Japanese Skill and Knowledge Transfer ── The Case of Exporting High-precision Production Technology to China and Vietnam[1]

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Abstract

In this study, I investigated the process of technology transfer, especially that of high-precision production technology from Japan. China's recent significant development has been largely due to foreign direct investment (FDI) and foreign technology assistance. China's government continues to focus on the importance of high technology and R&D capabilities. Precision tool making is an important skill-based technology that must meet tolerances as tight as 1 μm, which is required to produce high-precision parts used for core technologies in automobiles and electronics.

In recent years, the shift of FDI from China to Vietnam has been increasing. In this study I describe technology transfer projects of high-precision tool production from mother firms in Japan to joint ventures in China and the shift to joint ventures in Vietnam. Within that context, I examine high-precision technology formation processes.

1. Introduction

The transfer of technology and knowledge is an important issue for developing countries for their industrial and economic development. Japan, as a leader in high-technology-based industries, has been playing an important role in the transferring of technical skill and knowledge to other Asian countries. At the same time, Japan is facing controversy about whether to promote the upgrade of subsidiaries in Asian countries or to keep its core technologies at home to maintain Japan's international competitiveness.

High-precision production requires high skills and knowledge and is largely used for core parts in the automobile and electronics industries. The development of machine tools has replaced skilled workers at the intermediate precision level. However, micron-level precision parts cannot be produced by machine tools because the tools lack the necessary precision and productivity level. The needed technological skill and knowledge of high-precision products is difficult to transfer and indispensable for key industries.

In this study my goal was to investigate the process of technology transfer, especially the transfer of high-precision skills in the manufacturing industry from Japan to China and Vietnam.

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In recent years, the shift of FDI from China to Vietnam has been significant, due to the recent rise in labour cost in China and risk distribution management strategies. In this study I describe technology transfer projects of high-precision tool production from mother firms in Japan to joint ventures in China and the shift to joint ventures in Vietnam. Within that context, I examine high-precision technology formation processes.

First, the theoretical framework of technology transfer and the role of FDI, especially by multinational enterprises (MNEs), are introduced, and the importance of tool-making skills for achieving high precision in core technology is discussed. To examine the Japanese technology transfer practices in small and medium enterprises (SMEs), I surveyed and interviewed the Japanese subsidiaries in Shanghai in February 2007 and those in Vietnam in March 2008. Empirical research on tool-making firms is examined in case studies, and strategies for achieving high skill levels of workers are analyzed.

2. The Role of FDI in Technology Transfer

Technology transfer has been studied for many years from various perspectives. In the early years, the major issues were technology transfer from suzerains to their colonies. Later, technology transfer as part of military activities was studied. The impact of FDI on economic development and technology transfer has been a subject of study, especially since the 1970s. The economic rise of Asian NIEs in the 1970s and the development of Southeast Asian countries since the late 1980s have been attributed to the increase in FDI from Japan. Latecomer economies can enjoy the advantages of learning advanced technology more easily and faster (Gershenkron 1962). As observed in Asian NIE cases, these economies had the latecomer advantages of absorbing technologies faster through multinational corporations of the US, Europe, and Japan.

Following the Plaza Accord, the FDI trend accelerated due to high appreciation of the yen. After the Asian financial crises of 1997, FDI was re-evaluated as an important and a more secure source of finance than other forms of private capital flows of portfolio equity. FDI fulfils domestic capital needs and allows technology transfer to recipients.

The three basic ways for countries to acquire technology are: export, licensing, and FDI. FDI is one of the means available for a firm to transfer technology outside its home country, or that a host country can use to acquire technology. A firm may export products that embody the technology, a firm may license its technology to an agent abroad who then uses the technology to upgrade its own production, and a firm can set up a foreign establishment using FDI to exploit the technology itself (Maher and Christiansen, 2001).

