

An Influencing Factors Model of Technology Spillover in a Supply Chain Based on Self-organization Theory

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Abstract

With the increasingly important position of technology and supply chains in market competition, the phenomenon of technology spillover in a supply chain has become obviously prominent. In this paper, the writers summarized the factors affecting technology spillover in each supply chain organization stage by using foreign-funded enterprises and local enterprises as research objects to build the supply chain. We then applied self-organization theory to analyze the mechanism of action, clarified the relationship between the factors, and finally established an influencing factor model of technology spillover in supply chains.

Key Words: supply chain, technology spillovers, self-organization theory, influencing factors

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Introduction

Since the 1980s, FDI (Foreign direct investment) has become an important foreign capital in China and the main form of international advanced technology being transferred to China^[1]. In recent years, with the rapid development of foreign-funded enterprises and local enterprises available to build supply chains, foreign-funded enterprises are in a dominant position by virtue of technology and management advantages, while, local businesses are positioned subordinately. Because of the technology gap, advanced technologies and management modes are inevitably transferred to local businesses with technology spillovers occur as a result. Therefore, research on technology spillovers in supply chains has become increasingly necessary.

Technology spillovers in supply chains indicate the conscious or unconscious transfer between supply chains in technology node enterprises. The technology owner cannot get complete returns arising from the external economy, which is mainly reflected in: (1) the external economy, from spillover enterprises to absorbing enterprises in node enterprises; and (2) the external economy to absorbing enterprises in supply chain technology spillovers. At present, research on technology spillover in supply chains focuses on naming and analyzing the influencing factors.

This study is based on a cooperative project between Dalian University of Technology and Josai University⁶ and is called The Analysis of Technology Spillover Mechanisms towards the Upstream of a Supply Chain. Members of the project team have surveyed two groups of supply chains (see Figure 1), which includes six enterprises: SYCC (a Sino-Japanese joint venture), HY processing plant and Jinzhou YJ, Dalian RJ, HL-Panasonic Corporation (a Sino-Japanese joint venture), the OM Company (a Japanese company).

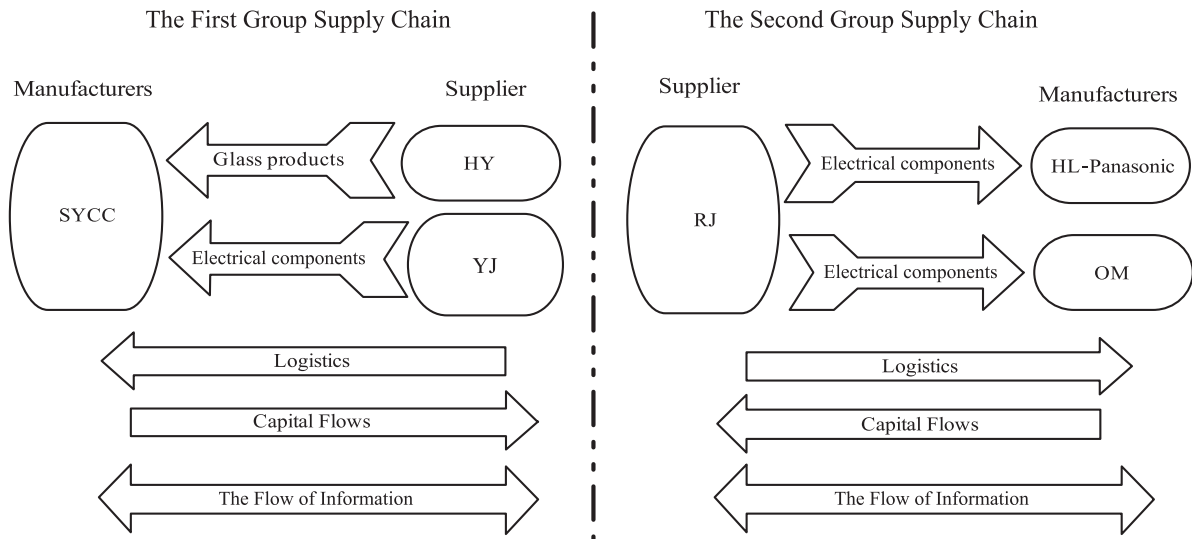


Figure 1 Supply chain diagram

⁶ Analysis of Technology Spillover Mechanism towards Upstream of Supply Chain (23530491) is sponsored by Japan Promotion Society and cooperated by Josai University and Dalian University of Technology

