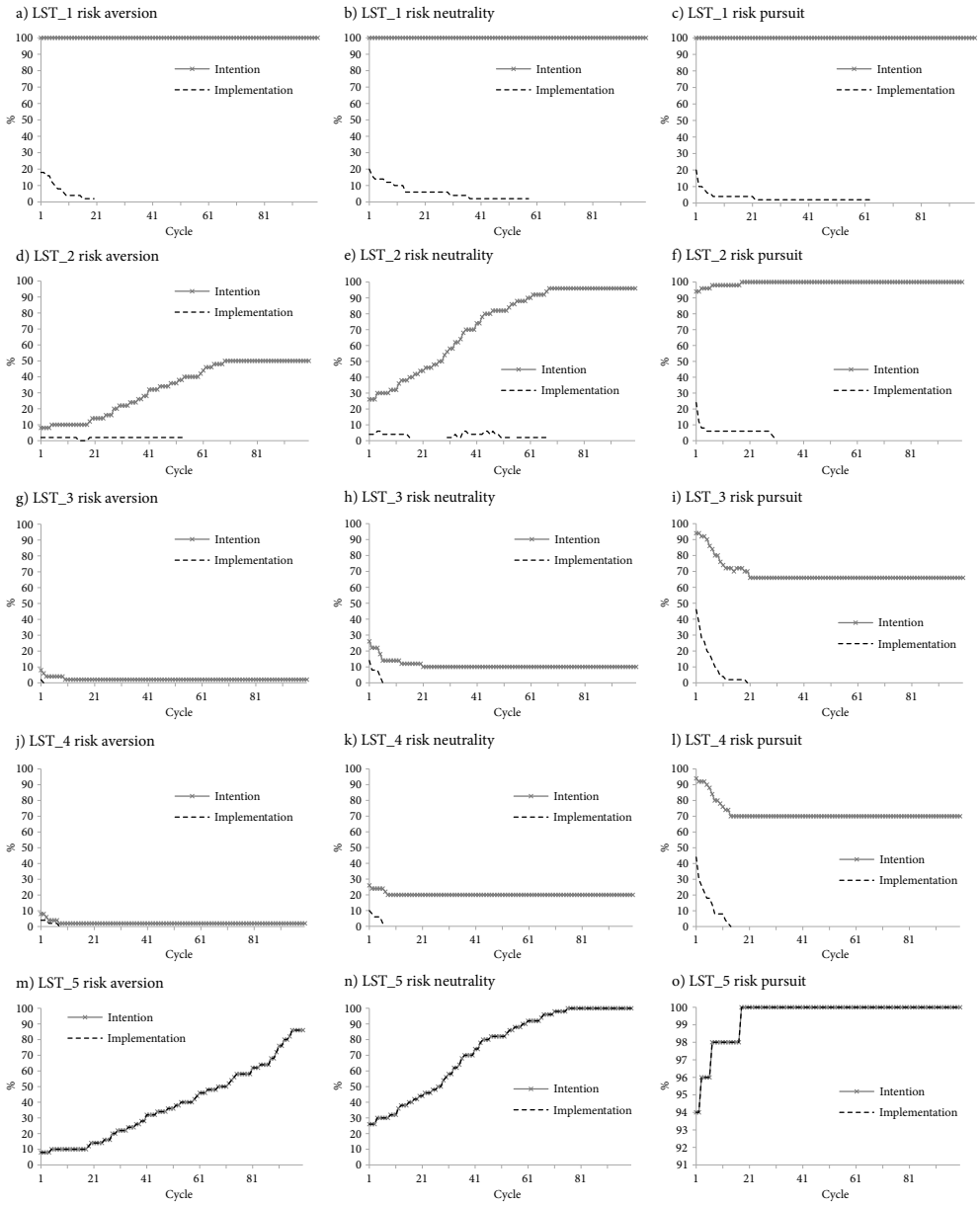

Figure 8. Evolution of entrepreneurs' innovation behavior in different policy scenarios of low-structured social capital

policy combinations, entrepreneurs' innovative intentions coincide with innovative implementations, and when they evolve to 100 cycles, entrepreneurs with different risk preferences basically choose to implement innovations because they provide the financial, technological and intelligence conditions needed for innovation and the risk solving guarantee provided by the innovation insurance fund. Further analysis of the evolution of entrepreneurs' innovative spirit under the above five scenarios, as shown in Figure 9.

