



# Research Progress on Synergic Innovation Theory - A Literature Review

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## Abstract

Synergic innovation is a new paradigm, and a new progress of innovation system theory. We reviewed the evolution of innovation theory, analyzed the background of synergic innovation theory. The study on synergic innovation 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 expanded from the "University-industry-government". Different methods have been developed to measure the synergic innovation effect and synergic degree. Furthermore influential factors and decision mechanism of synergic innovation behavior has been studied.

**Keywords:** Horizontal synergic innovation; Synergic innovation effect; Degree of synergic; Influential factors; Decision mechanism

## Introduction

Nowadays, knowledge became increasingly divergent, a single company was difficult to conduct R&D rely on itself [1]. Innovation was no longer separate activities, but dynamic and complicated integrated activities which related to multi-level, multi-agent, multi-stage and a variety of innovative elements [2]. Synergic innovation has become the key factor of enterprise rapidly accessed to technology advantage [3], as a new innovation paradigm, synergic innovation has gradually become a hot topic around the world.

## Evolution of Innovation Theory and Background of Synergic Innovation Theory

Schumpeter pointed out that innovation was the source of modern economic growth, and a kind of creative destruction. Since then, more and more scholars studied on theory of innovation. With the progress of science and technology, innovation became increasingly complex, presented a multi subject participation and complex feature.

Jonathan [4] analyzed the history of human science and technology innovation; found that a new technology in 20<sup>th</sup> century was harder than 19<sup>th</sup> century, because of limitation of economic and physical. Innovation increasingly relied on collective behavior and network relationship, multi-agent collaborative innovation was the most effective path [5].

Freeman [6] raised the concept of national innovation system (NIS), considered NIS as a network which composed by various institutions in public sector and private sector. Interaction effect of these institutions would promote the development, introduction, improvement and diffusion of new technology.

Lundvall [7] regarded innovation as a whole system that various factors related each other. OECD [8] stated that innovation and technology progress was the consequence of a complex relationship between the main bodies of knowledge production, distribution and application, and 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 [9] proposed the concept of regional innovation system (RIS), and defined it as an interactive learning system that formed by enterprises and other organizations under the institutional environment characterized as embeddedness. Innovation was the result of complex interactions between regional, national and even hyper-national organizations [10]. 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 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.

Haken proposed the idea of synergetics, which been gradually applied to synergic innovation theory [11]. Synergic innovation was the new progress of National Innovation System theory [12].

## Connotation and features of synergic innovation

**Connotation of synergic innovation:** Persaud [13] pointed out that synergic innovation was the collaborative progress based on research and development (R&D) cooperation between multi participants to elevate enterprise's innovation abilities. Synergic innovation ability included four dimensions which were R&D strategic synergy, operational management synergy, knowledge management synergy and innovation skill synergy. Serrano and Fischer described synergic innovation as a process to achieve new product R&D. During the process, the partners shared information, made plan and solved key technical problems together.

Synergic innovation was aimed at knowledge increment. In order to achieve major scientific and technological innovation, enterprise, government, university, research institution, intermediary organization and user cooperated and integrated deeply, came into being superimposed nonlinear system effects. Synergic innovation was more emphasis knowledge exchange and technology transfer in innovation behavior actors [14].

Research on synergic innovation has been expanded from inside to outside, namely from collaborate within enterprise to vertical collaborate inter-enterprise and furthermore to non-vertical (horizontal) collaborate.

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## Types of synergic innovation

**Synergic innovation within enterprise:** Synergic innovation within enterprise means collaborate between internal departments and staffs in an enterprise. Srivastava and Gnyawali indicated that quality and diversification of technology resource profile were helpful for breakthrough innovation. Enterprise should integrate innovation elements such as technology and internal resources. Hagedoorn and Schakenraad [15] thought that relationship had interaction and complementary effect in technology innovation thereby emerged more and more collaborative innovation in organization. Product innovation and supply chain process innovation efforts have traditionally been managed as separate activities, now collaborative innovation seek to integrate them, new management approaches and information technology solutions can overcome barriers that hampered collaborative innovation [16].

**Synergic innovation inter-enterprise:** Synergic innovation inter-enterprise mainly refers to a kind of vertical synergic innovation, which means innovations across firm boundaries through the sharing of ideas, knowledge, expertise, and opportunities, cooperation among supply chain members such as customer, suppliers, buyers, competitors and so on [17]. Many scholars especially emphasized the importance of "Users" to firm's innovation. Von [18] studied on user driven innovation since 1970s, put forward users should be predominance in the stage of idea formation, Charles and David believed that enterprise could cooperate with customers in different innovation stages through a variety of ways, the ability and skills of enterprise's synergic innovation was important factor for organizational success. Carliss and Eric [19] believed that both innovation by individual users and open collaborative innovation might displace producer innovation in many parts of the economy, which represented a paradigm shift with respect to innovation research, policy making, and practice. 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 incorporate upstream suppliers to product innovation or process innovation [20]. Clark and Fujimoto [21] found that this kind collaboration was conducive to cut down R&D time and improve product's quality. Johnsen and Ford [22] 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.

## 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 was one of the typical forms, most studies focused on it.

**Triple helix innovation theory:** Etzkowitz and Leydesdorff [23] proposed triple helix innovation theory which was Industry-University-Research cooperation innovation, and raised high concerns from academia, industry, and politics fields. There were three collaborative models between governments, industries and universities, respectively were national socialism, laissez-faire and overlap model. The overlap model was considered more conducive to cooperation innovation. The overlap field of university, industry and government was the core of innovation system; three parties' connection was an important factor to promote knowledge production and dissemination. Its meaning was to integrate university, enterprise and government which had

different value system and function, promoted knowledge convert into productivity, drove innovation spiral siding. Entrepreneurial university was the propeller of triple helix innovation, not only the source of innovation, but also the organizer of innovation activities.

