

Research Progress on Synergic innovation theory-- A Literature Review¹

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Abstract: *Synergic innovation is a new paradigm, is the new progress of innovation system theory. Reviewed the evolution of innovation theory, analyzed the background of synergic innovation theory. The study has been expanded from inside to outside, covered three fields, which was synergic innovation within enterprise, vertical synergic innovation inter-enterprise, horizontal synergic innovation within multi-agents. Horizontal synergic innovation is the main form of synergic innovation. Factors of synergic innovation have been expanded from the “University-industry-government” which advocated by the “Theory of Triple Helix”. Different methods have been developed to measure the synergic innovation effect and synergic degree. Furthermore the influential factors and the decision mechanism of synergic innovation behavior has been studied.*

Keywords: horizontal synergic innovation; synergic innovation effect; degree of synergic; influential factors; decision mechanism

0 Introduction

Nowadays, knowledge become increasingly divergent, a single company is difficult to conduct R&D rely on itself (Chesbrough, 2003). Innovation is no longer a separate activities, but a dynamic and complicated integrated activities which related to multi-level, multi-agent, multi-stage and a variety of innovative elements(Dan Liu, Yan Changle, 2013). In this context, synergic innovation has become one of the key factors of enterprise rapidly access to technology advantage (Jin Chen et al. 2014).

The report of the eighteenth congress of the Communist Party of China clearly put forward to implement the strategy of innovation driven development, and require pay more attention to synergic innovation. As a new innovation paradigm, synergic innovation has gradually become a hot topic

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around the world.

1 Evolution of innovation theory and the background of synergic innovation theory

Schumpeter(1912) pointed out that innovation is the core force of modern economic growth, it was a kind of creative destruction. Since then, more and more scholars studied on the theory of innovation. With the progress of science and technology, innovation has become increasingly complex. That kind of innovation which driven by entrepreneurial spirit, completed by single individual was more and more difficult. Innovation presents a multi subject participation and complex feature.

Jonathan Huebner (2005) analyzed the history of human science and technology innovation, found that developed a new technology in 20th century was more harder than 19th century, because of the limitation of economic and physical. Innovation increasingly rely on the collective behavior and network relationship, multi-agent collaborative innovation is the most effective path (Robert, 2008).

Freeman(1987) raised the concept of national innovation system(NIS), and considered NIS was a network which composed by various institutions in the public sector and private sector, the activities and interaction effect of these institutions will promote the development, introduction, improvement and diffusion of new technology.

Lundvall(1992), Nelson (1993), Patel & Pavitt (1998) regarded innovation as a whole system that various factors related each other. OECD (1997) stated that innovation and technology progress was the consequence of a complex relationship between the main bodies of knowledge production, distribution and application, and the innovation performance of a country depended on the way how these main bodies connected to be a knowledge innovation aggregation. Later, system approach of innovation expanded to the regional level. Cooke (1992) proposed the concept of regional innovation system(RIS), and defined it as a interactive learning system that formed by enterprises and other

organizations under the institutional environment characterized as embeddedness. Innovation is the result of complex interactions between the regional, national and even hyper-national organizations(Cooke, 1998). A single company was difficult to conduct R&D rely on itself, organizations should use both internal and external ideas, share risk and benefit with partners. Chesbrough (2003) proposed the openness innovation model. The boundary of organization's innovation activities was fuzzy, the enterprise's profitability depended on the ability of acquire innovation resources from external and convert it into commercial value.

German scientist Haken proposed the idea of synergetics at 1971, after the 1980s, the idea of synergetics has been gradually applied to synergic innovation theory(Yubing He, 2012). Synergic innovation was arises at the historic moment that innovation paradigm gradually became systematic, networked and collaborative(Dan Liu et al. 2013, Yongzhou Li et al. 2014), it is the new progress of National Innovation System theory(Jin Chen, Yingjuan Yang,2012).

