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Research on the key success factors of reverse innovation of the latecomer engineering and technical services enterprises

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Abstract

Purpose – Reverse innovation plays an important role in the innovation catch-up by latecomer enterprise. With the development of economic globalization, reverse innovation of the latecomer enterprise research has received increased attention day by day. The purpose of this paper is to reveal the key success factors and the realization mechanism of reverse innovation of the latecomer engineering and technical services enterprise.

Design/methodology/approach – This paper adopts the grounded theory analysis as the research method, by analyzing the phenomenon, collating the results, mining through the systematic data and verifying the theory temporarily. Therefore, it is ideal for the research to build the theory by analyzing the phenomenon. Before the serious coding begins, the reliability of coders is first examined. Coders extract some sample as the first test sample; then, three coders code according to the description and requirements and calculate the coding results according to the formulas that the noted scholar Holsti has proposed. Then, the authors perform the coding three times that include open coding, axial coding and selective coding, and then, the key factor model of reverse innovation of the engineering and technical service enterprise is refined.

Findings – The investigation reveals that technology localization, connection with the international market and industrial chain integration are the key success factors of reverse innovation of the latecomer engineering and technological service enterprise. Meanwhile, the latecomer enterprise gives full attention to local comprehensive comparative advantage to carry out technology localization during the reverse innovation. The diversified international coupling mechanism is an important support for technology localization. The engineering and technical service enterprise needs to pay attention to the service chain of the vertical integration in the process of reverse innovation.

Originality/value – The paper enriches the related research of reverse innovation based on a new industry and provides management support for innovation catch-up of the latecomer enterprises that have a big technological gap when compared with the multi-national companies.

Keywords Key success factor, Latecomer enterprise, Reverse innovation, Technical engineering service

Paper type Research paper

Literature review

The concept of "reverse innovation" was first put forward by Jeffery Immelt, the President of GE, and V. Govindarajan and Trimble. C from Tuck School of Business. They expounded the process of reverse innovation by focusing on the portable imager. Traditionally, the developed countries innovate and then the developing countries adapt

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and improve the innovation; however, the innovation process for the portable imager is just the other way round. It was first developed in the emerging market, and then, it was adopted by the developed market and, therefore, the term "reverse innovation".

Leading companies have powerful technical advantages and international operational experience, so it is inevitable for them to carry out reverse innovation. On the other hand, the reverse innovation conducted by latecomer enterprises, which are short of both technical advantages and international market operation experiences, are more worthy of in-depth analyses. Chen and Huang (2011) held that reverse innovation is the inexorable evolution trend of the innovation-pursuing pattern of the latecomer enterprises in the emerging market. Corsi (2012) brightly put forward that an innovation primarily executed by a latecomer enterprise is a strong and true reverse innovation.

In recent years, the reverse innovation carried out by latecomers from developing countries has drawn more attention. Many cases of reverse innovation by latecomers have been reported, such as India's Tata, the super cheap wireless telephone of Bharti Airtel, battery of BYD in China, portable digital color ultrasonic products of Mindray, large-scale wind turbines developed by Xinjiang Goldwind, small base station products of Huawei and first laser DV in China. From the perspective of innovation diffusion, reverse innovation focuses on the geographic boundary of the market.

Some research also suggests that reverse innovation involves breakthrough of the competitive edge of a market. Maeda and Mori (2011) deliberately used "Inverse Innovation" to replace the "Reverse Innovation", emphasizing that photovoltaic technology have matured at the global scale, and while these products may not have a significant place in the international mature markets, but the access to the international market that is occupied by multi-national corporation, in the future, may increase. Dong and Chen (2010) held that any innovation that originated from the domestic market, enjoyed commercial success and was introduced into the international market dominated by the multi-national companies can be called "reverse innovation".

At present, many scholars have conducted studies on the issue that why the latecomer enterprises achieve successful reverse innovation. Here, a number of representative viewpoints are presented.

The latecomer enterprises can realize reverse innovation easily in the industries with a smaller technological gap. V. Govindarajan and Ramamurti (2011) pointed out that as a result of the breakthrough of technical constraints in various medium technology industries, latecomer enterprises from the emerging countries will emerge as strong competitors of leading enterprises, just as the competition of Xinjiang Goldwind and Shenzhen Mindray that GE is faced with. Maeda and Mori (2011) held the viewpoint that latecomers can gain advantages in integrating the local innovation elements and global promotion even in a high-technology industry which is immature. Based on the research of the innovation of electric cars in BYD, Wooldridge (2010) pointed out that the latecomer enterprises in emerging markets can gain first-mover advantage by using the new technology to achieve reverse innovation.

The innovation resource based on local comparative advantage has contributed to reverse innovation of the latecomers. Jian *et al.* (2011) noted that factors that lead to the success of reverse innovation by latecomers are comprehensive, and the innovation resource with local comparative advantage include low-cost human resources, low-cost industrial supporting resources, industry supporting policies and so on. Lu and Mu (2003) emphasized that an insight into local market demand can promote innovation, and latecomers have the advantage of in-depth knowledge of local market demand. As the discovery of innovation opportunities, commercialization and industrialization of reverse innovation takes place in emerging markets, there is a need for in-depth knowledge of customer demands from emerging markets.

