Empirical Research on Influence Factors of Enhancing Independent Innovation Capability for Small and Medium-sized Technology-Based Enterprises

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***Abstract* — Aiming at the issue of influence factors of enhancing independent innovation capability in small and medium-sized technology-based enterprises (SMTEs), and based on the perspective of collaborative influence of both internal operations and external environment, with empirical research methods such as business interviews and the assistance of questionnaires to collect sampling data, this paper analyzed composition factors of enhancing the independent innovation capability in SMTEs through factor analysis. It also examined the construction validity of questionnaires and internal consistency reliability, evaluated structural model fitting results, corrected the model, and then verified the hypothesis. The empirical findings serve as a useful exploration for composition factors of enhancing the independent innovation capability in SMTEs.**

Keywords - Small and medium-sized technology-based enterprises (SMTEs); Independent innovation capability; Influence factors; Enhance

I. INTRODUCTION

At present with faster pace of economic globalization and wider areas involved, the development of small and medium-sized technology-based enterprises (SMTEs) is growing more and more rapidly, which makes theses enterprises have to shorten the life cycle of product research and development. SMTEs must carry out independent innovation activities to survive and develop in the fierce market competition; therefore they have to possess the capacity for independent innovation.

II. LITERATURE REVIEW AND HYPOTHESIS

A. Literature Review

It is affected by various factors to enhance independent innovation capability in SMTEs. Relevant literature mainly provides two kinds of research perspectives--enterprise organization and cooperation. The perspective of enterprise organization is further analyzed from single factor and multiple factors. In terms of the single factor. Lee[1] has studied impact of enterprise internal autonomy on the enterprise independent innovation ability in South Korea. Knut Blind's studies [2] suggested that regulations have a significant influence on enterprise innovation. Amsden[3]conducted the research on that impact of enterprise organizational attitude on innovation within the enterprise. As for the concept of multiple factors, Nika Murovec[4] maintained that internal R&D input, employee learning, level of innovative cooperation, and innovation attitude were important for realization of product innovation and process innovation, and played the determinant role in innovative absorption capacity. Zheng[5], from the perspective of culture and the structure of the enterprise, studies their influence on enterprises' independent innovation capacity. The cooperation perspective can also be considered from external support as well as internal and external coordination. As for external support, Fulya Sarvan[6] had an empirical analysis on the social network and proved that it is the foundation of enhancing innovation capability in the yacht manufacture. Richard[7] found that enterprises which are more adept at using the information provided by the regional innovation system have stonger innovation ability, since outside expert organizations affect the research and development (R&D) investment and resource allocation ability of the enterprise. When it comes to the concept of internal and external coordination, Patric Ronde[8] believed that independent innovation ability was influenced by enterprise competitiveness, research and development personnel, the local high-tech industry and universities and government R&D investment. Wong et al[9] found that organizational innovation is mostly decided by organization management philosophy, followed by management innovation policy, and finally knowledge management.

Now relevant literature focuses more static factors, one-way correlation analysis, relatively lacks dynamic collaboration and interaction among multi-class innovation stakeholders and needs to increase the accumulation of research results on enhancing independent innovation ability.

B. Hypothesis of Influence Factors of Enhancing Independent Innovation Capability in SMTEs

1) Internal Actors

This article will mainly discuss internal factors from four perspectives, enterprises' own resources, enterprise system, enterprise culture and enterprise knowledge.

(A) Enterprises' Own Resources

In order to carry out technological innovation, enterprises must have sufficient funds to support R & D and technical innovation talents. New Schumpeterian contends entrepreneurship as the primary factor, and Peters and Waterman also advocate that entrepreneurship is the main condition for the success of the innovation. Besides, a sound infrastructure can speed up the innovation in SMTEs.

Hypothesis H1: Enterprises' own resources can positively influence and enhance the capability of independent innovation.

(B) Enterprise System

Independent innovation activities cannot be carried out without the following factors in terms of enterprise system. Proper enterprise property system can optimize allocation of the internal resource; scientific and rational management system can stimulate technological innovation from employees; well-organized system can make clear the internal division of enterprise personnel to increase work efficiency.

Hypothesis H2: Enterprise system can positively influence and enhance the capability of independent innovation.