The Mechanism of Technology Spillover in Supply Chains based on Self-organization

This research is based on dissipation theory and synergetic self-organization theory, to study the general rules of self-organizing systems from disorder to order, and a lower order to a higher order^[2]. The self-organization of the supply chain means that the fluctuations caused by nonlinear interactions in the subsystem result in an order parameter, where the entire supply chain trends in that order^[3]. This specifically includes the following three types of process: (1) one where the outside forces (which the forces are from outside of the supply chain) penetrate freely, where the internal balance is broken, where a chaotic state is shown, and where self-organization evolves; (2) one where the internal energy is adjusted, node enterprise cooperation increases, and the where relationships become complicated; and (3) one where the cooperation model tends to be sophisticated, where interconnections tend to be simplified and where the degree of order may be raised to a higher level.

The power of an evolving self-organization supply chain comes from competition and cooperation among enterprises^[4]. Competition and cooperation must be maintained by elements influencing each other to a certain degree (logistics, information flow, capital flow, etc.)^[5]. Technology exchanges existing in the supply chain and between supply chains are subject to internal and external factors. These factors arise from inside the enterprises, between the enterprises and outside of the supply chain. They affect and restrain each other and mutually effect the technical energy's adjustment and distribution, resulting in what is called technology spillover. At the same time, the adjustment and distribution of this technical capacity causes fluctuations in part of the supply chain, completing the system functions and structures and ordering the trend in the supply chain. The ordered structure in turn, changes the nonlinear interaction between enterprises, adjusting the mechanism of the influencing factors and impacting the technology spillover effect, which is specifically shown in Figure 2.

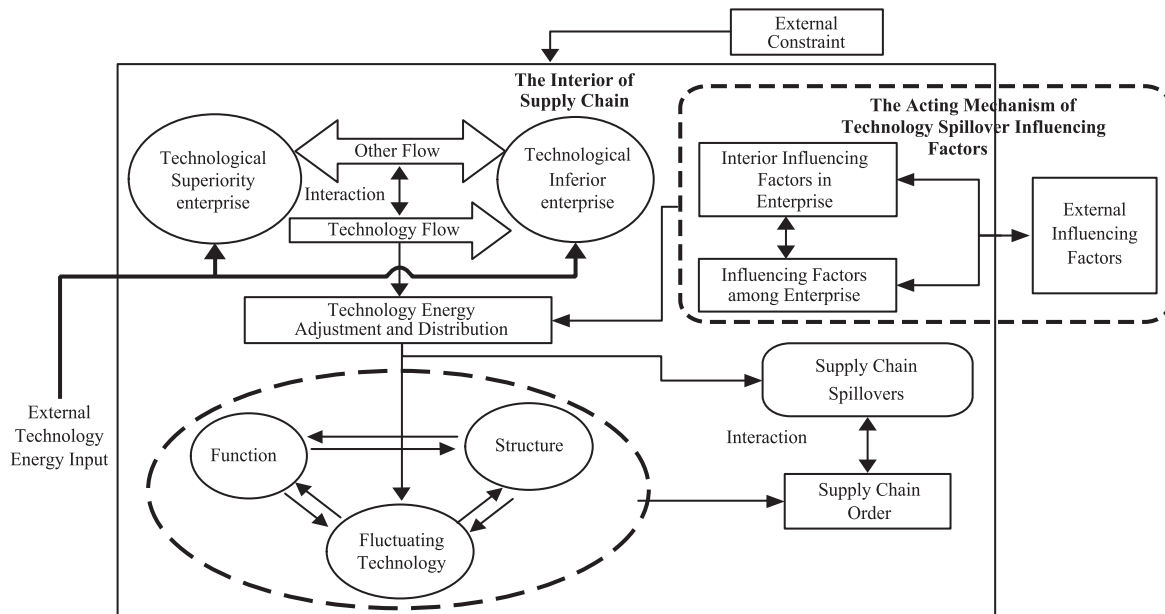


Figure 2 The mechanism of technology spillovers in a self-organization process in supply chains

