Research on Risk Factors of ICT Commercialization with Grounded Theory

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***Abstract*—Information Communication Technology (ICT) industry is going through a bottleneck period and the low success rate of technical commercialization is exactly one of the most important reasons impeding ICT's development. Through data collection and analysis of three ICT enterprises in Guangzhou, 21 risk factors of ICT commercialization are identified with grounded theory and the three-level ICT commercialization risk factor model is established in the views of technical management, project management and dynamic capability. On the basis of the identified risk factors, the Analytic Hierarchy Process (AHP) is used to evaluate the risk factors, and 10 key risk factors (TOP10) are selected. Finally, the structural relationship of TOP10 risk factors is analyzed with Interpretive Structural Modeling, and consequently an interpretive structural model of the key risk factors is constructed, and root risk factors are found. The research is aim to improve the success rate of ICT commercialization.**

***Index Terms*—information communication technology, technology commercialization, grounded theory, analytic hierarchy process, interpretive structural modeling, root risk factor**

I. Introduction

Global Information Technology Report 2011-2012, issued by World Economic Forum (WEF) in April 2012 in New York, illustrated that China only ranked 51st in terms of the development and usage of information communication technology (ICT). Though being top among BRICS, China was still far behind developed countries [1]. Many problems emerge during the development of ICT in China, such as the low ability of ICT innovation and the poor application of ICT. Besides, ICT industry is going through a bottleneck period and the low success rate of technical commercialization is exactly one of the most important reasons impeding ICT's development.

Grounded theory is a methodology that discovers and generates a theory from data. Since the sufficiency of a theory is related to its construction process, grounded theory emphasizes on studying from the direct observation without any exist theoretical assumptions, and to deduce the theory which reflecting the society accurately from original material through the systematic procedure, which means "establishing a theory with qualitative method" [2]. Different schools and numerous debate appeared during the development of grounded theory, and there are mainly three versions: classical grounded theory, emphasizing that core concepts and spirits that the social law contained in the data should emerge completely [3], without too many preset procedures; procedural grounded theory, which introduced in new concepts like axial coding and conditions matrix; Constructivist's approach to grounded theory.

In consideration of the universality, diversity and uncertainty of ICT commercialization risk factors, procedural grounded theory, which is more procedural and operable, is adopted to identify the risk factors according to its four-step method.

This paper is to study the risk factors of ICT commercialization based on Grounded Theory and explore its key root risk factors with Analytic Hierarchy Process (AHP) and Interpretative Structural Modeling Method (ISM), with an aim to improve the success rate of ICT commercialization.

Ⅱ. Literature Review

A. Information Communication Technology

ICT is a new field of technology and a new intelligent tool, which combines Information Technology (IT) and Communication Technology (CT), involving information acquisition, information storage, information processing, information transmission and sharing, and information display and application. The popularity of all kinds of intelligent equipment reflects that the communication and the computing industry are becoming more and more close. In the 1980s, IT and CT opened the door to the society of the Internet, network and information. In the 1990s, the spread of the embedded system technology open a new revolution. The Internet of Things, as a combination of the embedded system technology and the Internet, becomes another important milestone [4]-[6].

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B. Technology Commercialization

In a broad sense, technology commercialization refers to the whole process from the idea generation of new technology to the product industrialization. Reference [5] defined that technology commercialization was the process to realize the function of the potential technology innovation and product concepts with specific commercial activities and to achieve its technical value and use value as well, through breaking through the reality restrictions and obstacles from politics society, economy and culture, thus increase the market added value, and create the profit needed for the survival and development of the enterprise in turn. In a narrow sense, technology commercialization refers to the technology transfer and profit creation process included in the formation of the product and technology. Therefore, technology commercialization is a complicated innovation process, consequently different scholars made different classifications to the process of technology commercialization in terms of different research objective, mainly including the two-stage theory, the three-stage theory, the four-stage theory and the five-stage theory.

