The empirical studies of innovative technology source, learning mode and innovative performance relations on technology-based SMEs

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Abstract—the essence of technology innovation is the updating of knowledge and the technology source of enterprises innovation are multi-channeled. Different learning and innovation mode are needed to digest, assimilate and re-innovate the techniques which come from different sources. Based on the definitions about learning and innovation mode of Denmark scholars such as Jensen, Lorenz and Lundvall, the author concluded the techniques source channel and learning mode of technology-based SMEs (small and medium enterprises) when they implemented the technology innovation fund project and he believed that the enterprises will get higher innovation performances when they adopted and digested the technology by using the suitable learning mode adapted to the technology source.

Keywords—technology-based SMEs, technology innovation, learning mode, innovative performance, technology source

I. INTRODUCTION

The assimilation, utilization and re-innovation ability of technology are the fatal elements of the enterprise technology innovation performance. The enterprise innovation technology may comes from outside or inside. Externally, the technology was mainly adopted by the following ways: buy the patent/proprietary technology, bring into technological competent person, entrusted or work with the university and independent scientific center to research for its unique technology; internally, such as the founder of some SMEs are the owner of the technology, some companies have their own R&D center, To ensure the higher assimilation rate and quality, the company need to contain corresponding ability towards technologies of different sources, and adopted the suitable learning mode to digest and assimilate and translated into the real productive forces.

II. THE ESSENCE OF TECHNOLOGY INNOVATION

We knew the essence of technology innovation from its definition. Now there are six exemplary definitions of technology innovation occurs in the academic area: one is from J·A·Schumpeter. He believed that the technology innovation is to bring up a brand new “new complexion” of production elements into the production system(1912). The second definition is from the Chinese science and technology terms approval committee: technology innovation is the technique activity which may improve or create new products, producing process or service manner, and the important technology innovation can resulted in the vital change of social economic system. The third definition is from OECD. Technology innovation included the new product and new techniques, and the magnificent technical change of product and technique. The innovation is done when it can be realized or utilized in the market or in the production. The fourth definition is from National Science Foundation of U.S.A. S.Myers and D.G.Marquis(1969) defined innovation: Technology innovation is a very complex process, which concludes a series of activities of science, techniques, organizations, finance and business. It starts from new ideas, definitions, through solving all kinds of problem consistently, make the new subject that has economical and social values successfully applied. The fifth one is the definition of J.M.Utterback. He mentioned in his book Industrial innovation and technique diffusion, “different from invention and technical sample, innovation is the actually adoption or application for the first time in technology”. The last one is of R. Mueser(1980). He considered that technology innovation is an meaningful non-consisting event which characterized by its originality thinking and successfully realized. This definition expressed two special meanings: ① the unconventionality of the activity, including originality and discontinuous; ② It must be accomplished successfully at last.

From the above, The essence of technology innovation is to create new knowledge and convert it into real productive forces. If not, the process cannot be named technology innovation. Nelson and Rosenberg (1993) believed that the essence of technology innovation is “the renewal of knowledge”, which includes the design and machining process of the new product, and its premise is to acquire the knowledge and organization ability. Smith (1995) believed that the innovation ability which is the core to maintain the competing advantages was decided by the technology and knowledge, the knowledge basis of certain enterprise is highly localization and only the company itself can fully understand and utilize. Such knowledge and the corresponding social knowledge is exclusive to the enterprise, and it cling closely to the special techniques, productive convention and utilization of devices and management system. Hence, such kind of knowledge is unofficial and unwritten, is recessive, only for the internal company or group.

Knowledge is the basis of innovation, the techniques are all the forms of knowledge, the increase of the core competence is also the increase of the knowledge. Whether the enterprise can activate its reserved knowledge in degree, improve its innovative power is mainly depended on learning ability. Thus learning is the chief way to acquire knowledge and improve the innovation power.