2 Connotation and features of synergic innovation

2.1 Connotation of synergic innovation

Persaud(2005) pointed out that synergic innovation is the collaborative progress based on research and development(R&D) cooperation between multi participants to elevate enterprise's innovation abilities. Take the multinational corporations as research object, studied the relationship between enterprise's synergic innovation ability and cooperation between R&D units distributed worldwide in multinational corporations. Ability of synergic innovation is to accumulate, allocate new knowledge or reorganize existing knowledge, includes four dimensions which are R&D strategic synergy, operational management synergy, knowledge management synergy and innovation skill synergy. Serrano & Fischer (2007) described synergic innovation as a structured joint process to

achieve new product R&D. During the process, the partners share information, make plan and solve key technical problems together.

The core of synergic innovation is knowledge increment. In order to achieve major scientific and technological innovation, enterprise, government, universities, research institutions, intermediary organizations and users integrated deeply, come into being superimposed nonlinear system effects through the in-depth cooperation and resource integration between knowledge creation subjects and technology innovation subjects(Jin Chen & Yingjuan Yang,2012). Synergic innovation can achieve an overall synergistic effect through the interaction between supply chain enterprises, research institutes, universities, intermediary institutes and government, and coupling of innovation elements, which can not happened by separate elements. It is more emphasis knowledge exchange and technology transfer within innovation behavior actors(Xuemei Xie,2014).

Research on synergic innovation has been expanded from inside to outside.(Yi Su,2013), namely from collaborate within enterprise to vertical collaborate inter-enterprise and furthermore to non vertical(horizontal) collaborate represented by industry-university-research.

2.2 Types of synergic innovation

2.2.1 Synergic innovation within enterprise

Synergic innovation within enterprise means collaborate between internal departments and staffs in the enterprise. Srivastava & Gnyawali(2011) indicated that the quality and diversification of technology resource profile were helpful for breakthrough innovation, enterprise should integrate innovation elements such as technology and internal resources. Hagedoorn & Schakenraad(1990) thought that relationship in technology innovation has interaction and complementary effect, thereby emerge more and more collaborative innovation in organization. Chinese scholars carried on related

researches, such as enterprise should implement collaborative innovation in technology, organization and culture(Gang Zhang et al. 1997), technology and market innovation synergetic development(Jin Chen,2006), balance coordination of organizational innovation and technological innovation(Chong Xin et al.2013)

2.2.2 Synergic innovation inter-enterprise

Synergic innovation inter-enterprise mainly refers to a kind of vertical synergic innovation, which means the cooperation among supply chain members such as customer, suppliers, buyers, competitors and so on. Many scholars especially emphasized the importance of “Users” to enterprise innovation. Von Hippel(1988) studied on user driven innovation since 1970s, put forward users should be predominance in the stage of idea formation, Charles & David(2012) believed that enterprise can cooperate with customers in different innovation stages through a variety of ways, the ability and skills of enterprise’s synergic innovation is important factor for organizational success. Guisheng Wu(1996), Jin Chen(2001), Tongtong Zhen(2013) carried on relevant researches.

Some scholars studied the collaboration between enterprise and suppliers. In order to reduce R&D cost and time, increase product’s quality and value, manufacturers pay more attention to incorporate upstream suppliers to product or process innovation(Wynstra,1998). Clark & Fujimoto(1991) found that this kind collaboration was conducive to cut down R&D time and improve the product’s quality. Johnsen & Ford(2000) pointed out that supply chain management, partnership and network has been regarded as the best management practices by many organizations, which has a profound influence to enterprise innovation.

3 Horizontal multi agent synergic innovation

Horizontal multi agent synergic innovation refers to enterprise cooperation with non supply chain

numbers such as universities, research institutions, government, intermediary organizations. Industry-university-research cooperation is one of the typical form, most studies focused on it.