Both technical knowledge and market knowledge are important. Chesbrough (2003) proposed the concept of open innovation, of which the practical background is the concern of latecomer enterprises. Cisco has caught up rapidly by adopting open innovation, which is taking full advantage of technical knowledge and market knowledge from the outside. Chen and Huang (2011) summed up the experiences of reverse innovation success of China's high-speed rail technology and pointed out that open innovation strategy is one of the key factors of success. In the course of reverse innovation, we actively introduce new technologies rather than passively accept them, by digesting, absorbing and re-innovating and then putting them into practice.

Reverse innovation needs to pay attention to the synergy between technological efforts and non-technological efforts. Maeda and Mori (2011) pointed out that factors which influence reverse innovation should be analyzed from various points of view. Besides technical factors, outstanding R&D capabilities and senior managers and the determination of realizing reverse innovation throughout the involved organization, predictive power toward the technique and market, etc. should also be included. Lim gave the example of how Tata's Nano car expounded the importance of the non-technical collaborative innovation to reverse innovation by latecomer firms, such as the technical and organizational support, management system and market capacity. Humphrey and Schmitz (2002) proposed that organizational behavior, market behavior and technology behavior co-evolve in the process of innovation improvement from the junior level to the senior one. The success of the enterprise depends on a combination of technical strategy, market strategy and organizational strategy. According to research on growing interests in innovation by latecomer enterprises, Xu *et al.* (2003) put forward the concept of "comprehensive innovation" and thought that only synchronization between technology innovation and management innovation (including social and non-technical innovation in organization structure, processes, culture, management system, control system and coordination mechanism) can get the best performance.

In conclusion, reverse innovation of the latecomer enterprises has received increasing attention. But it is necessary to point out that studies on reverse innovation are focused on product manufacturing industry and are fewer in the technical service industry. Therefore, present research conclusions of reverse innovation are short of pertinence. As a matter of fact, some scholars have noticed that different industries have different innovative content and influencing factors in the innovation process. Levin *et al.* (1987) pointed out that there is diversity in the innovation of enterprises of different industries. Cohen *et al.* (2002) held that the decisive factor of technological innovation has a greater difference between different industries, and the same factors hold discrepant influence on different industries. Govindarajan and Trimble (2013) pointed out that the reverse innovation of different industries may require different methods, various cooperative relationships and even different value chain. Hence, this paper shows that it is necessary to dissect behaviors and key influence factors of the reverse innovation by latecomer technical service-oriented enterprises.

As we all know, the latecomer enterprises often face technical competitive disadvantage and lag behind in technology and R&D; thus, it is incredibly difficult for the enterprises in high-tech industry to realize that innovation is catching-up (Hobday, 1995). Currently, a group of outstanding engineering and technical services enterprises has entered into the international markets that are dominated by the multi-national enterprises; some of them have even realized crowding out effects toward the multi-national enterprises in the international market.

Therefore, this research intends to expand the research field on reverse innovation by latecomers, make the engineering and technical services enterprises an object of study and explore the critical success factors of reverse innovation and examine the corresponding intrinsic mechanisms, so as to provide guidance for the reverse innovation practice of engineering and technical service enterprises. Meanwhile, as a new model of innovation, the reverse innovation plays an important role in the innovation catch-up by latecomer enterprise, and this research focuses its attention on reverse innovation of the engineering and technical services enterprises, which will provide management support for innovation catch-up of the latecomer enterprises that have a big technological gap when compared with multi-national enterprises. In addition, this study provides guidance for making a relative policy on improvement of industrial technology capability by the local government.

Case sketches

The current studies pay little attention to reverse innovation in the engineering and technical service areas, and the theoretical basis for reverse innovation of the latecomer firm is not solid; therefore, it is difficult to carry out this study using the statistical description and questionnaire methods. This study adopts the grounded theory analysis as the research method, by analyzing the phenomenon, collating the results, mining through the systematic data and verifying the theory temporarily; therefore, it is ideal for the research to build the theory through the analysis of phenomenon (Glaser, 1992). Choosing the right case is the prerequisite for a successful grounded theory analysis (Pettigrew *et al.*, 2001); first, a sample needs to be selected in the principles of representative sampling; second, there is more concern about the richness of the information rather than the number of samples (Jia and Tan (2010); Xu and Liu (2004).

The case of Dalian East New Energy Development Co., Ltd. Pioneered by technology, East engages in various fields, such as technology research, engineering design, equipment manufacturing, complete equipment, engineering construction and operation management and other businesses which relate to new energy development, eco-environment improvement and energy conservation. The study shows the process of reverse innovation by analyzing the development of Cement Kiln Waste-Heat Power Generation Technology (CKWHPG) (Table I).