Background for Influencing Factors and the Mechanism of Technology Spillover in Supply Chains

Following is the research plan reported in this article. First we collected the research for six months (as specified in Table 1, Table 2), analyzed it and summarized the differences in cooperation content and cooperation modes in the three stages of evolution. Second, based on the technology spillover mechanism, we contrasted the two groups in the supply chain horizontally and vertically and summed up the results. Finally, from the three stages we applied self-organization theory to offer an in-depth theoretical analysis of the technology spillover influencing factors and mechanism.

Here is what we discovered. The first stage of cooperation affects the core products. The second stage results in expanding products. The third stage of cooperation shows that the content is mainly focused on R & D cooperation mode. As we carried out our research we found that the SY—YJ and the OM—RJ cooperation appear to be in the second stage of self-organization while SY—HY and HL—Panasonic—RJ cooperation appeared to be in the third stage of self-organization. Technology spillover in supply chains is mainly reflected in the technology, equipment, and the transfer of the management model, in personnel exchanges and training frequency, in advanced technology, in the degree of the utilization of equipment and in innovative abilities and other closely related factors.

Table 1 Technology spillover in the 1st group supply chain

	SY—HY	SY—YJ
The 1st stage	<p>Aim: (SY) lower cost; (HY) improve technology, enhance competition</p> <p>Content: provide glass parts</p> <p>Technology spillover (SY to HY):</p> <ul style="list-style-type: none"> ①quality and technical instruction ②technical training, problems solving ③regular exam and maintenance for technical equipment 	<p>Aim: (SY) solving the excess production capacity; (YJ) absorb advanced technology</p> <p>Content: provide electrical parts</p> <p>Technology spillovers (SY to YJ):</p> <ul style="list-style-type: none"> ①training and management instruction ②YJ uses JAM crimping machines and other equipment and optimizes production line
The 2nd stage	<p>Content: Enlarge cooperation scale and product types.</p> <p>Technology spillover (SY to HJ): Teach advanced cold chain management technology and help establish a sound management system</p>	<p>Content: provide high quality electrical parts</p> <p>Technology spillover (SY to YJ): Help YJ establish 5S management system and improve product quality.</p>
The 3rd stage	<p>Content: technology</p> <p>Mutual technical spillover: Share resources, design double-sided electrically heated glass and solve the problem of condensation.</p>	—
Summary	The cooperation ranges from products-based to technology-based and an enhanced cooperation level is realized. Technology spillovers are mainly concentrated in the teaching and guidance of the technology, which is closely related to personnel exchanges and training.	The cooperation is mainly concentrated in providing products and improving quality. Technology spillover is mainly related to equipment introduction establishment of management systems, personnel training, and the degree of utilization of the device.

Table 2 The 2nd group technology spillover in supply chain

	OM—RJ	HL—Panasonic—RJ
The 1st stage	<p>Aim: solving the excess production capacity (OM); absorb advanced technology (RJ)</p> <p>Content: Provide non-core components of the electronic health equipment.</p> <p>Technology spillover (OM to RJ):</p> <ol style="list-style-type: none"> ① introduce OM production index system and Products division detection method; ② improve production processes, introduce OM raw material moisture protection system and solve the problem of summer moisture. 	<p>Aim: realize “core technology” strategy, outsource (HL—Panasonic), and absorb advanced technology (RJ).</p> <p>Content: Supply electronic circuit boards and other projector parts</p> <p>Technology spillover (HL—Panasonic to RJ):</p> <ol style="list-style-type: none"> ① introduce Panasonic CM 620 Pick-and-place equipment and OM image detector ② under the guidance of HL employer, assemble production lines with the new device ③ accept technical personal’s training and regular exam in HL—Panasonic
The 2nd stage	<p>Content: enhance quality control</p> <p>Technology spillover (OM to RJ): Technical staff hold regular monthly meetings for the quality exchanges to help RJ solve specific quality problems</p>	<p>Content: enrich production types and improve quality control</p> <p>Technology spillover (HL—Panasonic to RJ):</p> <ol style="list-style-type: none"> ① Help RJ build meticulous management system: “quality management ② promenade, 5S management system, production planning appraisal system, RMBIS system.
The 3rd stage	<p>Content: technical exchanges</p> <p>Technology spillover (RJ to OM): RJ regular proposes suggestions.</p>	<p>Content: Set up a technology research and development associations</p> <p>Technology spillover (mutually):</p> <ol style="list-style-type: none"> ① Hold The loop real equipment R & D Seminar, ② share technical resources and design and hold “R & D” meeting regularly
Summary	Cooperation is mainly concentrated in the production supply and quality improvement due to technical exchanges. RJ technology improvement provides technical assistance to OM in turn.	Cooperation is related closely to product technology, technology spillover, personnel training of and exchange as well as technical resources and the degree of information sharing.