The sudden increase in FDI in China since the 1990s can be analyzed based on several factors. Dunning (1993) analyzed three advantageous factors of MNEs making decisions concerning FDI, namely, ownership advantages, location advantages, and internationalization advantages. The six main location advantages, pointed out by Lee and Houde (2000), are market size and growth prospects, natural and human resource endowments including the cost and productivity of labour, physical financial and technological infrastructure, openness to international trade and access to international markets, a regulatory and policy framework and policy coherence, and investment promotion. In the case of China, using the absolute advantage in terms of its location, China has attracted FDIs and has even been able to control the FDIs in order to facilitate technology transfer.

At the same time, MNEs were viewed as a major instrument of capitalism exploiting developing countries to expand accumulation in the developed world (Frank, 1973). MNEs were often claimed to exploit low-wage workers in developing economies (Frobel et al., 1980). In addition, as Amin (1976) argued, MNEs bring inappropriate capital-intensive technology, raise the costs of diffusion, and distort technology development in host countries. Therefore, as Singer (1950) argued, with the monopoly of MNEs over technology, FDI may weaken the recipient by diverting investment and resources away from local industries. Many argue that MNEs produce few linkages in developing economies, with sourcing of only low value-added inputs to local firms.

The questions arising here include how can SMEs obtain value-added skills and knowledge ? And in particular, how can those key skills regarded as core skills of Japanese techniques be transferred from Japan to China and to Vietnam ?

China is a fast-growing economy and has a huge domestic market and a high potential for further development. Ever since China switched its policy to an open economy at the end of the 1970s, economic development has been promoted. Chinese economic development has been accelerated since the middle of the 1990s, largely due to an increase in FDI from developed countries and technology transfer through the FDI. Chen (2000) pointed out that joint ventures between a Chinese firm and an MNE are the dominant form of technology transfer in China.

As far as technology transfer in key industries is concerned, the Chinese strategy is to attract large MNEs to invest in China, since MNEs are the major source of technology, and to revise regulation of foreign investment so that the foreign-funded enterprise sector is encouraged, including high-technology industries. This strategy is observed in capital-intensive and high-technology-based industries, such as the machine-building, automobile, and electronic industries. MNEs in these major industries have established brand image, distinct production, marketing bases, an R&D base, and human capital. Thus, establishing joint ventures between these MNEs and local firms is a fast way to enjoy latecomer advantages. To enjoy latecomer advantages, local firms have to reach certain level of technology. While higher technological gaps offer greater room for learning and absorption, government instruments defined to stimulate capability building may fail if local firms have not reached the technology levels necessary to participate in higher value-added activities (Rajah, 2004).

The machine-building, automobile, and electronic industries were primary promoters of active technology transfer through MNEs. However, the technological contribution and influence of MNEs to small and medium enterprises (SMEs) is limited. Research on automobile parts suppliers in Shenyeng (Sadoi 2005) showed that the first-tier suppliers are mostly joint ventures with MNEs; however, the second- and third-tier suppliers are Chinese firms that do not receive any capital investment or technology assistance from advanced countries.

In SMEs, management policy largely affects human resource development in each firm. SMEs, whose top management personnel have a technological background, help to promote the absorbance of high-level skills and technology through the spillover effect from MNEs. In these second-tier suppliers, most of which are SMEs, engineers and technicians obtain skills and technology through trial and error. Many directors of SMEs in the metal parts supply industry promoted their carriers from the rank of skilled workers within their companies (Sadoi 2005). These directors' technical background gave them a better accessibility to new advanced technology. The attitude toward human resources development affects the level and speed of skill formation (Sadoi, 2003).

In examining how the value-added skills and knowledge are transferred within SMEs, from the companies in Japan to their overseas subsidiaries, it becomes clear that the core skills are difficult to obtain even in Japan and require many years to master. One goal of research in this field is to determine how the core skills of Japanese technologies can best be transferred China and Vietnam.