Automation coking & refractory engineering consulting corporation (ACRE) coking and refractory engineering consulting corporation, China Metallurgical Group Corporation (MCC). ACRE is a large international engineering company; it uses the engineering technology as a foundation and engineering project management as its main business while realizing the managerial mode internationalized, business scope diversification, the technical equip modernization and the scientific project management. The study shows reverse innovation based on the course of development of horizontal well drilling technology (Table II).

China National Petroleum Corporation (CNPC) great well drilling company. China National Petroleum Corporation Liaohe Petroleum and China National Logging

Table I. Reverse innovation of pure low-temperature waste heat power generation technology (PLTWHPGT) of east

Stages	Milestones	Significance
Introducing and using advanced foreign technologies (2000-2005)	Entering the field of engineering equipment manufacturing and beginning to digest and assimilate Japan's first generation of CKWHPG, Dalian East New Energy Development Co., Ltd, was established	Accumulating abilities of manufacturing devices and laying a foundation for later independent technology R&D; entering the field of waste-heat power generation
Technical transformation and technical development based on domestic market (2006-2007)	Developing the second generation of PLTWHPGT successfully	Achieving adaptive technical improvement successfully
Export technology in reverse (2008)	Taking on the construction of the waste-heat power station of two Indian companies	Entering the international market for the first time and getting their technology recognized

Table II. Reverse innovation of large coke oven technology of ACRE

Stages	Milestones	Significance
Introducing and using advanced foreign technologies (2003-2005)	Introducing German 7.63-m large coke oven; since then, the country began a large-scale construction of the models of coke oven; researchers developed top-charging coke oven with a coking chamber of up to 6.98 m; the same year, a tamping coke oven successfully was developed with 5.5-m chamber	The digestion and absorption of large-scale coke oven technology These are representative products for large-size top-charging coke oven and large-size tamping coke oven, owning a number of improvements in view of the condition of our country
Technical transformation and technical development based on the domestic market (2006)	Built tamping coke oven with the world's highest chamber of 6.25 m	Large-scale technology of the tamping coke oven has reached international leading level
Export technology in reverse (2007)	Winning Japanese coke oven program, responsible for the coke oven design, complete equipment, etc.; built top-charging coke oven with a 6.98-m chamber through multiple heating and recuperative heating	Export technology in reverse and large-size technology of the tamping coke oven has reached an international leading level

Corporation co-found Chang Cheng Drilling Engineering Limited Company, China Petroleum Groups. Three main business sectors of Great Wall Drilling Company (GWDC) were drilling, well logging and energy development, which cover all the processes of petroleum engineering technical services such as drilling, logging, drilling fluid, cementing and drilling tool, as well as heavy crude oil, natural gas, coal-gas exploration business, etc. (Table III).

Research design

Research method

Grounded theory is a qualitative research method that is proposed by Glaser and Strauss (1967); the main purpose of this method is to establish a theory based on the experimental data. Researchers do not put forward the theoretical assumptions in advance but constantly practice according to the survey data and refine the original concepts by comparison, then create categories and establish linkages, and eventually, the categories are raised to theory. The existing studies are lacking in attention to reverse innovation by latecomer enterprises, and the related theories are imperfect; therefore, it is difficult to carry out research by using statistical description method and questionnaire. According to the research results of Rihoux and Ragin (2009), this research intends to use a grounded theory to carry out research, including open coding, axial coding, selective coding and reliability test.

In this research, we enforce coding step by step (Strauss and Corbin, 1990), and the data analysis steps are as follows: first, a coding group is formed. To avoid the subjectivity of the coding question that can be caused by the knowledge structure of coders, the author builds a coding group with a doctoral candidate major in innovation management, a top manager of the enterprise and the three coders; then, they discuss the final result of encoding until an agreement is reached. The second step is to immediately complete the notes. We record the contents of the discussion and the process of change to provide material for theory construction (Strauss and Corbin, 1997). The third step is the comparative analysis of the entire process of ground theory research. When we find new concepts and categories, we need to sometimes redefine them before comparing them with the formed concepts and categories.

Stages	Milestones	Significance
Introducing and using advanced foreign technologies (1992-2000)	Introducing advanced foreign horizontal well drilling technology	Launching the R&D of horizontal well-drilling technology
Technical transformation and technical development based on the domestic market (2001-2006)	Adopting horizontal well-drilling technology on large scale; improving techniques according to the different kinds of reservoirs	Applying technology to all kinds of special reservoirs, making a breakthrough in the combination of multi-lateral-well technology and horizontal drilling technology
Export technology in reverse (2007)	Adopting the horizontal well-drilling technology in Cuba parcel COJIMAR-100, which rewrote the history of no oil within 2,000-meter middle shallow	Driving benchmarking project by special technology, establishing a good brand image for GWDC by a leading-edge technology

Table III. Reverse innovation of horizontal well drilling technology of the GWDC

Data source and reliability

We use the field research, interview, expert consultation and archival data collecting as methods of data collection. Information was obtained from different sources, and only mutually verified one was adopted, so as to ensure that this investigation is holistic and comprehensive with internal validity and external validity, and the research data are verifiable.