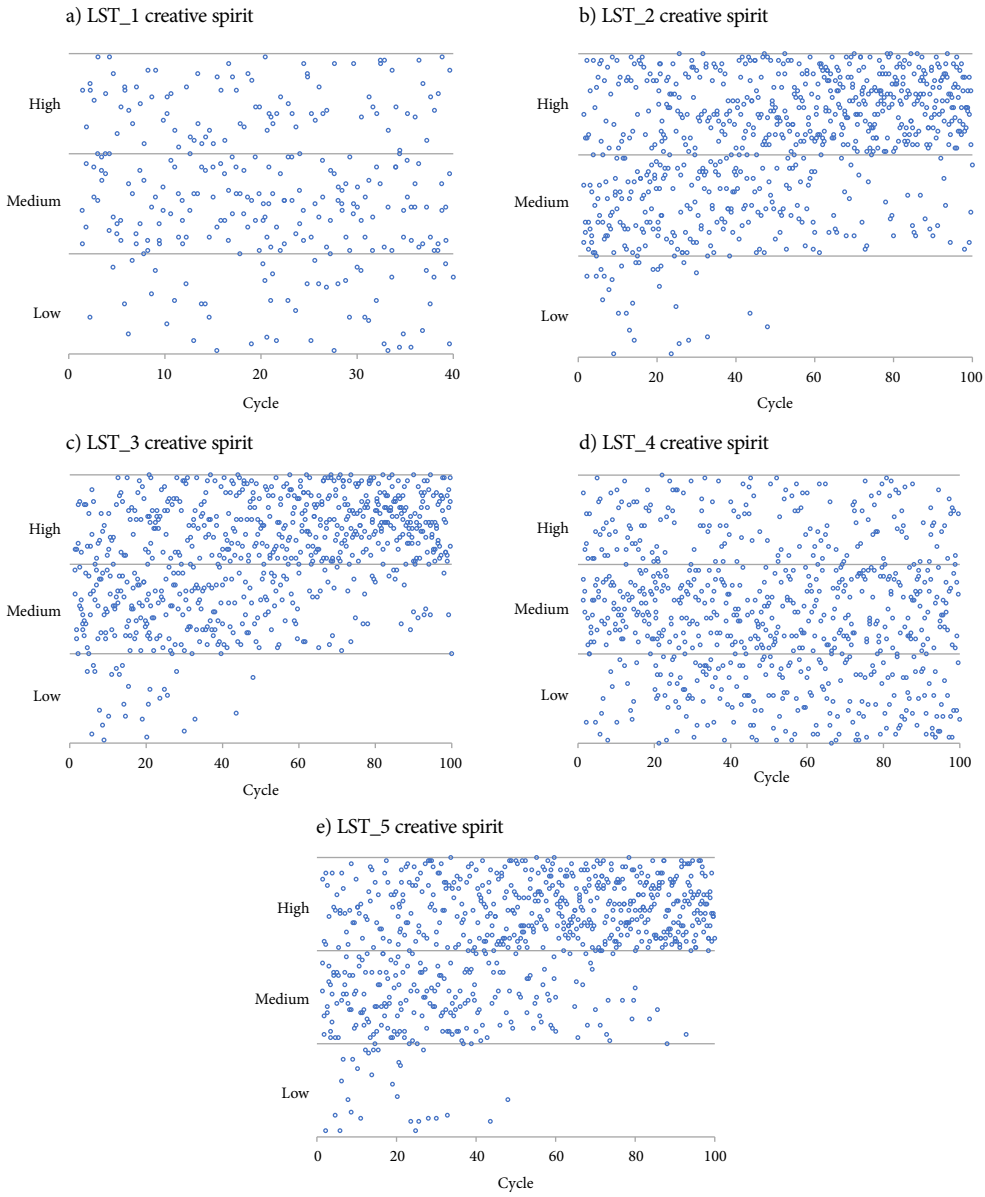

Figure 9. Evolution of entrepreneurs' innovative spirit in different policy scenarios of low-structured social capital