3. The Importance of Precision Tool-Making Technology and Skill Formation

Advancements in modern technology require high quality manufacturing and can be economically advantageous. The proper application of technology can yield significant cost savings with respect to both tooling and production costs. With advanced machine tool technology and proven tool paths, the following can be achieved: (a) cycle time reduction through increased spindle speeds, (b) tooling cost reduction through increased tool life, (c) elimination of benching via 5-micron-radius tolerances, and (d) elimination of polishing by a sustained cutting edge and the elimination of tool-change lines, which when combined can create mirror finishes.

High-precision production requires high levels of skill and knowledge and is largely used for core parts in the automobile and electronics industries. The development of machine tools has replaced skilled workers of the intermediate precision level. However, micron-level precision parts cannot be produced by machine tools because the tools lack the necessary precision and productivity level. Productivity is higher when products are made manually instead of by machine tools in the case of small volume production of a wide variety of products. Therefore, technological skill and knowledge of high-precision products is indispensable for key industries.

Tool-Making Processes and Required Skills

Manufacturing is becoming easier than ever due to advances in computer technology ; however, human skills where computer-controlled technology cannot take over are still required. In this section, the importance of high-quality tools in production processes and the human skill requirement for these processes are described.

Most manufactured parts start out as a wire frame drawing in a computer-aided design (CAD) system. Using the CAD system, designers are able to draft their product designs on the computer using a series of lines, circles, and angles. Once the wire frame drawing is completed, the designer must surface the part, which is the process of applying surface to the frame. After the surface of the part is complete, the design is sent to the manufacturing department to analyze the design and determine what kind of cutting tools are necessary to produce the part. Next, the areas where the smallest details will need to be machined are marked. This also helps in determining the size and type of tool that will be needed to manufacture the part.

Next, the programmer inputs the data for the part into the computer-aided manufacturing (CAM) system, and the system mathematically calculates a cutter path for the part. Basically, the CAM system tells the tool where to go to remove the unwanted material. Depending on the geometry of the part, there are several different cutter path movements that could be applied to obtain the desired surface finish. Learning which cutter path to use can only be achieved through trial and error.

The manufacturing engineers send the program to a machining centre to produce the part. Speeds and feeds are a main concern for the machine operator. If the speeds and feeds are not set properly, the tool will burn up or break. After machining, the dimensions and accuracy determine the quality of the final part. A critical point is the accuracy of the cutting tools, which affects the quality of the final part. Only by using accurate tooling, such as end-mills with radius tolerances as low as ± 3 microns, are quality finishes achieved.

A large portion of manual production processes has not been replaced by machines, even in Japan, which has the most technologically advanced machine tool industry in the world. The Japan People's Finance Corporation Survey (1992) of 2,079 parts manufacturers in Japan showed that on average, over 35 per cent of production processes had not been replaced by advanced machine tools and depended on manual skills. The same survey showed the number of years required to master these skills. In the case of machining, about 30 per cent of skills require 5-10 years to master and about 10 per cent of skills need 10 years or more of experience to master. Nowadays, highly advanced computer-controlled machine tools might have taken over a larger proportion of the processes that required human skills than at the time of the survey. However, the importance of having personnel with high-level skills remains the same. More importantly, the lack of highly skilled workers is problematic not only with regard to maintaining a sufficient work force of this type but also in having persons to develope highly advanced machine tools and maintain an international competitive technology level within the industry.

4. Precision Tool-making Technology in China ― Case Study of a Tool-making Firm in Shanghai

This case shows how Japanese precision tool-making technology and skills are transferred in its joint ventures in China. The technology and skill level of this firm show the advantages of accessibility of technology transfer from advanced countries through a joint venture partner. In this case, the firm developed its skill level to about the same or an even higher level than that of its joint venture partner.

In this section, the process of skill formation in the firm is described. Empirical research on eight Japanese SMEs in China was conducted by the author in February 2007 in the Shanghai area. The case of a tool-making firm was chosen here to analyze the skill level of the key manufacturing skills in various industries in Shanghai.