To obtain detailed and actual information, the data collection proceeds in three phases. In the first stage, we make full use of publicly available information and fully understand the sample enterprises by means of documentation, official Web site, annual report, newspaper articles, the interview of leadership, mainstream media and so on. In the second stage, we adopt field observation and the semi-structural in-depth interviews of the leaders who are familiar with the progress of enterprises to grasp the market trends and correlate the corporate situation. In the third stage, to cover for the lack of public information, we carry out face-to-face, phone, email, MSN, QQ, etc., interviews of the senior practitioners. It should be noted that in the first two stages of the interviews, priority is given to the senior management, who are mainly responsible for research and development; few technicians; marketers; senior practitioners; and customers, and each interview lasts for an hour or two. After the collection of the data is complete, to avoid one-sided view, we arrange the information by across transshipment and cross-validation (Yin, 1994). In other words, we verify the reliability of the data by interviewing suppliers, competitors, technical experts and so on (Table IV).

Coders extract some sample as the first test sample, and then, three coders code according to the description and requirements and calculate the coding results according to the formulas proposed by Holsti (1969), which are as follows:

Case company	Respondents	Historic files and archival data: Internal information	External information
Dalian East	The senior management, chief engineer, marketing staff, professional technicians (more than three-year working experience)	Work summaries and reports, management analysis reports, annual symposium summary, chronicle of events, in-house journals	Corporate Web site, media reports, interviews, books and articles
ACRE	Chief engineer, the people involved in equipment development department, technology development department and designing institute, the human resources minister	Market analysis report, the annual contest, annual report, training manuals	Same as above
GDWC	Industry associations-related experts, general manager, chief engineer, technical people	Work summaries, in-house journals, annual symposium summary, market analysis report	Same as above

Table IV. Field survey and archival data collection

$$R = \frac{n\bar{K}}{1 + (n-1)\bar{K}} \quad \bar{K} = \frac{2\sum_{i=1}^{n}\sum_{j=1}^{n} K_{ij}}{n(n-1)}(i \neq j) \quad K_{ij} = \frac{2M}{N_i + N_j}$$

where R stands for analyzer reliability, n stands for analyzer number, $\bar{K}$ equals to average analyzer mutual agreement degree, K_{ij} represents the mutual agreement degree between analyzer i and analyzer j, M equals to the agreement term number of analyzer i with analyzer j, N_i equals to the total number of the analysis terms of analyzer i and N_j means the total number of the analysis terms of analyzer j.

The degree of average agreement is $\bar{K} = 0.751 + 0.813 + 0.872/3 = 0.812$, and the reliability of analyst is $R = 3 \times 0.812/1/2 \times 0.812 = 0.928$, which is higher than the usual requirement of 0.8. Thus, this shows that the coders have high consistency.

General data analysis

Open coding

The purpose of open coding is to define the scope of the concepts and find a category by identifying the phenomenon. We use ROST CM6.0, an qualitative analysis software, for data analysis and to describe the characteristics of reverse innovation and semantic network analysis diagram of influencing factors by using semantic network analysis tool (Figure 1).

By using the semantic analysis tool of ROST CM6.0 to decompose the document, a network analysis diagram composed of relevant concepts is obtained. Due to invalid statistic results, according to the principles of eliminating the unnecessary keyword synonyms and consolidation, the following concept words were excluded: country, global, enterprise, economy, environment, development, form and growth. In this study, the word global has a similar meaning to that the word international. The coding used and their frequency are presented in Table V.

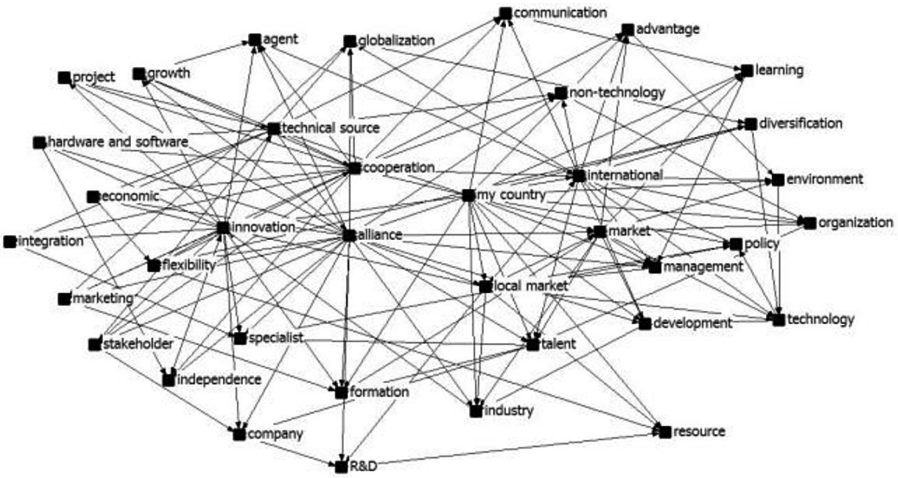

Figure 1.
Characteristics of reverse innovation and influencing factors of semantic network analysis diagram

