

Summer 6-30-2018

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Recommended Citation

Chen, Bin; Jin, Xin; Wu, Jing; and Yang, Hu, "Research on Innovation Ecosystem of the Crowd Innovation Space Based on System Dynamics" (2018). *WHICEB 2018 Proceedings*. 37.

<http://aisel.aisnet.org/whiceb2018/37>

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Research on Innovation Ecosystem of the Crowd Innovation

Space Based on System Dynamics

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Abstract: The crowd innovation space is a new innovation business service platform, developed from the traditional incubator, including makerspace, entrepreneurship café and so on. It is essential for mass entrepreneurship and innovation to get full use of the creativity of the crowd innovation space and explore new impetus in New Economic Norm. Based on the traditional enterprise innovation ecosystem theory, this paper explores the connotation of innovation ecosystem of the crowd innovation space. And then, we use the knowledge to model the innovation ecosystem of the crowd innovation space with system dynamics. Based on the model, we explore the operational mechanism of innovation ecosystem of the crowd innovation space. Through the analysis of the operational mechanism and connotation, we put forward to some proposal to improve the effectiveness of the service ability in innovation of the crowd innovation space.

Keywords: crowd innovation space, innovation ecosystem, system dynamics, knowledge

1. INTRODUCTION

In the article entitled "Guiding Opinions of the General Office of the State Council on Developing Crowd Innovation Space to Promote Mass Entrepreneurship and Innovation" issued by General Office of the State Council of the People's Republic of China, it emphasizes that the crowd innovation space is a new service platform under the new trend of "mass entrepreneurship and innovation"^[1]. It establishes four basic principles: adhering to market orientation, strengthening policy integration, expanding the scope of openness and innovating service mode. The creative role of the crowd innovation space is taken as one of the four basic principles. It is significant to develop a new situation of "mass entrepreneurship and innovation" and explore a new acceleration under the New Economic Norm. Through the research at home and abroad, this article summarizes the connotation and characteristics of the crowd innovation space, modeling it with knowledge using system dynamics and exploring its operational mechanism so as to provide theoretical proposal.

2. RESEARCH STATUS

The crowd innovation space is an all-inclusive ecosystem, which takes innovation as the core, entrepreneurship as the way and low-cost, facilitation, total-factor, open and integrated business service platform as the carrier to integrate innovation and entrepreneurship, online and offline, incubation and investment. As the core of the ecosystem of the crowd innovation space, innovation plays an important role in impelling makers to start up business. In recent years, innovation ecosystem of the crowd innovation space research raises great concern on academic and industrial circles. It is an in-depth study of this new model of the crowd innovation space, based on innovative ecosystem research. The current status of related research will be described from three aspects, including innovation ecosystem, innovation ecosystem of the crowd innovation space and system dynamics.

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Previous research on innovation ecosystem begins with the study of innovation. The earliest concept of innovation was proposed by the Austrian economist Joseph Alois Schumpeter in his classic book "Economic Development Theories"^[2]. Schumpeter's concept of innovation involves five aspects, but it only restricted innovators to entrepreneurs, neglecting the influence of innovators such as colleges, universities and the crowd innovation space. After Freeman drew on Schumpeter's core idea of technological innovation economics, he began to study more about the impact of institutional environment on innovation and economy^[3]. Cooker (1992; 2004) and Malerba (1996; 2002) began to focus their research on regional innovation. They divided regional innovation into knowledge-based application and utilization subsystems as well as generation and diffusion subsystems^[4]. Knowledge is taken as the core element of innovation. The term "ecosystem" was first proposed by Moore. At this time, the ecosystem mainly refers to the enterprise ecosystem. It is a dynamic structural system with certain interests constituted by the stakeholders such as customers, suppliers and intermediaries^[5]. At this moment, Moore neither noticed the innovation ecosystem, nor noticed the important role played by the crowd innovation space, which represented by makerspaces and incubators. The core concept of innovation ecosystem comes from the metaphor of ecology concept and the expansion of its extension. Moore (1996) studied the attributes of self-organization evolution and diverse symbiosis of innovation system itself^[6]. Adner (2006) emphasized that the essence of innovation ecosystem is the coordination of heterogeneous stakeholders to realize value creation^[7]. At this stage, there are mainly two paradigms of innovation ecosystem: closed innovation ecosystem and open innovation ecosystem. Closed innovation system refers that enterprises increase investment in research and development costs within the enterprise, in order to obtain a breakthrough in key basic technologies, thereby improving product quality and service levels. Representatives of the closed innovation ecosystem include IBM's Watson Labs, DuPont's DuPont Labs and Lucent's Bell Labs. The open innovation ecosystem refers to the idea that the enterprise's idea is not only obtained from internal enterprise, but also obtained from the external enterprise. The commercialization path of the idea is obtained simultaneously inside and outside the enterprise. Innovation ecosystem of the crowd innovation space is a typical open innovation ecosystem. Vanhaverbeke (2006) proposed that an open innovation ecosystem is a new path for developing countries to shorten their stock of knowledge and technology with developed countries rapidly^[8]. Chesbrough (2014) emphasized that enterprises in open innovation have to internalize external knowledge (internal-opening) and externalize internal knowledge (external-opening), ultimately realizing their own innovation performance and improving their own innovation capability^[9]. Innovation Ecosystem of the crowd innovation space is a typical open innovation ecosystem.