Establishment Background

Shanghai N Precision Tool Corporation（N tooling Shanghai）was established in 1992 with capital of 300 million yen, with 30 per cent provided by China partners and 70 per cent provided by N tooling Japan. The initial purpose of N tooling Shanghai was to act as a production base for export to Japan. N tooling Shanghai produces various kinds of machining tools and cutting tools. The product range is the same as that of N tooling Japan.

N tooling Shanghai increased its capitol to 60 million yen in 1996, 100 million yen in 1998, and 200 million yen in 2000 and has reached capitol of 850 million yen. In 2004, N tooling Shanghai was reorganized as a joint-stock company. The shareholders are 75 per cent N tooling Japan, 5 per cent Chairman of N tooling Japan, and three Chinese shareholders hold the remaining 20 per cent (18%, 1%, and 1%). The shareholders of the Chinese side are all the representatives of the village where N tooling Shanghai is located. The company reorganization reached five shareholders, which is the maximum legal number of shareholders in China.

N tooling Shanghai has five board members, four assigned from Japan and one assigned from the China side. All the board members are Chinese. The director is a Chinese dispatched from N tooling Japan. N tooling Shanghai has developed rapidly in its 15-year operation. The company began with 60 employees in 1992 and reached 600 employees in 2007, showing a 10-fold increase in the period. Land space for the plant increased from 7,600 m^2 to 9,045 m^2 as well. The total sales of N tooling Shanghai in 2006 was 125,300 million yen.

Products and Materials

N tooling Shanghai produces high-technology cutting tools, such as drills, reamers, cutters, end-mills, bites, tools, and diamond tools that vary with more than 700 styles and sizes to be used for cutting geometrics and unique surface treatment. A high quality of tools is required to save machining time, scrapping time, and downtime for the manufacturing industry. The company manufactures to tolerances as tight as 1 μm to assure precision and productivity.

Cutting tool regrinding is also performed to lengthen the lives of used cutter tools and reduce tooling costs. Many firms regrind their own drills and end-mills, and diamond tools are retipped to maintain high performance and make substantial cost savings at the same time. The used tools must be checked for micro-chipping on precision checking devices as well as for damage on the carbide blank before regrinding or retipping.

Most machine tools installed on the production site are from Japan, and a few come from Taiwan. Those from Taiwan are basic multi-purpose machine tools. Metal materials are of two kinds, valuable metal, such as tungsten and diamond, and general stainless steel. The former comprises 90 per cent of N tooling Shanghai's material cost, 100 per cent imported from Japan, while the latter is purchased locally.

N tooling Shanghai consists of tool designing, prototype making, tool making, quality control, and delivery. In many cases, N tooling Shanghai receives tool drawings from N tooling Japan or directly from customers. In some cases, N tooling Shanghai receives parts drawings of the parts that are machined by the tool. From the parts drawings, engineers of N tooling Shanghai design cutting tools and make drawings of the cutting tools. Based on the tool drawings, prototype tools are produced. After the prototypes are approved by the customers, tools are produced. All of these steps require advanced engineering skills and a high level of know-how. The fact that N tooling Shanghai can make drawings of the cutting tools from the drawings of the finished parts proves that the R&D capability of the company is quite high. In some cases, N tooling Shanghai is provided with the final parts only. In this case, engineers of N tooling Shanghai make a drawing of the final parts first, then make a drawing of the cutting tools to machine the final parts.

The cutting tool production process is as follows. First, a set of tool production order, drawing, and metal material is put in one tray and delivered to each worker. Basically, one tool is machined by one worker. On the first floor of the production shop, about 30 multi-purpose machine tools are placed for an individual worker. After receiving the tray set, each worker starts machining the metal material placed in the tray, accurately following the order.

The machined cutting tools are brought to the second floor for a quality check. On the second floor, CNC machines, quality measurement devices, and heat treatment machines are installed. CNC machines are used to machine standard tools. Quality measurement machines are all imported from Japan. A microscope with a magnification of x200 makes it possible to check micron damage of the cutting surface, which other Chinese local tool makers cannot detect with microscopes with a magnification of x80. A highly skilled worker checks the finished cutting tool with a microscope of magnification x200 and adds final touches for the cutting tool. Cutting tools that require heat treatment on the surface are outsourced to heat treatment firms.