The Influencing Factors and Mechanism of Technology Spillover in the 1st Stage of Cooperation

In this first stage, under the influence of a “core technology” strategy, foreign-funded enterprises outsource the non-core components production to local businesses, and local businesses actively cooperate with foreign enterprises to absorb advanced technology and management experience. A supply chain is initially formed under the influence of the external environment and the internal policies. Self-organization theory indicates that competition and cooperation within the system causes the system to spiral upward to ordered self-organization^[6]. A big gap between the supply chain and the potential technical capacity promotes a bilateral technical level to a reasonable balance in order to maintain a stable relationship of cooperation. To ensure product quality, the foreign-funded enterprises require cooperative enterprises to enhance their hardware technology. Local enterprises introduce advanced production equipment and accept advanced technical guidance. As a result, the external techniques which are introduced may enter the supply chain, resulting in energy competition

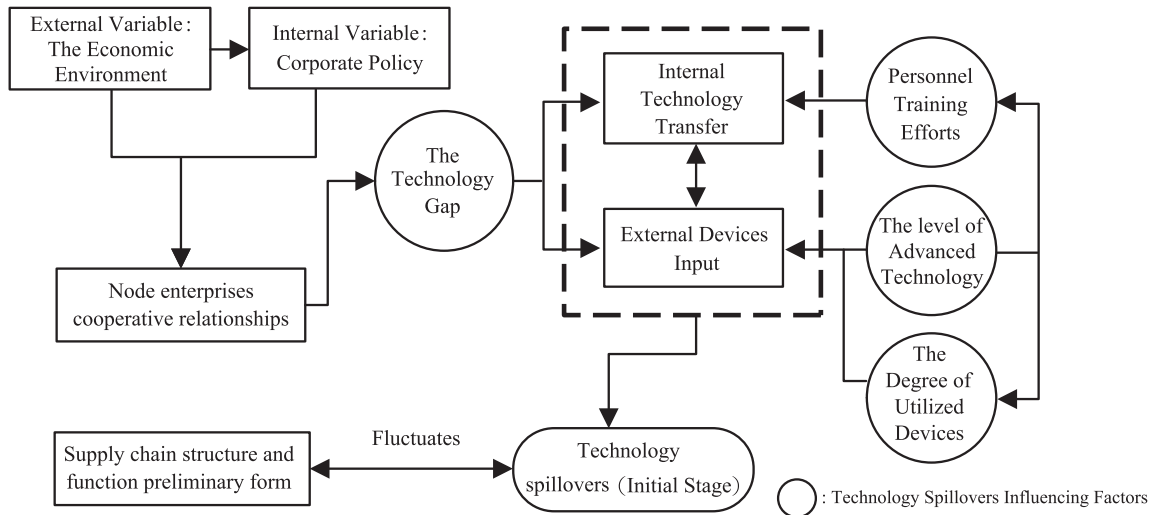


Figure 3 Factors and Mechanisms influencing technology spillovers in the first stage

between enterprises. Based on the conditions for cooperation, foreign-funded enterprises provide advanced technology and help with the training of technical staff. Business policies act as a guide for the corporate activities and as the basis for the exchange of supply chain technology. The technology gap affects other factors also; when there is a large technology gap, other factors have more room to take effect. The degree of advanced technology induces a transfer of equipment, and the degree of utilization of equipment at this stage is the main factor affecting the technology spillover process. The use of the device also cannot be separated from personnel training and exchanges. At this stage, personnel exchanges and training on both sides are mainly addressed in order to solve specific technical issues. The mechanism of the influencing factors is shown in Figure 3.