Applying a longitudinal design and data from 119 companies, an empirical research was made on the relationships between capability sources and technology commercialization performance based on "the enterprise resources foundation" theory in Reference [6]. The results illustrate that internal human and technology-based manufacturing sources are positively associated with successful technology commercialization, meanwhile formal and informal integration mechanisms also significantly moderate the relationships observed between capability sources and technology commercialization. Atul Nerkar and Scott Shane used the data of 966 licensed patents of MIT to the empirical analysis, showing that the three characteristics of technology: scopes, pioneering nature and the age of the invention all have an impact on the technology commercialization [7]. Most researches in the field of strategic management only emphasize on the influence of enterprise ability to the technology commercialization. The empirical research on the influence factors of technology commercialization from Wang Xinli illustrated that enterprise pay great attention to the technology, and also concern about the management during the whole process of technology commercialization [8]. Meng Lei constructed the new technology commercialization factors index system with literature analysis, and made empirical analysis based on the data of 191 SMEs, and the results demonstrated that technology, enterprise ability, entrepreneur capability, market and policy was significantly positively related to the performance of emerging technology commercialization, while the social environment was not [9]. Chang Yu, Liu Xiandong and Yang Li analyzed and evaluated the technology innovation ability of high-tech enterprise scientifically with ISM, combining with the specific examples in Xi'an high-tech zone. The application of the method and the analysis of the result was emphasized, and the solution to the problem was given [10].

In conclusion, scholars studied the influence factors of emerging technology commercialization from the aspects of technology, organization management, enterprise ability and external environment etc., and specifically speaking, the factors are technology, enterprise ability, market, policy and regulations and social environment. The narrow sense of technology commercialization is adopted in this paper, which means the marketization process of useful research achievements, and the internal risk factors of the technology commercialization will be explored.

III. Research On The Risk Factors Of ICT Commercialization

A. The Identification of Risk Factors

1) Question Generation

The idea of this research was from the program of Chinese Innovation Relay Center (CIRC), in which we discovered that quantities of ICT enterprises could not find out the technical requirements for the technology they owned, let alone transfer the technology into competitive advantage. Consequently, the question was focused on ICT commercialization risk factors finally, with the aim to improve the success rate of ICT commercialization and provide reference for CIRC at the same time.

2) Data Collection

Depth interview is an important way for data collection in the study with grounded theory. According to the research question, semi-structured interview questionnaires with mainly open questions (Appendix 1) was designed to ensure the interview efficiency and immediate feedback for the results, and they would be given to the respondents in the interview in paper. The interviewer put forward the questions first to make discussion for each interview, and the interview lasts for 1 hour. To ensure the integrity of the information, with the agreement of the respondents, the whole interview would be recorded, and all verbal information would be transcribed to the words veritably.

Firstly, company A in ICT industry was selected as a sample through theoretical sampling. After forming some concepts and attributes, company B and company C were extracted as research samples as well. Afterwards, with grounded multiple cases, concepts and categories would be revised and improved constantly, until the concepts were saturated and the relationship between categories was stable.

Sample 1: A Company, established in September 2009, is committing to the development and production of barcode reading equipment, supported by Technology Innovation Fund of Science and Technology Department of Guangdong Province. Z manager, the founder, developed the barcode reading technology independently when he was a graduate student and founded A Company after graduation. Since September 2009 to June 2011, A Company was in the stage of productization for the technology commercialization. Comparing with other products constantly, A Company carried out product

testing, preparing for the production and trial production. After June 2011, A Company turned into the commercialization stage with mass production and pushing the product to the market. At present, A Company was in financial balance, and its recent goals are improving the technical performance, guaranteeing the quality of products and services, and increasing new products, so as to achieve commercialization.as soon as possible.

Sample 2: B Company, established in August 2006, is a professional company engages in product development and integrated service provision in the field of Wi-Fi wireless communication and optical fiber radio. Having developed light load wireless technology independently, technical director M decided to make this technology commercial in cooperation with manager H, after considering the market demand for Internet of Things. B was regarded as a high-tech enterprise in Guangzhou in 2006. From 2006 to 2009, being in the stage of productization for the technology commercialization, B undertook the government programs and carried out product development and trial production. In 2009, the first generation of product was designed, without forming the complete product. Under this circumstance, B updated the product to the second generation according to the customer feedback during January to June in 2010, and when it came to the third generation in April 2011, the product has been mature and the industry standard has been formed. The annual income for B Company in 2010 was more than ￥100,000，but it soared to more than ￥2,000,000 in 2011, and currently B is in the stage from technology productization to commercialization.

Sample 3: C company, established in 2006, is committed to providing business process software and application for integrated solution to enterprises. Manager J, the founder of C, once worked in an information service company, and he found a new market segment in China, so he decided to leave the company and founded C Company to commercialize the technology. With the project cooperation with fortune 500 firms, C finished the product according to the customer's feedback and realized the technology productization. Since 2008, company C has recommended the product to the software company and its peers, so the software engineer would put forward professional needs and problems when they use the product in the development projects. In order to satisfy these needs, company C upgraded the product and matured the product, realizing the commercialization.