(C) Enterprise Culture

Enterprise culture affect the enterprise independent innovation ability by influencing the all aspects of the innovation process. Enterprises with strong sense of innovation of can make corresponding change according to the change of external environment, and take the initiative to innovate, thereby to enhance the core competitiveness. Employee can hardly innovate on his or her own because of the personal knowledge and ability limitation. Therefore it better to form an innovation team, fully coordinating human, material and financial and other resources.

Hypothesis H3: Enterprise culture can positively influence and enhance the capability of independent innovation.

(D) Enterprise Knowledge

According to the theory of learning organization, with the accumulation enterprise knowledge, the marginal productivity of enterprises will increases with lower production costs. Therefore, Enterprise innovation knowledge will be accumulated through the improvement of enterprise internal knowledge exchange and technical training and the establishment a good learning atmosphere.

Hypothesis H4: Enterprise knowledge can positively influence and enhance the capability of independent innovation.

2) External Environmental Factors

This article will discuss external environment including resource, policy and regulation, market, science and technology, social service and social culture.

(A) Resource Environment

Benefits from resource environment are manifested as follows. Some of the infrastructures are important carriers to transfer enterprise innovation, while some are guarantees of it. Quality of human resource environment directly determines the efficiency of independent innovation in SMEs. Good financing environment as well as abundant capital is the basis for SMTEs to ensure the smooth conduct of independent innovation. Small and medium-sized enterprises also need accurate and adequate information for it.

Hypothesis H5: Resource environment can positively influence and enhance the capability of independent innovation.

(B) Policy and Regulation

Governments need to give more support to independent innovation activities, increasing investment and other research funding. With inadequate protection from intellectual property rights, achievement of enterprise independent innovation can be easily imitated by other individuals at a lower cost. Some individuals, however, take advantage of the loophole of technology services and regulations, harm the interests of other enterprises, and damage the technology service environment.

Hypothesis H6: Policies and regulations environment can positively influence and enhance the capability of independent innovation.

(C) Market Environment

A sound market economy system can provide enterprises with accurate market information and properly guide the enterprises' production and marketing activities. Based on the market demand, enterprises can clear the direction of product technology research, therefore to produce innovative goods catering for the market. There is no denying that industrial profits will fall under the fierce market competition, forcing enterprises to carry out technical innovation. With low conversion of innovative product, a large number of scientific and technological achievements cannot be applied into practice, which will frustrate the research institutes and enterprises innovation regarding the independent innovation.

Hypothesis H7: Market environment can positively influence and enhance the capability of independent innovation.

(D) Science and Technology Environment

Enterprises can draw lessons from science and technology environment a large number of adoptable technical reserves and industry standardization technical system for their independent innovation. Given more manpower, material and financial resources enterprises cannot succeed without existing science and technology.

Hypothesis H8: Science and technology environment can positively influence and enhance the capability of independent innovation.

(E) Social Service Environment

Innovation consulting service center mainly provides enterprises with some enterprise-innovation-related policies and regulations, financing channels, market demand and innovation platform and personnel management information. Science and technology incubators can help and support

SMTEs by offering space and infrastructure. The main output of scientific research institution is the scientific and technological achievement, which can be converted into enterprise innovation products through intermediary institutions. University science park is the base of technology innovation, the base of the innovative talents cultivation and practice, and the catalysis base of high and new technology industry radiation.

Hypothesis H9: Social service environment can positively influence and enhance the capability of independent innovation.

(F) Social Cultural Environment

Self-directed innovation is a high-risk activity for enterprises, so society should give a tolerant atmosphere for innovation. Not only should it encourage enterprises to carry out innovation activities, but accept the result of failure and offer some good advice and help, so as to improve the innovation ability of enterprises.

Hypothesis H10: Social cultural environment can positively influence and enhance the capability of independent innovation.

3) Modeling

Based on the influence factors, we can build the model of influence factors of enhancing independent innovation capability for SMTEs. Influence factors consist of internal factors external environment factors. Internal factors are composed of enterprises' own resources, enterprise system, enterprise culture and enterprise knowledge, while external factors include resource, policy and regulation, market, science and technology, social service and social culture. Suppose these ten exogenous latent variables directly affect the capability of enterprise independent innovation.