III. THE EXTERNAL TECHNOLOGY

Literature shows that, the acquire of external technology means to adopt the existing external technology knowledge. Organizational study is the most important method of knowledge accumulation and ability development (Drejer,2000). The low efficiency of external technology absorption problem is mainly because of the deficiency of R&D (e.g. Veugelers,1997; Zahra,1996). Knowledge is the key resource of enterprises (Foss,1996; Grant,1996). The enterprises benefit a lot from the external R&D outsourcing or the technology through authorizing, however, restricted by its condition, some technology-based SMEs find difficulties in their technology innovation performances: Firstly, before
purchasing patent/proprietary technology, the company should find out the potential problems, if not, it will cost large amount of time to integrate the new technology to satisfy the need of innovation (Helleloid and Simonin, 1994). Secondly, to make accurate judgement and definition on core competence of the supplier is the basis for the company to get specialized technology through R&D contract. If you cannot find the “suitable” supplier, it will not get the right knowledge which may drag on its innovation plan. Thirdly, enterprises will not benefit from technology transfer and technology authorization when they lack of technology competence in corresponding domains (Girma, 2005; Kessler et al., 2000), for exogenous knowledge are usually hard to interpret (Bierly and Chakrabarti, 1996). Fourthly, if the company do not store enough corresponding knowledge to digest external technology, it will not communicated with the supplier by using similar reference and term frame, and may mislead the cooperator or bring out the target that the cooperator felt hard to achieve. If the knowledge embeded in technology is recessive and complex, the problem will become more complex. The technology obtained from authorization or contract may aroused organization study. Organization study and knowledge storage are positive correlation (Grillaches, 1979), thus the performance will be discounted for those companies who lack of technology basis. This demonstrated that enterprise will benefit from other companies’ invention when it has certain level corresponding technology knowledge. According to organizational studying aspect (Cohen and Levinthal, 1990; March, 1991), a company’s technology knowledge will enforce its assimilation ability. The research showed that the internal R&D input is a very important step in developing technology ability (Schonecker and Swanson, 2002) and improving the assimilating ability of enterprise (Cohen and Levinthal, 1990; Grunfeld, 2003). Such inputs enforced the accumulation of dynamic ability (Helfat, 1997), and also improved the effective power of external technology towards innovation activity (Gambardella, 1992; Mowery et al., 1996). This means the internal R&D input will enforce the assimilation, translation and utilization of the external technology. Purchase technology and become a shareholder and independence cooperation R&D can increased the company’s internal R&D resource invisibly. The more purchase of patent/proprietary technology, the more technology amount the company will possess, thus will suppress the opponent’s possession of the technology. To intake and utilize those external technology will be adapted to its R&D input. The total amount of enterprise’s internal R&D input was restricted by its own strength. Accordingly, when purchasing the patent/proprietary technology exceeds certain amount, internally it has no corresponding R&D ability to intake and utilize, it will restrict the repeatedly development of technology and effect the innovation performances of the company.

IV. INTERNAL TECHNOLOGY

Study shows that, the connections between enterprises and universities/researching organizations are not so close, the enterprise activity of researching the new product is separated from the researching project in universities/researching organizations, the enterprise occupied a subordinate status in the industry-university-research system. Now the national innovation system is centered in national key lab, a large amount of money was input to universities and researching organizations, while such places pay attention only to the pure technology, paper and patent, not the industrialization, it does not support the company independent innovation. For scientific innovation and the market are not connected well, the new technology achievements conversion rate is quite low, the successful rate is less than 10%, it is the great waste of the limited science and technology resource.

From the viewpoint of enterprise, which needs the innovation technology that conform to its strategic purpose and can be realized, such technology can match the production ability, relieve the input of the company is the best. So, some technology-based SMEs, when they possess certain R&D ability, will probably doing independent innovation and cooperate with universities/researching organizations, on one hand building on the positive of their major, on the other hand make full use of the external R&D resources, and combine them together to exploit the suitable new technology.

Nowadays, some technology-based SMEs was formed by the former personnel of universities/researching organizations, for certain period of time it will possess the comparative technology priority, however the delayed effect risk are still exist.