3) Data Analysis

Data analysis procedure of procedural grounded theory can be divided into three steps: open coding, axial coding and selective coding, and the samples were deeply analyzed in these steps. In the coding process, coding efficiency was improved with the help of mind mapping software MindManager Pro 7.0.

a. Open coding

Open coding means to disintegrate the original data, analyze the data word by word through comparing different events and concepts constantly, forming the category, the characteristic and the concept, with the aim to found out the category of the concept in the data, and then name it. The naming to the concept and category should reflect the reality adequately with multiple sources, including the literature, the interview record and the result from the discussion. During open coding, the researchers need to be open-minded, without any assumptions.

Part of the open coding from the records of A Company, B Company and C Company is illustrated in Table Ⅰ, Table Ⅱ and Table Ⅲ. With the reference of a large number of relevant literatures, 21 concepts and 9 subcategories were finally acquired.

Nine subcategories were abstracted as follows: HR management, organizational agility, technology utilization, strategic positioning, technology selection, resources allocation and integration, marketing, technology protection, and organizational learning. HR management refers to the total labor that helps to create value for the organization as well as the corresponding personnel management mechanism. Organizational agility means the enterprise’s responding ability to the change of market demand and internal problems rapidly. Technology utilization is to use, refine and expand the enterprise existing technical resources to improve short-term performance. Strategic positioning refers to defining the goal and market of enterprise to make the consumers be impressed with the product, image and brand. Technology selection is the technology characteristics the enterprise chooses in technology commercializing. Resources allocation and integration is the ability to integrate the internal and external resources and process of the organization. Marketing means to introduce the products and services directly from producers to consumer, in order to fulfill the demand and achieve the objectives of the company, and it includes pricing, distribution, advertising, publicity, sales promotion, personal selling and after-sale service etc. Technical protection means the enterprises take measures to protect the technology it use. Organizational learning is to effectively apply the knowledge to products and innovation, through system training or discussion, either formal or informal activities, to promote knowledge diffusion and create new knowledge.

b. Axial coding

Axial coding is to establish the association between different categories obtained in open coding with clustering analysis. Strauss and Corbin suggested applying the paradigm model, including causal conditions, theoretical phenomenon, context, intervening condition, action–interaction strategy, action results as the reference frame in analysis and link the categories in open coding together [2].

With repeatedly comparison between concepts and categories in the open coding and comprehensive consideration of the relationship between categories, three main categories were acquired with consideration of the relationship between categories, three main categories

TABLE Ⅰ.

EXAMPLES OF OPEN CODING ANALYSIS FROM THE RECORDS OF A

The records of A company	open coding		
	Coding	Conceptualization	Categorization
Manager Z: The team has technical background, but is weak in management. Actually, the staff is always busy with production and sales and does not consider much with the stress to survive, and we are lack of theoretical guidance and practical experience, as well.	Managers are busy with daily affairs and lack of management experience and theoretical guidance.	Project managers are short of capability and experience.	HR management
Manager Z: The company is definitely in chaos in production management, without reasonable procedures and clear division of labor, so when things go wrong, it is hard to be held accountable. Consultant X: Every time I go to the company, what I feel is a mess, with things lie in everywhere.	Disordered work/production process, together with unclear division of labor and informal management system	Disordered process of technology application	Technology utilization
Manager Z: We have not officially agents or dealers, telephone marketing and direct promotion are the important sales methods, and the product will be delivered to the customer directly or by mail.	Simple sales channel, low efficiency	Single sales channel	Marketing
Manager Z: We improve the product performance with the repaired products. As for the management, we make new rules according to the problems. The development goal in the future is to improve the technical performance, guarantee the quality of products and services, and increase new products.	Improve the performance with the repaired products and solve the internal problems immediately	Failed to respond to the change of market demand and internal problems rapidly.	Organizational agility

TABLE Ⅱ.