3.1 Triple helix innovation theory

Etzkowitz & Leydesdorff(1995) proposed triple helix innovation theory which is Industry-University-Research cooperation innovation, and raised high concerns from academia, industry, and politics fields. There were three collaborative models between government, industries and universities, respectively were national socialism, laissez-faire and overlap model, and the overlap model was considered more conducive to cooperation innovation. The overlap field of university, industry and government is the core of innovation system, three parties' contact is the important factor to promote knowledge production and dissemination. Its meaning is to integrate universities, enterprises and government which have different value system and function, promote knowledge convert into productivity, drive innovation spiral siding. Entrepreneurial university is the propeller of triple helix innovation, university can make significant contribution to formation of new enterprise and industry, it is not only a source of innovation, but also the organizers of innovation activities.(Chunyan Zhou,2006)

Some scholars criticized to triple helix innovation, someone though that the components of triple helix mode were not complete, should not be confined to universities, enterprises and government. A debate was raised at the Fourth World Triple Helix Conference in 2002, that is whether or not triple helix be extended to fourth helix? Chunyan Zhou et al(2006) proposed the double triple helix innovation model which was Industry-University-Research and University-Public-Research, some scholars attempted to expand the quadruple even more multiple helix, added some other elements such as labor, venture capital and informal sectors. On the basis of the triple helix model, Etzkowitz

etc(2006),Carayannis & Campbell(2010) added public and environment, and constructed the quintuple helix innovation model. Shapiro(2007) argued that research institutions should replace university as the element of triple helix model. Santonen(2007) considered that don't regard user as one of the element was the defect of tripe helix model. Some scholars defined the elements as government, industries, universities, capital and users.

3.2 Intermediary institutions

Besides the elements of government, industries, universities, capital and users, some scholars studied the function of intermediary institutions in synergic innovation. Hoppe & Ozdenoren(2005) believed that intermediary institutions were crucial in the marketization process of technical invention, which contribute to reduce or eliminate the uncertainty between technology inventor and adopters. University Technology Transfer Office(TTO) was very important in the Industry-University-Research cooperation, and was helpful to foster effective Industry Science Links(ISLs), some companies even regarded skills and expertise of TTO's staffs as the key factor to university-industry cooperation efficiency(Siegel et al,2000). Debackere & Veugelers(2005) analyzed the evolution mechanism of effective TTO, studied the incentive structure design of university scientific research team and execution of effective decision within TTO. Macho-Stadler etc(2007) build a theoretical model to explain the specific role of TTO to university invention licensing, companies were inadequate understanding to information quality of university's invention. Certification of TTO's reputation can reduce the information asymmetry problem about invention's quality, which will cause less but more valuable innovation be sold at a higher price, thereby make TTO get higher technology transfer income. Hellmann(2007) stated that TTO allows scientists engaged in scientific research, and achieved the efficiency of specialized division.

Along with the increasingly improving of cooperative innovation level, more studies focused on joint nodes between all kind of innovation actors. Intermediary institutions performed various tasks in innovation, which be called as third party (Mantel & Rosegger, 1987), bridges (Bessant & Rush, 1995; McEvily & Zaheer, 1999), agent (Hargadon & Sutton, 1997; Provan & Human, 1999), information intermediary (Popp, 2000).

Industry-University-Research is one of mode of synergic innovation, but synergic innovation is not limited to it. Synergic innovation surpassed the boundaries of traditional Industry-University-Research. Synergic innovation emphasized the close cooperation between all the innovation actors and the synergistic effect of varies innovative elements under the dynamic and complicated network environment based on information technology, consequently to complete the whole innovation process(Dan Liu, Changle Yan,2013).

4 Synergic innovation effect and measure of synergy degree

Synergic innovation effect means that the whole system larger than sum of individual participants, especially the effect of complementarities and externalities, through integration their resources by partners in innovation process(Meijers,2005). Synergic innovation effect not only depends on innovation resources, but also depends on the choice of innovation mode. Xuemei Xie(2014) measured the synergic innovation effect through five indexes, regarded synergy mechanism and environment as moderator variables, analyzed the influence of synergic innovation mode to synergic innovation effect.

Scholars measured system synergy degree by different methods. Leydesdorff (2014) developed triple helix algorithm, a quantitative method to measure the relationship of the triple helix. The algorithm is based on Shannon comentropy, the entropy value(T value) reflects the synergy degree of

collaboration between university, industry and government. Lin Li & Zehuan Yang(2013) established the evaluation index system of regional synergy innovation degree from four dimensions, and evaluated the regional synergy innovation degree of Hunan province in China. Ming Zhang(2011), Hongqi Wang & Yulian Xu(2012), Zhiyin Liu & Ming Tan(2012) engaged in similar researches.