Some scholars raised criticism to triple helix innovation. Someone thought that the components of triple helix mode were not complete, should not be confined to university, enterprise and government. A debate was growled at the Fourth World Triple Helix Conference in 2002, which was whether or not triple helix should be extended to fourth helix? Chunyan [24] 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 triple helix model, Etzkowitz [25], Carayannis and Campbell [26] added two elements of public and environment, and constructed the quintuple helix innovation model based on triple helix model. Shapiro [27] argued that research institutions should replace university as the element of triple helix model. Santonen [28] considered the defect of triple helix model was that not introduced "User" as an element.

**Intermediary institutions:** Besides the elements of government, industry, university, capital and user, some scholars studied the function of intermediary institutions in synergic innovation. Hoppe and Ozdenoren [29] believed that intermediary institution was 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 skill and expertise of TTO's staff as the key factor to university-industry cooperation efficiency [30]. Debackere and Veuglers [31] analyzed the evolution mechanism of effective TTO, designed the incentive structure of university scientific research team, and studied the effective decision of TTO. Macho-Stadler etc built a theoretical model to explain the specific role of TTO to university invention licensing. Companies were inadequate understanding 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 [32] stated that scientists could engage in scientific research and achieve specialized division through TTO.

Along with the increasing improvement of cooperative innovation level, more studies focused on joint nodes between all kinds of innovation actors. Intermediary institutions performed various tasks in innovation, which be called as third party bridges agent information and so on [33-35].

Synergic innovation was not limited in the mode of Industry-University-Research, but surpassed the boundaries of traditional Industry-University-Research; it emphasized close cooperation between all the innovation actors and the synergistic effect of variant innovative elements.

## 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 resources of all partners in

innovation process [36]. Synergic innovation effect not only depended on innovation resources, but also depended on innovation mode. Xie 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 synergy degree by different methods. Leydesdorff [37] developed triple helix algorithm, a quantitative method to measure the relationship of the triple helix. The algorithm was based on Shannon comentropy, the entropy value (T value) reflected synergy degree of collaboration between university, industry and government. Rejeb et al. proposed multi-criteria models to measure the innovation ability and synergy effects. Ketchen et al. [38] examined the extent to which synergy between process, content and context explained organizational performance.

### **Influence factor and drive mechanism to synergic innovation behavior**

Scholars conducted series researches on the influence factor to synergic innovation performance, collaborative willingness, collaborative efficiency and knowledge diffusion. Simonin [39] 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 and Salter [40] discovered the "inverted U" relationship between the scale of collaborative network and innovation performance, Knudsen and Nortensen found that reinforce interaction strength would slow down R&D speed and increase R&D cost.

Cohen and Levinthal [41] raised the concept of absorptive ability; R&D input could improve enterprise's technology absorptive ability. Laursen and Salter stated that enterprises with high R&D ability were more likely to cooperate with universities.

Gerben et al. [42] reviewed recent studies on determinants of success and failure of innovation. Agreement existed on some positive impact of factors such as firm culture, experience with innovation, multidisciplinary R&D teams. Some factors such as R&D intensity, fierceness of competition, top management support remained ambiguity. Influence factors also included the followings: enterprise's R&D input, research quality of academic, physical distance [43] information disclosure risk, benefit divergence, property of knowledge, management cost [44] synergic mode between university and enterprise [45,46], policy support, protect of knowledge achievement, interest allocation mechanism, financing channels.

Moreover, scholars carried out in-depth research on synergy mechanism and driving mechanism of synergic innovation. Synergy mechanism was the inner mechanism and control method that caused synergic innovation effect. Synergy mechanism composed by implementation mechanism, motivation mechanism and restraint mechanism [47], which can promote the formation of self-organization. Chen considered science and technology, market, and culture was the three factors to drive synergic innovation. Cultural differences would block knowledge exchange within university-industry collaborative innovation, so cultural conflict should be effectively controlled. Arza and Lopez [48] found that company's network ability rather than knowledge base was the driving force to connection of company and public research institutions. Sherwood and Covin [49] argued that benefit allocation mechanism was the key factor to Industry-University-Research collaborative innovation.

### **Research Review**

Current researches laid a solid foundation for synergic innovation theory. As a new innovation paradigm, there were some fields still remained to be further studied [50-53].

First, research on synergic innovation behavior, compared with traditional cooperative innovation, synergic innovation had difference and similarities. The similarities were that both of them in essence were a kind of cooperative behavior, emphasized the cooperation and share between variety innovation actors [54-56]. But there were differences in the matter of cooperation subject, cooperation mode, benefit allocation, terms of cooperation. Researches focused on enterprise cooperation innovation behavior, seldom concerned on the pattern of synergic innovation behavior and measurement on behavior, which deserve further investigation [56-60].

Secondly, research on synergic innovation effect, mainly included performance evaluation and its influence factors to synergic innovation. Performance evaluation on synergic innovation refers to evaluation index system, evaluation method, reliability and validity of evaluation [61]. Influence factors to performance of synergic innovation covered enterprise, government, research institutions, regional environment, and forms of cooperation and so on [62].

Thirdly, research on the driving mechanism, what was the driving force of synergic innovation? What were the obstacles to synergic innovation? How did these factors influence decision-making of synergic innovation? To answer these questions, must deeply analyze the driving mechanism of synergic innovation. For this purpose, further studies should be conducted through quantitative and qualitative analysis.

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