EXAMPLES OF OPEN CODING ANALYSIS FROM THE RECORDS OF B

The records of B	Open coding		
	Coding	Conceptualization	Categorization
Manager H: The declaration requirement of project for government is really demanding. You are asked to be profitable for two consecutive years after the project begin. Apparently the policy is contradictory. Suppliers are unwilling to give you discount at first, and if you are asked to pay for the sample you desire. However, the customer will buy the forming product only.	Hard to establish strategic cooperation relationship with the government, suppliers and customers with support	Difficult to establish a strategic cooperative relations	Resources allocation and integration
Manager H: Now is the most difficult time for us, for we are commercializing American military technology, so we have to select the suitable products for our country and explore the application field. We will cut off the programs proceed from the condition of the product and the enterprise next year.	The existing supporting facilities have fallen behind and hard to explore new applications	Out-dated supporting facilities	Technology selection
Director M: Large companies copy ideas and recruit employees of small companies with new technology. There are problems in intellectual property in China, while there is little worry in foreign counties.	Large companies copy ideas from small companies, with the problems in intellectual property	Weak intellectual property protection	Technology protection
Manager H: The cultivation and establishment of enterprise culture is related to the quality of the staff and the enterprise investment. We all hurry ahead without enough time and energy to give training to new employees. Generally we assign a mentor to the new and they learn by doing.	Lack of time and energy to give training to new employees.	Lack of system training	Organizational learning

were acquired with the paradigm model finally, namly technology management, project management and dynamic capability, which were illustrated in table Ⅴ.

Technology management refers to planning, guiding, controlling and coordinating the development and implementation of technical ability, so as to adjust and realize the strategic goals. Project management is the whole process from project investment decision to the end of the project, including planning, organizing, coordinating and controlling for the project target. Dynamic capability means the capability of enterprise integrating, improving, updating and resource reconstructing, adapting the enterprise to the external environment.

c. Selective coding

Selective coding is to aggregate all categories from the open coding and axial coding to the core category, verifying their relationship, and further completing the categories which were not fully conceptualized. It is found that the core category “the risk factors of ICT commercialization” can analyze other categories, combining with the interactive comparison and

discussion of the original record with the analysis with 21 concepts, 9 subcategories and 3 main categories.

TABLE Ⅲ.

EXAMPLE OF OPEN CODING ANALYSIS FROM THE RECORDS OF C

The records of C company	Open coding		
	Coding	Conceptualization	Categorization
Manager J: We provide training on demand as a utilitarian company. We never inspect the training results, since it will embody in the work, and it is normal for some people to perform better in working, while others still in a mess after training.	Temporary specific training according to the needs	lack of system training	Organizational learning
Manager J: At first, our customers were large enterprises, such as P&G and Wrigley. With their needs were satisfied gradually, we could not get stimulation from them. Thus we promote the product to the software company for being used in the project. As familiar with technology and product, the software company can tell problems and needs accurately.	Learn from the questions of the customer and feedback timely	Fail to respond to the change of market demand quickly.	Organizational agility
Manager J: There is a life cycle for each technology, so the product will inevitably move towards recession. In this sense, after understanding the reality, the enterprise should prepare for transfer, promote the value with service improve the operation mode, and solve the main contradiction of each phase.	The enterprise needs to take suitable operating mode specific to the technology life cycle	Technology life cycle	Technology selection
Manager J: Pirated software has great influence. Market positioning is very critical to access the specific industry and avoid the strong rivals. Otherwise it is difficult to success.	Market positioning is very critical to avoid being beaten by strong rivals.	Difficult market positioning	Strategic positioning

TABLE Ⅳ.

CONCEPTS AND SUBCATEGORIES FROM OPEN CODING

Concept	Subcategory
Project managers are short of capability and experience.	HR management
Unscientific evaluation and incentive mechanism	
Staff shortages	
Fail to respond to the change of market demand quickly.	Organizational agility
Failed to respond to the change of internal problems rapidly	
Highly centralized decision-making	
Slow technology update	Technology utilization
Insufficient ability for product improvement	
Disordered process of technology application	
Unclear strategic goal	Strategic positioning
Difficult market positioning	
Out-dated supporting facilities	Technology selection
Technology life cycle	
Difficult financial resource allocation	Resources allocation and integration
Difficult to establish a strategic cooperative relations	
Unclear division of labor and poor communication	
Single sales channel	Marketing
Little ways of promotion	
Weak intellectual property protection	Technology protection
Lack of system training	Organizational learning
Technicists are blindly optimistic to the technology prospect	

TABLE Ⅴ.