Most previous research call "the crowd innovation space" as "hackerspaces" or "fab labs". Hansen (2000) and other specialists focused on the networking capabilities and networking services of the crowd innovation space^[10]. Benkler (2006) defined the crowd innovation space as an innovation model based on "mass innovation", emphasizing its innovative functions and innovative models^[11]. Hwang (2012) and others started to study innovation ecosystem and gave full attention to the role of the crowd innovation space. Hwang mentioned in the paper that there are only $(n-1) / 2$ communication nodes between the traditional innovation network and the innovator. However, among the creative eco-networks, there are $n(n-1) / 2$ communication nodes due to the existence of communication nodes represented by the crowd innovation space^[12].

Through the previous research, we can find that the crowd innovation space is an important part of innovation ecosystem, while knowledge is the most important measure of innovation. At the same time, it can be found that innovation ecosystem of the crowd innovation space is a typical open innovation ecosystem, which has the characteristics of internalization of external knowledge (internal-opening) and externalization of internal knowledge (external-opening). We can find that the crowd innovation space is a core node in it, which has strong function of network construction.

Now the domestic academic community is only in infancy for the research on innovation ecosystem of the crowd innovation space. Zeng Guoping and others (2013) focused on the dynamic process of innovation ecosystem among elements, system and environment^[13]. Chen Jin (2013) found that a good innovation ecosystem needs the courage to break the conventional culture for optimal deployment from the perspective of culture innovation^[14]. However, they focused mainly on the theoretical aspects of innovation ecosystem without combining with modeling. At this stage, Chen (2015) and others conducted a case study on the entrepreneurship ecosystem of the crowd innovation space operation model, but mainly concentrated on entrepreneurship ecosystem^[15]. Based on the theory of innovation ecosystem, Huang Shifang (2016) analyzed the connotation of the crowd innovation space and regional innovation system, and took the crowd innovation space as the micro-ecology of the regional innovation system, demonstrating the later advantages of the feasibility of the crowd innovation space in the underdeveloped areas^[16].

System Dynamics is a new discipline founded by professor J.W.Forrester, who worked at the Massachusetts Institute of Technology. It based on the feedback control theory and quantitatively studied complex system by computer simulation technology. The advantages of dynamics analysis are that it can give the trend of the system through quantitative analysis. Li Zhenhua (2009) and others applied this viewpoint to technology business incubators and conducted empirical simulations based on cases^[17]. Xu Xiaocang (2017) and others applied it to the efficiency evaluation of innovation ecosystem, building a simulation model of regional ecosystem, simulating and predicting four aspects of enterprise behavior, including government, innovation talents and research institutions^[18].

Through literatures of innovation ecosystem of the crowd innovation space mentioned above, we find that domestic theoretical research is relatively scarce and lack of quantitative analysis. The few studies just focused on entrepreneurship ecosystem of the crowd innovation space, while just like its name, it emphasizes innovation. According to our previous summary, innovation ecosystem of the crowd innovation space has the characteristics of internalization of external knowledge (internal-opening) and externalization of internal knowledge (external-opening) as a typical open innovation ecosystem. Utilizing this feature of knowledge, we can construct a causal feedback structure, while it has a great fit with the connotation and characteristics of the system dynamics. We can model systems by using knowledge as a variable in creating innovation ecosystem from the perspective of system dynamics. Through modeling analysis, it explores the operating mechanism and development path of innovation ecosystem of the crowd innovation space, so as to provide theoretic guidance for effectively improving the innovation service capacity and efficiency of the crowd innovation space.