From Figure 9(a), Figure 9(b) and Figure 9(e), it can be seen that under the scenarios of innovation policy LST_1, LST_2 and LST_5, entrepreneurship innovation tends to increase, which explains the evolutionary results of entrepreneurship innovation intention is increasing step by step under the corresponding scenarios in Figure 7. Under the scenarios of innovation technology policy and innovation talent policy LST_3 and LST_4, there is no significant difference in the cycle of entrepreneurship innovative spirit.

It can be seen that in the case of low-structured social capital, we should first face up to the existence of innovation risk, prevent the negative impact of blind innovation on the sustainable innovation of new generation entrepreneurs and reduce risk aversion and risk-neutral entrepreneurs' fear of innovation risk through measures such as innovation risk guarantee system. At the same time, we should create conditions for entrepreneurs to implement innovation through a comprehensive policy of financial, technological and intelligence support, so as to effectively promote the continuous innovation behavior of the new generation entrepreneurs.

5.3.2. Evolution Analysis in the High Structure Social Capital scenario

When entrepreneurs have higher structural social capital, entrepreneurs can obtain financial support through banks, technical resources through technical cooperation with universities and scientific research institutes, thus solve the problem of intelligence shortage through communication with government departments. With the combination of this scenario and different innovation policy scenarios, the innovative intention and implementation of entrepreneurs with different risk preferences are shown in Figure 10 HST_1, HST_1, HST_1 and HST_1 represent the combination of policy scenarios of the Fifth Middle School and high-structured social capital, respectively.

From the policy scenarios of HST_1, we can see that entrepreneurs with different risk preferences have 100% innovation willingness. At the same time, entrepreneurs can obtain some capital, technology and intelligence support through structural social capital. Therefore, entrepreneurs who implement innovation have greatly improved compared with performances in corresponding LST_1, LST_2 and LST_3 scenarios. However, because the innovation insurance fund can only cover the loss caused by innovation risk, it cannot bring more innovation performance for enterprises, therefore the disposable capital of enterprises is declining. When the external structural social capital is insufficient to support innovation, enterprises may still be unable to continue to implement innovation because of lack of funds. As can be seen from Figure 10(d), 10(e) and 10(f), Under HST_2 scenario, compared with LST_1, LST_2 and LST_3 scenarios, the number of entrepreneurs who implement innovation is significantly increased and the innovative willingness of entrepreneurs with different risk preferences has also greatly improved. Due to the bottleneck of technology and intelligence conditions, the number of entrepreneurs who really implement innovation is still small. In HST_3 scenario, it can be seen from Figure 10(g), 10(h) and 10(i) that there is a lack of financial support. The high-structured social capital scenario is similar to the corresponding scenarios of LST_1, LST_2 and LST_3, and entrepreneurs with different risk preferences are less willing to innovate. At the same time, although the entrepreneurs who implement innovation in the early stage of evolution have increased their lower social capital structure, with the development of innovation implementation, the number of entrepreneurs who implement innovation has declined dramatically. The HST_4 scenario is similar to the HST_3 scenario. The scenario of HST_5 of the first four innovation policy combinations is similar to LST_5 in low-structured social capital. Because at that scenario enterprises are provided with the capital, technology and intelligence for innovation, and is guaranteed by innovation insurance fund, entrepreneurs' innovation intention coincides with innovation implementation, and when it evolves to 100 cycles, almost all entrepreneurs choose to implement innovation. The evolution of entrepreneurship in five scenarios is shown in Figure 11.