No.	Coding	Frequency
1	International	26
2	Resources	24
3	Alliance	28
4	Innovation	27
5	Policy	25
6	R&D	27
7	Market	33
8	Industry	29
9	Technology	27
10	Local market	32
11	Management	19
12	Talent	22
13	Expert	24
14	Advantage	24
15	Learning	26
16	Organization	27
17	Diversified	23
18	Cooperation	29
19	Communication	30
20	Non-technical	23
21	Project	25
22	Hardware and software	19
23	Integration	25
24	Stakeholders	21
25	Marketing	22
26	Agent	19
27	Flexible	26
28	Technical source	29
29	Independent	31
30	Supporting	25

Table V.
Frequency statistics of open coding

On the basis of the original code, we sum up the contents of materials and some concepts. There are three inductive principles in this study, of which one is based on high correlation of word frequency of the initial code, the second is based on the inner links between the concepts and the third summarizes the concepts based on the in-depth analysis. On the basis of original encoding, the contents and concepts in the data were summarized and condensed. From three aspects, above-mentioned contents and concepts were summed up. First, based on the original encoding of the word frequency, those with high relevance were abstracted, summarized and refined. Second, the internal connection between the two concepts and types of relationships on the initial connection were established. Third, the concept is analytically described and summarized to express its meaning. From the above-mentioned three aspects of extraction, combined with the actual situation of engineering and technical services enterprises, Table VI has been profiled accordingly.

Axial coding

The axial coding is to open code segmented information, establishing linkages by clustering analyses between different areas. To establish the associations, certain clues

No.	Category	Open coding
1	Agent learning based on the key talent of technology	Key talent of technology | the project's research
2	Cognitive of the local industry conditions	Home market | the local industry conditions
3	Interface management	Interface × management
4	Increase in investment on R&D	R&D × investment
5	Market development through the trial and error	Market | the trial and error
6	The support of local industry resources	Industry resources × support
7	Independent R&D	Independent × R&D
8	The localization market demand oriented	Home market × demand
9	Diversified learning of core team	Core team | technical and non-technical | learning
10	An open-platform hardware and software integration	Hardware and software × integration | open system × system platform
11	The improvement of system of technological innovation	Technological innovation × system
12	Cooperation based on two-way interactive	Interactive mechanism
13	Mechanism of project-oriented organization	Project | organization
14	The organizational restructuring	Organization × innovation
15	The domestic market internationalization	Multi-national companies | home market
16	Technology import	Technology × import
17	The cognitive of local comparative advantage	Resource | market diversification | cost × advantage
18	Industrial policy support	Preferential × policy
19	International technical communication	International | technical × communication
20	International R&D cooperation	International | union × R&D
21	International intelligence resources utilization	International | expert × cooperation
22	Search for the external technological resources	External technological resources × cooperation
23	The collaboration of multiple stakeholders	Core stakeholders | alliance
24	The embedded international marketing model	Independent marketing | the overseas agents
25	Organization and management system based on the multi-national business	Multi-national management × organization
26	Technical and organizational flexibility	Technology development | organizational management | flexibility

Table VI.
Open coding

need to be sought, and the areas for potential interconnections at the conceptual level need to be analyzed. Hence, we analyzed the open-coded area with the categories presenting differently and tried to parse out potential sequence or causality. After axial coding, six primary categories are shaped (Table VII).

Selective coding

The core category was mined from the axial category and linked to other areas systematically. Recalling the whole research process once again, the technology localization, international connection and vertical integration of local service chain can better express the whole coding, so these three words are regarded as the core categories in this study. In the end of this study, theoretical saturation testing was conducted, and engineering and technical service experts and scholars in the field of innovation management were consulted. No more new important categories and relationships were found by grooming the category extraction process (Figure 2).

Research findings

In this article, we perform coding three times, and then, we refine the key factor model of reverse innovation of the engineering and technical service enterprise. Further analysis shows that the enterprises need to make full use of the local comprehensive comparative

Axial coding	Category
Improvement in technical adaptation	Agent learning based on core technical personnel, perceive the local industry conditions, interface management, investment increase on R&D
Technology development by integrating new technology based on marketing differentiation	Market development through the trial and error, support of industry resources, independent R&D, the local market demand oriented, diversified learning of core team, open platform hardware and software integration
System technology optimization based on the service chain	The improvement of technological innovation system, cooperation based on two-way interaction; information construction
Passive international connection of technology and market	Domestic market internationalization, technology import, perceive local comparative advantage, support of industrial policy
Active international connection based on technical cooperation	International technical communication, international R&D cooperation, international intelligence resources utilization
Establish connections with the international market in terms of technical and non-technical	The collaboration of multiple stakeholders, the embedded international marketing model, organization and management based on multi-national business, project-oriented organization, technical and organizational flexibility
Improvement of internal organizational structure	Perfect the function of organization, training of professional and technical personnel, the compound talents training
Collaboration with external network	Cooperation with specialization technologies enterprises, open-ended R&D platform, collaboration with equipment manufacturers

Table VII.
Axial coding

advantage to carry out technology localization during reverse innovation; the diversified international coupling mechanism is an important support for the technology localization; and in the reverse innovation process, the engineering and technical service enterprise needs to pay attention to vertical integration of domestic service chain.

