

MEASUREMENT INDEX OF SYNERGISTIC INNOVATIVE CAPABILITY: AN EMPIRICAL INVESTIGATION ON THE SMES IN ZHEJIANG PROVINCE

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Abstract

With the trend of win-win model and collaborative development, more and more SEMs tend to cooperate with large enterprises, suppliers, customers, competitors, government, research organizations and intermediary organizations. Under the context of open innovation, this paper builds the measurement indicators of synergistic innovative capability which are based on the literature reviews of synergistic innovation and synergistic innovative capability. This study verifies the index system with the methods of factor analysis and reliability and validity test on 183 questionnaires of SMEs in Zhejiang manufacturing industry. Finally, this paper gives some suggestions for SMEs to improve their synergistic innovative capability.

Keywords: synergistic innovative capability, measurement index, SMEs

JEL code: M0, M1

1. Introduction

In the context of open innovation, independent innovation gradually exposed the limitations, especially in SMEs. Enterprises collaborate more extensive in innovation in order to integrate all kinds of resources and capacity which is required by enterprise innovation and achieve synergistic innovation. It can also make up their own deficiencies. Enterprises mainly cooperate with suppliers, customers, competitors, government, research organizations and intermediary organizations. On the basis of boundary-spanning knowledge searching, the enterprises integrate external resources with interactive effect and synergistic effect to achieve synergistic innovation. The organizational capability shown in this process, we call it synergistic innovative capability (see Makri M *et al.*, 2010).

However, as the main knowledge producers, universities and research institutions rarely commercialize knowledge or achieve added value. In other words, knowledge integration, knowledge transfer, knowledge diffusion and capitalization have not been highly valued. In the process of industry-university-research cooperation, the enterprises overlook the optimal synergy. At the same time, as the main element of innovation, the enterprises have no enough absorption of explicit knowledge and externalization of tacit knowledge. We think the government should improve the guidance and consistency of synergistic innovative policy to better promote optimal coordination among universities, enterprises and government (see Chen and Yang, 2012).

Industrial agglomeration and cluster are the main features of regional economic development in China. SMEs, make use of cluster innovation network, increase the investment, focus on “specialized, fined, peculiar and new”, improve the ability of coordination, and get information of technology, market, and talents. Moreover, SMEs cooperate with universities, customers, suppliers, scientific research institutions, government and intermediaries to improve innovation capability effectively and achieve sustainable development.

The synergistic innovative theory which is applied to enterprise research, gradually develops from individual research to systematic research. But the literature applied to small and medium-sized enterprises is less targeted and the literature clearly put forward "synergistic innovative capability" and specialize in in-depth research and empirical measurement is much less. How SMEs deal with the relationship with external partners, how their cooperation mechanisms operate and what factors influence the synergistic innovative ability, we will explore the measurement of synergistic innovative ability from this.

2. Literature Review

Hermann Haken proposed the synergistic theory in 1970s, he thought it was a self-organizing theory which was used to study the synergistic effect between subsystems and finally lead system structure to evolve orderly. Researches on synergistic innovation started in the late 1980s. From the point of synergistic innovation system, Chen and Jie (2006) put forward that synergistic innovation was a phenomenon of division of labor and synergistic association was widely found in the regional innovative system. The innovative subjects, enterprises, universities, research institutions and social service organizations, can realize technological innovation by meeting their respective supply and demand.

On the basis of this, scholars made further research on synergistic innovative capability. Persaud *et al.* (2002) put forward that synergistic innovative capability refers to the ability which can create new knowledge or integrate existing knowledge to more effectively create new products, new processes and new technologies and measured it from four dimensions by taking advantage

of unique R&D labs. Tsai and Wang (2009) did empirical analysis from the external cooperation level, they thought that enterprise can promote its own synergistic innovative capability by cooperating with universities, research institutions, competitors and suppliers. Agust and Josep Maria (2008) analyzed the synergistic relationship among enterprises, scientific research institution, university, suppliers and competitors, and concluded that the cooperation and synergistic innovation were positively correlated.

The influence factors of synergistic innovative capability which put forward by domestic and foreign scholars can be summarized in three aspects.

Firstly, the main influence factors at the enterprise level. For example, from the perspective of enterprise internal relationship and based on a survey of 79 units, Persaud (2005) analyzed the effects of autonomy, formalization, socialization and communication of R&D units on synergistic innovative capability. Yang (2011) studied the factors of synergistic innovation from the view of supply chain and concluded that inter-subjective relationship, innovative strategy and the capability for technical guarantee are the three main aspects.