3. ANALYSIS OF INNOVATION ECOSYSTEM OF THE CROWD INNOVATION SPACE

3.1 The connotation of the crowd innovation space

The main participants of innovation ecosystem of the crowd innovation space include: crowd innovation space itself, makers, start-ups, customers, universities, research institutions, governments, intermediary agencies and so on. In order to fully understand the connotation of innovation ecosystem of the crowd innovation space, we must clarify the positioning of each participant in it. The crowd innovation space can realize one-stop service, from innovation to entrepreneurship. The reason why the makers need a crowd innovation space is that the knowledge and equipment is not easily accessible to individuals. Universities provide a constant source of innovation for the crowd innovation space. Institutes focus on funding and the landing of experimental results. The government, as the watchdog of the innovation ecosystem, is more of a referee. Intermediary agencies are enterprises that point to start-ups offering various intermediary services.

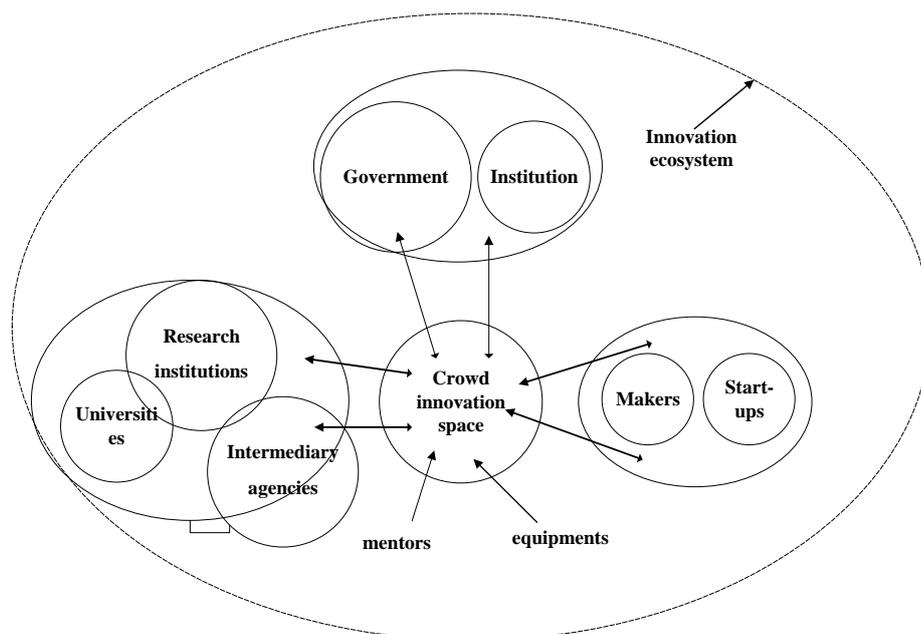


Figure 1. The ecosystem of crowd innovation space

3.2 Analysis of innovation ecosystem based on knowledge

Chesbrough proposed that valuable ideas could be obtained both internally and externally in open enterprise innovation ecosystem^[19]. Chesbrough divided innovation into positions, processes and paths. Positions represent the resources and knowledge that exists at this stage. Processes refer to the flow of knowledge and resources. Paths refer to the upgrading of knowledge and resources. In the innovation ecosystem, positions mean the existing knowledge distributed among the participating subjects. We can further divide the knowledge into internal knowledge and external knowledge. The knowledge that among the crowd innovation space which include the crowd innovation space itself, internal makers and start-ups, we can call it internal knowledge. The knowledge in universities, research institutions, intermediary agencies and external crowd innovation spaces, are called external knowledge. The growth of internal knowledge is mainly driven by the entrepreneurial mentors who generate creative knowledge by helping makers and start-ups solve problems. The entry of makers and start-ups can increase the internal knowledge and decrease the external knowledge. If it can be incubated successfully, the makers and start-ups will leave the crowd innovation space, which increase the external knowledge and decrease the internal knowledge.