Technology localization based on the local comparative advantage

Traditional technology localization theory emphasized that latecomer enterprises may digest, innovate and improve the technology so that it can be imported by the local market (Lall, 1983). In this paper, technology localization further emphasizes that the enterprises also need to carry out technical adaptive improvement when entering the international market. Technology localization, as a kind of innovative activity of latecomer enterprises, needs the support of local comparative advantage resources (Zhou, 2006). Hence, this paper shows that the latecomer enterprises need to pay attention to the comparative advantage which is based on local resources for the technology localization.

Technology improvement is based on the environment of the local industry. In the area of engineering and technical services, multi-national enterprise implements technological “blockade” for the latecomers. At the moment, the Government plays an important role to help enterprises obtain advanced technology. In view of the difficulty to import waste-heat power generation technology from abroad, the Government plays an important role. When Japan KHI constructs pure low-heat power generation plant for the Ning Guo cement plant, the Government takes the chance to carry out special subjects of pure low-temperature waste-heat power generation technology and equipment. Thus, East is able to digest the Japanese technology and improve the technique based on the local resources. Another reason is that the enterprises complete the R&D, promotion and application of low-temperature waste-heat power generation technology and equipment with a complementary combustion boiler, and create and nourish a clutch of competent technocrats. As some research indicates, the local technology and the industrial technological capabilities are the important bases for the latecomer enterprises to take advantages of the external resources (Jiang, 2004).

Technology innovation is based on the local market advantages and modernization techniques. By taking advantage of the market size, customer relationship management was strengthened. Field experiments are necessary for the innovation of the engineering and technology service enterprises, and huge domestic market demand provides them

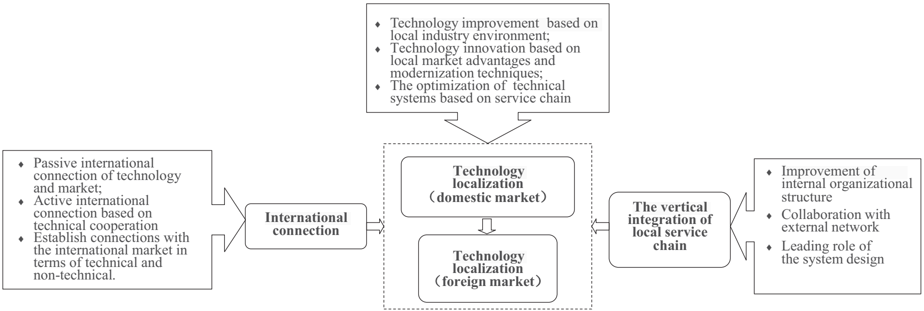

Figure 2.
Model of critical influential factors for engineering technical service corporation’s reverse innovation

with favorable experiment conditions. It has been pointed out that the local market is a strategic resource and can provide technological innovation opportunities for the native enterprises. Thanks to the market demands, East manages to develop second-generation technology. While due to lack of cognition of market demand, Japanese companies failed to develop appropriate techniques and, finally, were kicked out of the Chinese market. In view of the diversity of domestic market, local enterprises use state-of-the-art technology to make the service “productizing” to provide flexible technology solutions. China metallurgical Jiao Nai completes the construction of the imperial and metric component library based on a three-dimensional design software; also, the core model base construction, aiming to provide flexible technology solutions, is complete. Depending on the information technology platform, the Great Wall drilling carries out modularized management, which helps the work of enterprises using, at the same time, conventional drilling technologies and developing very special drilling techniques (serialization), to cope with the different areas and different well-type structures.

The optimization of technical systems is based on the service chain. In the area of engineering and technical services, competition is a synthetic complicated technique system, which includes engineering technology, equipment technology, construction technology, etc. Thus, the enterprises strengthen the innovation of system platform to promote synergy between relevant technologies. On the one hand, the enterprises establish technology innovation system, implementing engineering technologies innovation and, at the same time, enhancing the research and development of accessories, equipment, construction technological process, etc. For instance, East sets up an R&D platform, including equipment development department, technology development department and design institute, based on the support of tax and financial institutions. The Great Wall drilling also uses the local investment to set up an engineering and technology research institute, promoting the development of new technology and equipment. On the other hand, the enterprises establish a two-way interactive relationship with core enterprises in related fields, from simply supporting enterprises with technical requirements and parameters to cooperating in equipment research and development. The enterprises provide knowledge for production, management knowledge, NDT, etc., for local suppliers, help them learn the development experience from many famous foreign counterparts and lead them to adopt international standards and digest the advanced technology aboard. At the same time, the enterprises assist the local outstanding construction enterprises to absorb new technology quickly and lift construction technology base on their awareness and application of advanced technology.