Secondly, the main influence factors at the manager level. For example, from the perspective of organizational learning, Wu (2011) analyzed the influence of transforming leadership and social capital on synergistic innovation. Yang (2005) pointed out that the cooperation will also affect synergistic innovation.

Thirdly, the main influence factors at the external environment level. For example, from the perspective of external relations of cooperation, Tsai and Wang (2009) deeply studied on synergistic innovative relationship among enterprise, competitors, suppliers, customers, universities and research institutions through the empirical method. They obtained that this partnership can positively promote synergistic innovative capability of enterprises.

3. Theoretic Basic

Based on the empirical research of State Key Laboratory, Wang (2016) defined the synergistic innovative capability as the ability to make use of synergistic innovative network which constitutes of enterprises, universities, scientific research institutions, governments, financial institution, scientific and technological intermediaries to integrate multidimensional innovative factors and get maximum synergistic innovative effect. She proposed to measure synergistic innovative capability from five aspects, which are the level of planning of synergy innovation strategy, the level of finding partners to establish partnerships, the level of management and coordination, the input level of synergistic innovative resources, and output level of synergistic innovation. State Key Laboratory is an experimental platform for basic research and applied basic research. In essence, State Key Laboratory has an important responsibility to build an open platform for scientific researches, to collect talents, to carry out major project researches and to produce important scientific and technological achievements, which makes it an essential

part of the innovation network.

Similar to the coordination mechanism of State Key Laboratories, SMEs also obtain various kinds of knowledge, technology, equipment, information and even market from different partners to increase the depth and breadth of scientific researches and achievements transformation. SMEs mainly rely on the industrial cluster, and have broader synergistic objects. Suppliers can help SMEs identify potential technical problems and existing technical difficulties, and obtain key technical information related to product development and improvement. SMEs can quickly capture the changing market demand and trends to reduce market risk of enterprises innovation from customer feedback. Meanwhile, SMEs can reduce the risk of innovative practice by sharing knowledge and skills with competitors. SMEs can form differentiated development model to gain more competitive advantages by measuring competitors' technical level and technological strategy. There are two main advantages for SMEs to carry out synergistic innovation in industrial clusters. Firstly, innovative ability and resource complementarity between different innovation subjects. For example, universities and research institutes are the source of new knowledge and new technologies. Services like financial and consulting institutions are the important bridge between knowledge flow and technology transfer. Secondly, the interaction between related enterprises is also an important innovation resource

Wen and Su (2012) thought that to measure synergistic innovative capability should include three basic elements. Firstly, initiative cooperation which aims to innovate. In other words, whether companies can find partners and build partnerships actively before other similar institutions. Secondly, relational governance. A harmonious relationship is established between companies with different values but consistent goals. Thirdly, internal coordination. Under the guidance of innovation goals, inside activities such as resource allocation and knowledge integration are organized. Barton (2002) set up evaluation index of innovative capability which contains innovation, management, technological systems and technological awareness.

According to the innovation subject, innovation assistance and innovation environment of industrial innovation ecosystem, Liu and Zhang (2015) evaluated synergistic innovative capability of regional industry of Beijing-Tianjin-Hebei. They concluded that innovation environment support ability, industry upgrading ability, knowledge innovation ability, knowledge flow and cooperation ability and knowledge application ability are the main five aspects. The SMEs cluster provides a platform for the diffusion of technological innovation, and it also puts forward that cooperative innovation is an important mode of technological innovation of SMEs cluster. In 2001, some scholars put forward the theory of synergistic innovation for the first time, which played an important role in improving the innovation ability of SMEs. They thought SMEs with geographically concentration can maximize the effectiveness of innovation due to the intensive competition and cooperation network, which will help SMEs to reduce uncertainty, increase flexibility and enhance information exchange.

At present, the lack of internal innovation resources, the scarcity of core technology and the weakness of innovation are the short of SMEs. This, to some degree, promotes them to search for all kinds of external collaboration and acquire knowledge resources, finally to integrate internal and external resources for synergistic innovation. In other words, SMEs pay more and more attention to synergistic innovation and synergistic innovative capability. We believe that synergistic innovation is the overall synergistic effect produced by the coupling of innovation elements and the interaction between internal and external knowledge sources. It forms a pluralistic, cooperative and interactive model of network innovation, taking universities, enterprises and research institutions as the core elements, government, financial institutions, intermediary organizations, innovation platform, non-profit organization as the auxiliary elements. Synergistic innovative capability focuses on the ability to integrate complementary knowledge and resources to achieve innovation, including technology innovation synergy, market innovation synergy and organization innovation synergy.