With the characteristics of innovation ecosystem of the crowd innovation space, it can be modelled based on system dynamics using the causal feedback loop analysis. The internal knowledge and external knowledge are state variables, which fully describe the transformation of innovation ability in innovation ecosystem of the crowd innovation space. They satisfy the principle of the minimum set and independence. We constructed three feedback loops: two positive feedback loops and one negative feedback loop, based on the internal knowledge mentioned above.

Positive feedback loop 1: The mentors in the crowd innovation space, assist the makers and start-ups, which improve the performance of the crowd innovation space. The promotion of the crowd innovation space leads to higher rent, equity income and the government investment. The crowd innovation space will invest in intellectual capital with a certain percentage of the proceeds, such as inviting more entrepreneurial mentors, buying 3D printers and so on. All of this, can make the internal knowledge self-growth.

Positive feedback loop 2: the mentors in the crowd innovation space help the makers and start-ups solve the

problem of innovation, which will improve the reputation of the crowd innovation. The promotion of reputation will attract more start-ups and makers. It will bring their knowledge into the crowd innovation space, leading to an increase in internal knowledge and a decrease in external knowledge.

Negative feedback loop 1: Because of the service of the crowd innovation space, the start-ups will get a higher probability to get success. They will implement multiple rounds of financing, which will move them into a more mature enterprise stage and move away from the crowd innovation space. As the start-ups moving out, the knowledge which exists in it will augment the external knowledge and reduce the internal knowledge

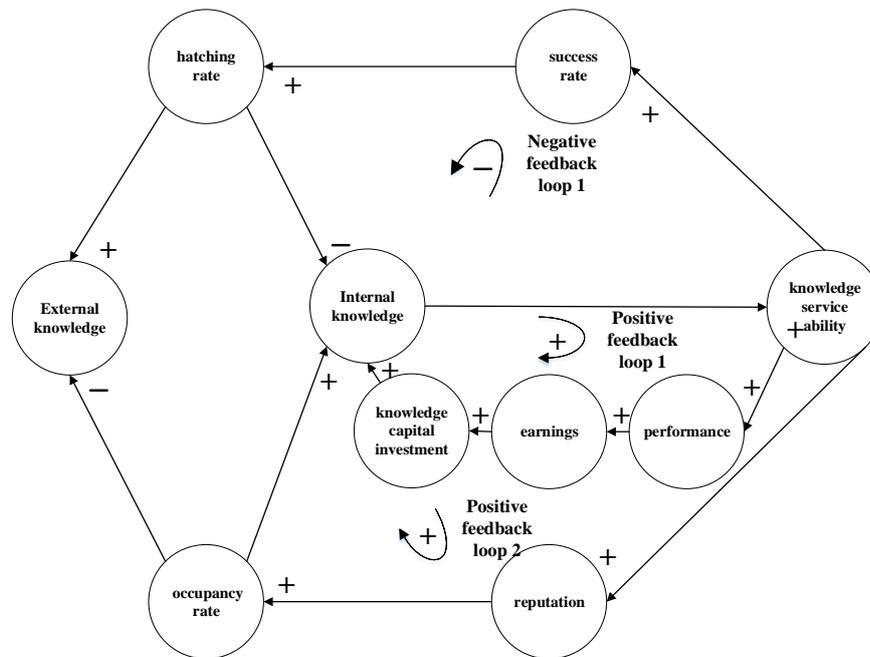


Figure 2 The feedback loop of innovation ecosystem of the crowd innovation space

4. MODELING AND SITUATIONAL ANALYSIS OF INNOVATION ECOSYSTEM OF THE CROWD INNOVATION SPACE BASED ON SYSTEM DYNAMICS

4.1 Modeling innovation ecosystem of the crowd innovation space using system dynamics

According to the feedback loops of innovation ecosystem of the crowd innovation space, we can determine the existence of two state variables, including internal knowledge and external knowledge. The rate variables are the change of the state variable in the unit time. we can determine five rate variables: internal knowledge endogenous growth rate, internal knowledge exogenous growth rate, internal knowledge reduction rate, external knowledge exogenous growth rate, external knowledge reduction rate. Another kind of variable is called auxiliary variables refer to the variables that follow the causal diagram, linking the state variables and the rate variables. We set more auxiliary variables in the model: the knowledge service ability, the performance, the space reputation, start-up success rate, the income of the crowd innovation space, the hatching rate and so on. One the basis of the establishment of causal analysis graph and model variables, the modelling of innovation ecosystem of the crowd innovation space, is constructed using system dynamics, as shown in figure 3.