AXIAL CODING ANALYSIS

Paradigm Model	Subcategory	Main category
Action–interaction strategy	Technology selection Technology utilization Technology protection	Technology management
Context	Strategic positioning HR management Marketing	Project management
Causal conditions	Organizational learning Organizational agility Resources allocation and integration	Dynamic capability

d. Theory construction

Focusing on implied relationship between the core category, the main category, and subcategory, the ICT commercialization risk factor model was constructed with grounded theory. And then we pay a return visit to the enterprises and discussed the initial model, with the original material and coding process of three samples, and revise the model with literature review. At last, the final ICT commercialization risk factor model was constructed in Fig. 1. When we coded and analyzed the three samples again, no new category and relationship was found, therefore the theoretical model is saturated.

B. Ranking of Risk Factors

Analytic hierarchy process (AHP) was used to rank the identified ICT commercialization risk factors, and

the AHP evaluation model was established (Fig. 2). Based on this model, eight experts were invited to evaluate the relative importance of each indicator in each level under the upper level criterion and scored them with the 1-9 scale. The relative weight of the each risk factor was calculated with YAAHP0.5.2, and all passed the consistency test. The comprehensive weight coefficient of D_1 - D_{21} was (0.1775, 0.0887, 0.0586, 0.0586, 0.0293, 0.0806, 0.1036, 0.0518, 0.0492, 0.0135, 0.0149, 0.0389, 0.0389, 0.0539, 0.0269, 0.0302, 0.0127, 0.0080, 0.0135, 0.0353, 0.0154). According to the weight coefficient, ten key risk factors were selected respectively, namely out-dated supporting facilities, unclear strategic goal, technology life cycle, weak intellectual property protection, slow technology update, insufficient ability for product improvement, lack of system training, difficult market positioning, unscientific evaluation and incentive mechanism, single sales channel. The hierarchy of ICT commercialization risk factors general rank is illustrated in Table Ⅵ, W_B, W_C and W_D are weight of the second level, the third level and the fourth level respectively.