The strong point of N tooling Shanghai is that most of the production processes are performed by multi-purpose machines. These machines require skilled operators who can perform different production processes on a daily basis, while single-purpose machines require routine operation.

Using multi-purpose machines elevates workers' skills and leaves large room for improving production processes and procedures by trial and error by each worker. In addition, to meet the variety of orders, each worker has to be trained through on-the-job training. Using multi-purpose machines provides on-the-job training (OJT) opportunities all the time. Even new employees start training using the multipurpose machines in the firm.

The problem facing N tooling Shanghai is the high turnover rate, which is nearly 20 per cent. This high rate is due to the high-level skills that the skilled workers obtain through daily operation at N tooling Shanghai, which are highly sought after in manufacturing industries in China. Those who have mastered high-level skills have many chances to get better-paid jobs in various industries. Moreover, many skilled workers start their own tool-making firms and become competitors of N tooling Shanghai. This situation is problematic to the firm, but has contributed positively to skill formation in the manufacturing industries in China.

Major Customers and Delivery System

The majority of customers are second- to fourth-tier parts suppliers for automobile makers. Upon receiving orders from customers, N tooling Shanghai produces or regrinds tools and delivers finished works to meet the needs of customers.

All the company's products were for export to N tooling Japan until recently. Gradually, it started to produce for the Chinese market and to export to the US and Association of Southeast Asian Nations (ASEAN) countries, such as Thailand and Singapore. Export to Japan comprised 65 per cent of the total sales in 2006. The dominant share, export to Japan, has been decreasing, while the share for the domestic Chinese market has increased to nearly 35 per cent of the total sales. Since N tooling Shanghai was established as a 100 per cent export-oriented tool maker, the technology and quality of the products were aimed to be equal to that of N tooling Japan. The director of N tooling Shanghai is an expert from Japan, a Chinese who studied in Japan and was employed by N tooling Japan. The Chinese director was dispatched from the headquarters in Japan to set up its Shanghai plant to achieve being a 100 per cent export tool maker for parts suppliers of the Japanese automobile makers in Japan.

Since the majority of N tooling Shanghai's customers are second- to fourth-tier parts suppliers, mostly SMEs, the number of products by one-lot order remains small. On average, the number of pieces for one-lot order is one to two pieces to Japan, five pieces to the US and to each Southeast Asian county, and 10 or more pieces to China. This small lot order with wide-variation products characterize the company's production system and affect its strength.

N tooling Shanghai has a proximate location advantage to Japan. To maximize the advantage, it has a unique order and delivery system, which is to receive orders from customers in Japan on Friday and produce the ordered tools on Saturday and Sunday, when Japanese customers do not operate because of the weekend. Finished tools are packaged using Japanese domestic carriers' packages with delivery address labels and are air-delivered from Shanghai International Airport, located about an hour's drive from the factory. After a two-hour flight, these packages arrive at the nearest international airport in Japan. The labelled packages are delivered directly from the airport by Japanese local carriers to the doors of customers. For orders received on Friday, the finished tools are delivered on Monday. This ordering and delivery system has strong competitiveness in the Japanese market without time lags because of the use of weekends.

5. Case Study of a Tool-making Firm in Vietnam

The author surveyed Ho Chi Minh City and its surrounding industrial areas in March 2008. Among the 8 companies surveyed, N tooling in Vietnam is examined here as a case of precision production being transferred to both China and Vietnam.

N tooling Vietnam was established in 2004 when investors were searching for a new production place followed by the establishment of a Shanghai plant in China. The major reasons for finding a new production site for N tooling Japan was that the labour cost in China was getting higher and the turnover rate in China had reached 20 per cent per month. Quite a few of the employees in China quit N tooling and started businesses as competitors of N tooling. Even worse for N tooling, the new entrepreneurs took with them many former colleagues from N tooling. From the technology transfer perspective, these entrepreneurs showed a horizontal transfer of skill and technology. However, from the company' perspective, it represents a skill drain from the firm.