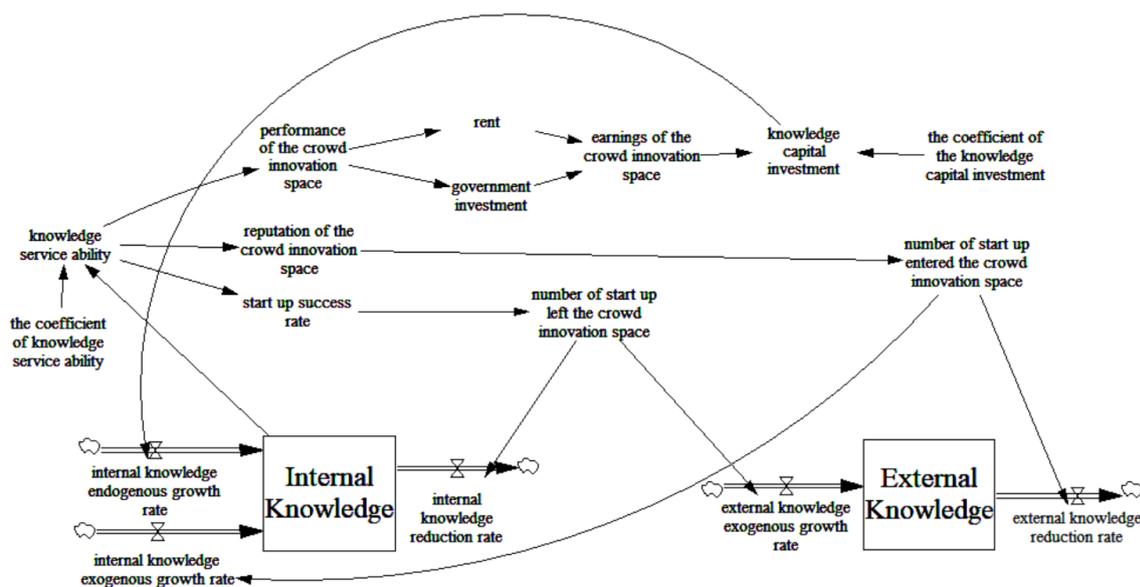


Figure 3. The modeling of innovation ecosystem of the crowd innovation space using system dynamics

4.2 Changing the coefficient of the knowledge capital investment

Keeping other variables unchanged, if we improve the coefficient of knowledge capital investment, the greater part of the earnings and will invest into the internal knowledge growth. This will make internal knowledge growth rate increased significantly. But because the growth of internal knowledge will also increase the number of incubators, which will reduce the external knowledge. The growth of internal knowledge increases the number of incubated enterprises, which increases the external knowledge. Therefore, the specific impact of external knowledge is still uncertain. After the expectation of the theory, the coefficients of knowledge capital investment are set as follow: condition1=0.1, condition2=0.11, condition3=0.13.

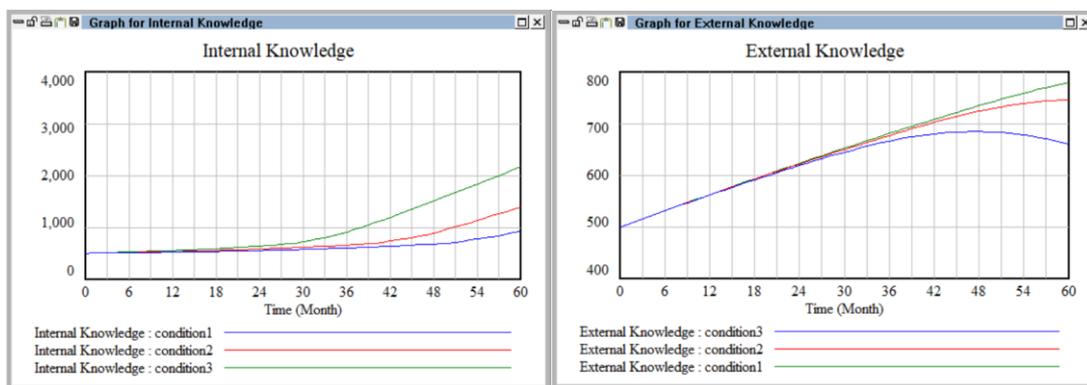


Figure 4. The evolution of knowledge under different coefficients of knowledge capital investment

The growth of internal knowledge is accompanied by diminishing marginal output, which conforms to the classical rice field conditions. By observing external knowledge, external knowledge also satisfies this condition. Although with the higher efficiency of knowledge capital investment, more external knowledge enters into the internal knowledge. The total knowledge still goes up steadily.