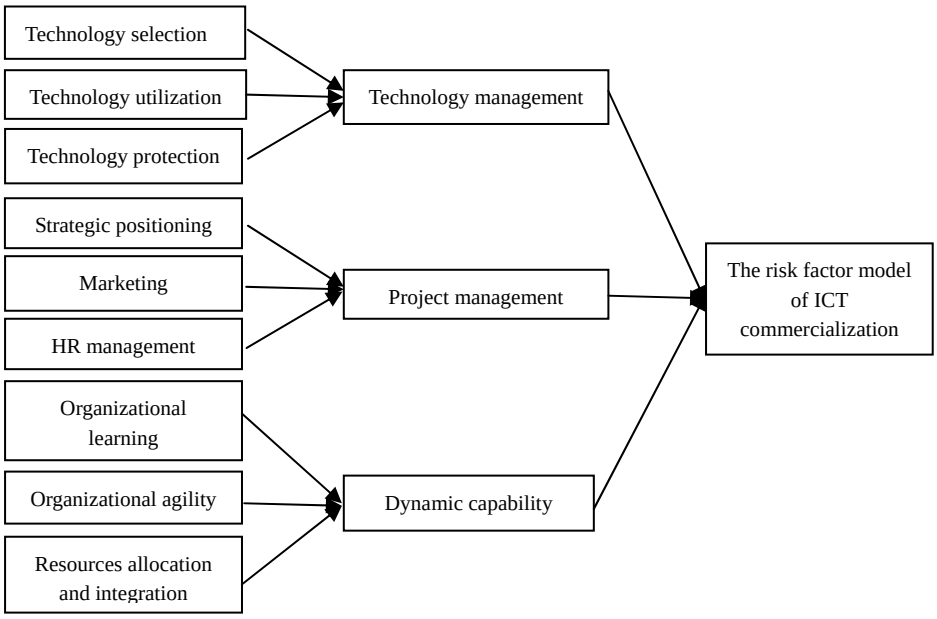

Figure1. The risk factor model of ICT commercialization

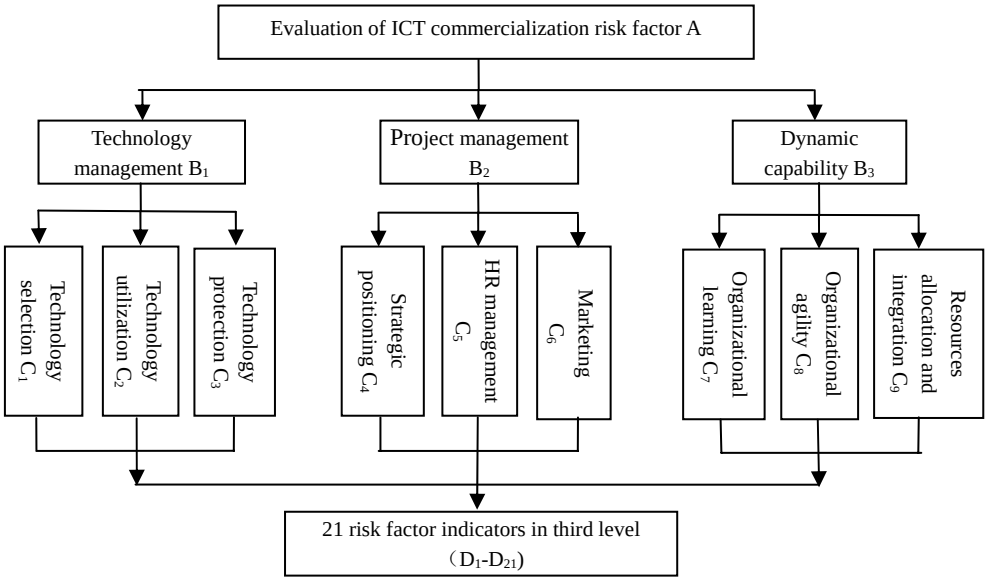

Figure 2. The hierarchy of ICT commercialization risk factors

TABLE Ⅵ.

THE HIERARCHY OF ICT COMMERCIALIZATION RISK FACTORS GENERAL RANK

A	B	W_B	C	W_C	D	W_D
The evaluation of ICT commercialization risk factors	B_1 Technology management	0.4934	C_1 Technology selection	0.2662	D_1 Out-dated supporting facilities	0.1775
					D_2 Technology life cycle	0.0887
			C_2 Technology utilization	0.1465	D_3 Slow technology update	0.0586
					D_4 Insufficient ability for product improvement	0.0586
					D_5 Disordered process of technology application	0.0293
			C_3 Technology protection	0.0806	D_6 Weak intellectual property protection	0.0806
	B_2 Project management	0.3108	C_4 Strategic positioning	0.1554	D_7 Unclear strategic goal	0.1036
					D_8 Difficult market positioning	0.0518
			C_5 HR management	0.0077	D_9 Unscientific evaluation and incentive mechanism	0.0492
					D_{10} Project managers are short of capability and experience	0.0135
					D_{11} Staff shortages	0.0149
			C_6 Marketing	0.0077	D_{12} Single sales channel	0.0389
					D_{13} Little ways of promotion	0.0389
	B_3 Dynamic capability	0.1958	C_7 Organizational learning	0.0808	D_{14} Lack of system training	0.0539
					D_{15} Technicists are blindly optimistic to the technology prospect	0.0269
			C_8 Organizational agility	0.0509	D_{16} Fail to respond to the change of market demand quickly	0.0302
					D_{17} Failed to respond to the change of internal problems rapidly	0.0127
					D_{18} Highly centralized decision-making	0.0080
			C_9 Resources allocation and integration	0.0176	D_{19} Difficult financial resource allocation	0.0135
					D_{20} Difficult to establish a strategic cooperative relations	0.0353
					D_{21} Unclear division of labor and poor communication	0.0154

TABLE Ⅶ.

ADJACENT MATRIX

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	0	0	0	0	1	1	0	1	0	0
R_2	0	0	0	0	1	0	0	1	1	0
R_3	1	0	0	0	1	1	0	1	0	0
R_4	0	0	0	0	1	1	0	0	0	0
R_5	1	0	0	0	0	1	0	0	0	0
R_6	1	0	0	0	0	0	0	0	0	0
R_7	1	1	0	0	1	1	0	0	0	1
R_8	0	1	0	0	0	0	0	0	1	1
R_9	0	0	0	0	1	1	0	0	0	0
R_{10}	0	0	0	0	0	0	0	1	0	0

TABLE Ⅷ.

REACHABLE MATRIX

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	1	0	0	0	1	1	0	1	1	1
R_2	0	1	0	0	1	1	0	1	1	1
R_3	1	0	1	0	1	1	0	1	1	1
R_4	0	0	0	1	1	1	0	0	0	0
R_5	0	0	0	0	1	1	0	0	0	0
R_6	0	0	0	0	0	1	0	0	0	0
R_7	1	1	0	0	1	1	1	1	1	1
R_8	0	0	0	0	0	0	0	1	1	1
R_9	0	0	0	0	0	0	0	0	1	0
R_{10}	0	0	0	0	0	0	0	0	1	1

C. Key Risk Factor Analysis

The ISM group with eight experts in the field of information and communication discussed the causal relationship between ten key risk factors, and after the iterative analysis for many times, the ISM group gradually reached a consensus on the relationship. With the help of ISM WIN 1.1, the interpretive structural model of ICT commercialization risk factor was established (Fig. 3). The adjacent matrix, reachable matrix and skeleton matrix of experts' judgment are illustrated in table Ⅶ, table Ⅷ and table Ⅸ.