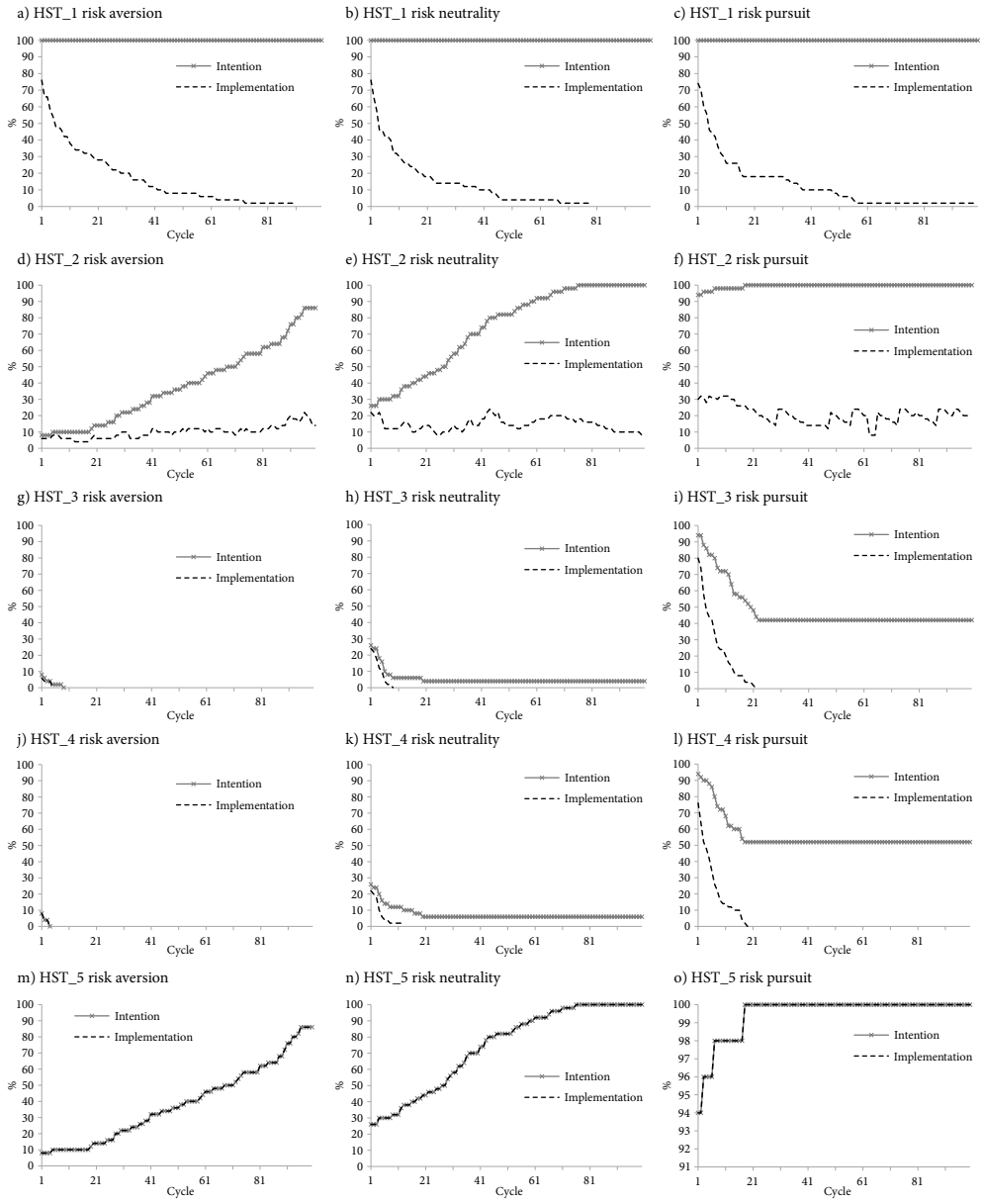

Figure 10. Evolution of entrepreneurs' innovation behavior in different policy scenarios of high-structured social capital