4.3 Changing government investment

Keeping other variables unchanged if we improve the government investment, it will increase the earnings

of the crowd innovation space. And then influence the growth rate of the internal knowledge under the condition that the coefficient of knowledge capital investment is constant. The effect of raising government investment would be similar to raising the coefficient of knowledge capital investment as to internal knowledge and external knowledge. So, we will discuss other variables such as performance of the crowd innovation space and internal knowledge endogenous growth rate. We set the maximum government investment as condition1=100, condition2=200, condition3=300.

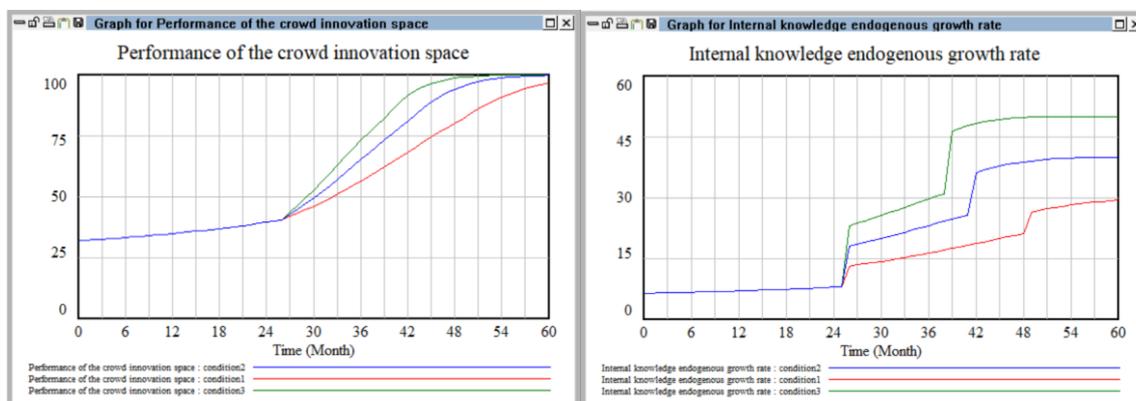


Figure 5. The evolution of innovation ecosystem under different government investment

By increasing the government investment, we can observe from the first chart that the greater government investment, the faster reaching the steady state value. But for the speed of steady state, there is diminishing marginal returns. The government investment can increase the endogenous growth rate of internal knowledge. And the increase of government investment can also shorten the time to steady state of the crowd innovation space.

5. CONCLUSIONS

In this paper, we first discuss the research status of innovation ecosystem of the crowd innovation space, finding that there is no systematic and theoretical research. Through the analysis of innovation ecosystem of the crowd innovation space, we model the system with knowledge based on the system dynamics. Finally, by adjusting the coefficient of the knowledge capital investment and government investment in the model, the following policy suggestions are proposed according to the scenario analysis of innovation ecosystem of the crowd innovation space using system dynamics.

First, the government should actively strengthen the investment in guiding funds for the crowd innovation space. It can be seen from the analysis of the model that government investment can effectively improve the innovation ability of the crowd innovation space and shorten mature time. Since there is diminishing marginal output effect, the government should make a balance between improving the innovation capacity of the crowd innovation space and avoiding waste of capital.

Second, the crowd innovation space should increase the knowledge capital investment. The knowledge capital investment here mainly refers to two aspects: on the one hand, it is the internal intellectual capital investment, such as hiring more mentors and expanding office space; on the other hand, it is the external knowledge capital investment, such as strengthening the crowd innovation space netting ability, associating the upstream and downstream enterprises and implementing one-stop service from knowledge to the innovation.

ACKNOWLEDGEMENT

This research was supported by the Beijing Social Science Foundation (No. 15ZDA50).

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