With the above analysis, it is the technology localization that helps to accumulate technical ability, especially the ability to create differentiated services. Some research has reported that for the latecomer enterprises, an independent innovation base on the local comparative advantage can help to grab the opportunity to overseas markets (Zedtwitz *et al.*, 2014, Feng and Ling, 2003). Having undertaken the project of Liaohe Oilfield, of which the geological conditions are similar to that Central Asia region, the Great Wall drilling manages to win the bid for the Central Asia project, but the multi-national enterprises have no experience to follow, due to the lack of project experience. For China metallurgical Jiao Nai, the successful South African, Brazilian and Turkish project bids were also based on similar reasons. The coke oven design must match the quality of coal, because the quality of coal is uneven in our country. China metallurgical Jiao Nai accumulates extensive experience during local project implementation, and therefore, it has the ability to carry out the design of coke oven according to different qualities of coal. German companies' coke oven technology is designed specifically for high-quality coal, although the companies have a high precision technology but cannot provide applied technical project for customers.

Diversified international connection mechanism is a crucial support for the technology localization

The enterprises link internal knowledge to external knowledge network which ensures that new technical knowledge constantly flows to the enterprises, and then, it can promote the technology innovation (Caloghirou *et al.*, 2004). This study believes that the enterprises integrate international technical resources and make it positive to interact with their technological abilities, which will be useful for technology localization, and the diversified international connection provides the channel support for the integration.

Technology and market are geared up to the international standards. Multi-national enterprises as the carrier of external technological resources provide an access to the international advanced technology for domestic enterprises and also produce a competitive effect. Domestic demand-oriented technical innovation based on technological learning is also encouraged (Cantwell, 1989). Early waste-heat power generation technology in China is for the sign kilns which are backward, for those entering Japan KHI and Germany Holtz, which intensified the domestic competition, and our country began to enforce advanced rotary kiln cement production technology to guide the research and application of pure low-temperature waste-heat power generation technology. Based on this, East uses local industry resources to develop the second generation of pure low-temperature waste-heat power generation technology which matches the domestic rotary kiln cement production enterprise and realizes the "crowding out effect" toward Japan KHI.

An international connection is based on technical cooperation. Technology-intensive characteristics of the engineering technology service industry make it important to pay attention to the external technological resources (Dong and Chen, 2010). To develop high-end equipment, long-term technical cooperation with foreign universities and research institutions is necessary. For example, the Great Wall drilling cooperates with the University of Houston to develop the electromagnetic wave logging while drilling resistivity logging equipment with independent intelligence property. Based on this model, the Great Wall drilling successively develops the LEAP800 logging system, GW, while drilling logging system and other key equipment. As a result, its horizontal drilling technology can be used for extremely complex geological environment at home and abroad. At the same time, it cooperates with leading enterprises and local enterprises in global markets to meet the local markets' demands and improve the development of appropriate technology. Similar study has also pointed out that a connection with leading enterprises can help enterprises obtain innovation resources and, thus, help them to establish new innovative ability (Jian *et al.*, 2011). In addition, cooperation with international leading enterprises and local enterprises helps to develop technology and supports supporting enterprises to absorb new technology. East carries out technical transfers and confirms technical plan with enterprises in the countries such as India, Pakistan and Turkey, on the basis of a rapid development to adapt to the local technology, which was originally dominated by enterprises. China metallurgical Jiao Nai establishes a technical exchange platform with enterprises from Germany, the USA, Japan and other countries, undertakes a number of international projects and helps the local outstanding construction enterprises such as China First Metallurgical Construction, China No. 4 Metallurgical Constitution, etc., to improve technical performance. It also cooperates with international experts to obtain intellectual support.

Establish technical and non-technical connections with the international market. The technical connection involves not only the use of external technological resources but also the use external technological resources through foreign direct investment. In addition, the enterprises strengthen the cultivation of compound talents (the abilities such as international communication, understanding the foreign culture, work abroad, etc.) and organize the international project team. As China metallurgical Jiao Nai mentions in an interview:

> […] overseas project operation make us feel that if the enterprises want to bring technology and management more in line with international practice, it must cultivate talent team that adapt to foreign engineering operation.

Regarding the non-technical connection, on the one hand, the market connection often manifests the core stakeholders docking and the widely embedded international marketing models. It is necessary to establish alliances with the interface enterprises, owners, construction enterprises and other key stakeholders and to build a marketing network which is composed of independent marketing and agent-directed marketing. For instance, China metallurgical Jiao Nai establishes alliances with CITIC International Cooperation Co., and lets it take charge of the overseas business docking, legal consultancy service, logistics distribution, etc. Thanks to this, it successfully bid for the world's largest iron and steel group Mittal's Newcastle coke oven renovation and coke oven gas purification project. The enterprises strive to build a marketing network that is composed of independent and agent-directed marketing, participate in foreign well-known exhibition, make joint bid with famous international enterprises, choose foreign agencies which have a good reputation and popularity to promote engineering technology and improve the international image. On the other hand, an organizational connection often manifests building up an organizational and management system which is suitable for a multi-national business. First, the enterprises set up overseas affairs department and establish the feedback mechanism that can accord the overseas feedbacks to deploy the equipment and human resources around the globe. Second, they establish a flexible management system. Overseas projects always need to send skilled employees to overseas, even hire local personnel; therefore, the enterprises redesign the personnel evaluation system, the performance evaluation system, incentive mechanism, etc. In addition, the enterprises adopt international advanced project management techniques and establish enterprise quality system that meets the international standards.