V. THE LEARNING AND INNOVATION MODE

From the angle of knowledge creation and accumulation, the higher performance can be achieved when the learning mode is fit for the knowledge form Maskell (1999), Piore, Sabel (1984) believes that the organizational learning mode can be divided into four classes. The first is learning from doing, we call it purchasing technology learning mode. It connected with the production process, the creation of knowledge is mainly from the practiced skill and the failure lesson. The second is the region learning, for the region advantages, the company will get the knowledge conveniently from the neighborhood university, independent scientific organization, enterprise, supplier, customers, etc. The third is the specialization, means the different companies in the same industry are in different places of the industry chain, the company downstream can acquire advanced technology from the upstream company. Besides, some technology-based SMEs provided mating for the core company, whose technology innovation are done for the core company, thus they can get information and technology from core company. The fourth is the learning based on coding, we call it own technological learning mode. It considers the scientific technology as the main source, to get, produce and utilize the knowledge in a scientific way, hold formal R&D activities, recruit high education personnel, etc.

Hence, the purchasing technology learning mode is more suitable for the external technology, the own technological learning mode is more suitable for the internal ones.

VI. CONCEPT MODEL

The external market purchasing technology can be divided into all entrusted technology R&D mode, purchasing patent/proprietary technology mode and purchasing technology becoming a shareholder mode according to the different acquisition ways. The proprietary technology R&D can be classified as independent proprietary R&D and mainly proprietary R&D combines cooperation with outsides according to the participants. The cooperators can be university, independent scientific organization, enterprise, supplier, customers, according to region, these people can be classified as independent proprietary R&D and mainly and R&D input will enforce the assimilation, translation and utilization of the external technology. Purchase technology learning mode is more suitable for the knowledge form Maskell (1999), Piore, Sabel (1984) believes that the organizational learning mode can be divided into four classes. The first is learning from doing, we call it purchasing technology learning mode. It connected with the production process, the creation of knowledge is mainly from the practiced skill and the failure lesson. The second is the region learning, for the region advantages, the company will get the knowledge conveniently from the neighborhood university, independent scientific organization, enterprise, supplier, customers, etc. The third is the specialization, means the different companies in the same industry are in different places of the industry chain, the company downstream can acquire advanced technology from the upstream company. Besides, some technology-based SMEs provided mating for the core company, whose technology innovation are done for the core company, thus they can get information and technology from core company. The fourth is the learning based on coding, we call it own technological learning mode. It considers the scientific technology as the main source, to get, produce and utilize the knowledge in a scientific way, hold formal R&D activities, recruit high education personnel, etc.

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The concept of technology source, learning mode and technology innovation performance are described in picture 1.
VII. RESEARCH ANALYZE AND DATA PROCESSING

A. Research analyze

1). Sample selection

In order to sum up the technology-based SMEs technological innovation fund in Tianjin city comprehensively, to make clear the situation and find the problem, improve the government public services for them, consisting improve their scientific research environment, to accumulate basic data for creating the innovative area, we inquired the 205 technology-based SMEs including the key high scientific and technological company which have received the innovation fund support through many ways as telephone, short messages, fax, e-mail and questionnaires, etc, the visited company include entrepreneurship center, Tianda scientific garden, Defu new world building, Biomedical mansion, Kaitai incubator, etc. Totally we got 81 questionnaire in return, in which 80 are valid, take up 39.02% in the whole questionnaires, 1 is invalid, then, we got 5 ones in succession, which was counted invalid for the long period of time. The categories of enterprises are in diagram 1.

2). Creation of index system. We have created the index system (appendix).