Factors and Mechanisms influencing Technology Spillovers in the 2nd stage of Cooperation

The evolution of self-organization in the supply chain in this stage is reflected in increasing complexity, that is, structure improvement and function improvement are accomplished mainly for the expansion of cooperation between the two sides. Expanded cooperation needs unified technical indicators and advanced management modes in order to support the continuous improvement of the product quality. Therefore, in this stage, technology spillovers are mainly shown in technical standardization and absorption of the advanced management mode of local businesses.

Sound system functions need subsystems for a broader deployment of energy and digestion of new technology, management systems, and personnel training. The resulting exacerbated nonlinear interactions result in up and down fluctuations in the supply chain. In this stage, the technology gap still impacts the supply chain. The increase in product types necessarily requires a unity of technical indicators, so advanced technical standards inevitably flow from the foreign-funded enterprises to local businesses. At the same time, technical standardization promotes improvements in the management of local businesses. The advanced management mode is absorbed by local businesses in the regular communication and training

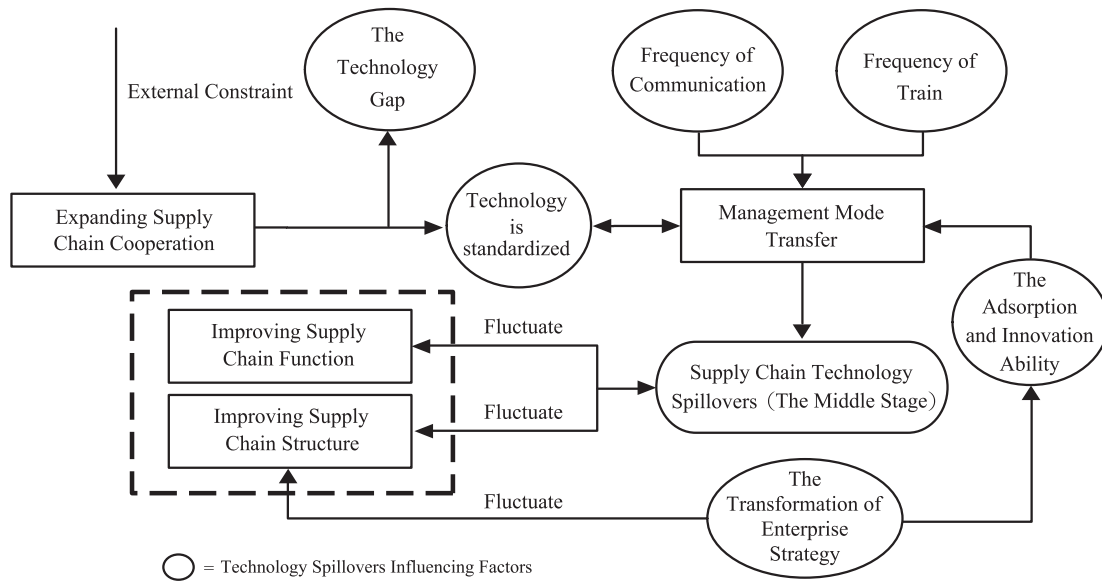


Figure 4 The Mechanism of influencing factors in technology spillovers in the second stage

processes of production staff. Combined with the actual situation, local enterprises take the initiative to digest and create their own management models. Thus, the technology gap is still an influencing factor in technology spillover. Technical standardization promotes a change of management mode, and it in turn, is affected. The increased frequency and intensity of personnel exchange and training expands cooperation between the two sides and promotes the transfer of management and technical standardization. The ability for creativity and the absorption of this creativity in local enterprises promotes the transformation of technology and management, affects the structure of the supply chain and results in functional adjustments in conjunction with the change of policy operations; this is specifically shown in Figure 4.

Factors and Mechanisms influencing technology spillover in the 3rd stage of Cooperation

In this stage, technology spillover is mainly revealed in the establishment of a joint R & D model. Its technical spillover factors are the narrowing of the technology gap, the sharing of technical resources and the degree of information sharing.