Based on the current situation of our country, this paper draws lessons from the measurement index of synergistic innovative capability research of Persaud (2005), Wen *et al.* (2012), and builds 4 dimensions and 12 indexes of the measurement index. They are knowledge creation and sharing, managerial and operational synergy, strategic R&D synergy and innovative proficiency synergy. Specifically, knowledge creation and sharing consists of four aspects: synergistic innovative power, the success rate of synergistic innovative capability, synergistic ability of team, channels to get research resources and knowledge innovation. Managerial and operational synergy consists of four aspects: the coordinate improvement of products (or services) quality, the synergistic improvement of process technology, the improvement of R&D management department, the efficiency of resource utilization. Strategic R&D synergy consists of two aspects: the number of R&D synergistic projects and long-term cooperative complex projects. Innovative proficiency synergy consists of two aspects: cost reduction of synergistic R&D and shortened innovation cycle.

4. Research Method and Result

4.1 Research Method

This paper takes SMEs in manufacturing industry of Zhejiang province for research objects, the samples consists of electrical machine equipment manufacturing, Telecommunication Equipment Industry, computers and other electronic equipment manufacturing. The manufacturing industry in Zhejiang province relied on “block economy” to support regional development. But manufacturing SMEs must carry out the transformation and upgrading, and follow the development path of “specialized, fined, peculiar and new” and open cooperation because of the internal and external difficulties. This provides an ideal scenario for our research. The questionnaire was modified according to experts’ feedback. To minimize all kinds of deviations, we did a small sample test and then a T test. The results showed that there was no significant difference among the size, age and industry type of enterprises. The questionnaires were partly filled by MBA students, part of them were sent to manufacturing SMEs by paper and network. The total 293 questionnaires were distributed and 243 questionnaires were submitted back (a 82.9% response rate). After removing 60 questionnaires because of the missing information, 183 valid questionnaires remained. Most of the respondents are people from primary and middle management layers, with a total number of 114 participants (62.3%).

Most of the participants are educated to bachelor's degree level (49.73%). The tenure level of the majority is from 3 to 6 years (26.23%) and the enterprise type covers all the manufacturing industry. Generally speaking, this study covers Hangzhou, Ningbo, Jinhua, Shaoxing and other cities, it has a wide range.

4.2 Result Analysis

This paper adopt Likert five dimension scale, the Cronbach 'alpha coefficient of synergistic innovative capability is greater than 0.7 (Table 1), which shows that the reliability is good. According to table 2, the KMO value of synergistic innovative capability is larger than 0.5, Bartlett test is significant at 0.01 probability level, this shows that it is suitable for factor analysis, The synergistic innovative capability extracts 4 factors from the sample data, explaining 73.405% of total variance.

From the second-order factor model of synergistic innovative capability, we got that $\chi^2=64.316(df=50)$, $\chi^2/df= 1.286$, RMSEA was below 0.1, good fit index (GFI), incremental fit index (IFI), normed fit index (NFI) and comparative fit index (CFI) were all above 0.90. In addition, table 3 shows that the factor loading of each dimension on synergistic capability is larger than 0.6, and all the values of AVE are above 0.5. It shows that the measurement scale of synergistic innovative capability has good convergent validity.

According to the test method of Fornell and Larcker, if each rooting values of average variance extracted (AVE) is larger than the coefficient of correlation between this construct with others, it conforms to discriminant validity. The rooting value of average variance extracted (AVE) of synergistic innovative capability is 0.722, this provides discriminant validity of the multidimensional construct.

Table 1. Reliability of constructs

Item	Variable	Alpha	Number of items	Alpha
Synergistic innovation capability	Strategic R & D synergy	.821	2	0.878
	Managerial and operational synergy	.810	4	
	Knowledge creation and sharing	.839	4	
	Innovative proficiency synergy	.851	2	

Table 2. Kaiser-Meyer-Olkin and Bartlett Test

Item		Synergistic innovation capability
The value of KMO		.844
Bartlett sphericity test	Chi square	982.559
	Df	66
	Sig.	.000

Table 3. Fitting results of synergistic innovative capability

Effect			standardized estimates	unstandardized estimates	S.E.	C.R.	P	CR	AVE
knowledge creation and sharing	<---	Synergistic innovation capability	.771	1.000				0.813	0.522
managerial and operational synergy	<---	Synergistic innovation capability	.758	.963	.168	5.726	***		
strategic R&D synergy	<---	Synergistic innovation capability	.692	1.242	.215	5.787	***		
innovative proficiency synergy	<---	Synergistic innovation capability	.664	.965	.175	5.528	***		
XTCX7	<---	knowledge creation and sharing	.729	1.000				0.840	0.569
XTCX8	<---	knowledge creation and sharing	.774	1.166	.123	9.481	***		
XTCX9	<---	knowledge creation and sharing	.720	1.019	.114	8.972	***		
XTCX10	<---	knowledge creation and sharing	.791	1.185	.123	9.652	***		
XTCX3	<---	managerial and	.693	1.000				0.813	0.522