TABLE Ⅸ.

SKELETON MATRIX

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	0	0	0	0	1	0	0	1	0	0
R_2	0	0	0	0	1	0	0	1	0	0
R_3	1	0	0	0	0	0	0	0	0	0
R_4	0	0	0	0	1	0	0	0	0	0
R_5	0	0	0	0	0	1	0	0	0	0
R_6	0	0	0	0	0	0	0	0	0	0
R_7	1	1	0	0	0	0	0	0	0	1
R_8	0	0	0	0	0	0	0	0	1	1
R_9	0	0	0	0	0	0	0	0	0	0
R_{10}	0	0	0	0	0	0	0	0	0	0

The model is a 4-level hierarchical oriented structure model to illustrate the influence

relationships between risk factors. The arrow from bottom to top indicates the risk factor in the low level can affect the one in higher level.

The conclusions made from Fig. 3 are as follows:

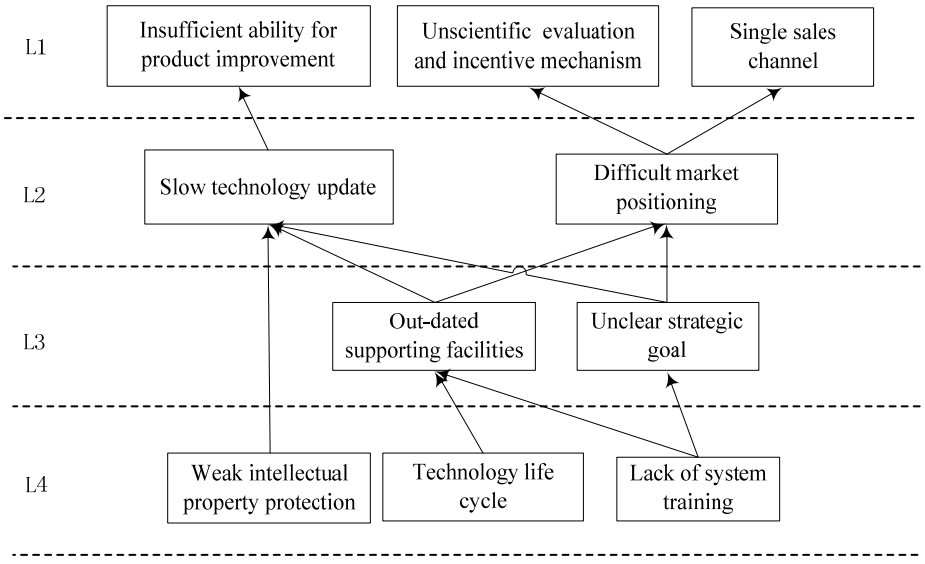

Figure 3. The interpretive structural model of ICT commercialization risk factors

(1) The risk factors locate in L1 are direct risk factors, determining whether the ICT commercialization can succeed or not, including insufficient ability for product improvement, unscientific evaluation and incentive mechanism, single sales channel.

(2) Slow technology update located in L2 will result in insufficient ability for product improvement in L1.

The difficult market positioning will affect unscientific evaluation and incentive mechanism and single sales channel in L1. At the same time, both the out-dated supporting facilities and unclear strategic goal in L3 are going to affect slow technology update and difficult market positioning.

(3) The factors located at the bottom (L4) are root risk factors, including weak intellectual property protection, technology life cycle and lack of system training. The three risk factors are the root risk factors for failure of ICT commercialization, and they will finally influence the implementation of ICT commercialization, through risk transfer by the risk factors in the middle level.

Intellectual property protection endows the inventor with the exclusive using right of the technological achievements in a certain period, which encourages the technology innovation for enterprises and provides a fair competition environment to eliminate illegal competition at the same time. As a result, the technology commercialization process will be accelerated. In the information communication industry, SMEs take an active part in technology innovation. When the intellectual property protection is weak, technology innovation or business model innovation in SMEs will be easily stolen, and core personnel will be easy to lose, which cause insufficient motivation and slow speed for technical update in SMEs. Meanwhile, the weak intellectual property protection makes new technology diffuse rapidly, and the large company relying on rich resources can update its technology fast. Thus, it further worsens the external environment of ICT commercialization for SMEs, and increases the risk of commercialization.