The supply chain uses fluctuations to deploy free energy, and to process and redistribute energy in order for the internal structure of the system function to grow its structure and function continuously evolve towards a new order^[7]. When the technology gap is narrowed to a specific degree, the two sides begin to seek cooperation on research and development and establish a long-term joint development model. In this process, the degree of technical resources and information become the key factors affecting technology spillovers. With the improvement in the level of sharing, the research and development mode is constantly being improved and changes from a products-based mode to a technology-based mode. The supply chain then jumps to a new level and begins a new round of technology spillover. The mechanism of influencing factors in technology spillover is shown in Figure 5.

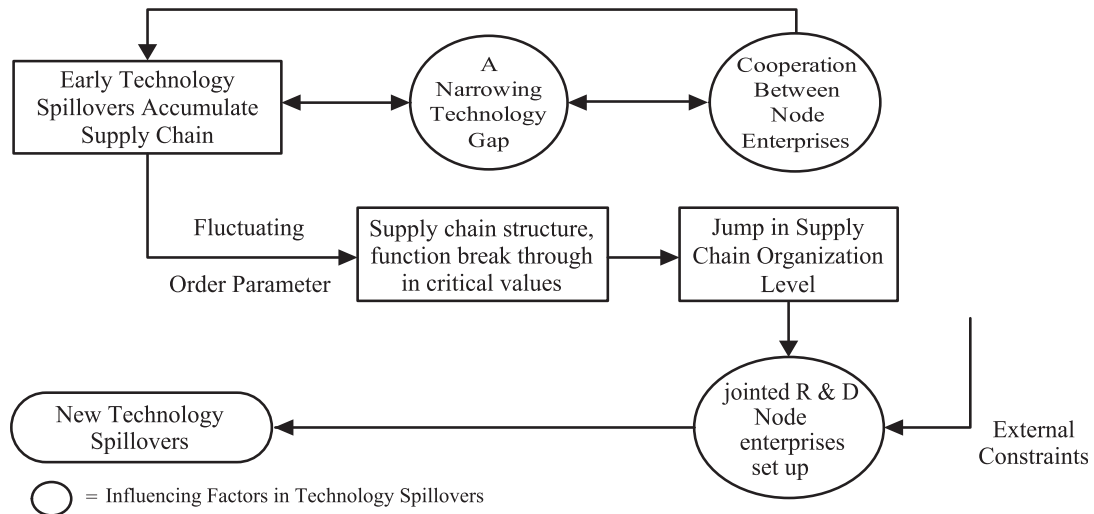


Figure 5 The Mechanism influencing factors in technology spillovers in the third stage

The Influencing Factors Model of Technology Spillover in Supply Chains

As can be seen from the research and analysis, there is a close relationship between the factors influencing technology spillover and the evolution of self-organization in the supply chain. The influencing factors in technology spillovers reveal different situations at different stages (as shown in Table 3), but some influencing factors are the same throughout the three stages.

The external environment and business operation policies affect the cooperation modes and constitute the basis of technology spillovers. The technology gap between enterprises goes throughout the various stages of self-organization, which is the direct driving force of technology spillovers affecting other factors. In general, the technology gap gradually narrows with the self-organization evolution of a supply chain. When the gap is reduced to a specific extent, the possibilities of technology R & D and cooperation between enterprises increases. The technology spillover shifts into the sharing of information resources under the mode of technology research and development.

The content of technology spillovers appears different in each stage. Thus influencing factors and the role of the mechanism are not the same. Initially, the technology spillovers are the transfer of technical equipment and some technology, which is mainly induced by the advanced technology. The occasional exchanges of personnel and the temporary training

Table 3 Influencing factors in Technology spillover in the three stages

	1st stage	2nd stage	3rd stage
Influencing factors	<ul style="list-style-type: none"> • Large technical gaps, • Frequency of personnel exchange, • Technical training, • Degree of advance technology 	<ul style="list-style-type: none"> • Narrowing technical gap • Frequency of personnel exchanges, • Staff training, • Enterprise innovation 	<ul style="list-style-type: none"> • Further narrowing technical gap • The degree of technical and information sharing