Table 3. cont

Effect			standardized estimates	unstandardized estimates	S.E.	C.R.	P	CR	AVE
		operational synergy							
XTCX4	<---	managerial and operational synergy	.679	1.041	.130	8.030	***		
XTCX5	<---	managerial and operational synergy	.680	.991	.126	7.873	***		
XTCX6	<---	managerial and operational synergy	.828	1.216	.131	9.282	***		
XTCX1	<---	strategic R&D synergy	.907	1.000				0.827	0.706
XTCX2	<---	strategic R&D synergy	.768	.803	.098	8.170	***		
XTCX11	<---	innovative proficiency synergy	.828	1.000				0.853	0.743
XTCX12	<---	innovative proficiency synergy	.895	1.136	.128	8.898	***		
x ² =64.316 x ² /df=1.286			GFI=0.946 NFI=0.936 CFI=0.985		IFI=0.985		RMSEA=0.040		
*** p<0.001 XTCX =synergistic innovation capability									

5. Research Conclusions

According to the result of the analysis data, it is not difficult to find that the four dimensions of synergistic innovative capability have good reliability and validity. They comprehensively measure the synergistic innovative capability of SMEs.

The cooperation between SMEs and other enterprises is complementary, it establishes technology innovation and accelerates the innovative process, which play a key role in

promoting synergistic innovative capability. On the basis of knowledge spillover effect of industry-university-research institute, SMEs obtain high-quality human and knowledge resources to enrich their internal knowledge type and structure. SMEs also create more innovative programs and increase the types of innovation results by using various forms of communication, research, cooperation. Meanwhile, SMEs communicate and cooperate with customers and suppliers to enhance mutual trust and capture more innovative and complex knowledge. SMEs search mature technology from suppliers and share knowledge with each other to improve innovation efficiency and reduce coordination costs such as retreat and rework. High efficiency, available innovative resources, the rapid communication, sustainable independent innovation and sharing of innovation achievements are the characteristics of synergistic innovative system of SMEs, they effectively overcome innovation problems, and further enhance innovative ability and environmental adaptability (see Zhang, 2010).

SMEs develop a diversified cooperative relationship by strengthening their synergy with suppliers, customers, competitors, governments, research organizations and intermediaries. It's useful to gain the trust and recognition from their partners, further consolidate established partnership, and attract more high-tech and high-quality partners and increase the possibility of establishing new partnerships. In a word, the promotion of synergistic capability is beneficial for enterprises to establish new cooperative relationship and consolidate existing cooperative relationships in the technological innovation network, so that the enterprise centrality can be promoted. SMEs play a bridge role in establishing relationships with partners. The stronger the synergistic ability of SMEs, the more stable the relationship between partners.

This paper puts forward some suggestions for SMEs cluster to manage and improve synergistic innovative capability.

SMEs should use collaboration advantages to cooperate with large enterprises. On the one hand, it can play its own advantages of flexible innovation mechanism and quick market response. On the other hand, it can quickly develop new products and technologies by making use of large enterprises' technology, equipment and funds.

Universities and research institutions should constantly promote the cooperation between scientific talents and SMEs, further open up laboratories to share scientific equipment. They train qualified scientists and ultimately provide researchers for SMEs.

SMEs should form an innovative alliance with suppliers and users, which is related to their partner's market position and competitive position. SMEs can better meet users' needs if they work with users. When SMEs work with suppliers, suppliers make clear about their innovation needs and participate in innovation to achieve the expected benefits, it shortens the cycle of

technological innovation and reduces costs and improves the success rate of innovation.

The government should improve openness of the synergistic innovative subjects and promote implementation of innovation activities. It should attract external investment and take more preferential tax policies to increase funds supply for SMEs. Government should perfect people shifting system and encourage entrepreneurship and play the regulatory role of talent price mechanism. Government should also introduce enterprises and research institutions to build innovative platforms. It's better to play the role of import platforms in undertaking economic and social development.

The intermediary, such as R&D service center, consulting companies, industry associations, market services, technology intermediaries and brokers, sets up a good platform for production-study-research cooperation and synergistic innovation. It also provides demands for innovative activities as well as services support. Meanwhile, it promotes the development of innovative activities, and it is a catalyst for innovation activities.

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