B. Measuring

This paper is mainly concerned about the measurement of variables such as innovation technology source, technology learning mode and innovation performance. The research is mainly based on the definition of learning and innovation mode by scholars like Jensen, Lorenz and Lundvall[1]. The scale of technology source had adopted the MKTOR scale of Slater and Naver, and made some adjustment on research of Turner and Spence[2], Harris[3], and define the two items as proprietary technology, market purchasing, and 7 small items. The scale of learning mode and technology innovation was mainly adopted the Oslo annual (OECD)[4] by OECD. The learning mode is primarily about two subject purchase learning mode and proprietary technology learning mode, while the technology innovation performance involves three items like patent, profit margin and new product type. This questionnaire contains the scale of 12 items and was designed by adopting Likert7. “1” means absolutely not, very small or very low; “7” means absolutely yes, quite large or quite high; the more points you get, the more possibility or extent will be.

C. Statistical data analyze

1. the ratio of R&D is comparatively high, which is adapted to the fund requirements.

In last two years company average proportion of annual R&D cost take up the whole sale volume

2. Enterprise technology source

3. the company lay emphasis to R&D, the proportion of the R&D personnel are large, which is adapt to the fund requirement.
4. Among all ways of technology acquisition, the proportion of all technology sources are

5. Purchase patent/proprietary technology

6. The technology source situation of various industries are as follows

7. Independence cooperation R&D

8. The learning mode adopted by the enterprises
9. The performances of enterprises (average)

| Learning mode | Market purchase technology learning mode | Independent technology learning mode |
|---------------|-----------------------------------------|----------------------------------------|
| Technology source | Market purchase technology | Independent R&D technology | Market purchase technology | Independent R&D technology |
| Numbers of patent applications | 3.4% | 2.9% | 3.2% | 4.1% |
| Numbers of patent license | 1.6% | 1.2% | 1.4% | 1.8% |
| Ratio of profit proportion higher than same industry | 9% | 5.5% | 6.3% | 11.7% |
| Numbers of increasing new products | 2% | 1% | 2% | 3% |

From the actual innovation performances, the Market purchase technology learning mode is more favourable for the external technology digest and assimilation and recreation; the independent R&D technology learning mode is more favourable for the internal (no matter independent R&D or not) technology digest and assimilation and recreation.

VIII. CONCLUSION

When operating innovation fund, the technology-based SMEs have the patent technology, which source are multi-channeled, and to study their innovation mode in different ways accordingly will have different learning effects. In the angle of innovation performance, the realities are: for the external technology, the Market purchase technology learning mode is more favourable for the digesting, assimilating and recreating, while for the internal technology, the independent R&D technology learning mode is more favourable. This research also tested one fact: The enterprises’ competence of learning technology has close connection with the enterprises’ R&D investment.

The shortage of this research is the small amount of sample. The recycled questionnaires are only 80 in the total 205 investigated companies, so the representativeness of the conclusion still needs further investigation. Besides, when speak of the patent situation of enterprises, the invention patent, utility, lay-out design are not taken into account. Technology innovation extent of practical contribution to enterprise will be examined in future research.

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Appendix

| variable | determinant | Index |
|----------|-------------|-------|
| Technology source | | |
| Purchase technology | Buy technology become share holder | Purchase and update production devices |
| | Purchase domestic and abroad patent license |
| | |
| Self-owned technology | Independent proprietary R&D |
| Outsource technology R&D | Outsource to non-local university / independent R&D agency |
| | Outsource to local company |
| | Outsource to local university / independent R&D agency |
| Independent proprietary cooperation R&D | Cooperate with local university / independent scientific agency |
| | Cooperate with local company |
| | Cooperate with non-local customers / suppliers |
| | Cooperate with non-local company |
| | Cooperate with non-local university / independent R&D agency |
| | Only pay for the R&D fees to the cooperate |
| | pay for the R&D fees and buy technological achievements shares |
| | R&D division and form technology alliances |
| Learning and innovation mode | Purchase learning and innovation mode |
| | Purchase the overseas and local technological achievements and patents license |
| | Purchase and update production devices |
| proprietary R&D learning and innovation mode | Integrate the functions of department |
| Create information collecting group |

- The patent applied number
- The patent licensed number
- The increasing proportion of the new products
- The proportion, the profit margin is higher than industry average