It can be seen from Figure 11(a), Figure 11(b) and Figure 11(e) that the evolution law of innovative spirit of new generation entrepreneurs under high-structured social capital is similar to that of low-structured social capital. Under the scenarios of innovation policies of HST_1, HST_2 and HST_5, entrepreneurs' innovative spirit shows an upward trend, which explains the evolutionary results of the gradual improvement of entrepreneurs' innovative

intention under the corresponding scenarios in Figure 10. Under the scenarios HST_3 and HST_4 of innovation technology policy and innovation intelligence policy, there is no significant difference in the cycle of entrepreneurship innovation.

We can see that the high-structured social capital plays an important role in the innovative activities of the new generation entrepreneurs. Therefore, the new generation entrepreneurs should actively construct the information network of resource sharing through various channels and create conditions for the success of innovation with the help of social resources. However, only sufficient structural social capital cannot guarantee the implementation and success of innovation. For the new generation entrepreneurs, first of all, ones should cor-

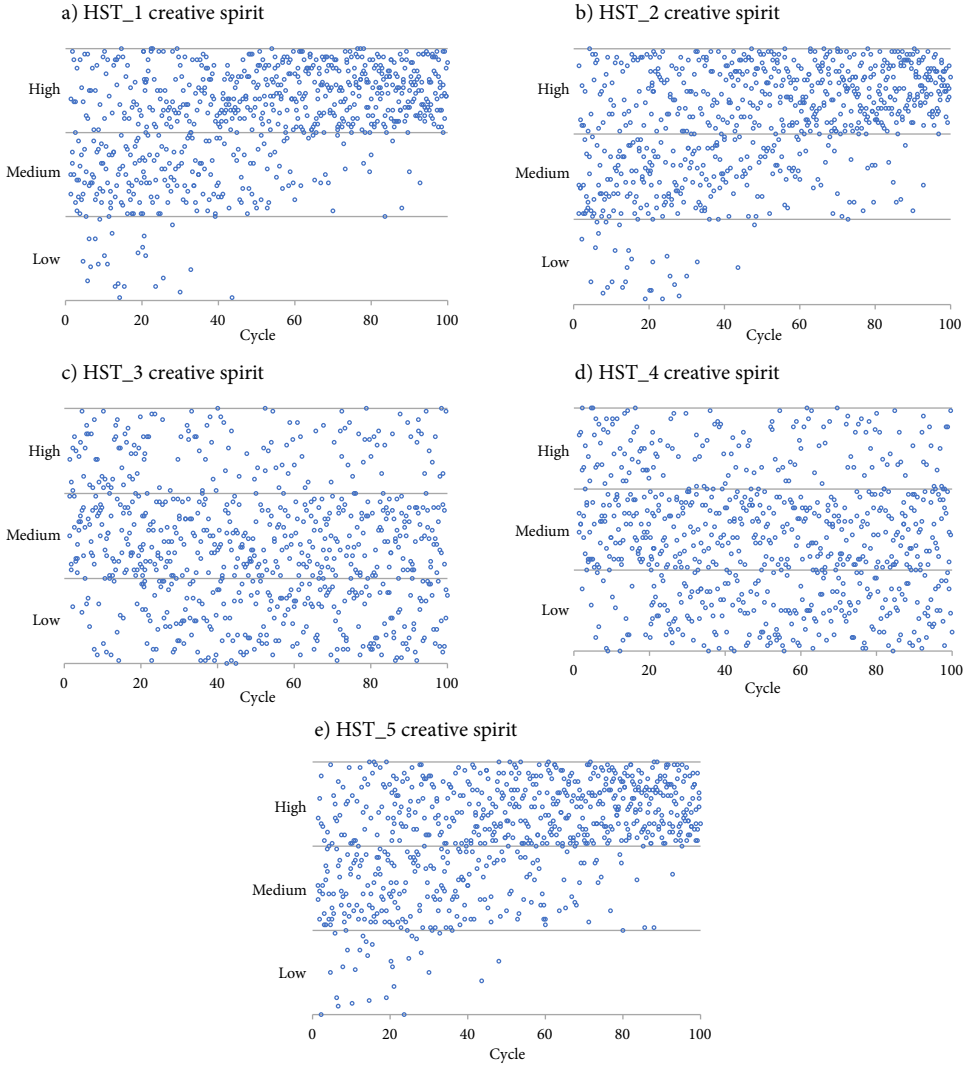

Figure 11. Evolution of entrepreneurs' innovative spirit in different policy scenarios of high-structured social capital

rectly understand the risk of innovation. They should not only prevent blind venture leading to loss of enterprise performance, loss of the ability to sustain innovation, but also review the situation when conditions are available, and actively improve the competitiveness of enterprises through innovation. As far as the government is concerned, on the one hand, it should reduce the threshold for entrepreneurs with different risk preferences to participate in innovation by establishing an innovation risk guarantee mechanism, on the other hand, it should provide comprehensive innovation funds, technology and intelligence support to ensure the development and implementation of innovation activities.

Conclusions

From the perspective of particular characteristics of new generation entrepreneurs, this paper constructs heterogeneous agents with different individual attributes (risk preference, innovative spirit, innovative ability, cognitive social capital) and resources (inherent capital, talent, technology resources), and maps the decision-making mechanism to agents' behavior rules. Employing computational experiment method, simulations under different scenarios are carried out to explore the dynamic innovation process of new generation entrepreneurs in different structural social capital and different policy environment. Experimental results show that:

(1) Innovation intention and innovation behavior are not always the same, which is similar to Guan, Zhao, and Du (2017)'s "attitude-behavior" gap research. This conclusion enriches the Theory of Reasoned Action model (Fishbein & Ajzen, 1975) and the Theory of Planned Behavior model (Ajzen, 1985). It explains the reverse effect and dynamic process of behavior result on behavior attitude, behavior intention and actual behavior. The research results of the influencing factors of innovation intention in this paper are basically consistent with those of Guan, Zhang, Zhao, Jia, and Guan (2019). This paper deeply analyzes the deep reasons for the high innovation intention and low innovation behavior of the new generation entrepreneurs in reality.

(2) Social capital plays an important role in the innovation of new generation entrepreneurs. In this study, the internal mechanisms of entrepreneurs' social capital proposed by Hernandez-Carrion, Cameron-Izquierdo, and Gutierrez-Cillan (2019) is visually verified by computational experiments. Entrepreneurs should try to construct their high-quality social networks to improve structural social capital which would help to enrich the innovative resources.

(3) Scholars have been disputing the impact of historical innovation performance on innovation behavior (Holmes et al., 2011). This study reveals the path that historical performance affects the innovation behavior of new generation entrepreneurs. It explains the reasons why McKinley, Latham, and Braun (2014) put forward that the continuous decline and temporary negative performance have different impact on enterprise innovation. The conclusion of the study reminds new generation entrepreneurs to correctly evaluate innovation risks to maintain sustainable innovation. At the same time, the government should protect the entrepreneur's innovative spirit by improving the innovation risk guarantee policies.

(4) The idea of trajectories of innovation is similar to prior researches (e.g. Filippetti, 2011; Juliao-Rossi et al., 2019). More deeply, this research studies the dynamic changes of innovation resources (capital, technology and talent) from the perspective of continuous innovation, and reveals the causes of the formation of innovation "bottleneck". Besides innovation fund, innovation policy should pay attention to provide accurate and all-round support by introducing talents, promoting the cooperation of production, learning and research.

This study only considers new generation entrepreneurs' special characteristics different from previous entrepreneurs, e.g. innovative spirit, innovative ability, risk preference, and so on. It does not specifically discuss the impact of age, gender, family background and other differences on innovation behavior. Further research will enrich the characteristics of individuals and conduct more in-depth research.

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