Technology life cycle can be divided into four stages: introduction stage, growth stage, maturity stage and decline stage. The life cycle stages of the technology have influence on the technical characteristics, the potential difference of technology, and the implementation of ICT commercialization successively. When the technology is in the introduction stage, it is not fully mature. The enterprise needs to adjust the technology constantly, redesign the techniques with process and corresponding equipment. The existing technology supporting facilities was far behind to what the new technology needs, so technology update is slow in the introduction stage. Even though the enterprise improves the product quality through "learning by doing", the efficiency is still not high enough. At the same time the high uncertainty of the market acceptance of new product leads to the difficulty to form clear strategic goal and market positioning, affects the performance evaluation and incentive mechanism and the establishment of sales channels, and finally influence the success of the ICT commercialization implementation. While the technology is in the growth period and mature period, technical performance, manufacturing process and marketing will become more mature, and the standard will be formed, and the gap in technical facilities will decrease as well. The enterprise can re-innovate by

learning to other benchmark enterprise, and the market has accepted the products in a certain degree, so the commercialization risk will reduce. When the technology is in recession, it is almost impossible to improve the technical performance, and the market demand atrophy. It is relatively easy for technology commercialization without great value, so the enterprise should develop the new technology as soon as possible.

Systematic training belongs to organization learning category of dynamic capability. Organizational learning is the core of dynamic capability, and it is crucial for technology commercialization and the maintenance of competitive advantage organization. Systematic training is helpful for the enterprise to spead, update, and make full use of knowledge. Besides, through the systematic training in technology, production and market operation, the staff can master more technical knowledge and production management skills, which helps to quickly understand and absorb new technology, reduce the technology gap, and make the strategic target of technology commercialization more clear as well. Furthermore, the training about strategic target will help the staff to make full sense of the project strategy and market positioning, and generate the sense of identity. Consequently, the active participation in the project will promote the successful implementation of technology commercialization.

Ⅳ. Conclusions

It is necessary to improve the success rate of ICT commercialization, especially in P.R.China.

The risk factor of ICT commercialization was studied with grounded theory and 21 risk factors are identified. AHP method was used to rank the risk factors and 10 key risk factors were selected, including out-dated supporting facilities, unclear strategic goal, technology life cycle, weak intellectual property protection, slow technology update, insufficient ability for product improvement, lack of system training, difficult market positioning, unscientific evaluation and incentive mechanism, and single sales channel. Finally, an interpretive structural model of the key risk factors was constructed through ISM method, and the three root risk factors respectively are weak intellectual property protection, technology life cycle and lack of systematic training.

There are three main innovation in this paper as follows: (1) apply an innovative research perspective to identify 21 risk factors of ICT commercialization with grounded theory and construct the risk factor model in the dimension of technology management, project management and dynamic capability; (2) evaluate the risk factors of ICT commercialization with AHP and select the TOP 10 risk factors according to the integrated weight; (3) analyze the relationship between TOP 10 risk factors and construct an interpertive structure model of the risk factors of ICT commercialization the with ISM method to find out the root risk factor.

Appendix A Questionair

Basic information about the technology and product:

1. What is the name of the technology your company's core technology or core product based on?
2. Which of the following does this technology belong to?
   a. Original innovation
   b. Integrated innovation
   c. Digestion, absorption
   d. Other innovation
3. How did you acquire the technology?
   a. Develop independently
   b. Develop cooperatively
   c. Buy the technical licensed.
   Others_____
4. Which stage of commercialization is the technology in?
   a. The laboratory stage
   b. Productization stage
   c. Commercialization stage
5. How long has the technology commercialization project lasted for?

Technology commercialization risk factors:

1. What factors will be considered when you decide to commercialize a technology?
2. So far, what risk factors have you met in the technology commercialization process?
3. What was the thing that the managers of technology commercialization project spent the most time on? And what difficult problems did they meet?
4. What is the problem you most fearful of?
5. What measures did the enterprise take when monitoring and controlling the risk factors? How is the effect?
6. Which experience did the enterprise obtained in the technology commercialization process? What is the shortage?
7. Do you have anything else to add with the discussion?

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