5 Influence factor and drive mechanism to synergic innovation behavior

There were not many literatures on the influence factor to synergic innovation behavior, but scholars conducted series researches on the influence factor to synergic innovation performance, collaborative willingness, collaborative efficiency and knowledge diffusion. Simonin(1993) found that the main influence factors to synergic innovation performance included alliance's cultural differences, previous experience, enterprise's absorptive capacity, knowledge type, learning barriers and alliance's relationship. Laursen & Salter(2004) discovered the "inverted U" relationship between the scale of collaborative network and innovation performance, Knudsen & Nortensen(2011) found that reinforce interaction strength will slow down R&D speed and increase R&D cost.

Cohen & Levinthal(1990) raised the concept of absorbing ability, R&D input could improve enterprise's technology absorbing ability. Laursen & Salter(2004) stated that enterprises with high R&D ability were more likely to cooperate with universities.

Influence factors also included the followings: enterprise's R&D input, research quality of academic, physical distance(Bishop et al,2011), information disclosure risk, benefit divergence, property of knowledge, management cost(Gilsing etc,2011), synergic mode between university and enterprise(Zeng etc,2010; Terry Shinn & Erwan Lamy,2006), policy support, protect of knowledge achievement, interest allocation mechanism, financing channels(Haiyan He et al, 2014), enterprise's absorbing ability, government funding, firm size, open R&D strategy(Xia fan et al, 2012), long-term

R&D orientation, government direct subsidy, cooperation experience(Yi Xu et al, 2014), firm size, absorbing ability, taxation policy(Wei Liu et al, 2013).

Moreover, scholars carried out in-depth research to synergy mechanism and driving mechanism of synergic innovation. Synergy mechanism is the inner mechanism and control method that caused the synergic innovation effect(Xuemei Xie, 2014). Synergy mechanism composed by implementation mechanism, motivation mechanism and restraint mechanism(Schiuma & Lerro,2008), which can promote the formation of system self-organization ability(Yin Zhou, Hua Liu, 2010)

Jin Chen, Yinjuan Yang(2012) explored the driving mechanism of synergic innovation, considered science & technology, market, and culture were the three factors to drive synergic innovation. Cultural differences will block knowledge exchange within university-industry collaborative innovation, so cultural conflict should be effectively controlled(Bjerregaard,2010). Arza & Lopez(2011) found that company's network ability rather than knowledge base was the driving force to the connection of company and public research institutions. Sherwood & Covin (2008) argued that benefit allocation mechanism was the key factor to Industry-University-Research collaborative innovation.

6 Research review

Current research achievements laid a solid foundation for synergic innovation theory, as a new innovation paradigm, there are still some remains field should be further studied.

First, research on synergic innovation behavior. Compare with traditional cooperative innovation, synergic innovation has difference and similarities. The similarities is that both of them in essence are a kind of cooperative behavior, emphasize the cooperation and share between variety innovation actors. But there are difference in the matter of cooperation subject, cooperation mode, benefit allocation,

term of cooperation. Researches focused on enterprise cooperation innovation behavior, but seldom concern on the pattern of synergic innovation behavior and measurement on behavior, which is necessary for an in-depth study.

Secondly, research on synergic innovation effect, mainly includes performance evaluation and its influence factors to synergic innovation. Performance evaluation to synergic innovation refers to evaluation index system, evaluation method, reliability and validity of evaluation. Influence factors to the performance of synergic innovation covers enterprise, government, research institutions, regional environment, forms of cooperation and so on.

Thirdly, research on the driving mechanism. What is the driving force of synergic innovation? What are the obstacles to synergic innovation? How these factors influence the decision-making of synergic innovation? To answer these questions, must to deeply analyze the driving mechanism of synergic innovation. For this purpose, on the one hand, we can conduct quantitative analysis by mathematical model; on the other hand, we may carry on the qualitative research on typical cases.

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