III. THE EMPIRICAL RESEARCH

A. Questionnaire Design

Questionnaire is designed mainly about influence factors of enhancing independent innovation capability in SMTEs with the main body is basic information of enterprise, the enterprise independent innovation, and test scales of influence factors of independent innovation in SMTEs. In this study, the test used 7 Likert Scale, containing 34 metrics reflecting 10 main influence factors.

B. Data Collection

This data were collected form questionnaires in three ways: on-site distribution, E-mail as well as distribution through a variety of social relations. In a total of 166 questionnaires issued, 139 copies were returned with the 83.7% of recovery, in which 73.3% (102 copies) were valid after being screened. In those 102 questionnaires, samples in this study cover a wide range of industries including the mechanical equipment manufacturing, electronic information technology, high-tech services, new energy, new materials technology, aerospace technology, biological medicine, resources and environment, etc., in which mechanical equipment manufacturing and electronic information technology have the largest proportion, followed by the high and new technology industry, fewer other industries involved. From the point of business area, most enterprises are located in North and East China, accounting for 81.37% of the total sample.

C. Data Quality Analysis

1) Descriptive Statistics

SPSS19.0 is used to measure descriptive statistics analysis, and descriptive statistics analysis results are shown in table I.

2) Reliability Analysis

Table II shows that the reliability value of factors of both enterprise culture (Cronbach α value = 0.568) and knowledge (Cronbach α value = 0.574) is lower than 0.6, but higher than 0.5, which indicates these two items are still reliable. The rest of the reliability value is greater than 0.6, illustrating that the rest of the items' reliability is very credible. So the overall scale of this study meets the requirements.

3) Validity analysis

In this paper, structure validity of the scale was evaluated by confirmatory factor analysis.

Confirmatory factor analysis results of internal factors: four indicators failed to pass, including Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Normed Fit Index (NFI) and Root Mean Square Error of Approximation (RMSEA), and the test scale needed adjustment. After removing factors A4 and B3, results of confirmatory factor analysis are shown in the Table III.

D. Fitting Results Evaluation on Initial Structure Model and Model Correction

Through confirmatory factor analysis, only 26 indicators remained, namely A1, A2, A3, B1, B2, C1 and C2, F1, F2, H1, H2, H4, I3, i2, I5, J1, J2, J3 and J4, K1, K2, L1, L2, L4, M1, M2. Then Software LISREL8.70 was used to fit the hypothesis model with maximum likelihood estimation.

After the first LISREL fitting, GFI and AGFI were 0.73 and 0.63 respectively, less than the minimum requirement 0.80, and NFI was 0.86, less than the minimum requirement 0.90, which did not mean that there was a problem in the conceptual model itself, but the model needed further correction for three indicators had not reached the standard. In fact, few hypothetical models can be fitted out only once with satisfactory results. Problems are likely caused either by existing problems of established conceptual model itself, or by the deviation of the questionnaire data. Therefore, the next step is to slightly adjust the conceptual model, to ensure that the indicators meet the standard of the conceptual model. The initial structure model and the revised fitting results are shown in Table IV.