N tooling Japan started a feasibility study in Vietnam in 2004. The director of N tooling Japan and the current director in Vietnam visited Vietnam and chose Vietnam Singapore Industrial Park (VSIP) near Ho Chi Minh City as their new production site at the end of 2004. At the first visit to VSIP, they decided to establish the plant there because of the good infrastructure of the industrial park and the available administration service of the local government for company registration, and the tax benefit.

The government of Vietnam offers various tax benefits to promote FDI in Vietnam, and this the tax benefit encourages export-oriented companies to transfer their production to Vietnam. For example, a 100% export-oriented company can enjoy in total 15 years of tax benefit. During the initial 4 years of making a profit, the company can enjoy 100% tax exemption. The following 5 years, their corporate tax stays at 5%. The benefit is different among various industries, but precision production, one of the core technologies for manufacturing, is ranked as having first priority.

The setting up of N tooling Vietnam was very fast. The production started just 8 months after the company registration in August 2005. The machine tools in N tooling Vietnam were all imported from China, Taiwan, and Japan. The machine tools from Japan were mainly used ones from N tooling Japan, while those from China and Taiwan were bought by purchasing division of N tooling China. Multipurpose tools were mainly from Taiwan.

The initial employees were 30 Vietnamese and three Japanese, one director and two quality control staff. Hiring Vietnamese workers was easy at the beginning. As soon as the company placed a job vacancy announcement outside of the factory gate, about 200 applicants came for 30 positions. No applicants had experience or formal training for precision skilled manufacturing work. The company runs three shifts 6 days a week. In 2008, the number of employees increased to 200, about a 7-fold increase in 3 years.

The production system in Vietnam is almost same as that in China, except that all the orders at N tooling Vietnam come from Japan, while about 70% come from Japan and 30% come from the domestic market at N tooling Shanghai.

The production system is as follows. First, customers in Japan order cutting tools to make certain parts. Engineering staff in Japan receive the orders from customers. The engineering staff make drawings of the parts and send the drawings electrictronically to Vietnam. In recent years, this drawing process has been transferred to China. In that case, after engineering staff in Japan receive an order, engineering drawing is done by Shanghai engineers in China. Then, the finished drawing is sent to Japan for inspection. Modifications are made in Japan if necessary. Then the electrictronic drawing is sent to China or Vietnam according to the schedule and the production processes the part requires. For example, heat treatment processes are outsourced in China but are not yet done in Vietnam.

In Vietnam, the operational processes include material selection, rough cutting, rough finish, NC processing, sectioning, profiling, marking, inspection, and shipping. After receiving drawings in PDF form, engineers choose suitable materials to meet part specifications, such as durability. Materials for the cutting tools are all imported from Japan. All the purchasing is done by the Japan side globally. Then, rough cutting is done. The finishing process can require as little as 0.005-micron clearances. The next process is engraving by the NC machine. Programming is done by Vietnamese workers. Sectioning is very difficult, because each process requires different tools.

The profiling process is very difficult and requires a long training period. Advanced workers are assigned especially for this process after receiving more than a year's training. Multiple-purpose machines are used here as well as in China. Marking is the process of indicating the production date and location on every cutting tool, such as 08320V, which means produced on 2008 March 20 at the Vietnam plant. Inspection and quality assurance are done by QA inspectors using x200 microscopes. Shipping to Japan is conducted using the same system as in China.

Initial training for the new Vietnamese key employees was done in China. Selected key workers were sent to N tooling Shanghai for six months of training. In the meantime, some Chinese staff were sent to the Vietnam plant as OJT and off-job training instructors. N tooling was trying to transfer technology from China to Vietnam rather than from Japan to Vietnam, mainly because of the training cost for both trainers and trainees.