The vertical integration of local service chain

The engineering and technical service enterprises incorporate members of industrial service chain into their dominant commercial system, which can help not only to optimize system technology but also to improve their competitive advantage.

Vertical integration of industrial service chain often manifests the optimization and integration of the internal and external resources. Based on the "internalization" governance, the enterprises perfect the function of self-management organization and set up high-quality teams that are composed of professionals and compound management talents, thus making their related services contain corresponding departments to manage. Based on "relational" governance, the enterprises establish the extensive cooperation mechanism. The enterprises set up R&D alliances with domestic scientific research institutes, industry enterprises and supporting enterprises and build collaborative network of equipment and research platform through industry–academy–research cooperation. For example, China metallurgical Jiao Nai builds cooperation with the Chinese Academy of Sciences, Fudan University, Shanghai Jiao Tong University, etc., and thus develops coking technology with independent intellectual property rights; then, it obtains coking project design and general contracting and engineering services of Japan, Brazil, India, etc. In addition, based on the leading role of engineering design in the project, the enterprises coordinate the relationship between the owners, the equipment manufacturers and the construction enterprises and build a close-knit community of interests. Thus, it can be seen that the enterprises can get market information on time and are able to control the investment as much as possible by collaborating with different stakeholders.

The international project can not do without the support of the local resources. Through service chain integration, the enterprises work closely with customers so that they can better understand their demands and interact with the supporting enterprises to promote the exchange of tacit knowledge, thus urging the supporting enterprises to perfect indigenous technology according to project requirements, and then, the flexibility of the technical solution which the enterprises make will also be enhanced. Through service chain integration, local engineering technology service enterprises own the advantages in project management and the allocation of resources and, thus, can make full use of the advantage of the local industry resources and the human resources. In overseas, as system service providers, the enterprises organize and build a union with the famous supporting enterprises and integrate excellent resources of related industries, thus forming international competitive advantages. Based on the combined fleet, the enterprises can send a large number of workers and technicians overseas within a short time and also ensure the supplies of equipments and materials at a reasonable price. And for the same overseas projects, the enterprises have an advantage over multi-national companies in the aspect of project period and cost. For example, based on the local service chain, the bids of the Great Wall drilling are only a quarter to one-third of the bids of Western multinationals.

Conclusion and future research

Conclusion

The theoretical contribution of this research lies in two aspects.

On the one hand, it enriches the related research of reverse innovation. This research intends to expand the research field on reverse innovation by latecomers; the existing studies on reverse innovation mainly focus on product manufacturing enterprises; and this research focuses on technology service enterprises. By taking the engineering and technology service enterprises as example, we identify the key success factors of reverse innovation of the technology services enterprises and come up with a model. It should also be noted that the vertical integration of local service chain is essential for the reverse innovation of the latecomer engineering and technical services enterprises and that it plays a much more significant role than in manufacturing. Also, the key factor model provides a basic theoretical frame for carrying out an empirical study with a large sample.

On the other hand, this research enriches the research of technological catch-up. Technology localization is an important content for the chasing theory; it expatiates on the sources of technological advantage of multi-national corporations from developing countries; and enterprises in developing countries not only simply imitate the advanced technology of developed countries but also improve advanced technology according to the local conditions (Lall, 1983). According to the findings of this research, technology localization based on the local comparative advantage that is put forward in the reverse innovation verifies existing research. Meanwhile, we have found that reverse innovation also emphasizes technology localization in the international marketplace, and technology localization is significant for the technology localization in foreign markets.

The practical significance of this research is that it provides guidance for the reverse innovation by latecomers. One is that technology localization based on the local comprehensive comparative advantage is the key point for reverse innovation. The implementation of the technology localization involves technology improvement based on the local industry environment, technology innovation based on local market advantages and modernization techniques and the optimization of technical systems based on the service chain. The second is that the diversified international coupling mechanism is an important support for technology localization. Therefore, the enterprises need to pay attention to multi-faceted connection with the international market in the whole process of reverse innovation. The way they interact with international market involves passive international connection of technology and market, active international connection based on technical cooperation and international connection in terms of technical and non-technical. In addition, the technology service enterprises need to pay attention to the vertical integration of service chain in the reverse innovation process.

Future research

Considering the typicality of the samples, this paper selects three engineering and technical service enterprises as objects; future research may consider enlarging the sample size as far as possible to ensure the comprehensiveness of research conclusions. In this paper, we adopt root analysis method, and the future research can consider introducing the empirical approach as an effective supplement to further verify the conclusions.

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Further reading

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