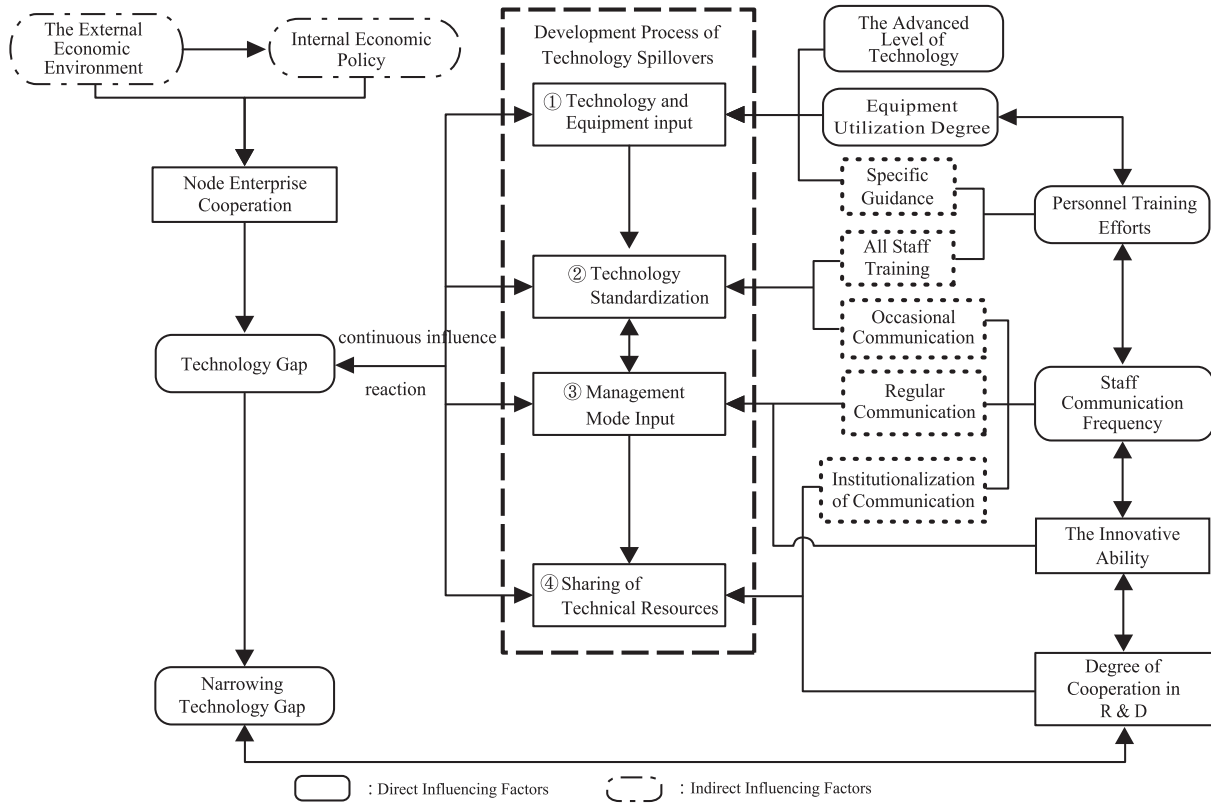


Figure 6 The Influencing Factors Model of technology spillover in supply chains

promote the use of technical equipment for the other partner. In the mid-stage, the technology spillovers are about technical standardization and the transfer of a management model in order to expand cooperation, and require a regular exchange of personnel and long-term training. The capability for absorption and innovation is particularly important. In the third stage technical resources and information sharing need to result in the establishing of a complete system of technical cooperation in order to ensure the conduct of joint research and development.

In short, technology spillover runs throughout the whole process of self-organization of the supply chain. The influencing factors interact and promote or constrain the technology spillover by the external constraints acting on the supply chain. The Influencing Factors Model of technology spillover in a supply chain is shown in Figure 6.

Conclusions

This paper, which is based on the self-organization theory of the supply chain, uses a field research situation and three stages of self-organization, to show that there are influencing factors and mechanisms involved in technology spillover in supply chains. A model of these influencing factors describes the mechanisms in-depth. The research shows that self-organization theory plays an important role in guiding technology spillover in supply chains.

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