The overall findings in Vietnam are that there were a quite a few highly skilled workers performing the finishing and profiling processes, which required a minimum of a year of specific skill training. These workers use multiple-purpose machines to shape a variety of parts. The skill levels at the China and Vietnam plants are about the same. The only difference between the two locations is that in China the company has R&D and drawing divisions. In China, the company has an engineering division whose workers can develop specification orders from Japan into drawings.

Conclusions

I have tried to analyze the technology and knowledge transfer from Japan to China and Vietnam, by choosing the cases of tool-making skills and know-how transfer. Tool-making skills are regarded as core skills, because they are used in various manufacturing industries where the machining process is essential. All the machine tools need various types and shapes of cutting tools for machining. Maintaining the high precision and quality of such cutting tools is the key to achieving high quality and precision and reducing the production time and cost.

High-precision production requires high-level skills and knowledge and workers with these skills and knowledge have not yet been replaced by advanced machinery in extreme high-precision works. Moreover, from a productivity and economy point of view, in tool making, where there is large variety and many styles, production cannot be replaced by advanced CNC machines or any computerized automated machines.

The research findings are: (1) workers produce tools by using multi-purpose machine tools to meet a variety of tool orders. As a consequence, workers acquire high-level skills while using multi-purpose machines on a daily basis to make tools and innovate and improve production processes by trial and error. (2) Regarding tool-making skills and the quality and accuracy level of the tools, the Chinese workers have achieved an internationally competitive level. (3) The skill and knowledge acquired in China has transferred to Vietnam, except for the engineering or drawing technologies. (4) Vietnam's tax benefits, lower labour cost, and low turnover rate encourage Japanese investors to shift production from China to Vietnam. (5) Skill levels in Vietnam are nearly as high as those in China.

Recent significant Chinese development has been largely due to foreign direct investment and foreign technology assistance. At the same time, very important production skills have been accumulated in core skills that are indispensable in key industries in China. However, the recent high labour cost and high turnover rate in China have been promoting the shift to Vietnam. The case of N tooling Vietnam showed that skill and knowledge acquisition has been accomplished by the same procedures as those used in China and the workforce skill level is approaching the same level as that in China.

References

Amin, S. (1976), *Unequal Development*, New York: Monthly Review Press.

Chen, J. (2000), *Growth Strategies of the Chinese Automotive Manufacturers* (in Japanese). Tokyo: Shinzansha Press.

Dunning, J. H. (1993), *The Globalisation of Business*. London : Routledge.

Frank, A. G. (1973), Development of Underdevelopment. In C. K. Wilber (ed.), *Political Economy of Development and Underdevelopment*. New York : Random House.

Frobel, F., J. Heinrich, and O. Kreye (1980), *The New International Division of Labour*. Cambridge : Cambridge University Press.

Gerschenkron, A. (1962), *Economic Backwardness in Historical Perspective*. Cambridge, MA : Harvard University Press.

Japan People's Finance Corporation Survey (1992), *People's Finance Corporation Report* 380.

Lee, H-L., and M. -F. Houde (2000), Recent Trends and Main Characteristics of Foreign Direct Investment in China. *Financial Market Trends*, No. 77 October. Paris : OECD.

Maher, M., and H. Christiansen (2001), Growth, Technology Transfer and Foreign Direct Investment. *OECD Global Forum on International Investment*. Mexico City, November 26–27 2001.

Sadoi, Y. (2003), *Skill Formation in Malaysian Auto Parts Industry*. Bangi, Malaysia : UKM Press.

Sadoi, Y. (2005), Technology Transfer in Auto Parts Production in China. *Proceedings of International Conference, Technology Transfer in Automobile and Electric Industry in Asia*. Kuala Lumpur, Malaysia.

Singer, H. (1950), The Distribution of Gains Between Investing and Borrowing Counties. *America Economic Review* 40 : 473–85.

Rasiah, R. (2004), *Foreign Firms, Technological Capabilities, and Economic Performance — Evidence from Africa, Asia and Latin America*. Cheltenham, UK : Edward Elger.