TABLE I .DESCRIPTIVE STATISTICS OF MEASUREMENT

Descriptive					
Names of Index	Code	N	Mean Value	Standard Derivation	Variance
Enterprises' own R&D input	A1	102	5.37	1.502	2.256
Cultivation of technological innovation talents	A2	102	5.40	1.530	2.342
Entrepreneurs	A3	102	4.76	1.530	2.340
Enterprise existing infrastructure	A4	102	4.58	1.518	2.306
Property system	B1	102	4.79	1.637	2.680
Organizational system	B2	102	5.24	1.244	1.548
Management system	B3	102	5.46	1.272	1.617
Innovation consciousness	C1	102	5.73	1.344	1.805
Team spirit	C2	102	5.65	1.340	1.795
Knowledge innovation	F1	102	5.50	1.280	1.639
Operation knowledge	F2	102	4.93	1.337	1.787
Marketing ability	S1	102	5.64	1.348	1.818
Independence R&D capacity	S2	102	5.13	1.426	2.033
Input capacity of independent innovation	S3	102	5.16	1.288	1.658
Innovation process management ability	S4	102	5.49	1.217	1.480
Social infrastructure environment	H1	102	4.40	1.451	2.104
Flow of personnel	H2	102	4.99	1.425	2.030
Financing environment	H3	102	4.76	1.351	1.825
Information resources environment	H4	102	5.31	1.290	1.663
Risk investment system	I1	102	4.64	1.413	1.996
Government's tax reduction policy	I2	102	4.84	1.355	1.837
Government's investment in scientific research	I3	102	4.92	1.447	2.093
Government purchase of innovative products	I4	102	4.79	1.531	2.343
Protection Regulations of Intellectual Property Rights	I5	102	4.88	1.556	2.422
Science and technology service system construction	I6	102	4.86	1.476	2.179
Market economy system	J1	102	4.92	1.405	1.974
Market demand of enterprise innovation	J2	102	5.50	1.200	1.441
Intensity of market competition	J3	102	5.25	1.278	1.632
Innovative product market conversion rate	J4	102	5.10	1.425	2.030
Science and technology progress	K1	102	5.28	1.285	1.651
Technology Standardization	K2	102	5.06	1.341	1.798
Achievements of the scientific research colleges and universities and research institutions	K3	102	4.90	1.538	2.367
Enterprise innovation consultancy	L1	102	4.57	1.353	1.832
High-tech business incubator	L2	102	4.61	1.365	1.864
Research institutions	L3	102	4.78	1.467	2.151
University of science and technology park	L4	102	4.56	1.571	2.467
Innovation culture	M1	102	5.01	1.361	1.851
Social tolerance for failure	M2	102	4.51	1.398	1.955
Valid N （listing status）		102			

E. Hypothesis Testing and Research Conclusion

In summary, if Critical Ratio (C.R.) of hypotheses H1-H10, except H3 and H10 are higher than the recommended threshold 1.96, assumptions can be verified. However, H3 and H10 experimental results show that when adjusting hypothesis model fitting results, the hypothesis of their paths should be deleted, which suggested that the hypothesis was not verified. The hypothesis testing results of SEM model are shown in Table V and the results of the path of the structural equation model are shown in Figure 1.

V. CONCLUSION

In this study, questionnaire was designed for collecting data of influence factors of enhancing independent innovation capability in SMTEs, followed by analysis of data reliability and validity, with the final hypothesis model testing.

TABLE II. ANALYSIS RESULTS OF SCALE RELIABILITY

Factors	**Code**	**No. of Metrics**	**Cronbach α Value**
Enterprises' own resources	Y1	4	0.687
System	Y2	3	0.716
Culture	Y3	2	0.568
Knowledge	Y4	2	0.574
Capability of Independent Innovation	Q	4	0.655
Resource	Y5	4	0.683
Policy and Regulation	Y6	6	0.837
Market	Y7	4	0.731
Science and Technology	Y8	3	0.725
Social Service	Y9	4	0.828
Social Culture	Y10	2	0.664
Total		38	0.942

Conclusions can be drawn that factors including enterprises' own resources, enterprise system, knowledge, resource environment, market environment, science and technology and social service environment have a significantly positive effect on the independent innovation capability, and can enhance it. On the other hand, positive effect of factors of enterprise culture and social culture environment is not obvious, so is their enhancing effect. This empirical research serve as a beneficial exploration for influence factors of enhancing independent innovation capability in SMTEs.

TABLE III. FITTING DEGREE INDICATORS OF CONFIRMATORY FACTOR ANALYSIS

Fitting degree indicators	Value (internal factors)		Value (external factors)		Toler-ance zone
	Initial	Adjusted	Initial	Adjusted	
Chi-square（χ2）	91.38	38.79	409.54	138.10	
Degree of freedom（df）	38	21	194	104	
Ratio of chi-square and degrees of freedom（χ2/df）	2.40	1.85	2.11	1.33	≤5
Goodness-of-Fit Index (GFI)	0.86	0.92	0.73	0.86	≥0.80
Adjusted Goodness-of-Fit Index（AGFI）	0.75	0.83	0.65	0.80	≥0.80
Normed Fit Index（NFI）	0.88	0.92	0.86	0.91	≥0.90
Increase Fit Index（IFI）	0.93	0.96	0.93	0.98	≥0.90
Comparative Fit（CFI）	0.93	0.96	0.92	0.98	≥0.90
Root Mean Square Error of Approximation（RMSEA）	0.118	0.092	0.105	0.057	≤0.10

TABLE IV. MODEL FITTING TESTING AND CORRECTION RESULTS

Fitting degree indicators	Initial Value	Adjusted Value	Tolerance zone
Chi-square（χ2）	574.32	215.73	
Degree of freedom（df）	350	142	
Ratio of chi-square and degrees of freedom（χ2/df）	1.64	1.52	≤5
Goodness-of-Fit Index (GFI)	0.73	0.85	≥0.80
Adjusted Goodness-of-Fit Index（AGFI）	0.63	0.81	≥0.80
Normed Fit Index（NFI）	0.86	0.90	≥0.90
Increase Fit Index（IFI）	0.94	0.96	≥0.90
Comparative Fit（CFI）	0.94	0.96	≥0.90
Root Mean Square Error of Approximation（RMSEA）	0.080	0.059	≤0.10

TABLE V. HYPOTHESIS TESTING RESULTS OF SEM MODEL

Path（Hypothesis）	Standardized	Critical ratio（C.R.）	Conclusion
Enterprises' own resources →IIC	0.13	2.44	support
Enterprise system→IIC	0.12	2.34	support
Enterprise culture→IIC	——	——	not support
Enterprise knowledge →IIC	0.41	5.56	support
Resource environment →IIC	0.20	2.89	support
Policy and regulation →IIC	0.24	3.16	support
Market environment →IIC	0.62	6.72	support
Science and technology environment →IIC	0.56	5.76	support
Social service →IIC	0.17	2.65	support
Social culture→IIC	——	——	not support

* IIC= independent innovation capability

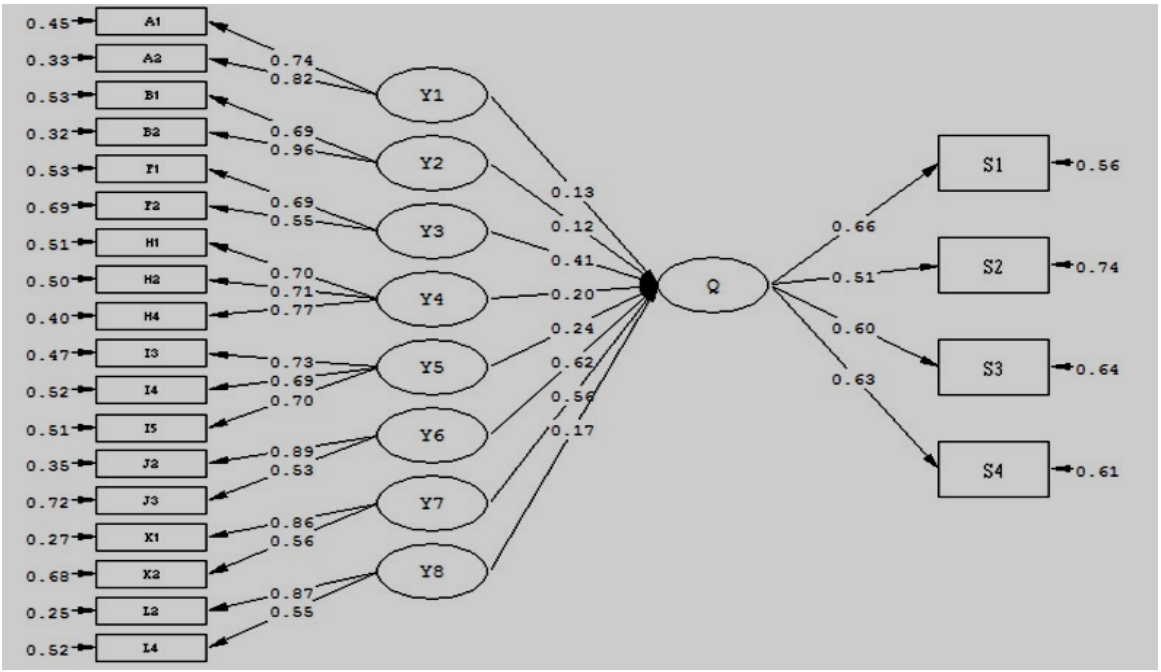

Fig. 1. Relationship path diagram

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